ng Young Douglas-Fir and Western Hemlock

Economics, Yield Control, and Thinning

Proceedings of a Symposium held June 16-18, 1969

Edited by

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FOREWORD

THESE are the proceedings of a short course in the management of young Douglas-fir and western hemlock conducted by the School of Forestry, Oregon State University, June 16-18, 1969.

Upon recommendations of participants in the 1968 short course, this course was designed to enlarge upon the inventory, operational, and economic aspects of management as presented in the 1968 proceedings. The course included one day of lectures and discussion on the campus of Oregon State University and two all-day field trips. Participants observed commercial thinning operations in Douglas-fir and western hemlock and the use of the Hypo-hatchet in chemical, precommercial thinning of Douglas-fir. They also participated in marking Douglas-fir for a commercial thinning.

The 67 registrants for the short course—all professional foresters—came from British Columbia, Washington, Oregon, and California. Two federal agencies, three state agencies, three universities, one city, and 22 private organizations were represented.

I would like to thank all of my colleagues in the School of Forestry who participated as instructors. I would especially like to thank the instructors from Boise-Cascade Corporation; Crown Zellerbach Corporation; Mason, Bruce, and Girard, Consulting Foresters; and the Department of Natural Resources, Washington. Without their help, this short course could not have been presented.

Alan B. Berg

INTRODUCTORY REMARKS

Carl H. Stoltenberg,
Dean, School of Forestry
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WELCOME to Oregon State University and to our second short course on the management of young-growth Douglas-fir and western hemlock.

For many years, our Forest Research Laboratory has devoted significant research effort in seeking to identify and assess alternative management possibilities in Oregon's young-growth forests. Investment opportunities in young-growth stands have a distinct advantage over planting, release, and many other wood growing alternatives, because the pay-out period is so much shorter. Thus, fertilization, irrigation, manipulation of growing stock, and similar opportunities are frequently attractive investments. For this reason, I am particularly interested personally in our young-growth research.

One of the ways we share the results of our research is through the publication of papers, brochures, and research bulletins. Another way is through conducting symposia like this one. These symposia have the distinct advantage of providing quick feedback from the participants on the relevancy of our research and the validity of our research results. Such feedback enables us to improve our research, thus making it more helpful to those of you who will apply it when the results become available.

This is the reason Professors Berg and Kangur have structured this symposium not only to present *our* results but to obtain ideas from those of you who are currently providing industrial and public leadership in managing the young-growth stands of the Northwest. We are looking forward to sharing results and ideas with you during the next 3 days.

YIELD CONTROL OF YOUNG-GROWTH DOUGLAS-FIR

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MY PURPOSE is twofold. First, I will develop a broad framework to evaluate the whole problem of young-growth management and yield control–a broad framework or frame of reference to keep us oriented. Second, I will discuss some key tools and techniques for yield control and tools and techniques that we in the Department of Natural Resources in Washington State have found useful in managing our young growth.

To make sure that everyone is thinking the same, I'll start with a few definitions. I will confine my detailed comments primarily to Douglas-fir. Principles apply to other species, but my experiences are with Douglas-fir. Generally, we are concerned with ages from stand establishment through 90 years, if you want to carry the rotations that far. Now, I'll define what yield control is to me. Someone else may have a slightly different definition, but to me, yield control of intensively managed forest stands is the accurate accounting of the inventory, the growth, and the drain of wood volume on a forest property, so that changes in any one of these three items (inventory, growth, or drain) can be reflected or translated into an effect on one of the other two items.

Inventory of the wood products, the growth of those products, and their removal are interrelated. When we are concerned with controlling yields, we eventually reach a point at some time in an organization's development where changes in any one of these three items can and should affect the other two. To help further define yield control, we can consider cyclic "phases" in time and "levels of management" (Table 1).

The time cycle is indicated on Table 1 by the arrow across the top of the page where three "phases" are given. Four "levels of management" are shown down the left column.

Table 1. Defining Control of Young-growth Management by Phases in a Cycle.

NOW → TIME PASSES → CYCLE ENDS		
INVENTORY County, district, stand	PROJECTIONS Needs, goals Expected growth, drain	ACCOMPLISHMENT Records Actual growth, drain Feedback, adjustment
NO MANAGEMENT "We have some second growth--	Forget about it now--	We'll get to it one day!"
LOW MANAGEMENT Broad survey or yield-table estimates of volume.	Growth estimate (if any) from yield table.	Some commercial thinning. No feedback--long cycle.
INTERMEDIATE MANAGEMENT Basic inventory; scale-cruise inventories of cutting units. Manageable areas defined	Refined yield-table estimates of growth. Goals set firmly.	Positive thinning program. Desire to know growth. Feedback wanted.
INTENSIVE MANAGEMENT Manageable units defined Permanent sample plots in units.	Growth from permanent plots. Goals tight, tied to growth.	Growth affects cut. Feedback essential. Time cycle short.

PHASES OF YIELD CONTROL

The phases are INVENTORY, PROJECTIONS, and ACCOMPLISHMENT. INVENTORY applies to the scope of any organization; for example, "all of the young-growth stands in western Washington," or "all the young-growth stands in Benton County," or it could be the young-growth stands in your particular ranger district, or tree farm. Similar principles apply in all these instances. The PROJECTION phase defines the needs and goals of the organization. Needs and goals differ between organizations. This is a key point to keep in mind. What may be working for one company with their level of intensive management will not necessarily work for another. The needs and goals of different companies obviously differ, and they must be well defined for any particular job of young-growth management. Under PROJECTION in Table 1, I have included expectations of both *growth* and *drain* in young-growth management.

The third major phase is ACCOMPLISHMENT. So far, I think we have talked about common things. Everyone inventories; everyone does some sort of yield or growth projection. Often, our accomplishment is the weak link that keeps these items from becoming a complete process. By ACCOMPLISHMENT, I refer specifically to the necessary records of actual growth and drain as a feedback and monitoring device to correct the growth and drain figures that you projected, perhaps 10 years previously. At this stage, you feed back this new information. Because of actual experience, you have more knowledge and a better feel for growth and drain, plus all the other problems that you did not anticipate 10 years ago when you made your projections. You are now in a position to adjust and begin a new cycle for the next 5 or 10 years. Here, again, note the cyclic nature. You make your estimate, you inventory, and you project growth and drain; then you stop and take stock, make changes, go back and carry out your operations for a while. You readjust all the figures you used and improve all the estimates you made. You begin a new cycle.

LEVELS OF MANAGEMENT INTENSITY

Now, let's look at the levels of intensity (Table 1) that could apply to your operations in young-growth management. I have labeled them "NONE, LOW, INTERMEDIATE, and INTENSIVE," for convenience sake.

If your young-growth management is NONE, you have some young growth you'll get around to some day, but right now you can't be bothered with it because your job is to do something else. I'm not condemning this position at all—just defining it. We have, for example, in our operations, one or two districts that have a heavy volume of old growth. A good deal of young growth is coming along, but these are primarily old-growth districts. Our main operation in those particular districts is liquidation of old growth. We have from 18 to 20 other districts where young growth is a major interest. We therefore have higher management intensity in one district than in another. Probably some have operations in the NONE category of young-growth management.

My definition of LOW intensity is: The inventory is a broad type of survey, perhaps the whole tree farm, a county, or a national forest inventory. A broad survey tells you roughly that you have so many million feet of timber in young growth. Your yield estimates, likely, could be from yield tables. Maybe you have a few plots in young growth and a more intensive survey on old growth. Perhaps an estimate of acres by age class, what the site index is, and yield-table yields are sufficient for the present.

For projection purposes, at a LOW intensity, growth estimates with yield tables may suffice. You can look at the tables and estimate so many feet of growth in 15 or 20 years. It gives you a rough figure, and that's all you need. For accomplishment at LOW intensity, you probably have commercial thinnings going because they pay, but you are accomplishing under your total capacity. You're getting into a program, but you're not really there yet. You'd like to do more, but you haven't the manpower you need to get this material moving. The actual growth figure is nice to have, but it

probably doesn't really have any bearing on the amount of young-growth removal. You like to think about it, but you haven't really used information on growth and drain to feed back to sharpen your future projections. This is what I call a LOW intensity; I think many of us just left this level and passed into INTERMEDIATE intensity.

In INTERMEDIATE intensity, the inventory is probably a good, permanent-sample-plot inventory. You have this established for your whole area. Besides, in your commercially thinned units, you have a more detailed inventory for sale purposes. In the Department of Natural Resources, we make detailed measurements (a cruise) for sales purposes so that thinnings can be sold at public auction. You have a parallel in your own operations. It may be getting a contract operator to take the company's material out on a unit. One way or another, you make an estimate or a measurement. You have that more intensive measure of a given stand's capacity to provide something that you need. You probably have an estimate of how many acres in each of the age-class distributions in your young growth. So you've gained a little over the LOW level.

For the growth estimate in INTERMEDIATE intensity you probably found out that good old reliable Bulletin 201 (11) doesn't quite give you what you need. You can still live with a yield table estimate, but you need a more precise answer, something more refined that will give yields by density classes, perhaps. Maybe you have built a refined yield table of your own, from your own permanent-plot data. Your goals in this INTERMEDIATE level have been developed to where you set a firm figure. For example, you might set 34 million feet a year to cut from your young growth. You've set this, you've committed yourself, and you've something to strive for. Absolute attainment of your young-growth goal isn't critical at this stage, however; perhaps only 30 million is all right. For the accomplishment phase, you have a good, positive commercial thinning operation under way, with men assigned for the task. They are specializing in young-growth management. You desire a more accurate estimate of growth. You think it is going to affect your operations. Maybe you are ready to begin developing into the next stage, INTENSIVE management.

Now, if you are practicing INTENSIVE management of young growth, you probably have organized manageable young-growth units into semi-permanent units, blocks, or compartments. You have them defined and have set them aside. You may have divided the district or the tree farm into four or five manageable blocks, tangible areas you can deal with. You probably have permanent sample plots throughout the whole ownership and even a good scattering down in the blocks to tell you more precisely what is going on there. Your growth estimates are either from a good overall set of permanent sample plots or from a close control on block growth and block drain. Your goals are tight. You have so many cubic feet of wood the mill will use. You have to get the wood to the mill. You are trying to use the most your holdings will give you. If a difference occurs between the estimate of growth and what is on the ground, it does feed back and affect the amount of drain.

This is the sort of thing that we envision they are doing in Europe where they have had intensive management for several hundred years. This is the ideal intensive management that we all, I think, have on our minds. This is something that we will attain—maybe tomorrow, maybe 10 years from now, but something toward which we are headed in our management.

I am going to take a poll now. The frame of reference is your particular job. If you are working on a ranger district, your frame of reference is that ranger district, not the whole Forest Service. If you are working for a state agency in a county, or maybe a district administrative unit, your frame of reference is your county or unit. What is the present intensity of young-growth management in western Oregon, Washington, and northern California? Is it NONE, LOW, INTERMEDIATE, or INTENSIVE, according to these definitions? The results of this poll (Table 2) look as though forest-management intensity is from LOW to INTERMEDIATE in the Douglas-fir subregion. This is worthwhile to know for a frame of reference. Sometimes we get excited because our practice appears far behind our desires. When we actually take stock and look around, maybe we are not as badly off as we imagined.

REQUIREMENTS FOR AN ADEQUATE YIELD CONTROL SYSTEM

You don't get adequate yield control in a system by accident. You have to design it; you have to change things to make it work.

Principles

You must keep three principles in mind in your yield control system. First, whatever you do should have some *acceptable accuracy limits* assigned to it. Obviously, you can't run blindly through a 10-year cycle of management from inventory through accomplishment without knowing or having some idea of how good your answers must be. Somewhere along the line you have to determine what "how good" is to your outfit. It may be a percentage error limit, of it may be accomplishing a minimum amount of work.

Second, your yield control system must be *practical.* You may have all the theoretical techniques and tools at your disposal to get tremendously accurate answers, but if the system doesn't work on the ground where several vital activities are going on, it isn't practical. Anything you use in a system of control has to be practical because it is a field tool.

Table 2. Present Intensity of Young-Growth Management in Western Oregon, Washington, and Northern California. Poll of Symposium Participants.

Intensity	Count	Percentage
None	3	5
Low	22	37
Intermediate	25	44
Intensive	0	10
Nonclassified	2	4
Total	58	100

Third, measurements for accounting and keeping track of growth, inventory, and drain must be *compatible* with accomplishment. You can't be in a position where one arm of your organization measures as the other arm accomplishes, and the two arms are unattached by a body in between. This happens. I am sure you have run across minor examples within your organization, where the right hand doesn't know what the left hand is doing. They have to be compatible, or your system isn't going to work. With these three basic principles in mind, let's talk now about some of the details.

Details of a Yield Control System

We deal first with *accuracy*. Table 3 shows my ideas of the accuracy, for LOW, INTERMEDIATE, and INTENSIVE management for two applications: a total district or county application, and a block or compartment application. I have expressed these figures as volume percentage error at one standard deviation. The percentage of error for a district, county, or a tree farm for the inventory of standing volume ranges from 5 percent to about 20 percent. If you estimate your basic inventory with a yield table, again the percentage of error is probably somewhere between 5 and 20 percent. The reason for this wide range is that, frequently, plots established over an entire tree farm, district, or county do give a low standard error of volume for the entire area. So you can get as low as 5 percent with a good, substantial, overall inventory for the entire area. The sampling on the other extreme with very few plots, however, might give a 20-percent error. So you are rattling around somewhere between 5 and 20 percent. I haven't assigned an error to growth estimates out of the yield tables.

The difference between the district, county, or tree farm and a local block within a larger area is sizeable. Notice what happens in Table 3. If you have a 5- or 20-percent error for the whole area, you have virtually no answer if you apply the same sampling intensity to just a *portion* of the total area. Plots widely scattered are of little help; only the relative few that occur in the specific block are useable. You just don't have enough sampling in this low intensity.

Yield table error is about plus or minus 25 percent on a local block application if it is from 5 to 20 percent on a county-wide basis. This is with a good tally of number of age classes, area for each age class, and the site index. The growth estimate for a block or survey, with Bulletin 201 (11) as an estimator of growth, is probably about 25 percent low. This is in comparison with periodic annual increment from George Staebler's (14) gross yield table work, and the attendant assumptions.

In an INTERMEDIATE intensity, you probably have a good system of permanent plots for your district or county. You have probably reduced the error to a range of from 5 to 10 percent of standing volume. For a growth estimate, you have probably refined Bulletin 201. Tables are available for this (7). The error in these refined tables is about plus or minus 12 percent.

My references for that particular error figure are two sources. One is the British yield tables for Douglas-fir (8). They have records of 50 years of growth from permanent plots in Douglas-fir plantations in Britain. They have developed a series of yield tables for managed stands. They found that, in spite of 50 years of growth data, their error for estimating volume (if you know the age and the site of the plantation and look in the yield table) is about the equivalent of one site index, about 12 percent. So, if a stand is site index 130 by the measurements on the ground, it could have the equivalent *volume* of a site index of 120 or 140.

Bob Curtis (4) dealt with gross yields in Douglas-fir. He obtained roughly the same error as the British. I don't believe that with refined yield tables we are going to better that. I think that's about the inherent quality of the yield table figures. It is a pretty good answer, really. From these figures, then, if you are applying refined yield tables as a basis for growth estimates, the error would probably be plus or minus 12 percent for the block. Drain, the measure of the material that is coming off, is probably from 5 to 10 percent on the intensively managed block. This would apply also to a district or tree farm.

Note one rather interesting thing here. Again, I am speaking from my own experience. The reason we have a low

Table 3. Approximate Accuracy of Some Usual Young-Growth Estimations.

Estimations	Volume error percent[1]	
	Total district, county or tree farm	Management block, or compartment
	Percent	*Percent*
LOW MANAGEMENT		
Inventory by broad survey or	5-20	No answer
by yield-table estimate (11)	5-20	±25
Growth by yield-table estimate (11)	--	-20 to -30
INTERMEDIATE MANAGEMENT		
Inventory by permanent plots	5-10	16
Growth by refined yield-table estimate[2]	±12	±12
Drain by material for cutting	--	5-10

INTENSIVE MANAGEMENT		
Inventory by block or compartment	--	±5
Growth measure:[3]		
a. 10-80% of stand volume can be growth volume for 5-yr period		In balance with magnitude of inventory error
b. Increment core sample (where mortality is negligible)		
Drain by "Absolute" measure of cut material (for sale or mill supply purpose)		±4

[1]At one standard deviation.
[2]Age and site index known.
[3]To adjust yield tables.

error on the drain and can tolerate something higher on these other phases, is that, with INTERMEDIATE intensity, we are focusing primarily on young-growth thinning *harvests.* This is where our emphasis in intensity is—the commercial thinning. We have to make sales to the public; you have to contract with your operator for so many thousand board feet. This requires a good measurement. You will want a 5- to 10-percent error. You will keep it that low even when the error of estimate of the whole picture may not be that good. As we progress into higher intensity, you will notice a few other things.

The inventory for INTENSIVE management is probably on a block or compartment basis. We aren't concerned as much about the answer by district or county. We have shifted our emphasis to provide a good answer for the management block. The inventory in the block is probably plus or minus 5 percent.

With the inventory and the growth measure, perhaps we can use yield tables (and their 12-percent error) and by some means, such as taking additional field measurements, refine this 12-percent error to a more accurate figure. This is possible. The British yield tables with their 12-percent error can be refined by a system of additional field measurements aside from the age, height, and site index. Those of you in intensive management are probably doing this additional field work to verify or correct the yield table system with actual data on the ground. In doing this adjusting, keep in mind that the *growth* error should be kept in balance with the basic inventory figure. For example, don't concentrate on a growth answer with a 10-percent error and apply it to a weak standing-volume estimate with a 15-percent error. The growth answer might be completely lost in an error of plus or minus 15 percent of stand volume. People have trapped themselves this way when their system "grows" rather than "is planned."

The drain for INTENSIVE management, where an absolute measure is required, may be around plus or minus 4 percent. Again, the purpose for such a low error is not necessarily yield control; we believe we need a more accurate answer to satisfy our buyers.

A second detail of importance in a yield-control system is *practicality.* For example, in our operations, where we thought

we had to alter our usual field procedure to gain additional information for feedback as part of yield control, we planned to make a usual inventory cruise of a unit that was for sale in intermediate intensity of management. More information was needed to make our yield-control system work. We had to modify stand procedure.

Our usual procedure was as follows: We had a 100-percent tree tally by forestry technician crews skilled in marking timber to be removed. Each time they marked a tree, they counted it with a "tally whacker." After several weeks of marking and tallying, several thousand trees were marked for sale.

To make our cruise, we found that the quickest, cheapest way was to send the forester in, after all this had been marked, to make a narrow, systematic strip cruise through the total sale area and measure DBH and sample for volume estimate on a defined area. We put this information together and processed and auctioned the sale.

We needed additional information, however, to find out what we were doing in the total stand. All our emphasis in normal sale procedure was just on what we were cutting. We still had no records for purposes of yield control—what the stand originally had been or what was left. All that was needed to complete our procedure was to add a "leave tree" tally as well as a "cut tree" tally to the cruise. Half of the information was already being gathered; only one extra step was added. This cost a little more, but was practical, and we didn't really ask the man in the field, whose job it was to move timber, to do much more than what he was already doing. We cannot add a lot of additional work to the existing jobs of the foresters on the ground. They don't have the time.

Compatibility through the cycle is another important consideration that, until 5 to 10 years ago, was a serious problem. We had scores of volume tables around; everyone used his own or the ones that were most convenient. When the time arrived to sharpen volume estimates with more precise volume measurements and a better volume table, you often found that the best volume tables were difficult to use. They have to be within your accuracy limits. Also, they have to be in a convenient form for the man who is marking and measuring on

the ground as well as for the inventory forester at the main office who is working with computer and formulas. This is a part of compatibility. Obviously, you have to measure the same way, but also your tools must be in a form practical for field application where the records are collected, as well as for the basic overall inventory and the growth estimates that are probably worked out on a computer. Both phases are important and must go together.

Let me show you an example of *in*compatibility. The average of about ten trees of nearly the same size and shape is 12.9 inches DBH, 89 feet tall, and form class of 82. The actual scale of a tree of those dimensions is 137 board feet, Scribner log rule. Both the standard volume tables in Bulletin 201 (11) and form class volume tables (5) list the scale for that tree as 170 board feet, a 22-percent difference. Volume for the tree in the tarif-table system (15) is 128 board feet, Scribner, a 6-percent difference from the actual. Many reasons account for the differences. I do not imply that the standard table in Bulletin 201 and form class tables are always 22 percent high. It only works out this way in this particular example. The point regarding compatibility is this: If the man with the computer is providing overall estimates for the total unit with a system of tables that says the tree has 128 board feet, and the man out on the ground scaling timber says 170 board feet, the whole system is completely incompatible. What one man is measuring is not at all what the other man is measuring. To have control where growth might affect drain, you can't live with these incompatible methods of measuring. If they are not compatible, you don't have a system.

The units of measure must also be compatible. You can't maintain yield control within the limits that you must have with board feet alone as your unit of measurement. It can't be done. Board feet just aren't consistent. Board feet on one size of tree isn't the same as board feet on another size of tree. We all know this, yet we seem to forget it. The solution is to take other measurements to provide a good basis for conversion of board feet to other units to keep control of the actual growth, drain, or inventory. Board feet in logs or trees of stated

diameter is different. If you know the diameter of the tree and its board footage, you can convert. But board feet alone aren't enough. Canadian experience confirms this. Canada has been using cubic feet for some time. Often, when I talk about cubic feet with American foresters, they say, in effect, "Canada has cubic feet, but when they use cubic feet they have to use something else with it, because nobody has a real feel for what cubic feet really means. So it isn't very good." American foresters are defensive. Actually, I think that American foresters know we should be using something besides board feet. But they are sensitive. They look over the border and say, "The foresters up there have it, but it isn't really working so well."

Within the last year, talking to a group of Canadian foresters, I expected them to say, "We are using cubic feet, but it isn't working out so well." But they didn't say that. They didn't imply anything wrong. They know that they must have different units of measure for different uses. I believe that most American foresters are defensive because they know they should be using cubic feet, but haven't been.

Really, the only logical choice of unit of measure for basic yield control is the cubic foot. I think most people will tend to agree with this, unless you want to go on a world market basis and use the cubic meter. Maybe this is the ultimate answer. If, however, we can't talk in cubic feet, one of our own units, we certainly aren't suddenly going to the cubic meter to deal and compete on the world market, even though that may be a dire necessity soon. A good, consistent, convenient means of conversion between the two units is the answer. Use the cubic or board foot where needed and have the necessary means of conversion between them.

TOOLS AND TECHNIQUES

Now that we have considered where we are going with yield control, we can concern ourselves with the particular tools and techniques that help to increase accuracy as management increases from LOW to INTERMEDIATE to INTENSIVE.

Three things I want to talk specifically about: the tarif tables (15), the Curtis Douglas-fir gross yield tables (4), and predicted thinning regimes for commercial thinning (and for fertilized stands, because we are already moving into that phase in many areas).

Tarif Tables

What are the tarif tables? Figure 1 is a specimen of a tarif table and an example of how it is used. The bottom half of the figure shows what one particular tarif table looks like. Remember that the tarif tables are a system of interrelated local volume tables. Let me review, briefly, precisely what I mean by a local volume table. You will recall in your Mensuration 1 class, you were told to collect the necessary height and diameter measurements, select a good standard volume table, and adjust the standard table to local conditions with your measurements. With the application of these tarif tables you can do that. How is this accomplished? There are several practical steps.

A limited number of height and DBH measurements from a stand are used in an access table. An access table is a listing of height, diameter, and tarif number. By looking up the tarif number for the measured trees in the access table and averaging, we obtain the average tarif number for the stand. The table in the book that corresponds with that average number is the local volume table that applies to the particular stand. You then have the table of volumes to assign to all the trees.

The access system is not, however, absolutely necessary. If optical dendrometer measurements were taken on sample trees and volume computed, the actual volume, DBH, and height can be the basis for determining the average tarif table that applies to the stand. Bear in mind also that the system can be computerized. When you feed a few measurements of sample trees into a large computer and it computes individual tree volumes and then applies those volumes to all those trees in a stand, it is doing essentially the same thing—making a local volume table. It is just faster and more accurate. Unless you measure every tree in the stand (which you will not do) by felling or by optical dendrometer, no matter how sophisticated

your computer is and no matter how intensive the measurements are, you still go through this same basic logic.

Therefore, when I say "tarif table" and "local volume table," I mean the conventional tables, as illustrated in Figure 1. But I also imply the equivalent formula form of the system as used in the computer.

Accuracy of Tarif Tables

The accuracy of these tables is about a 4- to 5-percent error (that is, the average error of each fitted tarif–regression–line to each basic set of samples). To achieve this low error, you need only take the simple prescribed field measurements. You could use a Barr and Stroud dendrometer to measure sample trees; this will increase the accuracy. You might cut the error in half, to 2 percent. This is the accuracy that is possible with this system. Quite obviously, it can be used for any phase of yield control as far as accuracy is concerned, but how about the practicality of it?

Practicality and Convenience

First of all, the system is as simple and direct in field application as other methods of determining volume of a given stand of timber. It becomes even more useful and practical after we have determined the particular table that applies to an area (Figure 1).

Within the tarif system (both formula and table form), we have various units of measure: cubic feet; international board feet; cubic feet to a 4-inch, 6-inch, or 8-inch top; and cubic feet total. If you prefer volume basal-area ratios rather than volume, that option is there as well. You can use it for the board foot answer for the man on the ground who is moving wood, loading on a truck, and hauling it out. You have cubic feet for use in yield control. Unit-of-measure changes are as simple as reading from one line to the other. It is convenient, consistent, and compatible.

To show you, roughly, how practical it is, I have an example of a mill study that we did in one of our young-growth management blocks (Table 4). The problem here is unique. It is

ACCESS TABLE

DBH	TOTAL HEIGHT (FEET)							
	60	62	64	66	68	70	72	74
12.2	22.2	23.1	23.9	24.8	25.7	26.6	27.4	28.
12.4	22.0	22.9	23.7	24.6	25.5	26.4	27.2	28.
12.6	21.8	22.7	23.6	24.4	25.3	26.1	27.0	27.
12.8	21.6	22.5	23.4	24.2	25.1	25.9	26.8	27.
13.0	21.5	22.3	23.2	24.0	24.9	25.7	26.6	27.
13.2	21.3	22.1	23.0	23.8	24.7	25.6	26.4	27
13.4	21.1	22.0	22.8	23.7	24.5	25.4	26.2	27
13.6	20.9	21.8	22.6	23.5	24.3	25.2	26.0	2
13.8	20.8	21.6	22.5	23.3	24.2	25.0	25.9	2
14.0	20.6	21.4	22.3	23.1	24.0	24.8	25.7	2
14.2	20.4	21.3	22.1	23.0	23.8	24.7	25.5	
14.4	20.3	21.1	22.0	22.8	23.6	24.5	25.3	
14.6	20.1	21.0	21.8	22.6	23.5	24.3	25.2	
14.8	20.0	20.8	21.7	22.5	23.3	24.2	25	
15.0	19.8	20.7	21.5	22.3	23.2	24.0	24	
15.2	19.7	20.5	21.4	22.2	23.0	23.9		
15.4	19.6	20.4	21.2	22.0	22.9	23.7		
15.6	19.4	20.2	21.1	21.9	22.7	23.		
15.8	19.3	20.1	20.9	21.8	22.6	2		
16.0	19.1	20.0	20.8	21.6	22.4			
16.2	19.0	19.8	20.7	21.5				
16.4	18.9	19.7	20.5					

Procedure for Use

1. Measure height and DBH of selected sample trees in the stand. Look up tarif # of sample trees in Height DBH Access Table for the species: e.g.,

HEIGHT	DBH	SAMPLE TREE TARIF # (from access table)
60	12.2	22.2
68	14.3	--
etc.		--
	Mean =	24.5

2. Average the sample tree tarif numbers. (example, 24.5) This "mean tarif" applies to the stand.

3. Look up page in tarif book for tarif table 24.5 (in this example). This "local volume table" provides choice for the stand in cubic or board feet to various merchantable top limits. Use appropriate figures for stand volume calculation. Volume/basal area ratios are available for use in Bitterlich estimation of stand volume.

TARIF NUMBER 24.5

TARIF TABLE

DBH IN.	TOTAL TREE VOLUME INCL. TOP AND STUMP CU. FEET		TOTAL TREE VOLUME INCL. TOP ONLY CU. FEET		VOL TO 4 INCH TOP CUBIC FEET		VOLUME TO 6 INCH TOP CUBIC FEET		BD FEET SCRIBNER		BD FEET INTER 1/4		VOLUME TO 8 INCH TOP CUBIC FEET		BD FEET SCRIBNER		BD FEET INTER 1/4		
	VOL A	GM A	VOL B	GM B	VOL C	GM C	VOL D	GM D	VOL E	GM E	VOL F	GM F	VOL G	GM G	VOL H	GM H		VOL I	GM I
2	0.3	0.2	0.2	0.2	•	•	•	•	•	•	•	•	•	•	•	•		•	•
3	0.7	0.7	0.6	0.6	•	•	•	•	•	•	•	•	•	•	•	•		•	•
4	1.5	1.0	1.4	1.0	•	•	•	•	•	•	•	•	•	•	•	•		•	•
5	2.6	1.4	2.5	1.3	1.4	1.5	•	•	•	•	•	•	•	•	•	•		•	•
6	4.1	1.7	4.0	1.6	3.0	1.8	•	•	•	•	•	•	•	•	•	•		•	•
7	5.9	2.0	5.7	2.0	4.9	2.1	1.9	2.2	6	7.2	9	10.7	•	•	•	•		•	•
8	8.1	2.4	7.8	2.3	7.1	2.4	4.3	2.8	14	9.8	21	13.9	•	•	•	•		•	•
9	10.5	2.7	10.2	2.6	9.6	2.7	7.2	3.1	25	11.9	36	16.2	1.5	3.9	4	17.0		7	23.1
10	13.3	3.0	12.9	2.9	12.3	3.0	10.5	3.4	38	13.7	53	18.0	5.5	4.2	22	19.2		32	25.0
11	16.4	3.3	15.9	3.2	15.4	3.3	13.9	3.6	53	15.4	72	19.5	7.8	4.4	42	19.7		58	24.3
12	19.9	3.6	19.2	3.5	18.8	3.6	17.6	3.8	69	16.9	92	20.8	14.2	4.5	61	19.9		83	24.3
13	23.6	4.0	22.9	3.8	22.4	3.9	21.5	4.1	86	18.4	113	22.0	19.8	4.7	82	20.3		107	24.2
14	27.7	4.3	26.8	4.1	26.4	4.1	25.6	4.3	106	19.9	136	23.2	23.4	4.8	102	21.0		132	24.4
15	32.1	4.6	31.0	4.4	30.6	4.4	30.0	4.5	126	21.4	160	24.4	28.2	4.9	124	22.0		157	25.0

DBH	V/BA RATIO		V/BA RATIO	% OF VOL A	V/BA RATIO	% OF VOL B	V/BA RATIO	% OF VOL C	V/BA RATIO	B/CU RATIO	V/BA RATIO	B/CU RATIO	V/BA RATIO	% OF VOL D	V/BA RATIO	B/CU RATIO	% OF VOL E	V/BA RATIO	B/CU RATIO	% OF VOL F
2	9.3		8.3	89.0	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
3	12.5		11.6	92.5	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4	16.3		15.4	94.4	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	19.0		18.1	95.5	9.7	51.0	•	•	•	•	•	•	•	•	•	•	•	•	•	•
6	20.7		19.9	96.1	14.9	71.9	•	•	•	•	•	•	•	•	•	•	•	•	•	•
7	22.0		21.2	96.4	18.1	82.3	6.8	37.7	21.1	3.1	32.0	4.7	•	•	•	•	•	•	•	•
8	23.0		22.2	96.6	20.1	87.6	12.3	61.1	40.6	3.3	59.9	4.9	•	•	•	•	•	•	•	•
9	23.7		23.0	96.7	21.5	90.7	16.3	75.6	56.8	3.5	81.5	5.0	3.4	20.6	8.9	2.6	15.6	16.3	4.9	20.0
10	24.3		23.6	96.7	22.5	92.6	19.1	84.6	69.6	3.6	97.5	5.1	10.0	52.8	40.8	4.1	58.6	59.2	5.9	60.7
11	24.8		24.0	96.8	23.3	93.8	21.0	90.2	79.6	3.8	109.0	5.2	14.8	70.2	63.2	4.3	79.5	97.7	5.9	80.4
12	25.2		24.4	96.8	23.9	94.5	22.3	93.7	87.4	3.9	117.2	5.2	18.0	80.7	78.3	4.3	89.5	105.5	5.9	90.0
13	25.6		24.7	96.8	24.3	95.0	23.3	95.8	93.7	4.0	123.1	5.3	20.3	87.2	88.5	4.4	94.4	110.5	5.7	94.6
14	25.9		25.0	96.8	24.7	95.4	23.9	97.1	98.7	4.1	127.3	5.3	21.9	91.3	95.5	4.4	96.8	123.3	5.6	96.9
15	26.1		25.2	96.8	24.9	95.6	24.4	98.0	102.8	4.2	130.3	5.3	23.0	94.0	100.7	4.4	97.9	127.6	5.6	98.0

Figure 1. Specimen of comprehensive tree volume tarif table and height-dbh access table for Douglas-fir.

Table 4. Results of Mill Study. Comparison Based on Calculated Scribner Scale to 8-Inch Top (4, 7).

Entry	Source of volume	Difference
		Percent[1]
1	Tarif table (height-DBH)	97
2	Tarif table (individual volume)	99
3	Total height-form class table[2]	96
4	Scale-book tally	86
5	Cant scale	115
6	International ¼-in. rule	113
7	Tarif (height-DBH) to 6-in. top	100

[1]Based on computed log scale.
[2]Girard (5).

the first time to my knowledge that the Department of Natural Resources ever did this sort of thing. We had a 35-year-old stand and wanted to thin it commercially. The stand needed it. We talked our sales people into allowing special procedures in this particular case. Loggers weren't accustomed to commercial thinnings yet. Rather than mark the whole area only to find that an operator would not bid on it, we marked an acre, brought potential bidders in, and said, "Look at this acre. We are going to mark the whole thing this way. There are lots of trees in there. If you come in and buy this, we will guarantee you 500 thousand board feet marked the way this acre is marked."

The guarantee was the real clincher. In our normal operations, we state average sale volume with a plus and minus error limit. Generally, the volume is there, but we don't say we'll guarantee anything. The results were good, in fact it was the best shot in the arm young-growth management had had to date in the Department of Natural Resources. This occurred in a severe fire year. This was the first instance, to my knowledge, in our organization where young-growth management took precedence over fire control. The forester in charge was called to go to a fire during the heat of that summer and he said, "I can't. I'm marking ahead of this guy and he's just 1 day behind me. I

have to mark this because the contract says we will mark ahead of him and he won't have to stop and wait for us. We guaranteed him this." Our district administrator said, "Okay; stay on the job and take care of the operator." This was a major step forward for an organization like ours that is fire-control oriented. Today is different. We are a much bigger organization, more oriented to young-growth management.

In the process of administering this sale to the portable-mill operator who bought it, we made a mill study. Table 4 shows some results. The entries are compared in terms of volume as a percentage of Scribner log scale to an 8-inch top. You can see that we had anywhere from 86 percent to 115 percent of the base. The key point here is that had we used our tarif table system alone as the basis, we would have come out right on the money. Volume to a 6-inch top was actually what the sale was sold on. We planned to give 500 thousand feet plus, allowing a 15 percent overrun because he milled it rather than removed the material as logs. This example worked out even better than we expected. If we had been within a few percentage points, we would have been happy.

That shows you what can be done with this tarif-table system and the various units of measure it conveniently provides—cubic feet and board feet, international and Scribner. It will do your job of yield control.

Douglas-Fir Gross Yield Tables

Let's look at what is available from the Douglas-fir gross yield table, Bob Curtis's work (4). This work may be used to project future volumes, future yield. Somewhere along the line, you need some means of projecting what you expect to grow in the next planning period in your management unit. Somehow you must estimate this, because you can't measure it. You can do this with these gross yield tables. They are within the limit of 12 percent plus or minus in the British yield table (8). Dave Bruce (2) compares Bob Curtis's tables with the intensively managed Douglas-fir stands in Britain. The Curtis tables (4) can be an adequate basis for projecting yields. You alter those tables into terms that fit your own needs. We have done this for our

department (7) as a convenience. It isn't necessary; it just makes them more practical than their original form.

Regimes for Projection Estimates

What is going to happen, you may ask, when you take 10-, 15-, or 25-year-old stands and fertilize and precommercially thin them? What will you do with them in the future? What do you expect them to yield? When? Sometimes projections of this sort are close to guesswork. None of us can afford to guess without some substantial basis. In the Department of Natural Resources we used Bob Curtis's findings as a basis for projecting. We have developed what we call standard "regimes." This is a label we hang on standard levels of intensive management in our young-growth stands, ages 15-25. Those are the age classes we are thinning. We are fertilizing some of these young stands as well. From the Curtis growth-rate data we have developed regimes that describe and project what will happen when we subject stands to certain treatment. We have projected for a range of site indexes what we expect to happen over the whole rotation. The importance of these "regimes" and their projection is quite sizeable. In the past year, the Department has raised its annual sustainable harvest (that is, allowable cut) from 540 million board feet to 774 million board feet per year. Of this, 144 million feet of the increase is based upon the future yields that we expect to get because of treatment in our stands. That includes fertilization and precommercial thinning.

How accurate are these estimates? They're probably basically as accurate as the yield tables that we developed them from—that is, plus or minus 12 percent of standing volume. This isn't bad. I think we can live with that. Some nagging questions, however, remain in the back of your mind. "Were those projections as good as they were cracked up to be and as sound as we thought they were? If not, what will we do about it?" If we keep the right records, if our yield-control system is complete, and if we use the right feedback, we can correct those estimates if they are drastically wrong. I don't believe they are; I think we are going to have to refine them, but I don't think they are way off. The right records, feedback, new measure-

ments, and new results build new regimes–make new estimates for the next leap ahead 10 or 15 years from now. Here, again, you can see this whole system at work with the need for the three phases of intensity to tie together.

These regimes also enable us to estimate the economic worth of our yield estimates. We aren't using them solely to project the physical yield of cubic feet or board feet. We also have asked ourselves, "What are these increased yields worth? Do they cost more than we receive back?" We found out that they don't. They pay off. We can make well above 7 percent (7 percent as of 1970), which is the rate of return option for much of our land in the State of Washington. (For school land, the money for timber sold goes into a permanent school fund which has about 7 percent return.) We think that anything we do has to make 7 percent or more.

We have examined these regimes for their economic impact. We have concluded that fertilization is sound, economically. Also, we can increase the yield because of this practice. We have been able to take this whole thing one further step and bring in a whole series of cost records. We compare costs with the dollar benefits that we expect for any particular management activity (for example, precommercial thinning). We compare benefits and costs and then develop benefit-cost ratios, all based on these same regimes. We supply our field people with alternative courses of action arranged by benefit-cost ratios. By choosing the best ones first before we go into the second-best ones, we optimize our activities. This provides the maximum dollar return for the people for whom we are managing the lands.

What you have seen, then, is a broad spectrum. I have defined yield control as I see it. You have seen how some of the important pieces–tarif tables, the use of regimes for estimating, and yield tables for estimating–fit into the broad picture, how they all go together, and how they can become a system. By now, I hope you see how some of these ideas can be applied in your own operations and to your management control problems.

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ECONOMICS OF YOUNG-GROWTH MANAGEMENT

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THE ECONOMICS of young-growth management is my topic. It should be comforting to you to find that so many of your colleagues are faced with young-growth management problems. This is what foresters have looked forward to for so long. Now here it is.

First of all, let's get a bit of perspective on what we are dealing with when we talk about young-growth management. Jerry pointed out that he considered young growth to be from 0 to 80 or 90 years of age. Consider for a moment how much land is occupied by this size of timber.

I have made some rough estimates, but they are fairly close. In the Douglas-fir region, that is, the west side of Oregon and Washington, about 15 percent of the commercial forest land is occupied by the 1- to 30-year age class. This is land that is stocked now. The 30- to 50-year age class occupies about 18 percent; the 50- to 70-year age class, about 8 percent; the 70- to 90-year age class, another 8 percent; and the 90- to 110-year age class, another 7 percent. By Jerry's definition of young growth, from 1 to 90 years of age, 50 percent of the commercial forest land of the Douglas-fir sub-region is in that age class.

Now, let's relate that to where we are headed, or where one might venture to say we **should** be headed. Good foresters want to be in control of the growing stock in terms of age classes. When we work with an average of stands from 1 to 90 years of age, we generally want about 33 percent in the 1- to 30-year class, instead of the actual 15 percent, in the 30- to 50-year class, which now has 18 percent, we would want about 22 percent; in the 50- to 70-year class that now has 8 percent, we would like to have another 22 percent; and, in the 70- to 90-year class, 22 percent instead of 8 percent. This is what we call the desired or regulated forest. We now have only one age

class, from 30 to 50 years, with the proportion we would like to have, but the others are out of proportion. As you know, this is one of our problems of management. It is desirable to get the stands of each management unit regulated as far as age-class distribution is concerned.

As another measure of the magnitude of the task ahead of us in young-growth management, I would estimate that somewhere between 20 and 30 percent of our harvest now comes from young growth (1- to 90-year age class). That's the roughest of my rough estimates. A little bit more perspective about what we are dealing with in terms of young-growth management can be had by considering the value of a 60-year rotation forest that has its growing stock regulated. If the land was worth $25 an acre and the growing stock $35 per thousand, it would represent an investment of about $250 per acre. In addition to this investment, we must pay at least 3 to 4 dollars per acre in annual costs. Actually, the value may be more like $50 per acre and $50 per thousand. Then you are dealing with an investment of $500 per acre in the regulated forest.

There are various ways that we might structure a discussion of economics of young-growth management. I have decided to talk to you in relation to six tasks or activities or functions that you, as young-growth managers, have to carry out. Call them what you will, but there are six of them: Let me name them for you. Then I will make some points regarding the economics of young growth as they relate to them. By the way, the tasks are not necessarily in the order in which they are performed.

The *first* function is recognizing opportunities. I like to talk about recognizing **opportunities** rather than about young-growth **problems**. I would take Jerry Hoyer to task about that, because I thought he talked too much about young-growth problems. I like to think that we have opportunities and that the manager's first job is to recognize these opportunities.

The *second* is the task of choosing among these opportunities or of ranking the opportunities.

The *third* one is measuring the expected results of taking advantage of each of these opportunities.

The *fourth* activity is that of scheduling the actions needed; that is, the scheduling of the actions to be taken in young-growth management. This includes scheduling harvests, scheduling treatments, scheduling plantings, thinnings, and so on. This matter of scheduling is very important, as I will demonstrate in a few moments.

The *fifth* task is that of generating income. This is a very important activity of the manager and one you must keep in mind, particularly because of the need to generate the income necessary to make reinvestments in opportunities for young-growth management.

The *sixth* one I call maintaining flexibility in young-growth management. These six tasks provide the framework for talking about the economics.

First of all, let's consider the matter of recognizing opportunities. I start out with this one because foresters generally do it very well. And it's always nice to start out with a complimentary tone. Foresters are great ones for recognizing opportunities. Just go out with one of them and start talking about his particular forest and he can tell you all kinds of things he would like to do. He would like to increase his protection, he would like to get rid of the root rot, he would like to thin—not only commercially, but precommercially. He is just full of ideas—a whole long list—about as long as you want it to be. This is a good point in favor of the forester. Later, I will be somewhat more critical of his performance of some of these six functions, but in this one the forester performs particularly well.

Hoyer has described numerous opportunities. He described them in what I believe to be a proper context, that is, as opportunities for increasing the output, or at least for maintaining the output. By output, we are talking about the output of wood, of timber. Some of these opportunities are: planting *versus* natural stocking; restocking the nonstocked areas (I consider the nonstocked to be young growth also); precommercial thinning; increased protection; commercial thinning; fertilization; and another one, which I call "effective marketing of the marginal material," the material that doesn't

market well all the time. That is quite often the part that needs particular attention. One of the things you must recognize in young-growth management to be effective in seizing opportunities for increasing output is that trees do grow without much help. What you have to do is consider what you can do. Stop and consider, once in a while, how well trees do grow in the Douglas-fir sub-region without much help from us. The natural growth capacity is impressive. As foresters we really haven't begun to avail ourselves of opportunities to help nature, such as precommercial thinning, fertilization, and so on. Timber is growing on a lot of the land on which the best we have done is to protect it rather effectively after the old-growth harvest, principally protection from fire.

Recognizing opportunities is important right now and will be more so in the future because forest properties are increasingly occupied by young growth—all over the region.

The past output of timber products from the Douglas-fir region, and the increases in that output, have mostly resulted from factors other than forestry; that is other factors than the things we do as foresters to grow trees better and faster. A lot of these gains in output or in our ability to maintain output have been the function of such things as roads. Road construction is certainly related to our forestry work, but it is not what I consider to be something foresters do to make trees grow faster. Other nonforestry factors have been utilization of small trees, utilization of culls and poor species, better logging equipment, development of new products by industry, and so forth. These things are all desirable and we, as foresters, have helped them along, but we certainly can't take credit for them or consider the increase in output a result of our growing trees faster or better. Most of these nonforestry sources for increases in output have been exhausted. They are no longer available for further increases. Further increases now become tougher to realize. It has become abundantly clear to me that we are going to have to start performing as foresters if we are to maintain the output or increase it in the future.

So much for the subject of recognizing opportunities. Let's move on to the second point; that is, the job of choosing among

the list of opportunities—the very long list of opportunities to increase the output from our young-growth management. You discovered long ago that you can't do them all. Some of you may not yet have had the opportunity to do any of these things that I call young-growth management, such as precommercial thinning and fertilization.

To choose among opportunities, an important step is to tie your system of forest activities together. You have to tie it together in such a fashion that when you do something significant to grow more timber you can demonstrate a significant change in the expected output. When you carry out one of the actions you have chosen, you have to be sure that the results will show up sometime. There must be some response. Foresters have been rather weak in this. Either on paper or in words you must explain to yourself and to others what is going to happen when the action you recommend is carried out. What you need is some sort of law of motion like we have in physics, such that when you do something on the input side you get some action on the output side. I have a gadget here that illustrates Newton's third law of motion: if you start some action on one side, then you get a reaction on the other. Action and reaction show up clearly and immediately. This is what I would refer to as a system—an effective system—and analogous to what can happen if you tie your forestry activities together in a descriptive and visible way so that you and others can see what happens.

While I was in research and since then during my consulting work, I have discovered that too few foresters have systems tied together in words and pictures—they can't describe what is going to happen when they select an opportunity and carry out an action. Too many forest systems are like this. The forester often proposes actions without being able to demonstrate the expected results. Some actions, of course, have more reaction than others. Changing the rotation in the old-growth management, for example, is like that. You move it a little bit, say from 100 down to 99 years and you raise the cut 1 percent. I am exaggerating, but that's about the way it is. That is the kind of effect you would like to have in all your activities.

I have reviewed management plans of both public agencies and private firms and found that the situation was just as I described here. They're doing things and nothing is happening. They propose actions without demonstrating the expected results. How can they expect to show the benefits in young-growth management and to get support for financing these practices if they can't show results in the expected output? This may seem like an oversimplification, but I can show you too many instances of planning activities for the management of young growth in which the forester fails to demonstrate their benefits. The landowner who reads the plans is expected to accept forestry on faith. Some past management plans (if I may step out of the Douglas-fir region for a moment) have been developed on the basis of the Austrian formula—a somewhat crude but often effective method.

In examining such a management plan recently, I found that an economic justification for a particular young-growth management activity was impossible, because the activity was not going to have any effect on the output. I can show you why this is true in the formula for their calculation of the cut from their forest. The forest was one that had young growth as well as residual and virgin stands.

In the Austrian formula, two important factors are the volume actually present and the volume that you desire in future growing stock; the difference between these two volumes will be removed during the regulatory period. Other factors are the growth in the virgin stands, the growth in the residual stands, and the growth in the young stands. These are usually actual growth from inventory, but a growth potential may be used for young stands. Another factor in the calculation is the regulatory period, which is related to rotation, but specifically indicates how fast you plan to harvest the excess volume in virgin stands during a first cut. This formula doesn't apply specifically to the Douglas-fir region, but the principles are the same as for some planners on this side.

I just recently examined a plan that had about 100 thousand acres of young growth plus quite a bit of residual. The plan therefore included young-growth management. For any of you to manage a forest of nothing but young growth would be

most unusual. You generally have some mature timber. It may not be virgin, but you have some at or near final harvest. In the east-side plan I refer to, some precommercial thinning was planned to increase the output. To justify precommercial thinning now, we must show an increase in the allowable cut, either now or sometime in the not-too-distant future. This is necessary to justify the thinning from an economic standpoint.

I examined the plan and found out that the growth estimates were all from inventory. Such growth data reflect only past conditions. Admittedly, there wasn't much they could do to manage the growth of the residuals. But why use such an estimate for the young stands—those stands in which they proposed to thin precommercially? I found that the foresters who made this plan did not tie in their precommercial thinning program with any expected change in the growth of the young stands nor in the growth potential of new stands. They had also implicitly assumed, in the management plan, that the future volume desired and the growth potential of the future stands would be achieved somehow during the regulatory period of 100 years. They had not estimated the reduced growth potential that would result if a regulated growing stock were not achieved. Benefits from the proposed forestry programs were impossible to determine. The plan exhibited great faith—somehow, the desired conditions would result.

If we are to defend, as our choice among young-growth management opportunities, the thinning of dense stands, we must be able to demonstrate some response. In the particular plan I reviewed, they had written themselves right out of the chance to show response to thinning, because they assumed future growth as if thinned. The Austrian formula can be used as a device for tying the forest together so you can see and demonstrate what happens. But you **must** use it properly. There isn't any economist alive who can justify investments in young-growth management under a planning system that assumes the results of management before management is ever applied.

I didn't know what to recommend for this particular plan. One of the things they might do is to recalculate a lower output, assuming no management; then, turn back to the boss

and say: If we do certain things, the cut can be raised. Ask him for the financing, and show him the benefits of the extra allowable cut.

This is what I mean by **demonstrating** a response. It is absolutely essential if economic justification is expected. Tie your system together in your management plan. Choose among your opportunities, by showing in your basic plan a measure of the output expected of any action. If you have this sort of plan you will discover a relation with other parts of the total system. And if these other parts happen to be run by people, they will likely join up with you and work with you. Then you will get more total action on the output side, because more things will be coordinated.

Before choosing among the opportunities, you must get the system tied together—much like the electrical system in your house is tied together. You must make a choice, or help management make a choice, among your good ideas, because not all of them can be put in practice. Only some of them will be selected. The basis for selection is the result in terms of expected output, of benefits at various times and places.

A side benefit results from getting the forest system tied together so that you can see the effects of making changes. Some of the changes that you can make are discretionary and cost nothing. One particular example is the regulatory period or rotation. You can arbitrarily change how long you are going to take to get the forest regulated, or what kind of products you want to grow or what size they should be. A change of the regulatory period can change the cut without your doing anything except making decisions and recalculating the cut. Of course, you want to be sure you decide on the soundest basis possible.

Let us turn to the third task—a most important one to an economist; that is **measuring** the expected results. If we have our system fully described so that our results show, then the results can surely be measured. By precommercial thinning, for example, you can shorten rotation, you can get more rapid growth in the young stands, you can control species, and you can get good stocking. The same results may be obtained with

genetically improved planting stock. Many of you have run through calculations that include the assumption of these kinds of results. The area-volume check, by which cut is commonly calculated in the Douglas-fir region, is influenced by the rate of growth that you forecast for the young stands. An increase in output can be shown in your schedule of harvest cut. Generally, you can have that increase now, or soon, by taking cultural action now in the young stands. This is about the quickest payoff you can get in forestry. Any investment that will assure your forecast of future outputs can justify an increase in the cut now. This works in any number of ways. I can illustrate one for you.

Take, for example, a situation in which a considerable amount of old growth remains, a planned conversion period extends for a rotation length, and the annual cut is constant. The backlog of old growth provides mature timber to be harvested. You can choose a schedule for harvesting over a conversion period that is short and thus cut off the mature timber in a hurry at high annual rates, or you can extend the conversion period for a long time, saving the old timber by cutting much less each year. If you use a range of conversion periods and run through several of these calculations (assuming no growth in the overmature timber that is available for harvest now) you would observe that the allowable cut varies inversely with the length of conversion period. Because some growth occurs in most of these overmature stands, you get a line something like that in Figure 1, which holds up in the longer periods. A single, selected conversion period results in a rate at which you can liquidate the volume that is now there. Similarly, we can plot the volume that can be grown in the new stands over the same conversion periods. This varies directly with the length of time, in the familiar shape of the yield curve.

This may sound like old-growth management, but I insist that most forest properties have some mature timber or timber that is going to become mature soon. Under the principle of even flow, as used on the national forests, a conversion period is selected equal to the rotation or something near that. Over the years of the conversion period, the harvest is so much each year

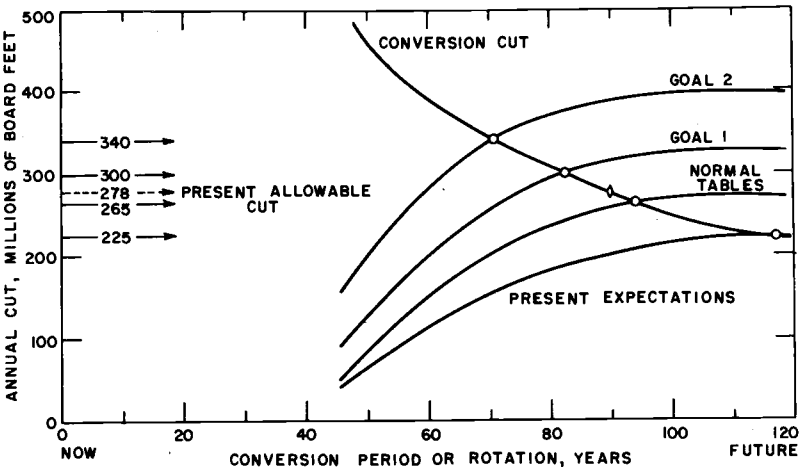

Figure 1. Effect of sustained yield goal on allowable cut for various conversion periods on a typical working circle under even flow.

from the old growth. At the end of the conversion, the cut will equal the amount grown on the first area harvested. To go on into the next rotation with a continuation of the same rate of yields, then the land area cut in the first year of conversion must produce at the same level as the conversion cut. If you plot the output expected from the new stands under different rotations, and if you then plot various conversion cuts on the same graph, the intersection will be the rotation and conversion period that will provide even flow forever.

This graphic system shows that any increased output expected from young-growth management can be used to justify higher cutting during the conversion period. Empirical estimation of yield (present expectations), based on the performance of young stands in the past, is quite often used. Consider what would happen under an intensive management program that increases future yields up to the higher goal, *I*. The program is reasonable because you have a long time to get busy at it—all during the conversion period. If you are in the fortunate circumstance of still having considerable old-growth material, you can increase the cut now and maintain it forever.

You can actually start cutting at the higher rate right now and spend the extra income on management to increase the rate of growth. The economist will tell you that this immediate additional output is valuable, particularly if it lasts over the whole period. You can easily justify the expenditure of some of that extra income—or maybe all of it— to raise the growth curve. In this particular instance, you will probably decide to shorten the conversion period and thus shorten the rotation. With this kind of story to tell, you can sit down with the owner and justify a program of raising the young-growth output. This is what the Weyerhaeuser Company did. Nothing more. They said they were going to do certain things that would raise future yield of new stands, and having done so, they could start taking the extra income right now, as well as in the future, to pay for the high-yield forestry.

As foresters, we must set up circumstances in which a proposed change will cause something to happen that we can recognize and will therefore justify the investments in the additional activities for the proposed change.

Although we do not want to talk about old-growth management, I do want you to keep in mind that you are harvesting now what someone else grew for you and, at the same time, you are trying to get the young stands managed and increase the total output. If you have made any calculations of discounted net worths or internal rates of return you realize that the sooner you can get the income, the higher the earning rate is on that particular investment. That is why it is so critically important, in your planning for young-growth activities and choosing among opportunities, that you have a full view of what can and will happen in all phases of your forest system.

I would like to illustrate with one of the most recent and unusual activities proposed for young-growth management—fertilization. I have had occasion to run some financial analyses of forest fertilization. I did this for a chemical company that was looking for a basis for a sales program to sell forest owners on fertilizers. A 20- to 30-dollar investment per acre is required in fertilization. If this is made on a very young stand, you may

have to wait as long as 50 to 60 years before you get any return. Just a quick examination of the tables of discount will show that you have to have extremely valuable timber in the future or a tremendous acceleration of growth rate to justify such expenditures carried for such a long time. One needs to have the application and response on stands that are near a commercial thinning, or some sort of partial removal, or the final harvest. Research findings with respect to older ages of application were sparse. Research on fertilization has been largely on young trees, and the results have been measurements of nutrient contents of needles and branches, of growth in diameter of young trees, or extra growth in seedlings. These are unsuitable for showing the extra response in terms of wood, when it occurs, and for calculating the economic benefits of fertilization.

We finally recommended that the company push for fertilizing stands near maturity. We made a chart to illustrate the phenomenon, based on various assumed extra yields.

You are probably familiar with what is referred to as the internal rate of return for investments. It is the interest rate that will make the present net worth of all the costs equal to the present net worth of all the future incomes.

This process was not used when some of us were in forestry school, because it takes many repetitive calculations. Repetitive calculations are easy for computers, which search and find the interest rate that will discount all the costs back and discount all the incomes back to the present, so that these two are equal. The result is the internal rate of return.

By checking on the yield tables and the information that was available on the response from fertilization, I found that in stands from about 40 to 70 years of age, which were growing at a periodic annual increment from 500 to 1500 board feet per acre per year, fertilization could increase periodic growth 20 to 80 percent over various lengths of time ranging from 3 to 10 years. I calculated the earning rate on the $30 fertilizer investment. I assumed that this horizontal axis is the number of years after the fertilization before thinning or harvest, which ranges up to 10 years and starts with 3. These are the earning

rates in this vertical direction. If you can get an extra response of 200 board feet per acre per year, for 7 years, you can get an earning rate of about 4 percent on a fertilizer investment.

If you fertilize in these young stands 7 years before harvest and get a response of 200 board feet per acre in mean annual increment, here is your earning rate. If you can get 300 board feet per acre per year extra yield, here is the extra yield that you can credit to fertilization. If the 300 extra board feet will last for 7 years, the internal rate of return is about 11 percent—a pretty attractive investment. If you can get 500 board feet per acre per year, then in about 5 years the return will be up to as high as 20 percent on the fertilizer investment. This is one basis for selecting how long before harvest that fertilizer should be applied.

This kind of calculation is what you can do in the economics of young-growth management. You must show that you can get responses from fertilization and get them soon. In this instance, we apparently can get some very attractive returns on investment. And this is just one aspect of the economic analysis of investment in fertilizer. Another would be that in which you raise the output of the stands in the future, which permits you to increase the rate at which you are harvesting the present mature and overmature stands. In both, you get an early return on the investment, which is very important.

I made some calculations recently for a forest with young stands and some mature timber that can be harvested now. It was a national forest which, as you can guess, had a great deal of old growth. Any enhancement in growth that, in turn, affected the rate at which they could cut, showed a very attractive financial return.

To give you some feel for the magnitude of the possible effects, I have illustrated a public working circle in which the various conversion periods give you a cut, with the area volume check, that slopes downward as the conversion period increases (Figure 1). If the agency should fertilize in the new stands, then in R years, these are the yields expected from the young stands. These slope up as the rotation or conversion period is lengthened. The intersection is the rate at which you can cut on

the old growth. What would be the effect of fertilization on this forest in which are some young stands that could be fertilized during the next 90 or 100 years? The effect would be to raise the empirical yield curve. The intersections with the curve that shows the conversion cut for various rotations would be at a somewhat shorter rotation and thus would indicate a higher immediate harvest under even-flow. As the older age classes are cut, the younger age classes will have a higher yield than they would have had, if you had not treated them.

With one of the computer programs that the Experiment Station recently developed, you can find out quickly what happens if you assume an increase in the future output of young stands. Recently, I calculated the earning rate on a public working circle that was at the embarrassingly low rate of 1.7 percent on the total investment. I set up a fertilizer program that was quite reasonable. I assumed that bare acres of young growth were fertilized as they became available for fertilization. The actual acres in these classes were set up on a schedule of fertilization to enhance the yields, before the final harvest. Under an even-flow type of calculation, this had the effect of making it possible to increase the cut by a certain amount. The rotation was shortened somewhat, because they were able to grow timber of a given size sooner with fertilization. Also, the volume of final yield was increased. By an investment analysis program, we found out what the earning rate was on the various alternatives tested. We could check for the internal rate of return between 0 and 30 percent. In this particular instance, when the computer got to 30 percent it was still going on—looking for the higher internal rate of return for the fertilizer investment. By planning a fertilizer program and making some reasonable assumptions about the increases possible in these age classes in the more distant future, we could show income immediately. Such a fertilizer investment showed better than a 30 percent earning rate.

You must look at this alternative or opportunity as a separate part of the whole forest. When I considered it with the rest of the total forest, the earning rate of the whole package, considering the value at the start, was raised from 1.7 to only

1.8 percent. The reason was the relatively few opportunities for fertilization in the area for some time into the future. In effect, this working circle is like a portfolio of stocks earning about 1.7 percent. If another stock earning at the high rate of over 30 percent were added, with such a small addition relative to the great volume of old growth and the acreage, the total average earning rate was not raised much. The opportunity for fertilization itself was well justified, however.

Admittedly, you are not in these circumstances with old growth on many private properties. But the same principle applies. You can always sort out the effect of doing something on the acres you have. In this instance on public land, fertilizer was applied to stands long before harvest. The reason we could afford to do it is that we could get yields right away from the increased allowable cut of overmature timber.

If young growth is the only kind of property you have and you fertilize early, carrying the costs so long will eat up profits. When costs are carried so long, the earning rate drops. It falls because of the need to discount the future incomes back to the present, in the earning rate calculations.

Several intensive practices can increase future growth and thus give current increases in cut. Genetic improvement has this characteristic; so does precommercial thinning. Commercial thinning can reduce the investment and permit you to take some of your income now. This is popular because you need income now, and unless you are getting a good growth rate without the commercial thinning, then you are well justified in removing part of the growing stock. An interesting thing about commercial thinning is the matter of scheduling. The objective is to get an early removal of expensive growing stock. All growing stock is expensive as soon as it becomes merchantable. When it becomes harvestable, carrying it any longer is expensive because of the implicit interest on investment. Growth is working for you, but you have the cost of money in the investment working against you.

Careful scheduling is important. You will find that you can't go wrong with commercial thinning, whether light or heavy. Effective marketing is essential in commercial thinning.

Now let's go on to the fourth point I made, that of scheduling the actions. In young-growth management, you need a rather careful scheduling of proposed activities. Timing is an important aspect. A schedule is the basis for getting a time dimension on the effects of changes that you want to make. Opportunities are going to arise in the future and you are going to want to change your activities. When you do, it affects the return. Scheduling of costs and returns is the basis for economic analysis of proposed changes.

The fifth point, the matter of generating income, is an important young-growth management activity. Funds for investment in young-growth management are easiest to get if you are generating some income from the forestry activities that you are undertaking. If you are stuck with young growth and none of it is harvestable, you have a problem. We must face the fact that many of the things we do in forestry are expensive relative to the resulting income. Some earning rates are high, but, overall, they are generally low. The best ways to help justify them is to generate some income whenever possible.

Here again, tie your forest together with a visible system of activities in such a way that you can talk about what income you can generate by one of these activities. The best situation is one in which you have timber, like the public working circles, to cut right now, in anticipation of future high rates of growth. You can justify costs immediately if you can generate income before too long. Not only does this look good economically, but you do not have to go somewhere else to get the dollars. We are coming rapidly to the end of the concept that forestry is "good". We must substantiate **how** good and **when**.

Last is the matter of maintaining flexibility. We have referred to this a number of times. Many factors are outside our control. For example, we cannot do anything about the market. Sometimes I think it is easier to predict what is going to happen 5 years from now than next month. But keep in mind, the factor that works in the long run against us, that is, the extended time required to grow trees, also works for us. It gives us flexibility in what we do and when we do it.

Plans made this year are not going to be carried out for a long time. The Forest Service, for example, can change rotation and conversion period. They should choose to grow the young trees faster to get more income without creating serious problems. The whole life of the new stands lies ahead of you, and time is available for taking many actions. You can maintain flexibility, and you should.

In summary, I would like to say that this group of six activities that you have an opportunity to carry out are the most important part of all in the planning. You can carry out each one in your thinking and on paper, beforehand. You can look ahead so that you can make sure that your actions will lead to results that will justify your proposals. This is the only basis for making any economic analysis of the effects of young-growth management. I certainly hope that you will keep this in mind and make every attempt to describe your forest as a system, so that when you propose an activity, you can find out when and whether it is significant. You can then show its effect on the output. Keep this in mind, and intensive young-growth management will progress.

MANAGING YOUNG TIMBER
A "SOUND-OFF" SESSION

Panel

Alan B. Berg, *Moderator*
Professor of Forest Management
Oregon State University

John F. Bell, *Mensuration*
Associate Professor of Forest Management,
Oregon State University

Gerald E. Hoyer, *Thinning Regimes*
Silviculturist, Forest Land Management Center,
Dept. of Natural Resources,
State of Washington

Donald Malmberg, *Thinning Operations*
Supervisor of Research and Development
Northwest Timber Operations,
Crown Zellerbach Corporation

Carl Newport, *Forest Economics*
Partner–Mason, Bruce and Girard
Portland, Oregon

Michael Newton, *Chemical Silviculture*
Associate Professor of Forest Ecology
Oregon State University

John F. O'Leary, *Logging Engineering*
Professor of Forest Engineering
Oregon State University

Lyle Seymour, *Thinning Operations*
Resident Forester
Luckiamute Tree Farm, Boise-Cascade Corporation

Audience. I would like to ask Mr. Hoyer about his comments on predicted yields for young-growth stands that have been fertilized, precommercially thinned, or both. How do you arrive at these figures? Through field data?

Hoyer. We used the standard yield tables as the basis for projecting the growth of both well-stocked and thinned stands. The tables are based on the growth rates developed by Bob Curtis. Also, we made some assumptions that we think apply. For example, we estimate, from plot data, the amount of growth we expect from the application of 200 pounds of fertilizer. The estimates are weak, but we must assume something to get started. Then we ask ourselves if the results are reasonable. We put these things together and project results. Carl Newport mentioned that information on fertilization is weak for making an estimate of actual returns that can be expected over a long time. We must do the best we can, however, with the information we have. We stuck our tongue in our cheek, made reasonable assumptions from what information we have, and made decisions.

Audience. Is there a danger of pollution from chemical thinning?

Newton. I haven't a good answer. I know of no research on pollution from chemical thinning, specifically. Studies were made of pollution from aerial brush control in which broadcast herbicides in dormant sprays and in foliage sprays were monitored in the stream and the soil. The herbicides, 2,4-D and 2,4,5-T, have a short life in the soil, and apparently the only material that gets into water is applied directly to the flowing stream. The implications in chemical thinning are different. We use an entirely different class of materials, the organic arsenicals, MSMA and cacodylic acid. Their behavior is different from that of 2,4-D and 2,4,5-T. I think we can say some things with confidence about chemical thinning. One is that tree injections preclude broadcast contamination of the environment. The materials are not highly leachable. We do not work directly over streams. We expect essentially no overland movement of these compounds to streams. So we expect zero contamination in streams, certainly below our detection limit. The compounds do not have a prolonged persistence in the soil,

which is in contrast to some of the claims about arsenics. Several reports recently claim that these materials degrade. One just published by Dartmouth Medical school suggests that the health hazards from the arsenicals, especially the organic arsenicals, have been badly overrated.

In fact, so little danger exists from the use of organic arsenicals that some livestock feeds, especially for poultry and swine, are supplemented with organic arsenicals as a means of improving the rate of weight gain. Some swine feeds in Canada, for instance, contain as much as 100 parts per million of one or another of the organic arsenicals in the dry rations. If we had to consider the maximum contamination that we are getting, or could get, in a thinning operation, the order of magnitude would be less than one-thousandth of the exposure that the swine are getting. Does this answer your question?

Audience. Do arsenicals leach out of wood when logs are in water?

Newton. Arsenicals are not very mobile, but may possibly leach out.

Audience. Might the internal rate of return, if calculated for the total property, hide the effectiveness of an investment such as fertilizing or thinning?

Newport. For a given property you can calculate an internal rate of return, make investments to increase the output, and recalculate the internal rate of return or the earning rates for the entire property, which includes the initial investment. The investment itself may be productive, although it may not make much difference on the total rate of return. Is this what you are asking? Some question arises that it will not show up in the total, but you can calculate the internal rate of return or the earning rate for just the investment itself. Therefore, you must know what happens to the yield when you make that investment to calculate the earning rate for that investment itself. On one chart, I showed the earning rate of a fertilizer investment of $30 that would be made from 3 to 5 or 6 years before harvest, depending upon the response. The earning rate of that particular investment could be high. You are right. You can obscure the effectiveness of this activity if you combine it with the earning rate of the total investment. It makes little

difference on the total. The activity may be highly justified if you consider it alone and look at the response that comes because of it.

Your question also brings up the matter of the effectiveness of various fertilizer applications. Probably the most uncertain thing about the fertilizer investment now is that some experiments indicate that applications of a given amount of fertilizer may cause no response, some response, or great response on apparently the same kind of forest. The periodic increment would be greatly reduced if, for example, half the area did not respond to treatment. That, in effect, would double the cost of response on the area that did respond. That is why we should determine the factors that control the response from fertilization.

With an economic analysis, you can calculate rates of return under different assumed responses and different assumed costs to assess the responsiveness of your situation. These calculations provide a guide to pinpoint those things that you must know more about. In certain situations, additional knowledge may make little difference in your decision. If you calculate the earning rate or benefit-cost ratio or whatever kind of financial guide you have and if you vary some of the growth and cost factors to see how they affect the output, you have a good tool for selecting those activities for which you need more information, or where you need to take some action. In fertilization, for instance, reducing the cost of application will affect the earning rate immensely. The effectiveness of an activity can be increased in many ways.

Audience. Do you recommend a single application of fertilizer shortly before harvest, or can several applications be made before harvest?

Newport. Research indicates that in some stands between 40 and 80 years old, a 20- to 80-percent increase in periodic annual increment will occur. Any stand this age with merchantable material could be called mature. I was thinking of one application of fertilizer. The evidence indicates that response in the trees will last for a time. My figures such as 200 or 300 board feet additional annual increment are the average for the period between fertilizing and harvest. Fertilizing just before

harvest is important because it helps you justify it as an investment. The longer between application and harvest, the more the cost of the investment becomes in interest rate. Fertilizing immature stands is costly because of the length of time between application and harvest. You may not be able to afford it unless it's indicated by other circumstances. For instance, the rate of liquidation of your presently mature timber ties in with the rate at which you will grow new timber. This is a situation that some companies, as well as the public agencies, are in. This is important to remember. If we wait until the old growth is gone before justifying intensive management of young growth, we will have lost the ability to generate income. Wouldn't it be unfortunate if we made conservative estimates of future output, and thereby missed the opportunity to generate cash flow now to increase the output of those stands in the future? This can happen under even flow when the rate of liquidation is spread out too long while new timber grows.

Sometimes, you can afford to invest in young stands because response is immediate; the growth response permits you to cut wood faster now because you are going to grow it faster. That sounds as if you are holding yourself up by your bootstraps, but really you are not if, in scheduling the harvest, you base the rate at which you will cut on how fast you think you will grow wood in the future. You must recognize that you do have the alternative, within the limits of the market, of cutting everything that is mature, immediately. That is the extreme, of course. Few foresters would get far with that kind of a proposal. You are going to schedule cuts for a purpose, to provide income. Some owners may want more income sooner, however. Your answer is, "No, we can't do that because, if we do, we will hit a time when we have no merchantable wood." So you spread the cut out. What controls how far you spread the harvest out, how fast you go? You do.

Audience. When is the best time to apply fertilizer? How long will the effects last?

Newport. I don't know. I suspect that if the fertilizer is applied at the end of the rainy season, you have lost a year right there. Fortunately, pelletized urea is not lost and remains on

the ground. It will be effective the following season. But you still have lost a year, with carrying charges of $30 for 12 months, because you did not get response. Some evidence indicates that measurable response from the takeup of fertilizer by the trees occurs for 10 or 12 years after application. Remember you do not necessarily have to harvest. The response is there in the form of extra wood. The longer you wait to harvest the wood, however, the lower the earning rate drops. For instance, suppose that the average increase in response over a 10-year period is 300 board feet per acre per year, but beyond that 10-year period, there is no extra response. The added value is still in the stand, but the earning rate would begin to fall because you are adding only years and no extra increment. If you must delay harvest for some reason, the economic guide might be the minimum earning rate, in Hoyer's situation, 4½ percent. You might want or need to carry the stand that long before harvest. In the situation I depict, however, the wise move economically is to harvest as early as possible, particularly if the extra earning income could be reinvested. If you have no more acres to fertilize, you may want to carry the stand because if you liquidate, the owner might decide to invest the income in something other than your forestry program. The mill owner will argue that his investment is a better earning investment than any you have. If you have more acres to fertilize, then, depending on the financial situation, you might be wise to harvest while the earning rate is high and reinvest in fertilizing another stand.

Audience. How would I allocate costs if I wanted to fertilize a young precommercial stand?

Newport. I would allocate the cost of fertilization to the young stand along with the carrying cost to the time of harvest. I don't know how you can make an economic analysis any other way. I believe you should fertilize trees that will respond so that you can take advantage of that response by harvesting before a long time elapses.

Audience. Would you harvest the entire stand?

Newport. Harvest the whole thing. If I thought young trees would grow more rapidly because of fertilizing, I would look at

the cost of the fertilizer for those trees and look at the yield. I would find the yields for the future and the cost now. A calculation of earning rates would probably indicate to me, from what I have seen so far, that the fertilizer on very young stands is not justified, unless, of course, you are stretching out your current timber under even flow. In that instance, anything that you can do to make the stands grow faster, given that situation, allows you to raise the cut right now. That is why the whole system of activities must be tied together so that you can credit the right activities to the right response and then compare their timing. That is the essence of what you do in the economic analysis–compare the timing. When you do this, you can see what is happening now under your present program, and then you can start talking about the opportunities for change, which is the basis for a lot of your existence. Make the change, evaluate the economics, and see whether it is justified.

Audience. Mr. Malmberg and Mr. Seymour, are your companies fertilizing stands, what have been the results, and what are your comments about fertilizing unmanaged stands compared to fertilizing managed stands?

Malmberg. Crown Zellerbach fertilized 12,000 acres using urea with 46 percent nitrogen. The response in growth has been from zero to over 100 percent. We fertilized primarily in the spring. The time of application is critical. This summer, our research man, Dr. Strand, is compiling the results of from 6 to 8 years of operational work plus his scientific work for nearly 14 years. We believe in fertilization in Douglas-fir. For 6 years, we have tried to fertilize western hemlock, but we still are batting zero. We put on three different loads this spring by airplane. We hope one of the three will work. We cannot record any success on fertilizing coastal hemlock. We have had some success in the high Cascades. As to managed compared to unmanaged stands, I prefer to see the stand under management with at least one partial cut. Precommercial thinning is all right, if you are interested in fertilizing young timber, but wholesale fertilization, which we have done with thinned and some unthinned timber, gives a different response. But we do see the variations on the economic impact. We have fertilized Douglas-fir, 90

years old and older, but our story is not complete. We are still in the discussion stage with this, in our corporation. We plan to expand our program next year, and the 5-year forecast shows considerable expansion. We need more scientific answers, but we won't wait until that story is crystal clear. We will not fertilize hemlock now, however.

Seymour. Boise Cascade Company fertilized stands only within the last year or two. We do not have information as to response. We believe, from the data we have that we get the best return on our investment by fertilizing managed stands.

Audience. Currently we are logging in several hemlock areas from 40 to 50 years old, with little concern for *Fomes annosus* root rot. Some of the area, thinned 2 or 3 years ago, shows few indicators of root rot. Does your research show how long indicators take to appear, and is *Fomes annosus* really a threat?

Malmberg. The Ph.D. dissertation by Peter Laird of Oregon State University concerns *Fomes annosus* in hemlock. He has some good answers. The impact of the study is that we will, in fact, discover our stands seriously infected with *Fomes annosus* whether they are thinned or not thinned. Another cooperative study by Dr. Driver of the University of Washington, in which we are participating along with other timber companies, is in progress. Dr. Driver's work with Ken Russell of the State Department of Natural Resources in Olympia, will provide far-reaching evidence from the Neah Bay-Forks area to our tree farm at Cathlamet that we must be careful. No evidence yet says do not thin hemlock. The strongest evidence may be from British Columbia where workers suggest that root rot may be more serious than we have admitted in the past. Our oldest evidence, and all the workers I have mentioned have seen the evidence, is a stand of hemlock, age 45 in 1947. It's still there. It has been thinned repeatedly. It is probably one of the oldest managed hemlock stands where pathologists can judge the seriousness of *Fomes annosus* in the tree, either on the ground or standing. We think we should watch it, but we see no reason to stop thinning hemlock. We think we should develop ways to avoid tree and root damage and to log with minimum

disturbance to the thin-barked and shallow-rooted hemlock tree. Apparently, if trees are not damaged, they are not infected. The money we have invested in research on this subject has been largely to try to cure the beast. But an investigation to find methods of thinning that reduces or nearly eliminates scarring and root damage is a fertile field.

Audience. A 45-year-old stand of Douglas-fir on site II in western Oregon is overstocked. Mr. Hoyer, how would you instruct your markers for the first thinning and any succeeding thinning to achieve maximum cubic-foot yield during a 70-year rotation? Dr. Newport, how would you instruct your markers in this stand for maximum economic return during a 70-year rotation?

Hoyer. To achieve maximum production of wood, a series of thinnings must be made. You just have to get it as it grows, more or less. A good rule of thumb for the first thinning is to remove up to about 30 percent of the standing volume in size classes that are merchantable in the area. We have used this one in our department. You can make up your own rule, depending upon the particular conditions in your stand. The important point is that the first thinning initiates management; you are in the stand. Even if you remove more volume than you think you really should, at least you are managing the stand; it is opened up, and you have started. So that first thinning is important to get the ball rolling. As far as yield removal for the rest of the rotation, I can't answer that directly. The Department of Natural Resources (DNR) refers to one publication as a guideline. It is more complex than we want to talk about now. Basically, however, a policy decision is made that implements the objectives of the company, and a suitable rule to measure growth rate is selected. We in the DNR use the growth rate tables developed by Bob Curtis. Tables indicate cubic volume to remove. The technique is not difficult. We developed it for our principles of operation. You can do the same for your objectives.

Audience. Should we leave the dominant and codominant trees that have already developed large crowns and cut the smaller, suppressed trees on the first thinning, or should we take

out the large dominants and codominants on the first thinning, and try to release the suppressed trees?

Hoyer. I would not take large dominant and codominant trees in the first thinning to release suppressed ones. This will not succeed.

Audience. In a 45-year-old stand?

Hoyer. In a 45-year-old stand, you will not release intermediate and suppressed Douglas-fir by taking out dominants. They do not respond. To get management underway, however, I would not hesitate to take some dominants and codominants in the first thinning. If you are judicious, you will not overcut in the dominant and codominants, and adequate leave trees in these classes will remain.

Newport. Does your father know that you are trying to grow maximum cubic feet of wood? He's one of our clients, and I don't think you should tell him. To answer your question, I must know several things. For example, do you have other timber or do you have a 45-year-old site II Douglas-fir stand only? Let us say that this is the only stand that you own, and you want maximum economic return. I would be somewhat inclined to tell you that you should have clearcut a few years ago. If you are going to consider the economics on site II with the markets that we have had recently in some areas, you probably should have taken your investment out and started over in a new stand, to keep your cost for regeneration and taxes down as much as possible. Your other alternative for growing more wood on that particular 45-year-old site II stand is, I think, to fertilize. The stand would respond to fertilization. Then I might suggest that you make a commercial thinning. If that is possible, and it probably is, then make a fertilizer application and take the harvest in a few years. Then you do have growing stock that you will not have again for a long time on that particular area, if you clearcut. This is the way you must think. What are your other alternatives, if that is the only acreage that you have?

You will find that in good markets, such as we have had, people who own 45-year-old site II timber tend to cut it. Now you may be off on your judgment; perhaps you should have cut

earlier or later, depending upon the market. But you should approach it this way. Now, this stand might be particularly valuable in the future, if you are faced with considerable current competition for wood and if you must strain yourselves to pay for the wood that you now buy on the open market. These are the things you must consider. No single prescription dictates what you might do. Therefore, you find many different prescriptions. For example, Dick Smith, who is affiliated with our organization, makes thinnings to create yield income and yet carries the stands into the future for his clients. He finds this successful because the clients then have growing stock for a longer time on the only acreage that they own. To start over would be expensive, and as they usually are not hurting for money, a high rate of return is not so important. They are willing to take some income and then hold this earning asset until it grows some more.

Audience. Is wind or snow damage a problem in thinned stands?

Hoyer. From what we have seen generally, I do not believe we can prove that damage from either wind or snow in thinned stands is any different than that in unthinned stands. I think this is generally true of most research work that has been done in Douglas-fir.

Malmberg. I estimate that this conference costs about $600 an hour. We need some information here if we are going to contribute to you and try to tell something that is worth $600 an hour.

Thirty-nine companies and agencies from California to Canada have representatives here. How many are thinning now? 40. How many started thinning within the last 5 years? 15. How many have been thinning more than 5 years? 15 or 18. How many who are not thinning now, expect to thin within the next 5 years? 4. How many have thinned more than 1,000 acres? 17 or 18. How many have thinned more than 50,000 acres? No answer.

Thinning will get off the ground in the next 10 years for one reason. We need the wood. Some of us have the heat on us now.

Some of you have said to yourselves and to me, and foresters in our company have said, "Where will we get the men to mark all those acres?" How can we get logs out of young timber without marking? How can we get logs three times out of a dense young forest without marking crop trees or cut trees? Can we get logs four times out of a young forest without marking cut trees or leave trees? How much more information do you need to suggest that thinning will grow bigger trees? How much more research do you need to suggest you can grow more net merchantable wood? How much more evidence do you need to suggest you can shorten the rotation? Or shall we talk about some compromise that will get more production at less cost for logging? Do you want to log without damaging the trees near the river? How can we help the watershed people and the soil people? How can we prevent water pollution?

Audience.. We have an old-growth stand with a 50- to 60-year-old young-growth understory. How do we manage this stand?

Seymour. Most of our holdings are well stocked with Douglas-fir young growth. But in certain areas we have scattered old growth as an overstory. We take the old growth right along with our thinning. We are fortunate to have good fallers with our contractors, and we have not damaged residual trees beyond what I consider ordinary damage in thinning operations. A small amount of damage always occurs, but taking out the old growth does not increase that damage greatly.

Zach. We have just finished an operation with an overstory of old growth (about 1 bar stocking) in a young-growth stand. We had an operator take the old growth out. We took no young growth the first time. We have damaged or lost practically nothing. I don't think you could find any larger old growth around. The recovery was half merchantable and half utility. Rowley and Parker, the loggers, did a fine job. Boise-Cascade purchased the logs. We are overloaded with old growth, so we will hold our young growth probably longer than most. The next cutting will be a thinning of the young growth. The area has roads and is ready for management.

Audience. Did you mark in there?

Zach. We did some sample marking and gave instructions. This is standard with us. We supervise more closely than most foresters are able or willing to do. Also, we have always had excellent relations with the operator. They know we want a good job, and we appreciate it and do our part, we think.

Audience. Are not salvage operations needed for 2 or 3 years after thinning?

Seymour. On our Black Rock lands, we expect to make a second thinning in about 5 years. Any damage from the initial thinning will be removed then. I do not believe we get enough damage to make a follow-up thinning.

Malmberg. Lyle Seymour talked about fir. I suggest that hemlock, 5 years after the tree is dead and down, is not worth much. If high-grade utilization is your goal and enough trees are dead, blown down, dying, or leaning to justify the salvage operation, by all means do that. A 60-year-old forest on the coast is a risky one for wind damage. If serious blow-down occurs, enough volume can be picked up, and why not? The roads are in and the landings and the market are there. But can you afford it? It depends on your goal or your point of view. Can you log a few thousand board feet? If it is on 100 acres, the volume could be sizable. You could log 2,000 board feet per acre. You know what 2,000 board feet of that value and grade, in 60-year-old hemlock or fir, means in dollars. Many of you have gone back after you logged 2,000 board feet. But to go back for a reason other than to salvage the dead, dying, or damaged is risky economically. I would support Lyle's idea of coming back in 5 years and getting some, but not all, of it. The risk is less in the fir than in the hemlock, because of deterioration rates.

Zach. We salvaged hemlock from stands that run from 90 to 100 thousand board feet per acre of old growth with 40 percent hemlock. To begin with, there were many rotten hemlock snags. About 2,000 board feet of hemlock per acre continue to die, plus another 700 board feet of Douglas-fir old growth, primarily from bugs. We log at least every other year.

The area is open, and the roads are in. We have one logger that does practically nothing else. We receive little less in stumpage than we do from competitive bids.

Audience. Are copies of the tarif tables available now?

Hoyer. We have three basic publications that cover the development, use, and practical application of tarif tables. The local volume tables are available for $3.00 from the Commissioner of Public Lands, Department of Natural Resources, P.O. Box 168, Olympia, Washington. The system has been used in Europe for many years. We have refined it, added board feet as a unit of measure, and provided ease of converting from one unit of measure to another. The work was confirmed by sending the basic formulas to Europe. They were also tested on trees in the southeastern United States, Australia, and South Africa. The basic tables, then, apply to trees in general. The key is "access tables" that provide a means of selecting the tarif table appropriate to a particular stand. The access tables can be obtained free of charge. So, we have the basic tables, the access tables that apply to particular species, and a third paper that describes the formula and the basic theory from which it is derived. The tables by Curtis are still available, I believe, from the U.S. Forest Service, as a Forest Science Monograph.

Audience. I am sure you realize that we have a great opportunity to develop stands for reduced logging costs in the future and to realize wood volume that would be lost in the next 10 years through mortality. I am interested in knowing if we are still stuck with the 10-year-old methods for conventional marking of the stands and setting them up? Is anyone working on mechanizing the harvesting process of young-growth stands? Don Malmberg has worked on high-lead techniques, I know, and has done a lot of work on mechanization. From what I have seen on a thinning program, foresters are still doing a high-yield silvicultural selection for thinning on the stands. We are still stuck with the logging process of bringing the tractor up, dragging the chokers out, and hooking onto the logs to pull them--nothing really new. John, can you comment on that?

O'Leary. I think probably you have in mind the method of harvesting Don Malmberg is trying at Seaside. Instead of

marking each tree, narrow strips are cut about 70 feet apart. I have seen tree selection done two ways. One is the way we do it on McDonald Forest. We mark nothing. We let the faller pick his tree. We spend some days training the faller in what we want him to do. The other is the old-fashioned way of marking the trees to take out or to leave. I think much research must be done on the steep ground where cable is used. For instance, in strip cutting, how far apart should strips be, how wide should the strips be, and how should trees be felled toward the strips. Should you buck logs in the woods or at the landing? Should you take the limbs off before yarding?

Berg. At the short course last year, we had an argument about whether a stand should be marked by an operator or a forester. This was a heated argument because we were in a stand marked by an operator. Lyle and Don, should stands be marked by loggers, foresters, or technicians?

Seymour. I advocate marking by the forester. I have seen stands marked by operators, and I don't think I am happy with what I saw. Evidently the owners of the stand were satisfied. It did not fit my concept of thinning stands. I think the decision boils down to what you are trying to do with a particular stand. When should you let the operator choose his trees, and when should a forester mark it? We are trying to produce veneer for future plywood mills, and I do not want loggers cutting prospective veneer trees now.

As to equipment, I believe a more efficient method on the flatter ground than setting chokers behind a skidder is needed. I have watched grapples work, however, and our loggers can outlog a grapple about four to one.

Malmberg. The man that asked the question is Karl Foeste of Crown Zellerbach, Clatsop Operation, Seaside. I think we are touching on an issue that could be valuable. Some preliminary remarks are necessary, or we might take a position too soon. The position could be described as a mousetrap snapping closed. That could be your mind which says, "I do not want to hear any more." And then you would lose your fair and reasonable outlook. We think you should be careful. I have had some head-on collisions with this viewpoint already, because I came

at our people straight between the eyes. Some Crown Zellerbach people deal that way. Others, however, would like to see the evidence of experience, cost, and benefits. As we do not have the evidence to build this case, we suggest we should get it, because we need the wood. And maybe some of you do also. Get it for what reason? To increase production and to lower cost—these alone are good reasons. Add safety and we may be able to attract young men into the thinning business with that factor alone. Root and tree damage is important. If we can prove that scarring damage to root or tree is reduced or almost eliminated, we can hang some value on that.

Let us assume that a system exists. It might not even be thinning, but it can produce logs from the dense young forest, not the forests you described this morning with 25 thousand feet per acre and the ages you talked about. Move out on the coast where we have obstacles such as you have never seen, unless you've been on the coast. We have stocking densities so high that the men marking trees, as Karl and many of you have, say, "There has to be a better way than this." When the logger starts felling and gets all these hangups, he complains that the cost of yarding and felling is high. He says, "There has to be a better way." What could be a better way? Already you have heard someone here say, "Let the power-saw operator mark his own trees." One of our divisions, with about 20 logging contractors, has two that they trust with this idea. Another division with nearly 30 contractors has three. This suggests to me that we may have a system that will satisfy 10 percent of our logging capability. What do you do about the other 90 percent? Come and see our Clatsop area next Wednesday and kick the "teeth" out of it, if you see a need to. In 5 or 10 years, we may have a way, on fairly good forest land, to get a lot of logs. Maybe not in the beginning, but at the end of this period, we may have a forest that looks as good as any managed forest. That is why we have left felled trees on the ground for you to judge. What do they look like? As Berg rightfully said last year, "Who is going to mark the trees?" College graduates? Some of you men here know what happened at Vernonia 20 years ago. You almost had to be a graduate forester to cut the trees. Do

you believe that is necessary today in the Pacific Northwest? How about a technician? How about a man that has not been to a school of forestry? Would you trust him? What can be done to get logs out of a dense young forest without marking the trees to cut or the trees to leave? I see the Shaver brothers back there wondering what this is all about. They have marked more timber I think, for more years, than anyone in the Crown Zellerbach Corporation. They have used a lot of cards and paint. I wonder if they are ready to say, "Please find a way to log timber without marking."

What is the first cut under this idea? First, mark no trees. Let me demonstrate on the board. Here is a rock road. Where will we get this first cut? Well, we will go here every 100 or 150 feet where the terrain will let us and cut from 15- to 20-foot-wide clearcut strips, at whatever yarding distance possible. Logging costs skyrocket if you can not log a strip. Tree size and yarding distance are still critical. Like the fat cat says in the movie, "We want to move with speed, speed with the rubber-tired tractor." Therefore, if we can do this job and make a profit, we are not fooling. As Carl suggested, find an opportunity that will immediately create income, and you might get the money to buy that idea. But management may not go along with the idea to take cash from profit at 8 percent interest and a promise that you will get it back. Make money on the first cut, a pretrailing cut. Can you make the second cut without marking trees? Cut another corridor. You already have one 15 or 20 feet wide. You may say that is not thinning, that it is only clearcut and strip. With clearcut and strip, you must have a market, or you work for nothing. If the trees are small and of mixed species, or if no market exists, the idea is not sound. You must have a market for the product, or you do not play the game. Now, you have the first cut, but you did not mark any trees. No need to mark for size, decay, or any other factor. The second cut is strips or corridors 12 feet wide. You will see them on Wednesday in a demonstration we set up for you.

Next, a series of herringbone strips are cut which feed into the skid trails. How far apart do you make the strips? You will

see 27- and 54-foot centers. One is a heavy cut, which yields about 44 percent. The other is a fairly light cut, which yields about 22 percent and leaves enough for the second cut. How about the third cut? Make another corridor 12 or 15 feet wide in the forested strips remaining.

We want to build this case. We are excited about it. We suggest that you compare. You might be proud of your remaining forest.

The first year, cut the skid trails, let it stand a year, then start the first corridor. Maybe this was the second year. Two years have gone by. We have produced wood twice. Wait 3 years and apply the second corridor cut. Five years have gone by, and you have produced wood three times out of the forest. We suggest that a case can be built, but we will have to prove it on measured evidence, not on estimates. Tie it down, hard and tight. Now the honeymoon is over, we have logged the forest three times, first pretrailing it and then making two corridor cuts, and we did not mark trees to cut or leave. What does that do to your forestry and engineering departments? What does it do to your natural resources? Let us find out.

For the fourth cut, what are you going to do? The question was, "Is there a system of thinning or not thinning that can produce small logs from a dense young forest without marking timber?" The fourth cut might be the one that sets you on fire. You can make a low, heavy thinning with the diameter cut, but how and at what penalty? Perhaps 8-10 years after the third cut, you can make the fourth cut. If this can be justified, then the answer to the question, "Can you get logs four times out of a dense young forest?" is "Yes," by pretrailing, cutting a corridor, waiting 3 years, cutting another corridor, waiting again, maybe thinning a little, no marking, and making a diameter cut. What is the average diameter by this time? How old is it? Thirty-five to 40 years? What is the management goal? A 60-year rotation?

After 10 years, this one stand is 45 years old, and this other is 50 years old. We have, on the higher site land, logged four times. We must have a market to implement this system. We do have the market right now. We are testing the method

now, but we must speed up some of these cuts. So Wednesday afternoon you will see one method that has 12-foot strips. You move 27 feet from the center line of that strip and put 12-foot strips again, which is a heavy cut.

You say, "Is there any release? You got logs, but you didn't thin." Where is the limit of increase in diameter growth from the edge of the strip? What is light? How do trees grow? Let us log from this road. At what distance from tree to tree can you get some response? This cutting pattern leaves 15 feet of trees. A report soon to be released suggests that in radiata pine, 30 feet would be the pattern of release. Thirty feet in the forest offers no release. But on the edge, release comes with less and less distance until you reach 30 feet. We are estimating 15 feet in hemlock. We would like to try it in Douglas-fir, because Douglas-fir, according to the researcher, will respond much like radiata pine. The big question is hemlock. We are estimating half the distance. We suggest that this method can produce logs at a lower cost and a higher production and truly lends itself to mechanization of the harvesting process. This is nothing more than what we said of cable thinning a couple of years ago in hemlock. But the key point is, what are the benefits? When you complete the heavy, low thinning, then the question is related to your own experience. I have thinned the whole property. What do I have left in final trees? I have some of the biggest and the best trees. People like that idea. The biggest and best trees are there for the final harvest. We invite critical analysis of this method because we do not have the evidence. We suggest that it may be the way to solve the problem of foresters who say I get tired of marking timber, I have to hire someone to mark timber, or we are thinning now and can not find people to mark timber. All these are real people-problems. This shows a way out, besides turning the job over to the power-saw operator.

Audience. I have found that a conscientious logger does not want to mark the trees because it is a fixed logging cost to him.

Audience. How many trees will be there for the final cut?

Malmberg. Our policy now calls for a 12- by 12-foot spacing or about 300 trees per acre. That is when we start the

new forest. We start thinning when stands are 35 to 40 years old. By age 60, we do not want more than 100 trees per acre. A fine growing stock of about 100 well-distributed trees will not penalize our growth.

Audience. What do you anticipate as satisfactory growth?

Malmberg. Carl Newport talked about growth potential. We can take a gain with thinning, we can do something about the growth potential with fertilization, and we can certainly salvage wood. We say to you who thin 90- and 100-year-old stands–*that* isn't thinning. Maybe it is prelogging, partial cutting, or intermediate harvest. We say thinning is concerned with the younger ages. If you want to call thinning 90- or 100-year-old stands thinning, you are not going to change anything about grade, reaction, distribution, or yield in the tree, which is over, long before the tree is 90 years old. Thinning is truly in the younger ages, not at 90 years.

We have borrowed research plots from the Forest Service and other people that have plots, and we have 23 years of information on Douglas-fir. We are going into our tenth year on carefully measured hemlock, on site III or better. If you have 100 square feet of basal area in Douglas-fir or 150 square feet of basal area in hemlock on site III or better, you will have no penalty in growth. The one key is quality of the growing stock. Do not take the stiffness or the grade out of the stand and leave several hundred little trees that can hardly stand up. A basal area of 100 square feet per acre in Douglas-fir is a guide, nothing more. The foresters at Vernonia say they have to log when they do not even have 100 square feet. We have 85 square feet, but we still have to log. This is only a guide. Our research suggests that if you have Douglas-fir on site III or better, 100 square feet of basal area will grow about as much as any level you have, which includes the control. Also, with hemlock, this is a guide only. But a heavy cut made because of market opportunity is great. I am the manager of this division. I will cut more and make more money. The forestry people say you will pay a penalty if you go below 150 square feet in hemlock. So I go to 135. I pay a penalty. What is the magnitude and the duration of the penalty? With 15 feet less, how many square

feet of basal area is the timber growing per acre per year? Maybe 5 or 6 feet. What is your penalty? Three years to get back to normal. Then you can tell your manager, "Go ahead—take all you want down to 135 feet. You will pay a penalty in reduced yield, but only for 3 years or so."

Audience. Have you gone far enough with the study to know the topographical limits?

Malmberg. No. We have on high-lead work. We are setting it now on tractor operations. We want to manage all of our acres intensively, not 50 percent or whatever the ratio is. We are after 100-percent operability.

Audience. I can see that this system has application in a healthy stand. In British Columbia, we have heavy mortality. How would you anticipate adapting this system to pick up loss in mortality outside of the strips? Do you just ignore it?

Malmberg. If the mortality is salvable, then we have something to talk about. If the mortality is too small or of the wrong species to be salvable, then you have to live with that. Salvable mortality, for either pathological or entomological reasons, must be moved quickly. With this preroading system, you can move wood much faster and safer and probably operate with less volume per acre. We cannot mark the trees at early ages. That is prohibitive for us.

Audience. I can't see Mr. Malmberg's system working in our country for various reasons. Accordingly, I suggest that we have to stick with people marking timber. I believe we can follow part of his plan, however. We can lay out the skid road or herringbone pattern on the initial thinning, and proceed from there to the marking. I would like any comments on that. Another thought that came to mind concerns Larry Zach's comment. Our situation has groups or scatterings of old-growth timber in small young-growth stands. Each needs a different kind of equipment. For example, a machine capable of handling a 60-inch log is not efficient in handling a 12-inch log. Would you, John, comment on that?

O'Leary. I think if you had large old sugar pine with a young stand under it, you should log it in two stages, the first time with a D8 or D7 to log the large trees and to build your

roads and the second time with smaller equipment. I think you possibly can use Don's idea. I can see your point. The country in southern Oregon is quite different from Don's country on the coast. I have a question that concerns cable logging on steep ground with this logging system. Would you still use the herringbone cut the same way?

Malmberg. No.

O'Leary. How did you plan to log on steep ground?

Malmberg. We get three cuts by dropping the strip downhill and yarding uphill. We haven't tried logging downhill on a strip. We think uphill yarding causes less damage to the soil and timber. After we have completed the clearcut strips, then we think we must side block with one cut to log out some of the remaining trees. The next cut is the last. Then we start the new forest. That, John, calls for felling timber at an angle. Possibly, the herringbone system will work on some ground. As we pointed out, the system can be very effective where it works, but it does not fit all geographical areas such as some parts of southwest Oregon. If we log three times down the mountainside with a strip clearcut, I think we can build a splendid case because of no damage and faster, safer, and cheaper logging, but the last (fourth) time, we must log at an angle to the slope. Then we might have trouble because of increased time and manpower, scarring damage to the trees and soil, and maybe safety for loggers.

Audience. You were talking about site III plus land. You are advocating this system strictly for the coast to have merchantable trees in about 30 years. You are not talking about the east side of the Cascades where we have to thin just to get a merchantable stand. Can this system be modified, for instance, for lodgepole pine?

Malmberg. That is my opinion. Some men in our company say that we must develop our eastern Oregon stands as well as those in interior British Columbia where the gross growth is 30-50 cubic feet per acre per year. How can we get the wood out of these stands--clearcut it? We want to get some wood out once or twice before clearcutting. I suggest that we develop an approach that lends itself to mechanization in the harvesting

process. That to me is the idea—not growth per acre. Stands in eastern Oregon and Washington may have only one or two thinnings before the final cut and the start of the new forest. On site III or better lands, the spectacular growth rate makes intensive management practical. This does not mean that we are not interested in management where the rain or growth is less. We just have not worked on these problem yet.

Audience. Don, do you actually lay out the herringbone pattern in the field?

Malmberg. Yes. Wednesday, Karl Foeste and Gerald Outslay will present this method. A mile of this kind of work a day is a nice, comfortable walk in the woods compared to marking a thousand trees a day.

Hoyer. I would like to comment on Don's statement about the first skid roads that are built in young stands. I recall about 10 years ago in some of our first thinnings in 40-year-old stands for the state, we allowed the logger to put in a logger's standard road. He laid out the skid trails himself. This did not happen always, but often the skid roads were logger's choice. I have observed since then that, in the second thinning in the same stands, we are still using the roads the first logger put in, because they are convenient. We will continue to use them. This lends weight to what Don says. Why not take a step further? Do what Don is suggesting, and lay them out where you want them? If you do this, I think you can gain 5 more years. If you clearcut the roads, the volume of cut trees from the road will be enough to jack up the sale, where perhaps it would not be, otherwise. What Don says makes a lot of sense. If we had done this 10 years ago in some of our first thinnings, we would have better road systems for operations today.

Malmberg. I am glad to hear that. Perhaps Professor Newton can add something about ecology. What will we get on these strips in 10 years? Will we have a lot of small hemlock, alder, or fir? Could you take a guess, Mike? Are we going to have a light problem? Could you second-guess it before we get the evidence?

Newton. I think that will be unimportant. If you use the roadways, by the time the vegetation has grown enough to be a

problem, you will have driven through it another time, so you will not be worried about it. I do not think vegetation will develop enough in 5 years to cause trouble. The alder may be 20 feet tall, but that will not slow down present skidding equipment. Visibility is the only problem that I can imagine because of vegetation on roads.

Audience. We have been concerned here with laborsaving devices for foresters. I think we all realize that the logger is the one who really keeps us in business. Unless we can lay out a road system similar to the one that has just been presented here, we are in trouble. We haven't many good loggers left, and we are finding it hard to get loggers. We must have something like this to keep quality logging and to keep the logger's interest in harvesting our products.

Audience. We have talked a lot about second growth today, and we haven't mentioned measurement, except that Mr. Hoyer talked about blowing the whistle every so often in the marked stands. I think, Mr. Bell, these foresters should know how to inventory stands after they are marked—to get an accurate tree size for instance. Our managers and our loggers say, "What is the log size going to be? Is it going to be 20 or 40 cubic feet? What percentage will be standing or cut?" Will you give us some background on an operational basis on removing the logs?

Bell. Are you primarily concerned with sizes of the material that you are removing removing?

Audience. Especially sizes, and how much basal area is left in the residual stand.

Bell. This is primarily for management purposes?

Audience. For management and inventory purposes. How much is left after the removal of your marked trees?

Bell. The intensity of the estimate will differ, depending upon the management needs. You could merely sample as you mark, keep a rough tally of diameter and height classes, and estimate from that. You may be interested in getting some indication of the percentage of leave and mark. For this, you might measure a series of point samples with some kind of an angle gauge, such as a Relaskop or prism. If you are selling the

thinned material on the open market, you should have a better answer. I think that techniques such as 3-P sampling with stand volume tables or tarif tables would be an excellent system. An unequal probability sample combined with the tarif tables would work well for sales.

Audience. You haven't mentioned tree size. Would this be an accurate method to get tree size?

Bell. Yes, by recording diameters and heights.

Audience. I prefer to have the marker concentrate on marking and not on tally whacking. We have been successful first in marking and then cruising the stands. From the same prism point, we estimate the marked volume with one factor prism and the leave volume with another factor prism, so we get the percentage removed as well as tree size. After the removal we have an inventory of the residual stand.

Bell. This depends on how much time you want to spend. I see nothing wrong with making two passes through a stand. It depends, as you say, on how you are organized. If you have men that do an excellent job of marking and other men that are good at measurements, then this would be a fine way of doing it. Any time you use more than one system, in this instance two prisms, you have to watch for personal error. You are keeping track of the trees that you have marked with one prism and the leave trees with the other prism. I assume that you feel justified in two different prisms because of the tree count and the difference in sizes. In this situation, I think the key is to watch the personal error and place the right tree count under the right column. That can cause errors if you do not watch it.

Berg. Mr. Bell and Mr. Hoyer, in my experiences with marking, trees shorter than normal and trees with broken tops and excessive sweep are removed. How do you handle this in the inventory?

Bell. This is a problem that concerns volume tables.

Berg. Yes, local volume tables used to determine thinned volume.

Hoyer. In our experience, few young-growth Douglas-fir were as seriously damaged as you are talking about. In marking 10,000 trees on a 500-acre sale, the percentage of trees damaged

and the loss in volume are immaterial to the volume estimate that you get by applying the tarif table to those 10,000 trees. I do not think tarif tables have presented problems in estimating volume of the poorly formed trees that are removed in the first or second thinnings. That effect of poor form on volume is negligible as long as your sample trees for selecting the tarif are made up of trees of poor form. A proper local volume table will measure what is there. The few broken and slightly damaged trees that are there will have little serious effect on the overall volume.

Audience. How do you estimate the volume of trees that are broken?

Hoyer. A sufficient sample to estimate the average tarif amounts to about 20 trees. If all trees were broken or damaged, then we would have a tough problem. Access tables would not do the job alone. Some sort of direct measure or adjustment from normal trees to broken-tree volume would be needed to take care of the abnormality.

Berg. Did you want to comment on that, John?

Bell. I do not think I need to say anything further. I know Bill Groman has examined tarif tables in relation to measurements on trees that he made with the Barr and Stroud dendrometer. I think a comment from you, Bill, would be interesting.

Groman. We measure by tree volume rather than by the access tables. We use the volume times the access constant to get the tarif. Generally, this is consistent within the diameter class.

Bell. This morning Jerry mentioned the access tables. These tables have examples of how to select the volume table in two or three ways. If accurate volume measurements are available, the volume tables are somewhat more accurate than the height-diameter access table. When we had good volume measurements with the Barr and Stroud optical dendrometer, we could key ourselves into the volume table and essentially get the same answer.

Audience. I have a question for Mr. Newport about the economics of thinning in a fertilized stand. We thin a stand the first time at about 40 years of age and fertilize it 4 or 5 years

later. You said that fertilizing stands close to rotation age, or 5 or 10 years before rotation age, was economically practical. Don't our yields increase, however, if we wait until the age of from 80 to 100 years before we harvest it? If we fertilize at 45 or 50 years, we will get some increase in our yield in future thinnings. Does this justify fertilizing at a younger age on an economic basis?

Newport. As long as you recover the extra growth before too long, this is a possibility. Some time ago we wanted to determine how we might more effectively measure the response to thinning on land owned by a company represented here. We watched them surreptitiously as they fertilized an area. We went back later only to discover that they were cutting the stand 1 year after fertilizing, and I am sure there was no response at all yet. They shot $30 down the drain for the fertilizer application on those acres. They were cutting in a good market, however, and the high point of the market was much more valuable than fertilization. These things happen sometimes. The application does not have to be before final harvest, necessarily. It can be before the next thinning. The fertilizer should be applied on areas with a possibility of some response. Some areas are overstocked, the trees have little growing space, and fertilization has a tougher time giving a response. You should fertilize only on areas stocked so that a real response is possible. One way to do this is to thin first. Let the trees recover after thinning. Then give them a shot of fertilizer. Then thin again. As long as you continue to do this and get a return on your investment in fertilization, you can presumably repeat these steps. Precede each thinning with some fertilization, if you get a response. My point is, if you fertilize a stand and then wait a long time, you cannot make a high return.

Audience. Would it be justifiable though, economically, to take some of the revenues from that thinning and apply it against the cost of fertilizer?

Newport. That is right.

Audience. You could not apply it all?

Newport. You would not have to apply it all. You could choose an amount to recover the investment on the fertilization. Then let the stand continue to grow and respond. This is

somewhat analogous to the basis on which Don scheduled his thinnings. He is actually concerned with a commercial thinning, which means he takes some growing timber. He does not liquidate, because the residual stand will grow fast enough to be a good investment. This is not true in a dense stand. So he takes some of the investment in a thinning, with the idea that the remaining stand is a good investment in itself. I may have given the impression that rotation was something critical. What you are really looking at is the stand itself as an opportunity. Whether the stand is 45 years old, 60 years old, or 10 years past rotation makes no difference. In a stand, consider what the opportunities are for enhancing the timber growth and making some money at the same time, with an effort that is less than the return that you will get. This is the way you look at each opportunity. Nothing is sacred about the rotation. A hemlock stand has too much growing stock. If the area is clearcut, then some trees that are earning a good rate of return are taken also. But most foresters will take only part of the stand in a thinning and leave the rest of the trees still earning at a good rate. In Don's program, he must be careful about following that kind of procedure. If it is good to take a 12-foot-wide strip, it may be good to take 100-foot-wide strips every 100 feet. Take it all. If the residual stand grows in value, he can store something for the future market. Not only is volume stored, but the stand is growing. If it is not growing, then I think he should take 100-foot-wide strips every 100 feet. Take it all at the young age of 45 years.

Audience. Carl, would you elaborate on the economic criteria of site class?

Newport. Let us say you think you need more acres in your total property. You have some mature timber, but you have been constrained in cutting this in the past, because you cannot promise high yields from young stands in the future; therefore, you have constrained the rate at which you are cutting old growth. In that circumstance, you may find that if you can purchase and rehabilitate certain high-site areas, you will get an immediate response in the rate at which you can cut

the old growth. If you can do this then, it acts just like the fertilization or precommercial thinning in the other instance I talked about.

Audience. Can we spend 80-120 dollars per acre on site II lands?

Newport. The procedure would be to determine the present rate at which you are harvesting your mature timber and then examine the array of activities to see if you have opportunities that you have not counted. If they add growth in the future, put this into your system, and it may permit you to cut at a faster rate now. An investment of about 10-20 dollars per acre on anything in which you must wait over 50 years is out of the question. It will not have a high enough rate of interest to compete for money that is available for investment.

Audience. This is a critical thing.

Newport. Very critical. That is why I have emphasized that you must be concerned about generating income. We must generate income both now and in the future. If you can generate income only in the distant future and must invest money now you will have a difficult time justifying that investment. If you can generate some income now because these types of forest are tied together, you have an opportunity right now, in many instances, to justify the rehabilitation of acres that are not now rehabilitated. I think this is extremely important to recognize. If you follow the national situation of the public forest land and this matter of plowing funds back into management, you will recognize the current importance of this concept. I think we should not pass up an opportunity now to generate income from the public working circles and tie it to activities on the young forest that we will regenerate or the young stands we have there now. This is one of the biggest steps forward we have made in forestry recently. People on the national level who control the purse strings understand this now. That is what happened with the Washington Department of Natural Resources, I am sure. Jerry would admit it. They found that young-growth management was tied to the rate of cut. The rate of cut of a forest would bring dollars to the fund

that pays the expenditures of the same forest. This procedure makes investments available now for rehabilitating acres that we could never otherwise justify at very low rates of interest.

Audience. Stockholders, though, are a different bunch of people.

Newport. Certainly, that is right. But you have many things going for you. Some of the stockholders of the companies that you represent react the same way. That is why I say, if you can show them that you will generate income in your forestry activities, they will listen to you. If they have old growth, mature timber, and they are liquidating it on a constrained basis, constrained by how fast they will grow new timber, then they can raise that rate. You see many examples of this. This is in effect what Georgia-Pacific did. They made a decision to get money now, to generate income. They could have had the opportunity and done nothing, or they could have done something to grow timber for the future. You can find different degrees of this. Some said they were making a big mistake, that they were cutting too fast. I think you have to recognize that just because they did not let themselves be constrained about how rapidly they could grow timber in the future, we can not condemn them for it. We might criticize them for the quality of harvest treatment or the speed of regeneration, but their decisions about how fast to harvest were based on finances not on forestry.

Some of us are less constrained than others by our views of what the future will bring. We smoke and do not worry about cancer, for instance. So we must recognize that we have many opportunities, if we look at them properly, to do things that we did not think we could do otherwise.

Audience. You need a good public relations system.

Newport. You must back up the public relations system with something. If you do not, you will soon be in trouble.

Malmberg. I would like to reinforce the point that Carl made repeatedly today. I challenge the words "problems in young-growth management". He suggested the word "opportunities in young-growth management". I would like to present the point of view that when you deal with your management

people on the subjects of fertilization and precommercial thinning, you do not use the word "loss". I suggest we drop the word "loss" and substitute the word "investment". You do have an opportunity to make more money by precommercial thinning. The key words are financial analysis. How much investment, not how much loss, will return what kind of percentage? It must be more than 4½ percent in some companies, or it is a no-go situation. You will not get the money. You have to show through financial analysis a return greater than 4½ percent or the manufacturer, sales department, or equipment developer will get the money, and you will not. One problem in presenting a program is words. Don't say, "It will cost me so much, and it will be a loss for so many years." This is the wrong use of words. The investment opportunities are there. Let us talk in terms of opportunities and investment, not problems or cash losses.

Newport. One more comment, lest you get the idea that all I think about is money. The same thing applies to other aspects of management. Sometimes the firm is simply interested in trying to produce wood. They plan to make a profit by converting and selling wood products. So, to a great extent, they think in terms of producing wood. But they should think about the environmental factors such as water, soil, and pollution. They should also document the returns in environmental benefits so that the operation is not entirely a matter of dollars and cents in discounting. If, for example, you have several alternatives, and they all will produce about 5 percent return on your investment, you should also consider what else they will do. If one of them benefits the soil or water it has much more value to most stockholders than you realize. They do not want to pollute any more than other people do. You can measure these factors and get a value return from them.

MARKING TREES FOR THINNING–A FIELD PROBLEM

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A FIELD PROBLEM in marking Douglas-fir for thinning was conducted on two experimental plots in the 500-acre Black Rock Unit of the George T. Gerlinger State Experimental Forest 3 miles west of Falls City at Black Rock (Figure 1). The stand was 55 years old.

Each participant marked trees for a commercial thinning in an unthinned control plot and a plot that had been thinned three times (Figure 2). Their instructions were to assume that this marking in the previously thinned stand would be for the

Figure 1. Instruction in the marking of young-growth stands of Douglas-fir at Black Rock.

Figure 2. Marking a 57-year-old stand of Douglas-fir for the last thinning before harvest cut at age 70 years. The stand has had three previous thinnings.

last thinning before final harvest at age 70 years, and that two thinnings would be made in the unthinned stand—one thinning now and another between 5 and 10 years from now before final harvest at age 70 years.

The purpose of the exercise was to provide instruction in marking stands for commercial thinning and to demonstrate the wide range of marking that can be performed in a stand. Even if a forester is not required by his job to mark stands for thinning, he should know, in general, what kinds of trees to remove and what kinds to leave as crop trees, as well as develop a feel for levels of growing stock to maintain.

On the previously thinned stand (Plot 18, Table 1), an average of 70 trees with a volume of 9,500 board feet per acre was marked (Table 2). Averages of 108 trees and 33,600 board feet per acre were left (Table 2). The range of 68 to 144 trees per acre left by the participants is considerable, however, and it illustrates the diversity of opinions among foresters as to what stocking is necessary for adequate growth.

On the unthinned stand (Plot 19, Table 3), averages of 148 trees and 18,700 board feet per acre were marked (Table 4); 140 trees and 29,600 board feet remained. With a second thinning scheduled for this plot, excess growing stock could be left at this time.

Table 1. Basic Data for a Stand Thinned Three Times; Plot 18, (Douglas-fir Only, Site III).

Stand item	Trees	Avg dbh	Basal area	Volume	
	No.	*In.*	*Sq ft*	*Cu ft*	*Fbm*[2]
Stand in 1956	344	10.8	221	7,886	33,615
Removed[1]	130	---	93	3,474	14,775
Mortality	36	---	8	258	370
Growth	---	---	70	4,281	24,645
Stand in 1968	178	14.0	190	8,435	43,115

[1]The first intermediate cutting, a crown thinning, was made in 1956. The stand was cut a second time in 1961, and a third time in 1965.
[2]Scribner log rule.

Table 2. Results of Marking in Previously Thinned Stand; Plot 18.

Foresters		Trees		Basal area		Volume	
Class	No.	Range	Avg	Range	Avg	Range	Avg
				Sq ft	*Sq ft*	*Fbm*[1]	*Fbm*[1]
			TREES PER ACRE MARKED TO CUT				
Private	38	34-100	68	20-80	45	3,030-16,530	8,680
Public	26	34-110	76	26-74	53	4,700-16,660	10,620
All	64	34-110	70	20-80	48	3,030-16,660	9,470
Berg	1	---	84	---	55	---	10,390
			TREES PER ACRE TO BE LEFT AFTER THINNING				
Private	38	78-144	110	109-169	144	26,585-40,085	34,435
Public	26	68-144	102	115-163	136	26,455-38,415	32,495
All	64	68-144	108	109-169	141	26,585-38,415	33,645
Berg	1	---	94	---	134	---	32,725

[1]Scribner log rule.

Table 3. Basic Data for Unthinned Control; Plot 19, (Douglas-fir Only, Site III).

Stand item	Trees	Avg dbh	Basal area	Volume	
	No.	*In.*	*Sq ft*	*Cu ft*	*Fbm*[2]
Stand in 1956	391	10.0	215	7,496	28,605
Mortality	103	---	23	724	1,025
Growth	---	---	64	3,515	20,705
Stand in 1968	288	12.8	256	10,287	48,285

[1]Scribner log rule.

Two factors cloud the results. First, we don't know how much experience each participant has had in marking. I have found that beginners mark fewer trees for removal than markers who have been at the game for some time. Second, the attitude of each marker at the time of the exercise and the effort that each participant expended in choosing trees to take or leave cannot be evaluated.

The exercise showed that a marker has many choices in selecting trees. A pattern of marking, by organization, did appear, however. Foresters in the same organization tended to mark the same way, which indicates that each organization has a marking system' that complements its management program. In this test, foresters employed by public agencies were inclined, on the average, to remove more growing stock in thinning than those employed by private companies (Figures 3, 4, 5).

The results of my marking are presented as an illustration of what one forester with considerable experience in marking stands to various densities will do (Tables 2, 4). It is not intended as the final word or the "only way" to mark. For instance, although I am satisfied with my marking of the unthinned stand, I believe I should have marked more trees to remove in the previously thinned stand.

Table 4. Results of Marking in Unthinned Control; Plot 19.

Foresters		Trees		Basal area		Volume	
Class	No.	Range	Avg	Range	Avg	Range	Avg
				Sq ft	*Sq ft*	*Fbm*[1]	*Fbm*[1]
TREES PER ACRE MARKED TO CUT							
Private	38	80-200	144	60-160	95	9,500-35,660	18,488
Public	26	88-204	156	68-152	101	12,500-30,620	19,060
All	64	80-204	148	60-160	98	9,500-35,660	18,720
Berg	1	---	180	---	122	---	22,680
TREES PER ACRE TO BE LEFT AFTER THINNING							
Private	38	88-208	144	96-196	161	12,625-38,785	29,797
Public	26	84-200	132	104-188	155	17,665-35,785	29,225
All	64	84-208	140	96-196	158	12,625-38,785	29,565
Berg	1	---	108	---	134	---	25,605

[1]Scribner log rule.

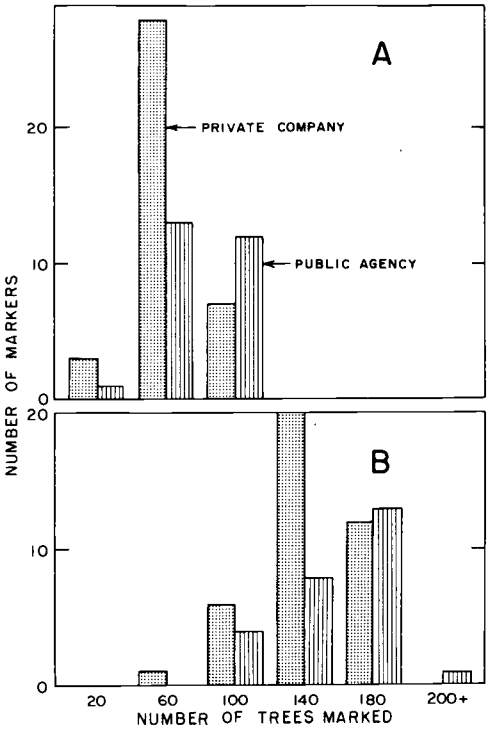

Figure 3. Number of trees marked in 1969 marking problem at Black Rock: fourth thinning in Plot 18 (A) and first thinning in unthinned Plot 19(B).

Evidence from Black Rock, soon to be published, indicates that light thinning in stands 40 years old or older will not accomplish the release necessary for increased growth. Reduction in growing stock must be severe, but preferably in at least two separate thinnings spaced at least 3 years apart to maintain the health of the stand. On the basis of research results, I judge that between 70 and 80 trees per acre and about 100 square feet of basal area would be most desirable as growing stock on Plot 18 after this thinning. Because of the dense stocking in the unthinned stand and because a second thinning is scheduled soon, more growing stock can be retained on Plot 19.

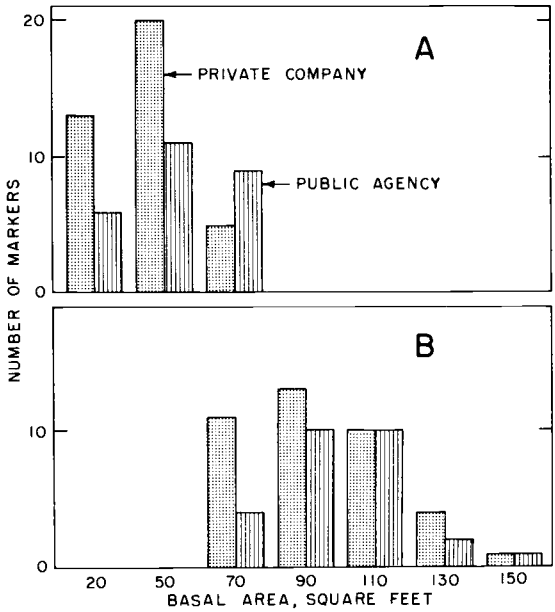

Figure 4. Basal area marked in 1969 marking problem at Black Rock: fourth thinning in Plot 18 (A) and first thinning in unthinned Plot 19 (B).

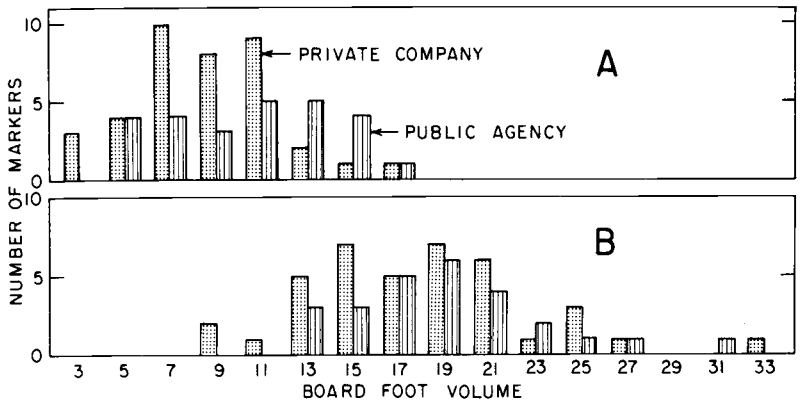

Figure 5. Board foot volume, Scribner log rule, marked in 1969 marking problem at Black Rock: fourth thinning in Plot 18 (A) and first thinning in unthinned Plot 19 (B).

On the whole, foresters tend to be cautious and mark fewer trees for removal than would be beneficial. I believe that those participants who marked for removal fewer than 120 trees on Plot 19 and fewer than 80 trees on Plot 18 were not marking heavily enough.

CHEMICAL THINNING: SOME OPERATIONAL ASPECTS

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USE OF HERBICIDES for spacing forest stands is an established practice. Along with the savings and benefits accruing from the replacement of power saws with injectors have been the usual problems of gaining experience with a new practice and new equipment. Chemical thinning has demonstrated enough merit to stimulate workers to find solutions to the various problems. We will review here some of the problems and questions in connection with chemical thinning, and suggest answers in accordance with the current state of the art.

Equipment

A question that frequently arises pertains to the choice of equipment for the job. Several types of injectors are available, each of which may suit a particular job. The simplest is the hatchet and squeeze bottle. This is particularly well suited for small jobs, where a large element of wastage of chemical will not increase cost or contamination substantially. Dosages are approximate, work tends to be slow, and a somewhat larger dosage is required than with automatic injection. This method is very slow on steep ground. It has the important advantage of low initial investment, and it will do the job with equipment the average farmer has on hand.

The in-line injectors, used extensively in the South for flatland hardwood control, are heavy and slow because the operator must walk around each tree. In open areas, this instrument may have much virtue, as with juniper control on

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rangelands. In precommercial thinning, however, and on brushy or steep ground, it has handicaps. Cost, $40-50 per instrument, is moderate.

Injection hatchets may be either automatic, as with the "Hypo-hatchet" (manufactured by the Ansul Co., Marinette, Wisconsin), or manual, as with the "Chem-axe" (Key Chemical Co., Anacortes, Washington). Both have the advantage of one-hand operation and are easy to handle in rugged terrain. Because both are used at waist level, they expose the operator to some splattering until he develops a nonsplattering stroke. Both offer a low labor requirement for extensive areas. The Hypo-hatchet is shown in Figures 1 and 2.

Figure 1. The Hypo-hatchet in operation, thinning lodgepole pine.

Figure 2. Thinning hardwoods with the Hypo-hatchet. Note the chemical container attached to the operator's belt.

Trouble shooting

A common complaint with chemical thinning is that trees are not completely killed. This may or not justify correction, depending on species and age. The most frequent cause of incomplete killing has been that cacodylic acid has been used at a cut spacing greater than 4 inches between centers, in summer, and on trees with thrifty crowns. We recommend MSMA (monosodium methyl arsonate), in general, rather than cacodylic acid. MSMA is available either as "Silvisar 550" (Ansul Co.) or "Glow-on" (Key Chemical Co.). It costs less than cacodylic acid and is more effective in most conifers. It is

especially effective for total kill in the dormant season. The dosage of one stroke for any tree up to 3 inches, plus one per additional inch of diameter should cause almost total kill.

Flashback (killing of adjacent trees through root grafts) has been of concern to foresters in thinning. The degree of trouble is related to the chemical used. "Tordon" (Dow Chemical Co. trade name for formulations containing picloram, 4-amino, 3,5,6 trichloro-picolinic acid) is mobile and causes a maximum amount of root-graft killing in most species. Cacodylic acid causes a small amount of unexplained mortality, but MSMA rarely causes flashback.

Toxicity of compounds that contain arsenic causes alarm. Unfortunately, the alarm is amplified by doctors and ecologists who do not distinguish between organic and inorganic arsenicals. Cacodylic acid and MSMA are organic arsenic compounds and are less toxic to most mammals than 2,4-D, although cows have shown a tendency toward sensitivity. These compounds are eliminated quickly from the body with no known gross metabolic complications, unless taken in massive dosages. Some people are known to be skin-sensitive, and it is a good precaution for all workers to use a protective skin cream on faces and arms; gloves should be worn. It would be almost impossible to inject a full charge into flesh, because of inertial requirements for operation of automatic equipment. Moreover, the injury sustained by the blade would be substantially more severe than that caused by absorption of the herbicide, even on the remote possibility that a major share of the ejected material should find its way into the bloodstream. The possibility of such injury must be compared with the disasters that occur with considerable frequency with power saws. We think time will show chemical thinning to be a much safer alternative.

Chemical spattering is of concern to operators. The previous reference to skin cream deserves attention. The causes of spattering are a high swing and withdrawal of the blade while emission is still occurring. A low swing is possible, especially once the operator discovers that a light stroke is all that is necessary for penetration to the sapwood. If the instrument leaks after withdrawal, it can and should be repaired.

Slow emission of fluid has caused a slowdown in some operations with Hypo-hatchets, caused by excessively viscous chemical or by a sticky piston. MSMA, especially, thickens to syrup in cold weather. Fortunately, this material is most effective in cold weather and some dilution will not impair its effectiveness appreciably. Dilution with more than a 20 percent addition of water should not be necessary. Occasionally, highly fluid solutions will be emitted slowly because of a sticky piston. The piston should be removed and silicone grease applied. If, after reassembly, the piston still sticks, it sometimes helps to remove one of the piston rings to reduce drag, or both rings if it still drags. If removing the rings doesn't help, the spring should be replaced.

Leakage leads to waste, spattering, and unnecessary exposure to herbicide. Injector hatchets take a severe beating, and valves may become worn. In the Hypo-hatchet, sticky pistons are responsible for most leakage, and can be repaired as above. In the Chem-axe, valves become jammed, or polyethylene or other plastic fittings may become fatigued so that they leak with extended use. They are replaceable.

Bit orifices may become plugged, which stops emission of herbicide. This problem is generally limited to mature alder with its granular bark. If continued use on mature alder is anticipated, the bit can be ground from the orifice upward in a vee groove, so that the sharp shoulder at the orifice is removed. This should deflect the bark, rather than jam it into the opening.

Loosening of the handles of Hypo-hatchets has given some trouble. One solution is to grind the set screw to a point and mark the handle in the appropriate spot with a center punch. The pointed set screw in the mark on the handle should hold the head in place. If the handle becomes loose, it can be tightened by tightening the set screw.

Some people object to being unable to prune away interfering branches. We find that removal of branches is usually unnecessary, however. We simply bend the branches aside and strike wherever possible. This approach works even in bushy spruce.

Costs

Labor requirements for chemical thinning cannot be estimated with confidence. The limited amount of experience with operational work precludes estimates that consider such factors as overhead and quality control, along with long-term fatigue. Our experience with 1-acre plots treated with Hypohatchets in various forest types suggests the following: 1) In the range of 300 to 2,000 treated trees per acre, production appears independent of forest type. 2) Production is essentially not influenced by slope up to 50 percent. 3) At least 1 man-hour is required to cover an acre, regardless of how little needs to be done, and during this hour a man can treat some 300 trees while he covers the ground. 4) Stands of more than 300 treated trees per acre can be treated at rates of 300-700 trees per man-hour, with the upper limit in stands of 2,000-trees-plus treated per acre. 5) Chemical costs vary with material. MSMA, at $5.50 per gallon, is used at the rate of about ¾ of a quart per man-hour, which is close to operating cost for a power saw. Costs can be tied to this on a per-acre basis. Cacodylic acid costs more than twice as much, which increases costs over MSMA from $1.50 to $7.00 an acre, depending on time necessary for treatment.

Residual stand

After the first signs of defoliation, chemically thinned stands do not appear substantially different from untreated stands except from below. Snags are hidden from view by green dominants, and dead foliage is retained for only a few weeks. The continuous carpet of red slash is avoided completely, and the dead trees without foliage probably represent minimal fire hazard.

Insects, especially a problem in ponderosa and lodgepole pine stands, are apparently unable to raise broods in trees treated with either cacodylic acid or MSMA. Initial attacks are infrequent, regardless of season, and studies of brood development indicated total mortality regardless of degree of attack or season. This effect has been investigated in some detail in ponderosa pine; lodgepole pine and Douglas-fir appear to follow the same pattern.

We don't know precisely the effect the standing dead trees will have. They may cause some damage by rubbing the leave trees (although we haven't seen it). They may stiffen the stand against wind and snow damage while the residuals increase in stiffness. Some evidence indicates that dead trees protect against sunscald and that chemical thinning may eliminate a source of infection for root rots to an important degree in at least one species.

We don't know how growth rates in stands thinned by various methods compare. In view of the differences in stresses on residual trees according to method, we might expect a somewhat different distribution of growth along the bole. Thus, growth will have to be compared on a total tree basis until we find whether or not the method is important in this respect.

Field Demonstration of Hypo-Hatchet

We established plots thinned chemically to demonstrate a small operation so that you could get the feel of how it is done. We also have equipment here today that we will put into action. Here are a half-acre plot that was treated with a Tordon herbicide and a half acre that was treated with a mixture of MSMA, 2,4-D, and 2,4,5-T with a Hypo-hatchet tree injector. We treated from 1,500 to 2,000 trees per acre. We tallied the trees treated and the time required to treat them. I think you will see that we were working in stands sufficiently dense to test the operational feasibility. The stands were treated 5 weeks ago, and I haven't been back since, but my spies tell me that most of the foliage is now on the ground.

The trees were not marked before treatment. Harvey Holt treated one plot and I treated the other. We applied one injection for trees up to 3 inches in diameter, two injections from 3 to 5 inches, and three injections for trees up to 7 inches. We used the same dose for the softwood and hardwood, of which you can see a fairly substantial mixture. Usually, we give the hardwoods an extra lick or two because we have had a little more difficulty killing them. We use the same juice for everything and I'd like to you to note, as we go through the area, the responses we get in trees of various species and sizes.

We have had a lot of questions about control when stands are not marked. How do you control operators without marking? It has been our experience that marking before treatment is not necessary. Eventually, the operator gets the feel of it, although, particularly on the first thinning, he may have difficulty knowing exactly where he has been. Within a week, color begins to show up on the crown. Within a month, a contractor can be accountable for having met or failed to meet the specifications of the job. What is more, if an operator is going to be used for a year, for instance, or if a company is going to have a crew continuously, the crew will eventually get the feel for the job.

My personal feeling is that little training is really necessary to get a crew whipped into shape to do the kind of job we want. I think that public agencies should recognize the need for reserving a bonus for contractors who come within certain standards of the contract.

You can draw your own conclusions as to whether you like Tordon or MSMA. I would like to have you look for flashback; it may or may not show up.

We have noticed that Tordon has great mobility in root systems and in soil. When we treat a stand with Tordon, we expect that it will travel through root systems and that we will kill a percentage of the untreated trees, depending on how many stems we treat. In this stand, we treated about four times as many stems as we left and we would expect a high percentage of damage in the residual stand with Tordon. With MSMA we have seen little of this. In ponderosa pine, bark beetles are not affected at all by the Tordon, as nearly as we can tell. The trees that we treat with Tordon essentially look like trees that have been felled and left lying on the ground. They are riddled with *Ips* and *Dendroctonus ponderosae*. Trees treated with MSMA have little insect activity in them, and no live insects emerge. This question has come up quite a few times, so I thought I would emphasize this point–MSMA seems to be bad news for bugs.

We treated from 500 to 700 stems per man-hour with an average of 1.8 strokes per tree, I estimate. Most of the stems that we treated were from 2 to 5 inches in diameter. This is

consistent with our treatment in ponderosa pine, in spruce-hemlock, and in northern hardwoods in New England. So, as an average for a person whose living doesn't depend on it, I'd say that is a fair approximation of what a worker can do. A contractor with some incentive for doing a fast job probably could maintain that rate on a week-by-week basis if he is treating from 1,500 to 2,000 trees per acre. On a half acre here, I treated 780 stems in an hour and 15 minutes. In some of our test plots below, I treated 280 stems in 18 minutes. The average, however, was about 700 stems per man-hour. Operating efficiency decreases a little with increasing steepness of ground. But here we were working on a 30 or 40 percent slope and this didn't interfere with our operation at all. With a hatchet and oil can or squeeze bottle, or the in-line type of injector, the steep slope would slow you down.

Questions also have been asked concerning the merits of the various types of equipment. We developed the Hypo-hatchet at Oregon State University, so we are partial to it and tend to be a little biased. With handaxe and oil can, performance is slow but the equipment is inexpensive. Probably, for a small operation the cost will be less with a handaxe and squeeze bottle or oil can. The economics of saving on equipment probably is questionable for areas over 40 acres. I don't know the relation between the type of equipment and the response from treatment. It looks to us as if immediate emission of chemicals with an automatic injector gives a better response than when there is a delay in emission. We think there is some connection between tension in the tree and the effectiveness of equipment. If an injection into a tree fills the cut instantly, the transpirational tension in the tree is satisfied, and the injection cut empties almost immediately. By the time the injector is pulled out, no residual chemical is left in the cut. You have to look very quickly to find some in there. With the hatchet and squeeze bottle or oil can, the chemical stays in the cut for a bit longer. On a comparable basis, we may get 80 percent kill with a hatchet and squeeze bottle whereas we get 90 percent with the Hypo-hatchet. Whether this is significant in the long haul, I can't say. But this does suggest that perhaps a bit more juice may be needed if you use the manual equipment.

QUESTIONS

Audience. What concentrations of the chemical do you use?

Newton. We use Tordon-225 (Tordon plus 2,4,5-T) undiluted, which is probably more than needed. With overkill, such as you get with full strength solution, you probably also get more flashback through root grafts. Of course, the cost for chemical is higher when it is applied full strength rather than diluted. Probably with Tordon, you can use some dilution. We don't know the minimum dosage yet. With MSMA, we used 6.6 pounds per gallon undiluted in some of our test plots. Here, we used 2 pounds per gallon MSMA, plus a half pound of 2,4-D, and a half pound of 2,4,5-TME. I'm sorry I will not be able to show the results with 6-pound-per-gallon MSMA, but, from the results here, 2 pounds is apparently strong enough. I think it is.

This is a Hypo-hatchet ready for action. Ordinarily, on an operational job, I have 1 or 2 quarts of chemical strapped on me so that I needn't return to the car often to refuel. A quart of chemical is good for about a thousand injections of 1 cc each. This is a production model of the hatchet. You notice a grooved bit here and here. Those who have used the hatchet, or any of the injection equipment, have complained of being splattered in the face by chemical. One of the reasons is that the injection stroke activates the automatic pump, which may not be able to express the chemical in the cut because of the wood on both sides of the bit. As the hatchet is rolled out, the operator might get a spurt in the face. The channels I've ground in the bit are shaped so that, if the pump does spurt, the chemical will eject away from instead of toward the face. Now, let's head out to the plots and see how these hatchets operate.

The age of this stand is between 15 and 20 years. We wanted to leave from 250 to 300 trees per acre. Notice the rate of kill. If you take a look at this tree you can see that the foliage is discolored. The tips of the branches are entirely brown, with some of the old needles left.

We estimate that in a stand such as this one perhaps 10 to 15 percent of the residual trees will be affected by a Tordon

treatment through root grafts. We are not able to predict which trees will be affected. Tordon is especially effective on hardwoods. I know of no species of hardwood that will withstand this chemical.

Audience. How long do you think it will take for these trees to die completely?

Newton. Tordon may take as long as a year. With MSMA, you see response within a few weeks or it is not going to occur. We have never seen conifers fail to respond to MSMA. It is more effective on conifers than Tordon is, but MSMA won't kill some species of hardwoods. For instance, although effective on bigleaf maple, it is not effective on alder.

Audience. Is MSMA effective on vine maple?

Newton. It is good on vine maple. Vine maple with stems less than 1 or 1½ inches in diameter are difficult to treat. The stems must be bent over for treatment. Ordinarily we prefer to treat at breast height.

Audience. Do you get a different response depending upon the height of the injections?

Newton. Not in conifers, except where green branches extend to the ground. In hardwood, the height and amount of sprouting may vary with where the cuts are placed. There is speculation that it goes both ways. I've seen less sprouting with some compounds with waist-high injection than with root-collar injection. A bigleaf maple treated with potassium salt of Silvex, for instance, will die away from the injection cut slowly. Actually, the only sprouting we've seen was where they have been killed quickly right in line with the injection cut. The further away from the root collar, the slower the demise and the less likelihood of sprouting. But I don't know whether or not this is a general thing.

We are standing in a fairly low-density job. It is clear which trees should be cut or killed. They are not contributing anything and they should be removed. They will die probably within a year or two whether this stand is precommercially thinned or not.

Further above are some stands where dominance is not expressed, and obviously, precommercial thinning will do more

good. In a stand like this, I would speculate that we get more response from precommercial thinning if we over-thin by taking some of the dominants and codominants. This is the kind of stand I would cut back to not many more than 200 trees to the acre. I think we have to hit it that hard to get an adequate response on our leave trees.

Audience. What is the age of the stand?

Newton. The dominants are about 20 years old.

Audience. What effect does time of year have on the effectiveness of the chemical?

Newton. Conifers are not very sensitive to season, but there is a better response in fall and winter. This is true for both Douglas-fir and ponderosa pine. We treated some ponderosa pine when the temperature was below freezing and the cambium was totally killed. Of 180 trees we treated in that season, 179 of them were completely dead. The other one had one or two green branches on it.

Audience. Do you increase the dosage during the winter?

Newton. No. In fact, the reverse may be possible; on conifers, in winter we may be able to get by with slightly lower doses.

Audience. Is the manufacturer going to change directions for application?

Newton. I won't try to explain the manufacturer's recommendations, which are for Silvisar 510 (cacodylic acid, 5.7 pounds per gallon). On conifers, we are using MSMA almost exclusively now, and I would guess that this pattern of good winter activity is perhaps best expressed with MSMA.

Audience. Did you try one hack or 3 hacks on the 5-inch tree?

Newton. On ponderosa pine in December, one hack on a 5-inch tree will put it right out of business. We haven't found the minimum dosage for Douglas-fir. I expect that it is about one injection for a 4-inch tree.

The problem in making recommendations for minimum treatment is that someone doesn't get the word, doesn't do the job, or our minimum recommendations don't pan out. And so we like to be a little on the safe side. I don't think there is any question but that a well-placed injection on a 3-inch tree is

going to kill it. Some green crown might be left after one injection in 4- to 5-inch trees.

How important is a little tuft of green crown? Is a 95-percent job enough or do we have to shoot for a 100 percent? That's the question that you have to answer for yourself. I personally believe that anything over 95 percent is gravy and if it costs us 20 to 30 percent more to get a 99 percent job, then it is not worth it.

Audience. How about rain? Does treatment during a heavy rain make any difference at all?

Newton. I think not. I have had quite a bit of experience working in the rain and I haven't seen any failure that I attribute to rain. But that doesn't mean there might not be some effect.

Why don't you all gather around? I'll treat a tree and I'd like to have you see how fast the juice is taken up in the injection cut. It disappears almost immediately. This is Silvisar 510. It comes with a blue marker dye so you can see where the injection has been made.

Glow-on has a fluorescent-orange dye that makes an orange mark. I presume that if the chemical dribbles down the side of the tree it glows more brightly. But most of the dye is placed out of sight behind the bark. When I am working back and forth in a stand I look for a mark on the tree. It may be a little easier to see if it has fluorescent dye, but I don't think it saves a whole lot of time.

Audience. We have been using an axe and oil can because when we use the Hypo-hatchet it sometimes gums up and no chemical comes out. We found that the dye indicated whether we were getting juice or not.

Newton. The grind that I put in this bit has two effects. It provides a relief port for the juice so it doesn't spray you in the face. It also provides a chamfer on the upper edge of the emission port so that when it goes in against a granular bark, the bark rolls out, rather than in. This is especially a problem in granular-bark species like alder. In beech, in the Northeast, we find the same thing, particularly in trees of 10 inches or more. Is this consistent with your experience?

Audience. We had most of our problems in alder.

Newton. Thus far we haven't had trouble with any of the conifers. This modification, which I made with a 40-cent stone and a file, took about 5 minutes. It seems to solve the problem for even the worst hardwoods. Just put a chamfer on the upper edge of the opening.

In this plot treated with MSMA, you can see that the effect has been much more extreme than with Tordon. Tordon 225 costs about $22.00 a gallon; the MADT that we used in here will probably sell for something like $4.00. They are both used full strength.

In this stand, the effects of thinning are much more striking than in the plot treated with Tordon. I was able to treat about 700 stems per hour while achieving this effect.

Audience. That's the first hour?

Newton. Yes, but I had already treated an acre before I came here. In Vermont, working in stands where I treated from 400 to 500 trees per acre, I was able to cover about 10 acres a day.

Notice that the ground is covered with needles that have dropped. The question has been asked repeatedly, what about the fire hazard? Take hold of a treated tree and give it a shake. The crown is in your lap. Little green is left—a few needles, but most of them are dead. We have essentially zero survival of trees treated with MSMA. All the small trees here, of course, were given just one injection.

Audience. What's the purpose of the T & D with this? Are you prepared to make a recommendation or is this just a trial or experiment?

Newton. This is a trial with experimental material. I would say that Silvisar 550, which is the commercial formulation of MSMA, or Glow-on, either one, is capable of doing this job operationally, just as we have done it here. I would recommend using straight MSMA on this basis.

Audience. Do you use the same chemical for both Douglas-fir and hardwood?

Newton. For Douglas-fir primarily or hardwood primarily?

Audience. Both.

Newton. If you are treating primarily hardwoods, my recommendation differs from that for conifers. For conifers, I

would say MSMA. Silvisar 550 and Glow-on are trade names of two MSMA formulations that are specifically for this purpose.

Audience. Are the directions with them?

Newton. The directions are on the label.

Audience. And do the directions seem right to you?

Newton. Yes, the directions for Silvisar 550 were developed in our laboratory. Silvisar 550 is an Ansul product. Ansul also manufactures the Hypo-hatchet. Glow-on is manufactured by the Vineland Chemical Company and distributed by Key Chemical Co., in Anacortes, Washington.

Audience. Any comment on the extra viscosity of Glow-on for use in the hatchet?

Newton. Highly viscous material needs to be thinned slightly. A 25-percent cut with water will bring them down to a suitable viscosity for the hatchet; perhaps even less dilution will do it. We think effectiveness will not be impaired.

Audience. Is the concentration the same in both formulations?

Newton. Glow-on is 5½ pounds per gallon and Silvisar 550, I believe, is 6.6 pounds. Glow-on is a bit more viscous because of the addition of dye.

Audience. If you follow the directions on the label, are you going in the right direction?

Newton. By and large, yes.

Audience. What were we looking for, Mike, when the D & T were added to the MSMA?

Newton. A broad spectrum chemical for both hardwoods and conifers.

One problem with mixing chemicals with MSMA or cacodylic acid, is that the solubility of MSMA goes down when you mix in 2,4-D; 2,4,5-T; or Tordon. MSMA is a good enough herbicide so that anything we do to cut down the amount of MSMA we put in may be hurting us. This formulation was ½ pound of D, ½ pound of T , and only 2 pounds of MSMA per gallon. Well, I rather suspect that we lost more than we gained by adding the 2,4-D, because commercial Silvisar 550 has 6 pounds per gallon. We know that is extremely effective on conifers. I don't think we would see as much green in the tops with Silvisar 550 as we see here today.

Audience. Silvisar and Glow-on are primarily for conifers. What do we use on hardwoods?

Newton. Primarily on hardwoods? You're in Southwestern Oregon?

Audience. We're in Linn County, western Cascades.

Newton. Well, MSMA is extremely good on bigleaf maple. If most of your hardwood is bigleaf, then I would use MSMA in the September-November period.

Audience. What about vine maple?

Newton. MSMA is effective on vine maple. If you have much alder, MSMA is poor. You *can* use MSMA if you cinch up your cut spacing good and tight, forming nearly a frill.

Now, one very important difference between hardwoods and conifers–conifers can be treated any time of year with, perhaps, optimum in midwinter, but hardwoods must not be treated except during the growing season. On bigleaf maple we can stretch the season somewhat, but alder simply is not affected until it is in full leaf. If we treat alder in the winter, it will bud out in the spring as though it had never been treated.

Several questions have been asked about hardwood control. My answers have been related to treatment, currently in use for thinning. If the injection job is primarily for hardwoods, you would be well advised to consult the Oregon Weed Control Handbook. This is published annually and has summaries of the most recent recommendations. It is available from the OSU Cooperative Agricultural Extension Service.

If you have primarily alder, which I know many of you west-siders do, you can treat it effectively with 2,4-D amine in midsummer. Dow Formula 40 is one and Weedar-64 is another. The directions are not on the canister. You inject every 3 inches of circumference on alder with 2,4-D amine at full strength.

These products will kill cherry, dogwood, white oak, and alder, but it won't do much for conifers and it won't do anything for bigleaf maple.

Audience. How about that MSMA on dogwood and cherry?

Newton. Not very good on cherry. I haven't enough experience with dogwood to make hard and fast recom-

mendations. I'm pretty sure 2,4-D amine will take it. We have had some experience in McDonald Forest with that.

Audience. Have you worked on myrtle?

Newton. No. Have you?

Audience. No—I have treated willows.

Newton. 2,4-D amine will take willows pretty well.

We have had some experience recently with adding a little Tordon to 2,4-D amine. I recommended to Bruce Starker recently that he put just a snip of Tordon into his 2,4-D. He mixed a batch of two parts water, two parts Formula 40, and one part Tordon 101. That mixture gave some of the best hardwood control of mixed species I have seen yet. But he didn't have bigleaf in the stand and I know the mixture would not affect it.

Audience. Would you say that again?

Newton. Two parts water, two parts Formula 40, and one part Tordon 101. That mixture looks awfully, awfully good. There was very little effect on the conifers from the Tordon in there.

Audience. Was the mixture good on most hardwood species except maple?

Newton. Yes, I treated cherry, several species of willow, alder, and cottonwood successfully.

Audience. How does plain Tordon come into this?

Newton. We've treated hardwoods with plain Tordon. The Douglas-fir gets curly as all get out. We had several plots for chemical tests on bigleaf maple in which a substantial percentage of the suppressed Douglas-fir developed yellow, curly foliage and all the other symptoms of Tordon injury; many of them died. When such a small amount of Tordon is sufficient to cause this much injury to residual conifers, I'm scared of it.

Audience. Any work in hemlock?

Newton. We have some work in hemlock. MSMA is excellent for treating hemlock; Tordon also will kill it. If you climb into the tops of a hemlock stand after a Tordon thinning, you may note that many of the residual trees, although they look fine from below, have the yellow

symptoms on top. This scares me about Tordon in hemlock. Until recently we didn't know any better. We didn't have any material other than Tordon to use. Crown Zellerbach thinned quite a few thousand acres with it. It was on Crown's land that we saw the worst of the yellowing. Some work we are doing now suggests that MSMA is an excellent hemlock killer.

One other thing about hemlock. Don Malmberg yesterday mentioned Pete Laird's work, which showed that *Fomes annosus* will enter an injection cut made with Tordon. It's in almost every injection port. A tree treated with Tordon has a streak of *Fomes annosus* down to the roots in line with each injection. With MSMA, he has been unable to demonstrate *Fomes annosus* infection even with a deliberate attempt to infect. Trees felled after treatment with Tordon have a high incidence of *Fomes annosus.* Trees felled after treatment with MSMA have been essentially clean. As it turns out, Pete's laboratory work determined that MSMA is quite antagonistic to the organism. This suggests that MSMA may actually be a preventive measure. Perhaps, if trees were treated with MSMA before harvest, the stump would no longer be a suitable infection court for the residual stand. No one is willing to say at this stage whether *Fomes annosus* is such an important problem that these measures need to be taken. But this is the pattern that Laird found in chemical treatment. His work is concerned with preharvest killing of trees in thinnings of 40-year-old stands.

Audience. Where do you place Tordon as far as general use on the average operation? Is it still experimental?

Newton. I'm on the fence with Tordon. Tordon is a good herbicide. It will kill many species that can't be killed easily with other herbicides. For roadside brush control and this type of treatment, I'm sure Tordon has a place. But for treatment of stands of Douglas-fir or for general site preparation, in the hands of the average user, I would say Tordon is dangerous. We may learn to use it so that we can be reasonably confident of using it safely, but right now I'm scared of it and would not recommend it for precommercial thinning under any circumstances.

Audience. Have you treated a stand younger than this one? Are limbs likely to cause injury?

Newton. I personally have not worked in stands much younger than this. I think Crown has thinned some stands that are younger. I don't find access to stems to be a major problem. Some people have complained about it. Some say the Hypo-hatchet is not satisfactory because you can't use it as a chopping instrument to reach trees. But I don't chop through the limbs to treat a tree anyway. I reach in and give it a lick where I can and forget about it. I think that a lot of foresters have made mistakes with this injection equipment. They use it as an ax to chop the tree half off. They feel that they must have a straight shot at the tree to get a lethal dose into it. I think we are shooting for a 95 percent job, not a 99 percent. If I get a glancing blow, I would rather leave it than waste the time trying to get another shot at it. The chances are good that it will die with only a glancing blow. The recommended dosages have enough margin of safety so the trees will be pretty well sickened if they so much as get an exposure to the chemical.

Audience. What happens if you hit yourself with the ax?

Newton. Well, you ought to know enough to stop. It takes about 150 injections to give you a lethal dose of juice and if you haven't learned to stop by that time, why there is not much hope for you.

Audience. Is it better to put a cut on each side or both cuts on the same side?

Newton. Ordinarily, a cut on each side is better. Also, a tree is easier to kill with one lick if it has a small crown rather than green crown that goes to the ground.

Audience. We contracted a thinning in a stand similar to this for $35.00 an acre. The operator went completely broke at it. We had to raise the price to $55.00.

Newton. What equipment was he using?

Audience. The small cup-shaped ax with the squirter. The contractor didn't like that so he then used the hack-and-squirt method with the hatchet and a small squeeze bottle.

Newton. Much slower than this?

Audience. Much slower. The contractor couldn't–I don't know whether he was color-blind or what–see what he had treated and what he had not. He had no idea whatsoever. When he used the powersaw, of course, he knew what he was doing because the thinned trees were cut off.

Newton. It takes quite a different approach.

Audience. Do you think you get more wood in the end by thinning these trees now?

Newton. I think so. I think in 5 years this will be a fully stocked stand, and I think the growth rate on the leave trees will be far better than in the unthinned stands. I think the stand will be closed even before the leave trees become merchantable, and that I didn't kill enough trees in here.

Audience. Do you always end up with about 20 percent more trees than you want?

Newton. You have to shoot for about 20 percent more. We want 240 leave trees per acre and usually end up with 300.

Unfortunately, dye doesn't work in MSMA. This is cacodylic acid that I have been using today. MSMA reacts with the dye and turns it a very pale green. It is not satisfactory.

Audience. We have found that Glow-on shows up with no problem at all, we can see it clearly.

Newton. Well, I've found that I don't need dye. I can tell where I have been whether the stuff has Glow-on in it or not. Usually, I more or less remember where I have been, even though I may not be able to see it. As you drift along, your eyes just tend to level off on a 35-foot strip. I work back and forth and I can always see where I have been. It is easy to keep track–with or without Glow-on.

Audience. Do you try to hit on the sides so that you can always see when you are making your next run?

Newton. I don't pay attention to it. I just hit the stem wherever it is convenient. Perhaps 1 percent of the trees, I hit twice. Avoiding that amount of duplication is not worth making a special effort. The trees that I do hit twice are good and dead!

Audience. Are any of these herbicides dangerous to cattle in the way they are used?

Newton. MSMA, cacodylic acid, 2,4-D, and Tordon are low in toxicity, and cattle are essentially not exposed unless there is a spillage. The chemical is taken up by the tree immediately. The organic arsenicals MSMA and cacodylic acid are less toxic to most animals than 2,4-D. There is some evidence of sensitivity in cows, however, and we must be careful not to spill. These chemicals are sodium salts, and could be used like salt licks.

Audience. Is aminotriazole hazardous in a pasture?

Newton. Aminotriazole has among the lowest toxicity of all the herbicides. It has a reputation of being carcinogenic on rats in chronic dosages that probably exceed by a substantial margin anything that any livestock could possibly be exposed to. I don't think there is any hazard. Tests with feeds for horses, dogs, cattle, and swine with 10,000 parts per million of aminotriazole show no toxicity. It is perhaps less toxic than table salt. Whether the reported carcinogenic effects would carry over, I couldn't say. Just as a matter of course, I like to be careful with this stuff, but I don't hesitate to use it.

Audience. I was asked this question by a neighbor the other day. His daughter has a horse and he wondered what he could use to treat vegetation along the fence.

Newton. Probably a mixture of dalapon and atrazine would be best. No carcinogenic stigma is attached to these compounds. Such weeds as blackberry and snowberry could be spot sprayed with aminotriazole, with essentially no hazard.

Any further questions on chemical thinning? Well, I think the important aspect of chemical thinning is economics. I think unquestionably trees could be treated chemically in this kind of stand much more economically than they can be felled.

I will briefly mention a few fringe benefits before we go. One benefit is that the stand remains stiff. The trees may get chewed up slightly by the dead snags from wind action, but I doubt if the wind is likely to lay them over, as long as the residual dead trees are in place.

Also, the stand probably will not hold as much snow. This is speculative, but a dead crown will not hold snow and a live crown with a dead crown to lean on would be able to hold up

more snow than it does by itself. How well this works in practice, I don't know. Bark beetles are discriminated against by MSMA and cacodylic acid in ponderosa pine and Douglas-fir. We don't know about other species. The bark beetle story is interesting and long, so I won't go into it. But some chemical materials do give protection to trees. I would say we have a real prospect for treating windfalls with MSMA to keep bugs from going into them. Bugs are vectors for fungi—sap rots and others. When MSMA is applied to a down tree that has a little live crown left, we suspect that potential for infestation by bark beetles will be essentially zero. We tested this hypothesis in preharvest-dried, standing trees and it seems to be valid. We have yet to investigate down trees. But it is interesting to speculate on the first real means of bark beetle control for windfall areas.

Audience. What about treating trees infested with bark-beetle before you fell them?

Newton. We haven't tried this. Buffam recently reported success in control of mountain pine beetle in ponderosa pine in exactly this way. Cacodylic acid is now registered for this use. These trees were not under attack, and were treated before felling. This should eliminate beetle attacks before they occur. What happens frequently is that the beetles lay eggs in trees, but the eggs do not hatch. The degree of entry to the tree depends upon the time of year of treatment. If you wish to prevent entry, August or late summer treatment is indicated for ponderosa pine. If you want beetles to enter and die, then a June treatment seems to be indicated. In winter treatment, you get some grade in between. *Dendroctonus* probably won't go in at all except in ponderosa pine treated in early summer.

Audience. This could have a real practical application. Especially with a pocket of infected trees that can't be logged, but must be eliminated before the infection spreads, or at least before it enters a cold deck.

Newton. It has real prospects. Harvey Holt's work with preharvest drying has been interesting. If you have questions on sap rot or insects in commercial Douglas-fir that has been killed

before harvest, or on the weight of those trees, Harvey Holt will be publishing that information; it is now available in his thesis.

Audience. Would the herbicide have the same effect in incense cedar or white fir?

Newton. The effect has been consistent on all the trees we have treated so far. Even to the point of debarking. MSMA applied at certain times of the year seems to loosen the bark on most of the trees we have treated–ponderosa pine, Douglas-fir, hemlock. And the bug-kill patterns seem to be the same. I have no reason to expect differences among coniferous species except for dosage.

Audience. Mike, you say it loosens the bark? You just peel it off?

Newton. Yes–in fact, in a lot of Harvey's preharvest trees, the bark came off before it got to the landing. That's with MSMA only applied 6 to 20 months before felling.

Luckiamute Tree Farm
BOISE CASCADE CORPORATION
Independence, Oregon

Host
Lyle H. Seymour
Resident Forester

THINNING IN 50-YEAR-OLD DOUGLAS-FIR

A recently marked area being logged with rubber-tired, four-wheel drive skidders.

Lyle Seymour. The creek we have been following is the Little North Fork of the Luckiamute (Figure 1). The main Luckiamute River is to the south of us. Boise-Cascade started a thinning program here in the fall of 1966. We thinned very little

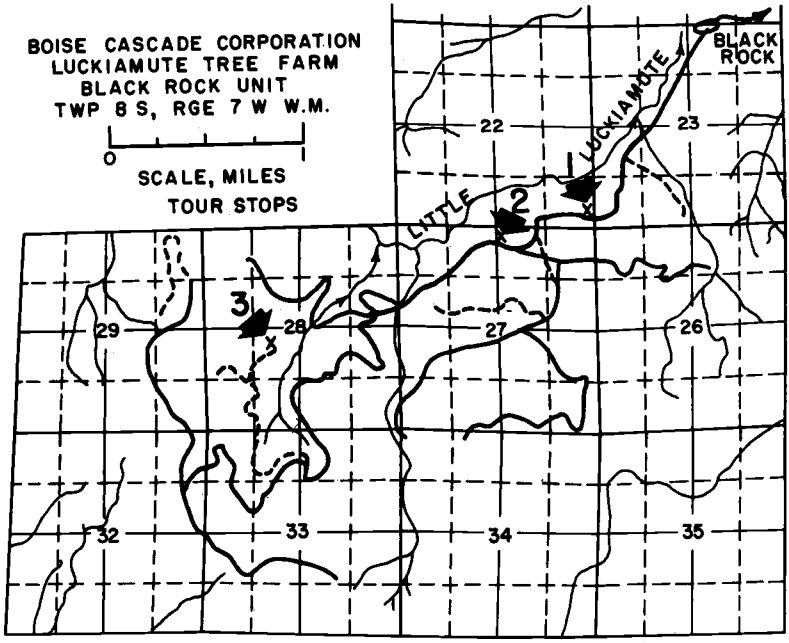

Figure 1. Black Rock Unit of Boise Cascade's Luckiamute Tree Farm. Arrows indicate stops.

that fall because we had no roads in the area and only one dirt road along the boundary. We started to thin the area along the road, but the rains soon prevented that.

Our main thinning project started in 1967, along with a road building program. Some of the area we came through has been thinned. I thought we would first stop here where the operator is actually working. The next stop will be in an adjacent area that was thinned in the fall and winter of 1967-68 with rubber-tired skidders. The last stop will be an area thinned last summer with rubber-tired skidders on gentle ground, and a Skagit SJ-4 on the steep ground.

Audience. Lyle, is that your alder clearcut we see?

Seymour. That's right.

Audience. Why did you seed the area?

Seymour. Well, some small Douglas-fir were growing on the area at the time we cut. We seeded to get additional stocking. We knew alder was going to come back in also.

Audience. Why didn't you plant large seedlings instead of seeding?

Seymour. I think the seed will restock the area.

On this stand, the original volume was 31,000 board feet Scribner to the acre. We marked about 8,900 feet to the acre, or about 28 percent of the volume. Total basal area per acre was 230 square feet, and we marked about 54 square feet of basal area, or about 26 percent. As a guide, I try to mark 30 percent of the volume. I mark the stand the way I think it should be marked. Generally, I mark from 28 to 32 percent of the volume. I want to emphasize that 30 percent is not a fixed figure for the marking process. If I have ten trees in a small local area, I'll remove five or six of those trees if I think it is needed.

Audience. What is the method of marking you use?

Seymour. Thinning is not related to bole spacing here. I want crown openings. This is a 45- to 50-year-old stand (Figure 2), the number and spacing of trees varies from area to area, and growth has slowed down tremendously in the last 10 years. In fact, some of these areas are growing hardly at all. I believe I need to open the crown canopy. I mark for crown opening, rather than for spacing on the ground.

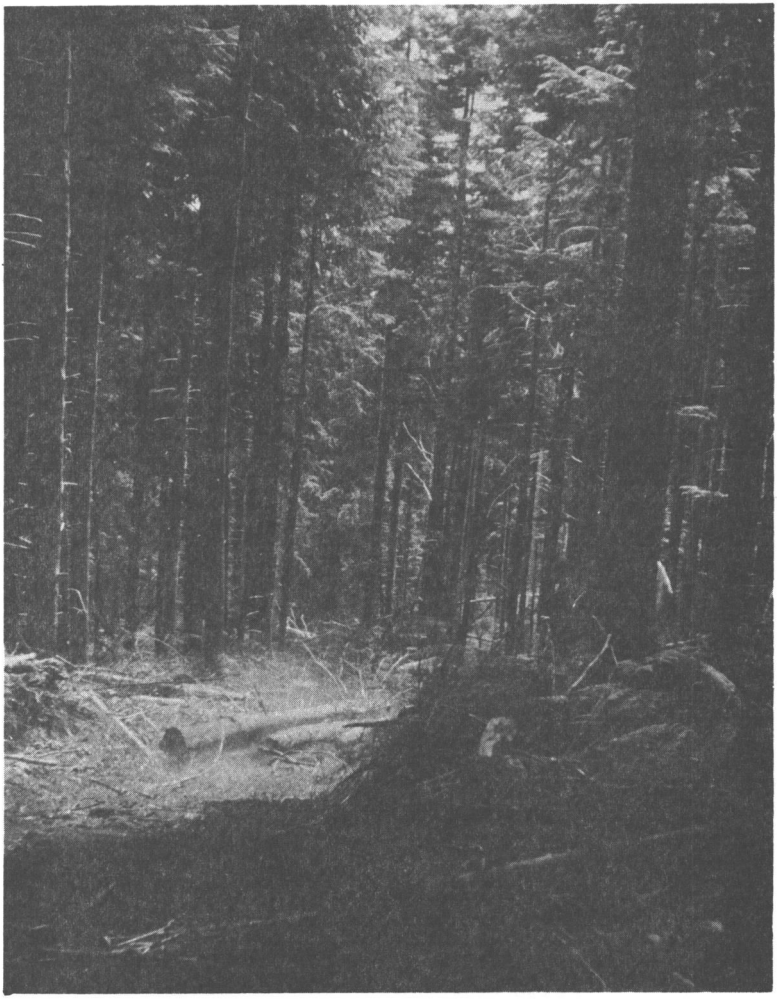

Figure 2. The stand immediately after the first thinning. A turn of logs is disappearing around the bend in the skidroad.

Audience. Will you be back 10 years from now to thin again?

Seymour. About 5 years.

Audience. What has been your market breakdown in products?

Seymour. About 20 percent poles and piling and the rest sawlogs.

Audience. How many times will you thin in here?

Seymour. We estimate the rotation will be 70 years. We expect to thin three times before rotation age.

Audience. What do you plan to do with the hardwoods in here?

Seymour. We cut the merchantable trees and leave those that are not.

Audience. What do you do in the finger draws that are stocked with hemlock and cedar?

Seymour. I do not cut more hardwoods than necessary for silvicultural reasons. Alder is merchantable to a 10-inch top only, so much of the tree is not merchantable at present. In time they will be, though. In Washington, they are able to sell to a 4-inch top.

Audience. Are you interested in killing the hardwoods?

Seymour. No.

Audience. You don't think that additional growth in the conifers along the creek would justify the killing of the hardwoods?

Seymour. I don't think so. We get a good price for hardwood logs. As I say, we will take out the merchantable trees and let the remainder grow for the time being.

Audience. How many loads do you get out in a day?

Seymour. Two skidders will produce about four or five loads a day (Figure 3).

Audience. Are these company loggers?

Seymour. No, gypos—called Pee-Wee Logging Company.

Audience. Do you have pressure to leave an untouched corridor along the creek?

Seymour. Yes.

Audience. How much of a corridor do you leave?

Seymour. We don't designate any particular width. We just don't log close to the creek. Perhaps 60 to 100 feet. In general, we thin the fir and leave the hardwoods along the creek. We anticipate that the practice will prevent creek pollution.

Audience. Are you at liberty to tell contract logging costs?

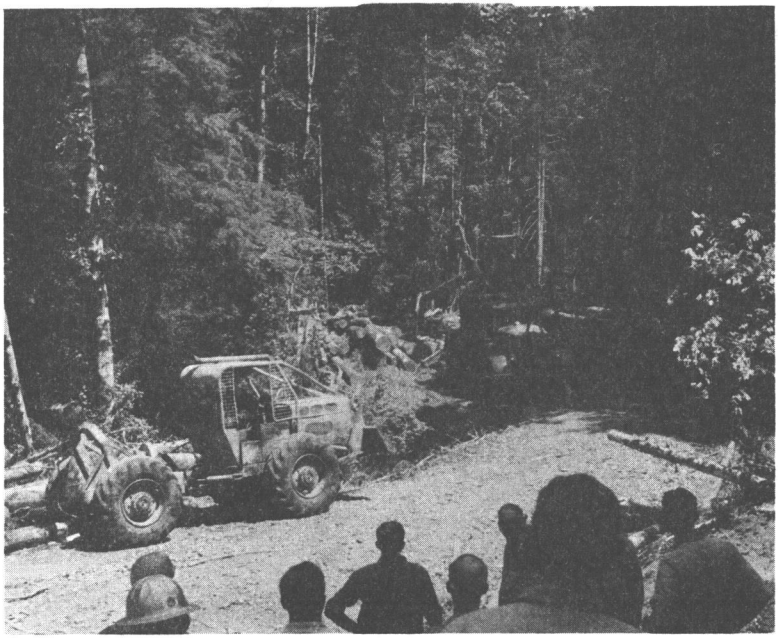

Figure 3. Skidder and truck at the landing. The first thinning in a 50-year-old stand of Douglas-fir.

Seymour. No. I'm sorry, I can't tell you that.

Audience. How large a crew do you have working here?

Seymour. Well, Pee-Wee owns four skidders and leases one. They have a cat that they use as a supplement to the skidders. They also have a loader. They don't necessarily all work in this particular area. Sometimes I have five here and sometimes only one or two of them. There are two partners, five loggers, and four fallers–eleven men altogether.

Audience. Who does the trucking?

Seymour. We do.

Audience. Who loads?

Seymour. The operator loads.

Audience. Do skidder operators set their own chokers?

Seymour. The operators set their own chokers.

Audience. What's their production?

Seymour. About 8,000 to 12,000 board feet per skidder per day.

Audience. How much of an area do you give the operators at one time?

Seymour. All trees are marked for cutting. I don't mark to satisfy the loggers specifically, but to improve the stand. I also, of course, mark all the dead and dying trees. There is considerable snow breakage here; I think we have more defect than Berg does on the research area.

Audience. Do they know they are going to have, say, 10 million feet to work on here?

Seymour. Oh, yes, we tell them at the beginning of the year. We work on a budget. This year on this area we will cut 4 million feet. On the Santiam Unit near Mill City, there is either a million or a million and a half feet and the loggers will be there in another week or so. They know at the beginning of the year how much they are going to cut for that year.

Audience. Who do you sell to?

Seymour. The poles and piling all go to Sheridan. The logs are hauled to about five different mills. No single mill seems to be able to handle all the production.

Audience. How long has the operator been here now?

Seymour. He started in 1967.

Audience. Do you think he is competent to mark?

Seymour. No. We tried that, and they weren't happy with us at all. They did a fair job for the small area and they were really trying to do a good job. The cutter said, "If I have to go out there and pick my own, I want about $4.00 more a thousand for cutting the damn trees." I can mark it for less than that myself.

Audience. What percentage of your time is occupied in actual marking?

Seymour. Probably about 50 percent of my time.

Audience. Do you think there is an advantage in having a faller see what his pattern should be?

Seymour. Yes.

Audience. Even though we locate the skidroad by hanging ribbon, it is difficult for a faller to imagine that this is the skidroad.

Seymour. We must watch the fallers. We have two fallers, one working on each side of the road. Part of the damage on the left is due to poor felling. I complained to the logger about it. Apparently he has been talking to his fallers in the last day or two. On the other side, every log is lying right. There is very little tree damage and the skidder will have a much easier time getting the logs out. No comparison between the two fallers. Although they are both good fallers, the one on the left was in too much of a hurry.

Audience. Did you build the cat road before or after the timber was down?

Seymour. We cut the timber, then built the cat road.

Audience. The right-of-way was felled?

Seymour. Yes.

Audience. Then the road was in when the cutters felled the timber?

Seymour. Right–they knew the exact direction to fell. One faller had 90 percent of the trees felled to lead. The other had trees in every direction. This slows down production, and the logger does not hesitate to criticize the faller on this score.

An area thinned in winter of 1967-1968 with rubber-tired, four-wheel drive skidders.

Seymour. This stand was thinned in the fall, winter, and spring of 1967-1968 (Figure 4). I don't have much information on it, but we removed about 30 percent of the basal area. Last fall, I think it was, we removed 200 special poles requested by a pole buyer. We found poles of the right size to fit the order. It's difficult to tell where the poles were removed. The stand now has 164 square feet of basal area. Net Scribner volume residual was 31,000 board feet. Average diameter was 13.2 inches. The information is from permanent plots that should be fairly representative of the stand. Now this was a real heavy stand with about 42,000 board feet Scribner per acre. I think we took about 11,000 board feet per acre out of here.

Audience. How old is this stand?

Seymour. Forty-six years. It is a site II.

Audience. What was the minimum top diameter?

Figure 4. Appearance of the stand and skid road one year after thinning.

Seymour. A 6-inch top. We use tarif tables to determine volume. It saves us time. Now on the right-of-way, we checked the tarif tables and had to reduce the volume about 6 percent on practically everything we cut.

Audience. The tarif tables were high?

Seymour. Yes. We had to subtract 6 percent from the tarif tables to get volume.

I don't want to spend too much time here. I want to show you an area we tried to log in winter weather, especially the mainline cat trail. It was dug up pretty badly in places. I think we must pretrail thinning areas and allow them to settle for a season before using them, to prevent this damage.

Audience. Why would pretrailing prevent this?

Seymour. The removal of stumps and roots creates holes and soft spots that must be allowed to settle and firm up.

Audience. How long would you let it settle?

Seymour. I'd let it settle for a year anyway.

Audience. I agree. I just wanted to know your reason.

Seymour. I believe roads should be built in the summer for logging the next summer or the following winter. You would not tear up the ground nearly as bad. I'm talking here about the main skidroad. Loggers tend to use one certain cat road going in and out and that's the one they tear up so badly. On the areas adjacent to the skidroad, it is difficult to see where the cat tracks were. This cat road is in better shape than normal. But you can see dips and bumps. We did get some root damage on the trees along the road. How this will affect the tree, I don't know. I think it's bad. Every time the equipment goes over a stump a hole is created–especially in winter logging. A root will do the same.

Audience. Who laid the road out?

Seymour. The logger. He picked his own route.

Audience. Would you continue to let the logger choose his location?

Seymour. No. If we accept the preroading idea, then I will locate the skidroads.

Audience. Is it necessary to have as large a landing as this?

Seymour. No. I was carried away on that one. We have no other landing here that large.

Audience. The logger would like that.

Seymour. Oh, yes, he'd like it fine. The logger did have a lot of logs to take care of at one time on this landing, but, ordinarily, I make a landing smaller than this.

Audience. Do you sort logs on the landing?

Seymour. Yes. The hardwoods must be sorted, for instance. Quite often we sort the hemlock from the Douglas-fir. For a while, we were sorting the larger Douglas-fir from the smaller fir. Then, of course, we must sort poles and piling. Poles from 80 to 110 feet in length, such as the ones from these stands, take a lot of landing space.

Audience. Are you using any front-end loaders?

Seymour. We haven't tried them.

Audience. If you would continue your road, what would be your primary concentration point in layout? The straightness and, of course, the general coverage of the area you have planned for that road?

Seymour. Right. I'd put in more than one road to a landing though. For this landing, I'd put in two or three main roads at least. This particular landing takes care of a large area here—about 100 acres.

Audience. What was your average skidding distance?

Seymour. The average skid was about 700 or 800 feet. The longest skid was about 1,500 feet to reach a corner.

Audience. Do you feel that the layout of your truck roads is adequate?

Seymour. Yes, but we have more road to construct. We have less than half the roads that we need at Black Rock.

Audience. Would you suggest minimizing the skidding distance? Reducing the 1,500 feet skid, for instance?

Seymour. No. Most of our yarding is less than 1,000 feet. We yard up to 1,500 feet only to remove a few trees in a finger or a long corner.

Audience. Lyle, do you divide your area into winter and summer shows with winter logging along gravel roads and summer logging on dirt spurs? You can put in a dirt spur for but little more than a skidroad. Then yarding costs are reduced considerably because the skidding distances are reduced to, say, around 600 feet rather than 1,500. Over the seasons, can you cover more acres that way?

Seymour. Yes, that's right. But each dirt spur requires a landing. Most of our landings are large enough to handle poles

and piling. The longest time for a turn was about 17 minutes. The turns average about 11 or 12 minutes. I believe that for this area, the landing is adequate. Occasionally, the logger must reach out more than 1,000 feet to reach areas to which it would not pay to run a road. Most of the area can be reached from this landing with less than 1,000 feet skidding distance.

Audience. We had the same experience. In general, the emphasis has been on the yarding distance, but the logger wants a better landing and would prefer to skid further to get a better landing set-up. Of course we have many sorts, more than you do here, but we don't have piling. The trucker needs a place to turn around and a big loader needs a place to set up, and, by the time a landing is built for all that, it's quite large. I think that 100 acres are needed to serve one landing. I am delighted with this and the loggers are happy.

Seymour. The first logger had self-loading trucks, but he couldn't find them when he wanted to haul. He didn't have one of his own. Then the company decided to haul by regular logging trucks.

Audience. Are self-loading trucks popular?

Seymour. Very popular in this area. That's the trouble. In the summertime, every small logger wants one of those trucks to get his little dab of logs. The self loaders are so busy they can't serve everybody. They're very hard to get ahold of here.

Audience. Is this a company loader?

Seymour. No, it belongs to Pee Wee Logging Company.

Audience. With a self loader, though, you're hauling the loader back and forth and cutting your pay load.

Seymour. A self loader is also limited in the length of log they can handle. With long logs, the self loader has a lot of trouble.

Audience. Are you selling any of this by weight?

Seymour. We do sell by weight at Seaside but not here.

Audience. How many more thinnings will you make?

Seymour. I anticipate making two and maybe three. I wouldn't say for sure on that. We haven't developed our full program yet. We're feeling our way.

Audience. How about spacing on this main skidroad here?

Seymour. Oh, I try to put them about 300 feet apart at the end, if I can. Between 200 and 300 feet depending on the topography.

Audience. What was your log size?

Seymour. The average log size for the low elevations of Black Rock is between 90 and 110 board feet. At high elevations, the log size drops to about 75 or 80 board feet.

Audience. Have you used cubic foot scale?

Seymour. We discussed it, but so far we haven't used it. Part of the reason is that our accounting system is set up for board feet.

Audience. What do you think about preroading under contract?

Seymour. Until a short time ago, the logger had nothing to preroad with except small skidders. I think it's practical if the loggers have a cat. After 2 years, the loggers decided that they can't get along without a cat.

Audience. So you'd actually want to put a main skidroad in with a large cat—perhaps a D7?

Seymour. Perhaps a D6.

Two distinct areas, a steep area, thinned by cable logging with a Skagit SJ-4; and, a gentle area, thinned with rubber-tired, four-wheel drive skidders.

Seymour. The area to our left was thinned with a rubber-tired skidder; the area to our right—out on the ridge—was high-leaded with a Skagit SJ-4 (Figure 5). We high-leaded a distance of 600 feet, along the draw below us. The average production per day was only about 8,000 board feet for the Skagit. There was some damage off that ridge from the main line. We weren't too happy with the situation at all.

Audience. How many logs per day?

Seymour. 160 to 200 logs per day.

Audience. How many men on the side?

Seymour. One chokersetter, who sometimes had a helper, and the Skagit operator. They also had a rubber-tired skidder to pull the logs away from the Skagit to a landing or to a wide spot

on top of the hill along the road. So they used a basic three-man crew.

Audience. Who chose the landing?

Seymour. The operator. Either the skidder operator or the Skagit operator unhooked the log depending upon who was available. Generally the skidder operator would be there, but he

Figure 5. This stand was recently logged by a cable system.

didn't have much time to fool around. In his spare time, he would reach down 100 feet or so off the road and grab any close logs.

Audience. Any poles out of here?

Seymour. Yes, we took poles out of here. They weren't as long as those at the lower elevation. This is shorter timber. It is site index 160 and 150.

Audience. How many board feet per day of this type timber on this topography can a good faller put down?

Seymour. The faller said that, last year, he averaged 10 thousand board feet per man per day overall, which would include the flat and steep ground, the better timber down below, the not-quite-as-good timber here, and some very bad timber on top of Fanno Ridge. Some of the cutting on the ridge was really small, with about one 32-foot log per tree. A 40-foot log per tree was about the longest. Even so, he averaged 10 thousand board feet overall per man per day cutting and bucking—this includes both poles and logs.

Audience. They are paid by the thousand?

Seymour. They are paid by the thousand, yes.

Audience. Generally are the logs long?

Seymour. Yes. We cut around 40, 42, 44 feet as a rule. Or I should say 26 to 40 feet. We use long-log logging trucks.

The plots showed that the high-lead show removed 45 percent of the basal area. I don't believe that the entire high-lead area was marked quite that heavily, although I did intend to mark more heavily than for the area logged by rubber-tired skidders. We discussed various ways of laying out the high-lead show and whether to make corridors or to mark a little more heavily and see how logs came out that way. The Skagit burned up before we had time to try out all our ideas. In this show, we didn't make corridors as such. If a tree interfered with logging, the operator had authority to remove it. I believe the area, as a whole, was marked to remove about 40 percent of the basal area. We still have 138 square feet of basal area per acre in this area according to the plot data, and 225 square feet of basal area in the other area. And that was marked to remove 34 percent of basal area.

Audience. Lyle, will you thin the high-lead area again or clearcut the next time around?

Seymour. I'd like to thin once more before we clearcut. But we are not sure.

Audience. I would think you would.

Seymour. I think we will, but not in 5 years. I'd say 8 to 10 years, because of the heavier cut this time.

Audience. You didn't mean 200 square feet did you?

Seymour. Yes.

Audience. That seems like an awful lot of basal area for this place.

Seymour. On a fifth-acre plot we had 30 square feet of basal area left.

Audience. That's 150 square feet.

Seymour. 150, that's right.

Audience. That looks a little better.

Seymour. Right. This particular area was marked by a student from Oregon State who worked for us.

Audience. What was the average volume removed per day?

Seymour. About 8 to 9 thousand board feet on an 8-hour basis.

Audience. This is about two loads?

Seymour. Roughly two loads. The stumpage price was calculated for 12 thousand board feet per day, so the logger didn't come out as well as he should have. Part of that was because of a breakdown. The Skagit had a gasoline engine that didn't work too well. Also, the logger was always moving something–either the line or the machine. We are considering a tower now. I don't know how we'll come out with it. The tower is so expensive, but even so it might be better than the Skagit.

Audience. Did they yard through the boom?

Seymour. Right. And then they turned the boom sideways. We experimented with the felling here and finally decided that straight up or down the hill was best. The fallers tried cornering the tree while they were felling, but they had considerable trouble.

Audience. Did you side-block any?

Seymour. No.

Audience. Do you fell snags?

Seymour. From now on we will. Not because of fire, but for safety.

Audience. This close to the road? You don't have to fell?

Seymour. Not for fire but for safety.

Audience. What did you say the daily production was on the high-lead?

Seymour. It was about 8 to 9 thousand board feet per day for a three- to four-man crew.

Audience. Did you use the SJ-4?

Seymour. Yes.

Audience. Did you load with the same machine?

Seymour. No, we had a Bantam loader here at that time.

Audience. Have you thought of starting your thinning later in the season so that the bark could stiffen up a little bit?

Seymour. Well, when we first started thinning, I told the logging boss that we should stop in the spring. He said, "No, we need the logs."

Audience. I was curious, because it looks like the logging below resulted in only slight barking compared to this.

Seymour. Well, that was done in the winter time. You can see very little damage compared to what is here. Really, even though it is late in the summer, the bark is still loose where we're working right now. It makes a difference. But I still have to consider the cutting budget and an even flow of logs. So we have to live with the damage. We'll see. We haven't any measure of damage effects yet.

Audience. It looks to me as though you could have clearcut some of the alder patches in the spring and then start felling for thinning now. Then the bark would be tight by the time yarding started, and you'd be in good shape.

Audience. Do you have much snow up here?

Seymour. We were out of here by the time snow came. We got out in early October. There was a lot of snow this year, about 2 to 3 feet of snow. Last year, there were 5 to 7 feet in here.

Audience. What was the volume per acre?

Seymour. We took out about 8 thousand board feet and a lot of stems. The original volume per acre was about 23,000 board feet.

Audience. There's less soil disturbance and less tree damage than with track-laying equipment.

Seymour. I like the high-lead for that reason, if you can get an efficient one. I don't think the ground lead is economically efficient. Of course, they had never logged with one before. So maybe they could become more efficient–I don't know. It looked to me like some type of a carriage system that could run, stop, and hold would have been more efficient. But I'm an amateur at this too. We discussed all types of systems.

Audience. What was your cost compared to tractor yarding?

Seymour. About $7 more per thousand.

BANQUET DISCUSSION

Alan B. Berg, *Moderator*

Alan Berg. Gentlemen, I'm sorry that we did not get back to the marking problem, but the breakdown of the bus prevented that. It is difficult to discuss marking except in a very general way without being in the forest. I had hoped we would be able to discuss reasons for marking or not marking individual trees at the plots. I am sure the discussion would have been spirited and enlightening. I thought there would be at least several trees that no one marked and several trees that everyone marked—with a broad range in between, in which perhaps part of the group would have marked a tree and the other part wouldn't have marked it. At least I do have preliminary results of the marking. I can report that every tree on both plots was marked by someone!

The exercise did point out, however, that there are many ways to mark a stand. We will, of course, tabulate the data so that you can compare your marking with the average and with others.

I would like to talk to you for a moment about the Black Rock area. You can study the data in your notebooks at your leisure. The Black Rock unit is 500 acres and a part of the 1,000-acre, George T. Gerlinger Experimental Forest of 55-year-old Douglas-fir, owned by the State Forestry Department. The School of Forestry has an agreement with the State to conduct research on this 500 acres.

We have more than 60 plots at Black Rock. The basic schedule consists of four replications of 4 treatments; no thinning (control), maintaining a level of basal area between 160 and 190 square feet, between 130 and 160 square feet, and between 100 and 130 square feet. Various other treatments are corollary to these treatments.

Each 1-acre plot is divided into ¼ acres, so that the proper distribution of growing stock can be assigned more evenly on each plot.

When we first started management in 1953, little thinning had been done in Douglas-fir in the Pacific Northwest. Information from Denmark indicated that somewhere between 130 and 160 square feet of basal area per acre was a good level of growing stock to maintain. For instance, over a period of some 60 years the Danes had maintained a Douglas-fir stand (site III) between 130 and 160 square feet of basal area. Production from the schedule was the equivalent of that from an unmanaged stand of site I in the Pacific Northwest. So this was a thinning schedule we tried—to maintain a stand of between 130 and 160 square feet of basal area. Of course, we realized that the Danes had started management when the trees were about 15 years old, and our stands were 40 years old—therefore the reaction of the stands would be quite different. We found one area in Black Rock that did have a basal area of 160 square feet per acre. In a natural Douglas-fir stand of that age and basal area, however, the trees are clumped, which affects response. Another stand that had about 200 square feet of basal area was also reduced to 130 square feet in one thinning. During windstorms the first winter, I didn't sleep at night, and the next morning I would hurry to Black Rock to see what had happened to the stand. Nothing had—there was no blowdown.

We also tried a field-choice system, which allowed the marker to decide in the field which trees and how many and when they should be removed in thinning. With this system, we found that we were reducing the stands to between 150 and 180 square feet of basal area. The response from these two schedules was satisfactory, so we decided to bracket these schedules by keeping more than 160 square feet on some plots and reducing others to 100 square feet. In addition, we reduced a plot to 100 crop trees per acre. We thought we had finally reduced a stand to the point that loss in growth would be serious. Some foresters thought we would lose the stand by windthrow. Neither loss occurred. So we reduced another plot to 75 square feet of basal area and 52 trees per acre. This is plot 31. The 52 trees were to be final crop trees. After logging, the plot was underplanted with western hemlock. We reasoned that

by the time the Douglas-fir crop trees were 90 years old the hemlock would be 45 years old. During this time the hemlock will have been thinned several times.

We wanted to test the underplanting with hemlock for three reasons. First, the total production of the forest might be increased. Second, a pulp company could convert a Douglas-fir forest to a hemlock forest and still maintain the best Douglas-fir trees over the rotation period. And third, *Poria weirii* is a problem in the stands at Black Rock, as it is all over the Northwest. Hemlock, although attacked by *Poria weirii*, is not as seriously infected as is Douglas-fir. The spread of *Poria* might be reduced in a stand composed of two species. Both the Douglas-fir and the hemlock are now growing rapidly. A reduction in growth of the Douglas-fir did occur for the first 2 years, but now the growth with only 52 trees per acre is equal to that of the natural stands.

We believe now that adequate growth can be maintained with few trees per acre. For instance, stands can be reduced to 100 square feet of basal area or less and still maintain growth. The level of growing stock maintained, and therefore, the kind of marking performed, will depend upon the desires and the needs of the landowners. A company that needs wood for its pulp mill is interested in growing the maximum amount of wood in terms of cubic foot volume. Another company, because they purchase large quantities of sawlogs at a reasonable stumpage for their sawmill, is interested in the yield, in the percentage of growth, that their forest land is earning. Public agencies of course will mark in a different way than a private company, as they have different objectives in management. Each will mark for thinning in a different way, leaving different size classes and numbers of trees at each cutting. So it is very difficult, I think, to discuss marking without stating the objectives of management.

I invite any of you who would like to visit Black Rock to contact me. I am very willing to show you what we have done, or to give you any data or information we have on this area.

Now you are all relaxed, I hope, and have many questions. So far, in this course, we have talked about inventory of the

stand, about some of the economic problems and about some of the operational aspects. We'll see more operations tomorrow when we visit Crown Zellerbach at Seaside. Now I hope you'll ask questions and make comments.

Audience. Alan, before you go any further, would you comment on the release that can be expected after thinning in a 55- to 60-year old stand. Comments today indicated that some foresters do not believe that trees will respond to release at this age.

Berg. I'm certain that a stand of that age will respond to thinning. I don't think there's any question about that. I have seen stands as old as 90 years that have responded to thinning. I think that response at age 80 or 90 years depends on the kind of stand that you have. If the stand is relatively open, with good crowns, which indicate good root systems, they will respond to thinning. If the stand is dense, and the crown structure is poor, the stand will not respond as we might think that it would. But a 45- to 55-year old stand is not past the age at which it will respond to thinning.

Because of stand age, there are two general aspects to young-growth management in the Pacific Northwest. First, a large area of forest in the Pacific Northwest is within the age span of 35 to 80 years. These stands, because they developed naturally over a long period of time, must be treated in a certain way. They have been molded by nature, and what we do to these stands is controlled to a large extent by what nature has done to them in the past. This is a situation all of us face because these stands do exist. This is the problem that we, as researchers, are trying to solve at Black Rock.

Second, large areas of Douglas-fir 25 years old or less now exist in the region. Management of these stands will be different from older stands. The level-of-growing-stock and other studies are trying to answer this problem. The solutions to management problems in stands of age 40 years are different than in stands of age 15 years.

Audience. I'm Morey Boles from the Department of Natural Resources, State of Washington. I enjoyed the field trip very much today. Especially, I was intrigued with the high-lead

thinnings shown by Lyle Seymour. The State of Washington is embarking upon a sizable program of high-lead thinnings. Lyle, how many acres of high-lead thinning do you plan? How has the program progressed so far? What are some of the problems?

Lyle Seymour. I estimate about 3,800 thinnable acres in the Black Rock area. About 65 or 70 percent of that is ground of the high-lead type. The contract logger that you saw yarding with the rubber-tired tractor completed the high-lead thinning in the fall of last year. He used a ground-lead Skagit. Unfortunately, during the winter, the Skagit burned and our high-lead thinning program stopped. The operator wasn't completely satisfied with the Skagit—mostly with the rigging. He damaged the main line on the ground-lead. I don't remember his costs for replacing main lines and haul-back lines, but it was high. Also, he estimated that he could get between 11,000 and 12,000 board feet per day. From our time studies, his actual production was between 8,000 and 8,500 board feet per day. The difference came from breakdowns and from numerous moves of either his ground-lead rigging or the machine itself. It required about 20 minutes to move a block and make a new road. It required about 45 to 50 minutes to move the machine. He moved the machine about every other day and his roads about 2 or 3 times a day. Now, the operator wants to try some type of tower system with a carriage that can pull sideways a certain distance to cover more area from each yarding road. But tower systems are expensive; a small one will cost $60,000. We must determine if we can afford to pay him what he thinks he needs for it. So our cable thinning is temporarily halted.

We passed another small area of high-lead thinning where the slope was across the logger's roads. The damage here was considerably more than the area we saw where logging was straight up and down the hill. So I might caution you to watch for side slopes. Every log yarded across the hill seemed to want to run downhill and damage a tree. I had adverse comments from the Timber Manager about that particular small area. The damage was considerably higher. With the type of machinery we had, logging downhill with ground lead maintains less control of the log than a system with a carriage.

In regard to corridors, we decided to mark a shade heavier and give the logger the option of cutting out an occasional tree along his main-line yarding road. It was satisfactory. So we have not developed corridors, but we plan to try corridor logging with strips 10 to 15 feet wide and compare that with what we did last fall.

Berg. I might ask John O'Leary if he has any comments on high-lead or steep ground logging?

John O'Leary. In the past year, I've observed six cable operations that have been financially successful. Of the six, only two used the common high-lead. Two used the running skyline concept, the others had some variation of the common slackline skyline. Marvin Rowley, for example, has a slackline operation. I think the key to success is men that want to do this kind of work. A choker setter behind a cat, transferred to a cable side, will not necessarily perform efficiently. Also, yarding distance must be short–not over 500 or 600 feet. Any distance beyond that is inefficient. A concave slope is desirable. The greatest promise is probably some form of the skyline with a carriage. The big stumbling block here is lack of an effective stopping device on the carriage so the carriage doesn't run uphill when side blocking. The only good way is to put a haulback on the carriage. This, of course, adds another drum on the donkey, and the cost goes up. But there are carriages now, actually made in the last 6 months, that have a good device to hold the carriage to the skyline for side blocking. But the right operators, the right kind of slope, and yarding distances less than 600 feet are the most important factors.

Audience. John, will short yarding distance increase road costs prohibitively?

O'Leary. If you cannot afford road costs you cannot afford to thin.

Seymour. Incidentally, the maximum yarding distance on the Boise-Cascade area visited this afternoon was 600 feet.

Audience. Who constructed the roads, Boise-Cascade or the operator?

Seymour. Boise-Cascade built all the roads for the operator.

Audience. How many acres were in the setting?

Seymour. About 32 acres were high-leaded.

Audience. How can you avoid damage from rolling and sliding logs in the skyline system?

O'Leary. I don't think that you can avoid damage entirely. It's a matter of trying to keep it down. I think probably one of the best ways to avoid damage is to maneuver the log in from the side, not at a full 90-degree angle. Bring logs into the skyline road in a herringbone fashion. Pull the skyline as tight as you can, so that you are pulling up on the log, and the front end of the log has some lift to it. This way, you are not dragging the whole log across a residual tree. If you get part of the log above the ground and bring it in at about a 30-degree angle, you cut down damage quite a bit. If you are going to thin again in another 5 years, you can remove trees then that have been damaged. If you are not coming back a second time, the choker setter should carry a power saw with him, cut the damaged tree, and remove it.

Audience. What do you think about tree-length logging?

O'Leary. You can't turn tree-length logs. In any skyline thinning system, you frequently must turn the log. If the log has any length at all, you will have trouble when you try to turn it. If the tree-length log is large, you must have a large skyline system. Anything over a ½-inch line, say ¾ or 7/8, you can't pull out by hand—at least it's difficult to pull out by hand. Then you must string hay wire, and once you start stringing hay wire, the logging costs go up excessively. With a ½-inch line and a strong man like Mike, you could put the line on his shoulder and kick him down the hill! With a line larger than that, you are going to run into time on a steep sidehill, and it's going to cost you money.

Audience. John, Weyerhaeuser is currently operating two sides with two Skagits, using a skyline with a carriage. They find their optimum distance is about 800 feet and they will go out 1,400 feet.

O'Leary. What age timber?

Audience. Douglas-fir, 50 to 55 years old. They cut 20-foot corridors every 150 feet and then fell the trees toward

these corridors. The machine completes about 1 1/3 corridors per day. The damage is light. Their biggest problems are breakdowns and the labor situation. But they are satisifed with this system. They get about five loads or 25,000 board feet per day, average.

O'Leary. Again, this is not the common high lead. This is a form of skyline. The donkey has three drums, and with three drums the equipment will cost between 60 and 80 thousand dollars.

Audience. Is this 25,000 board feet for the two machines?

Audience. No. This is per machine. The average load contains 14 trees.

Audience. How many loads with a skidder? Four loads?

Audience. With the average skidder about three loads per day.

Audience. In tractor logging, as a comparison, how many loads would two rubber-tired skidders yard in 8 hours?

Seymour. In the type of timber you saw today, the operators were averaging about 11 to 12 thousand board feet per skidder. Over the whole operation last year, they averaged about 9 thousand board feet, including good and bad timber. But in the type of timber we kept time records on, they removed 11 to 12 thousand feet per skidder per 8-hour day.

Audience. The skidders are worth about $30,000 apiece?

Seymour. No, about $20,000.

Audience. You were yarding about four loads a day with $40,000 worth of skidders?

Seymour. Yes.

Audience. This is the point. You should consider the merits of the cable system against the rubber-tired system. You shouldn't arbitrarily use a yarder on steep ground and a tractor on gentle ground. You should not cat log ground that you don't want to tear up.

Audience. But 90 percent of young-growth stands are on steep ground and you can't use a tractor.

Audience. Possibly you can get more production from so-called tractor ground with a yarder system than with tractors. Better take a look at this.

Audience. Using a yarder in place of a tractor?

Audience. Right. You should seriously consider it.

O'Leary. I doubt that.

Audience. We have a different situation in our type of mobile high-lead logging. We move along the road with a track vehicle, a $95,000 machine. We skid perpendicular to the road at all times and the operator uses the trees near the road as rub trees. He fells from the bottom of the slope up, with the trees falling up hill, and then skids tree-length. The choker setter is not always climbing through the debris that would be on the ground if we felled the trees nearest the road first. It's a high-lead show. The skidder has a 50-foot boom. The operator puts the boom down over the slope and skids tree-length. When he gets the tree up near the road, he can lift it completely off the ground. He swings the logs across the road and quickly lays them in the ditch. He has drums that have 700 feet of line on them, but beyond 500 feet, the cost goes up. This logging is as cheap for us as cat logging.

Audience. How critical do you consider stump height on a thinning operation as far as subsequent logging is concerned?

Seymour. It is very critical for both yarding and felling. and felling.

Audience. I noticed that most stumps were quite low on your operation, but what do you use for a guide line?

Seymour. As low as possible to the ground. The fallers kneel to fell. With tractor logging, the stumps must be low enough so the tractors can straddle them, which means a maximum of 9 to 12 inches in height. We prefer stumps 6 to 10 inches in height. We had trouble when we first started because the fallers didn't want to bend that far down. It didn't take long to convince the skidder operators that the stumps had to be down where they could climb over them or straddle them. The fallers conformed and didn't argue too much.

Audience. Cal, what do you do about stump heights at Shelton? Are they low there?

Cal Poe. Well, I'd say a maximum height of 18 inches and try to keep them below 12 inches. A good part of the volume of a tree is in the stump so the stump height should be as low as possible to get this value.

Berg. I see fallers cut a low stump–for instance 6 inches–and then long butt the log. This has always bothered me.

Audience. The faller doesn't know whether he must long butt until he gets the tree down. He might have to long butt it if he is cutting for piling. I think this is right, yes.

Audience. Isn't an 8- or 12-inch stump unrealistic in a contract?

Berg. I personally think that a 6-inch stump is not unrealistic now. With the modern saw, the faller can get right on the ground with the blade. Most fallers I've seen working do kneel when they are felling.

Audience. Don't try to make a young-growth logger out of an old-growth logger. Start with a young, inexperienced man, and teach him. He will do a good job, and you will get 6-inch and even 4-inch stumps.

Berg. That has been our experience also. It is difficult, if not impossible, to bring an old-growth logger into a young-growth stand and make a young-growth logger out of him. His thinking is set. But if you can find a young man without experience, talk to him about what you are trying to do in your forest, and get him interested, you will have a good worker. I have felt for some time that perhaps the operator in the woods should be a professional man. Schools of forestry–for instance, our logging engineering department–should be training professional men for this job. I think this would solve many of our problems–marking as well as operating problems.

Seymour. It's wrong to say that an old-growth logger can't learn to log second growth. They aren't stupid.

Berg. The old-growth loggers we have tried to work with have not produced.

Seymour. Who worked with them?

Berg. I did–and my logger. For instance, we have trained college students, who have never been in the woods before, to use a power saw in felling for thinning. In a week, they were doing a creditable job. We have trained them in skidding–even to skid with horses–men who have never worked a horse

before. Within a week they were performing satisfactorily. This is the same with rubber-tired skidders.

Audience. Can they talk to the horse the same way as the old-timer did?

Berg. A young man interested in the management of young growth, who understands what you as a forester are trying to accomplish, can learn rapidly to operate a power saw, or to skid with a tractor or a horse. Yes, he can talk to the horse as well, if not better, than the old-timer.

Seymour. To leave high stumps is not only critical from the standpoint of the present operation, but I think also for future operations, particularly if you are trying to grow poles or good veneer logs. A tree felled on a high stump might destroy a $200 pole. Low stumps now will save future timber.

Audience. I seem to remember Don Malmberg making a statement about a 20-percent breakage loss in piling in the final cut of a stand that had been thinned several times.

Audience. A 20-percent loss in piling or a 20 percent loss in volume?

Audience. I don't know. If the 20-percent loss was in volume, that's serious: if the loss was in piling, that's terrible!

Audience. There have been questions and comments on the comparison of tractor and cable systems. Does anyone here believe that it will be necessary, from a silvicultural point of view—with such considerations as soil problems, root damage, and windthrow—to yard with a cable system in some stands, such as hemlock and other shallow-rooted stands? Even on so-called tractor ground?

Audience. In the future, won't flat ground be logged with a tractor and grapple? I think this equipment will reduce cost.

O'Leary. I had a sad experience with the grapple last year. For 2 weeks, I studied an operation with a Huff S7 with chokers and the same machine with the same operator on the same stand but with a grapple attached. I was to demonstrate that the grapple was more efficient than chokers, but, with the chokers, production improved by 30 to 40 percent! This test was on ground quite similar to what we saw today. It also was

quite brushy. We needed a plumber with the grapple to keep the hoses hooked up. It sprayed the whole country with fluid before we finished.

Audience. John, has a loader for small logs, say a maximum of 8 inches in diameter, been developed to load a log truck in 15 to 20 minutes without building a landing the size of an airport?

O'Leary. A self-loading truck would do it.

Audience. Not in 15 to 20 minutes.

O'Leary. Yes, it will.

Berg. For a moment, let's get back to the question that Mitchell asked. I think it is important. He is concerned about the spread of rot by the use of tractors. Perhaps a high-lead system would slow the spread or stop it. Does anybody have any comments? Pathologists are quite concerned about the spread of pathogens through the forest with skidders. Is a high-lead system going to stop or slow the spread?

Audience. From my observations, the damage from cable systems is less than that from tractors.

Mike Newton. A comment in connection with this problem. The stumps left in thinning offer a large infection court for *Fomes annosus*. The infection will spread to living trees in the residual stand through root grafts. If you are doing nothing to pretreat the tree or to treat the stump at the time of cutting, you are leaving the stand wide open to *Fomes annosus* infection regardless of the logging method.

Audience. In the hemlock stands we're thinning, we are treating the stumps–but to treat every root and butt area damaged by tractor wheels becomes an impossibility.

Audience. When you add $10 or $15 a thousand to logging costs, and try to sell those costs to the general manager, you had better have a well-documented case for doing so. If you don't, I know what the general manager will tell you. They must talk to the stockholders and tell them why they didn't get a dividend last year.

Audience. Has anyone actually tried high-lead thinning on cat ground?

Audience. I'm not an engineer, but I can't see stretching cable very far on perfectly flat ground. I don't think it could be much more than 400 feet.

Berg. I think we have three old-growth loggers trying to subvert this short course.

Audience. Darrell Schroeder has a point. If you can produce enough volume on tough ground with a high-lead machine to make a profit, you should produce more volume and a greater profit on gentle ground. You will obviously need lighter rigging. A high-lead system does not necessarily produce more volume on gentle ground than steep ground.

Audience. Let me add to this. Historically, since the advent of the tractor, we have said this ground will be logged by tractor and this ground will be logged by cable. Regardless of whether you are clearcutting old growth or second growth or thinning, the application of cable-logging system can be more economical than the tractor. You must consider the investment, the number of men and other factors. Weigh all these factors and then look at it again.

Berg. One comment. I'm willing to stay here until 6:00 a.m. At 6:00 a.m. I'm leaving for Seaside. It is now a quarter to 10 and it will be at least 10:00 by the time we get to bed; if you want to continue to talk, fine; if you think this is the time to break it off, let's stop. All right, meeting adjourned.

Northwest Timber Operation
Clatsop Division
CROWN ZELLERBACH CORPORATION
Seaside, Oregon

Hosts
Donald Malmberg,
Director of Research and Development
Gerald Outslay, Research Forester
Karl Foeste, Research Forester

PRECOMMERCIAL THINNING IN WESTERN HEMLOCK VOLLMER CREEK

The 40-acre stand was first thinned in 1961 at 15 years of age.

Donald Malmberg. Glad to see you're on time. We estimated you would arrive a little later. We think we have a good show planned for you today, if you can bear with just a little bit of dust. I understand Boise-Cascade entertained you yesterday, so you are broken in already. What you are going to see at this stop is 40 acres of young-growth hemlock (Figure 1). We will walk up the road about 700 feet, turn right into the stand, and go up a cat road. On the left will be the unthinned stand (Table 1). We won't stop, but just take an easy walk right on through. We have one stop planned where we'll discuss what we did, how we did it, and how we measured it. The debris along the road is the result of the last logging of this small forest. When we start from here, please, if you'll just turn your smoking light off we will be grateful. We'll walk to the area thinned annually (Table 1). It's a narrow foot path and most of it is single file until we get up onto the cat road and then it's double file. Let's go.

Audience. You have thinned here eight times?

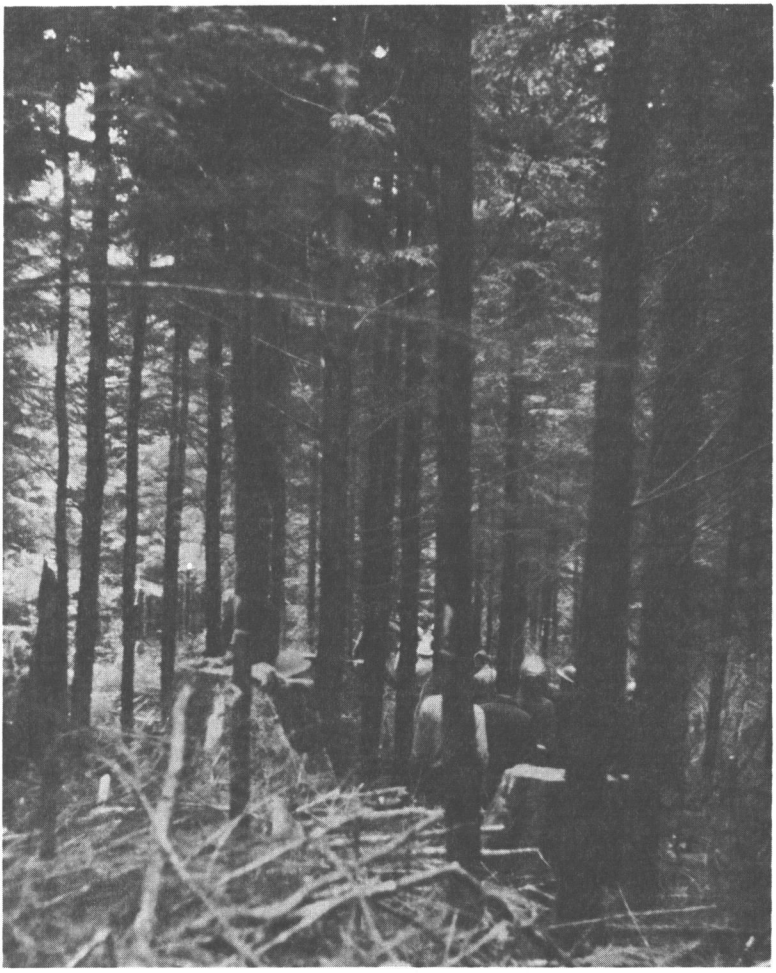

Figure 1. A hemlock stand at Vollmer Creek, thinned in 1961 at age 15 years, Crown Zellerbach Corporation, Seaside, Oregon. A commercial thinning will be made in 1971 at age 25.

Malmberg. Yes. This is an example of the annual thinning regime proposed by Fleming Juncker. It sure grows fast! And we harvest only the larger trees.

Audience. How large is this area?

Malmberg. 40 acres in this thinning experiment.

Table 1. Stand Statistics per Acre in Precommercial Thinnings on Vollmer Creek Compared for Two Years.

Item measures	Thinning treatments							
	None		One		Two[1]		Eight	
	1961	1966	1961	1967	1961	1966	1961	1968
BEFORE THINNING								
Trees	6,190	4,190	5,940	316	5,550	674	6,350	760
Basal area, *sq ft*	103	147	109	124	129	148	106	180
Avg DBH, *in.*	1.7	3.3	1.8	8.5	2.0	6.1	1.7	5.5
REMOVED								
Trees	0	0	5,628	0	4,869	178	3,652	100
Basal area, *sq ft*	--	--	83	--	69	21	14	20
Basal area, %	--	--	76	--	53	14	13	11
Avg DBH, *in.*	--	--	1.6	--	1.6	4.7	1.0	6.1
AFTER THINNING								
Trees	--	--	312	--	681	496	2,698	660
Basal area, *sq ft*	--	--	26	--	61	127	92	160
Avg DBH, *in.*	--	--	3.8	--	4.0	6.8	2.5	5.2

[1]Stand age in 1961 was 17 years; age of other thinned stands was 15 years in 1961. Old-growth forest was removed two years sooner on one side.

Audience. Do you plan to leave all the roots on this?

Malmberg. No, but we'd like to. It certainly makes good chips.

I'd like to make a commercial cut in August of 1971, but we're concerned with the limbing cost. Hemlock limbs do not break off when the trees fall.

I would like to discuss the background of this forest. In 1950, the old-growth hemlock was clearcut in here and the logging equipment was moved out in 1951. There was no burning. In 1960, we were looking for an area for a trial in precommercial thinning and selected this 40-acre piece. In 1961, we finished our mechanical thinning. The trees are not 10 or 11 years old, however—they are 14 years old even though it was not 14 years from the time of clearcutting the overstory. Without the burning we believe there were already trees 3 or 4 years old on the ground. The men that did the logging insist there weren't any trees. Well, there were. On some of the land there was a carpet of small trees. But if your eye is not accustomed to looking for them, you do not see them. So we stand by our guns and claim that the trees are a little older than the division claims they could be. But I think the division is coming around to admitting that maybe they are. The trees are large enough now to be impressive.

We tried almost any kind of equipment we could lay our hands on for the mechanical thinning. We divided the area into four pieces (Table 1). An unthinned control area of 8 acres was divided into plots. There are three areas with various treatments—and the objective is to grow maximum fiber.

We have just walked through the control. We are now standing in plot 8 of the area thinned once. We spent nearly 5 man-days per acre to reduce it from 5,940 trees to about 312. The goal was to leave the biggest and best trees on a spacing of 12 by 12 feet. The trees were free on all four sides—the stand was completely daylighted. If you were to read the management specifications on this area you would find that this test was designed to fail. We thought it was a deliberate overcut. The management foresters are having fun with us now. They're saying, 'What kind of a research department are you?" I don't

think this stand has failed. This experience pushed us into chemical thinning in the year 1962 to find a way to thin faster, cheaper, and safer. You may have observed the sun scald on the west side of the trees in this 15-acre forest. Well, it was thinned only once. Now I think we should hear a bit more about what has happened since the thinning. Jerry Outslay, the research forester for Northwest Timber, is here with his assistant, Karl Foeste. We will hear from both of them about what they see in the way of operational work on other areas.

Jerry Outslay. As we walked up the trail this morning, we passed through one area that has been thinned eight times. On that area, we have been following Fleming Juncker's approach by removing trees of larger diameter. We remove about 15 percent of the basal area every year to maintain a basal area of about 100 square feet. There are about 660 trees per acre left. Further up the trail, we came past the control. The control is the same age as these two areas. At the 1966 measurement, there were still about 4,000 trees an acre left as compared to the area thinned once, which has about 300 and the area thinned twice, which has about 500 left. As we walked on through the area, you could see the difference in average diameter between treatments. In the area thinned annually, the diameter at breast height averages about 9 inches. You will notice that some of the trees have been pruned. We have pruned about 70 trees per acre up to a height of 16 feet.

When we leave here, we will go through the area thinned eight times. We thin every year, so the ninth thinning is scheduled this fall. In the last two or three thinnings, we removed the wood to roadside and utilized it. We have a four-man logging crew that has been working on these research projects as well as the operational aspects. The trees in the area thinned annually were felled in the woods and limbed to a 4-inch top. Previous time studies and operational work have shown that 30 percent of the faller's time is spent in limbing. On the last thinning, we felled the trees, yarded them to roadside, and then removed the limbs. About 5 loads of logs were taken to the sorting yard and then we noticed that we had managed to get only three sides of the trees limbed. We

consequently had to send a faller to the sorting yard to remove the rest of the limbs. The point that I'm bringing out here is that there is a very strong demand for some type of delimbing unit for young timber. The three yarding machines we used to remove logs were the Bombardier Ram Skidder, the Skagit Hustler, and the Katrack K60, which you'll also see today.

You will notice that there are paint marks at selected locations on the trees. Karl will review briefly for us how we collect the growth data for these projects, particularly this one.

Karl Foeste. First, before I explain our method of collecting data, I thought I would give you some comparisons as to what you see here and what you could expect to see in a normal stand at the same age in which nothing has been done. For instance, as Jerry Outslay mentioned, we have an average diameter of 9 inches here and, in a normal stand of this age and site class, the average diameter is 3.7 inches. Net cubic foot volume to a 4-inch top in this stand is 2,800 cubic feet and in a normal stand it is 900 cubic feet. Scribner board foot volume in this stand is 5,540 board feet and in a normal stand there is no Scribner volume. This is a real point in favor of getting into these stands at an early age and managing them. Many foresters say that with the method we used here, we couldn't afford to do it, but we have other methods now that bring our costs down. When you look at differences of 5,000 board feet in this stand now as compared to none if you had left the stand alone, and 2,000 net cubic feet now as compared to only 900 cubic feet in an unthinned stand, the arguments for management are convincing.

We have developed a cruise system at Crown Zellerbach that we are quite proud of. The system is very accurate for measuring growth. Our first system had fixed radius plots of 1/10-acre circles which gave us changes in basal area. But we weren't always sure what our volume changes were. We have now developed a completely computerized method. To give you an example of how the field data are gathered, we first establish a plot center. A 12-inch pin is placed in the ground at plot center and, with a Speigel Relaskop, we measure at least 10 trees per plot on an area this size, Cp8 or Cp7. We like to have

at least 100 sample trees for the area. We have 10 plots established here. So we pick 10 trees per plot and measure them at D4 to the nearest tenth of an inch. This isn't difficult to do. With the Relaskop, we measure the diameter of the tree above D4. Usually we measure the diameter at 16 feet to get the form factor at D16, but we can measure them at 10 feet to get the form factor at D10. This depends upon the size of the stand. I believe that we used 10 feet in this stand. We can measure the total height of the tree. In hemlock, we must estimate the leader growth because of the droop. So, in hemlock, we might be off some, but we don't feel it's too far. With Douglas-fir or spruce we can usually see the tops and we can actually measure the height growth with the Relaskop. We also want to know the size of these trees back 2 years. So we measure the growth for the last 2 years with an increment borer. We bore the tree on both sides breast high to measure the diameter growth. The information is entered on a card, sent to Portland, and a computer print-out, which gives us the growth per acre in the last 2 years, is returned to us. It is possible to go back 1, 3, or even 4 years, but the farther back you go, the more difficult it is to get a reliable answer. So if we measure the stand this year, estimate growth back 2 years, and then measure it again in 2 years, we are relieved from reboring the trees. The measurements are made when we first establish the plot. And this way we can keep a continuous record of the growth.

Audience. What are the paint marks on the trees behind you and how are they applied?

Malmberg. The marks are 12 feet up the tree and are used for grading and determining form. A spray paint can is fastened on a pole with a metal strap to reach the desired height. The nozzle is activated by a special device that applies the paint.

This the only time today we will stop in a forest this young. Remember that in 1950, big timber was standing here. The new stand is now in the 1969 growing season. Next year, this will be a 20-year-old forest. Without burning and with the trees already here, is there a chance to avoid overstocking the land in the first place? It is difficult with 5,900 trees per acre to bring it down to this level of growing stock. Is there an

alternative or a way to prevent this? Is there a way to avoid the necessity of precommercial thinning? This is a difficult problem, especially without burning, and it looks like we are going to have to do a lot of precommercial work. We had talked in terms of a loss in here, so we made an economic analysis. If this were all pulp wood without lumber possibilities at all we would in fact have made more than 8 percent. I think this is important. How do you go to a board of directors and convince them? We have to come up, as Dr. Newport suggested, with an opportunity and an investment that shows a real rate of return—not based on faith but on hard economics. We suggest this is a real opportunity and our company is doing something about it. In this division, on a research basis, we treated 2,200 acres by chemical thinning and girdling, as a result of this experience. Our effort this year is on about 5,000 acres. But we want to step that up significantly in the next 5 years, because we keep coming back and looking at the opportunity these results suggest. But can it be mechanized? How? What is the real message we offer you here today? Because there is sun scald on the thin-barked hemlock, perhaps we made a mistake with the mechanical approach. We did get sun scald on 4 out of 10 trees. In the next cut, the year after this one, August of 1971, I believe we'll remove most of the sun-scald trees. But the opportunity is here for growth and yield and economic return. And that's what you must look at today. The first 5 years after thinning, this treatment grew 162 percent better in diameter than the control did. Our goal is to find a way to get at least a 30 percent increase in wood per acre. How? This already has gone the other way. It isn't growing at that rate anymore or trees would average 14 inches in diameter at age 25. My hunch is that the average diameter is going to be between 11 and 12 inches at age 25. But that is big enough to log with what we know now. Even with power-saw limbing. So there must be tremendous opportunity. If you like balloon bread, that's all you're looking at. These trees are fat and full of water. Like the spruce we wanted to show you that's 20 inches on the stump but 5 inches at 32 feet. That's heavy taper. We have a friend up the trail we'd like to call your attention to. You might have

seen him. He said, "I'm 22 years old, I'm 14 inches in dbh, and I'm 56 feet tall." And that's big enough to log by today's standards. If you can get your company to loosen up on money to do what we did here, or something similar, you will get the same results. With chemical thinning, we think it is practical. Are there questions on this before we leave it? Because we are going into larger timber next.

Audience. I'm a little confused–why did you prune?

Malmberg. Good question. The reason we prune trees is to produce knot-free lumber. No other reason. We think we can afford it at two bits per tree. We have never been able to get the cost below two bits a tree if we prune up to 16 feet. The reason for pruning is to get knot-free wood at a very young age on a short rotation. We have pruned here and in other test areas only for experimental purposes. We do not recommend it for operations. Why? This forest is on a 40-year rotation, so when we log next time the stand has only 15 years of life left. The objective here is to grow fiber–not saw logs, not poles, not peelers. Do you see any tree that might have grade in it other than pulp very soon? Those of you who have been reading trees, say, "I can see them now." That's what our cruisers did. It isn't all pulp now because of the export market. We are pruning experimentally so that when management asks, "What will happen when you prune at age 10, 15, 20, and 25 years?", we'll have some answers, not guesses. We'll have some measured evidence. But it still costs a lot of money to prune. Australia strongly recommends pruning on radiata pine. For their reasons, for their goals. The same in South Africa. For their reasons, for their objectives. We're moving the other way. For the production of fiber, wood–not necessarily knot-free wood–at young ages. The only reason to prune, fellows, is that young timber will not drop its limbs. If you want knot-free wood, you must prune.

Now, when we take off single file through this trail, we'll cross a blue line boundary back into the area where we cut every year. The man who proposed this says we'll cut every year until final harvest. We now have about 600 trees per acre and it's difficult to keep it down to 100 square feet of basal area.

We found that we couldn't if we took only 15 percent a year. In a few years, we think we can because cubic volume is increasing and the basal area growth is flattening off a little. But in the beginning we couldn't.

Audience. What is the reaction of the mill to this kind of tree? Do they like it? Can they live with it?

Malmberg. We haven't discussed this particular wood with the sawmill people. We have made paper out of it and are very pleased with it. Pleased how? Pleased as to quality. Pleased with brightness, with tear strength, but unhappy with yield. The bone dry unit is low in fiber because it's juvenile wood. The cell wall thickness and the fiber length are different, which is interesting to paper manufacturers, because they can blend it with other fibers and make another product—a high-quality product. But you must have more of this wood to make a given pile of pulp for paper products. When the logs lie in the sun, some of them pop right open. They're heavy and full of water. When the sawmill people get wood with one ring per inch or get two rings per inch, they are not happy, but they are using it, aren't they? They aren't requesting 5 or 6 rings per inch, because it looks like the choice is not theirs to make. That's an old-growth standard, fundamentally. It doesn't fit the young-growth opportunity. So you have to write another page in the manual again.

COMMERCIAL THINNING IN WESTERN HEMLOCK

The stand is 38 years old and covers 1,000 acres.

The Skagit Hustler No. 1 and the K-60 Katrak Tractors.

Two tractors work in combination in a pretrailed thinning operation.

Outslay. This area is a thousand-acre unit that we have been working with. We have established the roads and trails throughout the area to develop the stand. Two experimental yarding machines are thinning this ground. Part of the timber you've come through has been thinned once, some has been thinned twice. It's about a 40-year-old, actually a 38-year-old, predominantly hemlock stand. The fallers have finished. It's

conventional, planned thinning–removing trees about the average diameter of the stand. The first machine coming out with a turn is a Katrak (Figure 2), and behind it is the Skagit Hustler (Figure 3). We have about 28 miles of skid trails built,

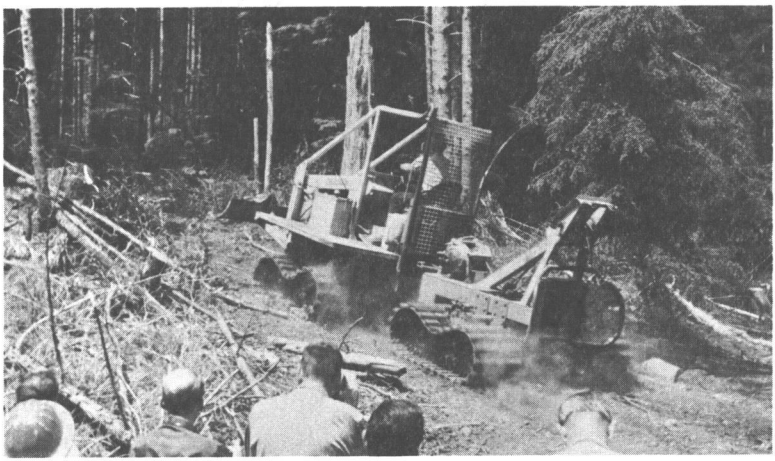

Figure 2. The K-60 Katrak.

Figure 3. The Skagit Hustler with a turn of logs in a pretrailed thinning operation.

each trail averaging about 600 feet in length and spaced 100 to 150 feet apart. Karl and I will be around here so you can ask us any questions that you might have on the operations. Don, do you have any other comments you wanted to make?

Malmberg. Remember this stop in relation to the next one. Jerry told you that the area has been pretrailed. Each trail has been left for a year to harden, to prevent equipment from sinking in the mud, and to capitalize on the speed of the skidding machine. If you were to walk out any of these 28 miles of skid trails, you'd notice that the stumps have been plowed away with a bulldozer or blasted away. The trails are clear, free, set up hard. They are ready for speed vehicles. We have two machines, working in combination, one much heavier than the other. The Skagit Hustler weighs nearly 9 tons now. The original weighed around 6 tons. It's had considerable modification. It has a blade in the front, a tilt apron in the back. The first, the lead vehicle, is the Katrak K60, about 7,200 pounds. It's in the beginning stages of testing for us. So you see the two of them working together. The idea here then is pretrailing, leave it for a year, and come back with conventional thinning. The first thinning has been completed, and this is the second cut, which has been done the same way. We are suggesting that this might be the old way or the hard way. At the last stop, we want to illustrate the new way, or the easy way. There you'll see timber lying there. We have not started to yard. So keep that in mind. Here's a machine, here's a system. Logs are coming out. Tree-length logs. A few of them bucked for grade, but mostly tree-length logs. That's what you see here. And this time, all the alder is coming out—not some of it, all of it. This creates some holes in the forest.

As these rigs come out, we should watch them turn around. Maybe we can get the operator of the Katrak to turn on a little speed and demonstrate how it goes up the hill. It can do that in the rain. Just because it's nice today, doesn't mean it can't rain here! I think we've tried four different types of equipment here. The equipment manufacturers are trying their darndest, but they haven't developed a machine that we can recommend for logging here. But they think they may have one now. We can be critical, but they have a lot of credit coming.

Tests of High-Lead Strip Thinning and Tractor Corridor Thinning on the Youngs River 71 Spur

Near the high-lead strip setting, an approach to thinning that favors mechanization in the harvesting process when applied to dense 30- to 40-year-old stands of young-growth was illustrated. Can logs be produced three or four times from a young forest without marking trees to be cut or crop trees to be left? Why not? What are the costs, benefits, penalties, and manpower requirements? Critical comments were invited to stimulate discussion of this controversial approach to stand development.

Malmberg. Walk single file up the trail a couple hundred feet until we get to a stump where Jerry and Karl can tell you what they did, how they did it, and why they did it. Then we'll walk out through the other side and down to trail number four to see the results of a high-lead strip with the Bantam yarder in 40-year-old hemlock. Jerry, in the interest of time, can you give them the idea of what they're going to see first and what they'll see when they cross the strip? The plea we're making is to look at this operation, think about it, and see if any part of this has merit or justification. We think we could get in over our heads fast without measured evidence to prove or disprove the system. It looks so exciting to us that we might get into operation before research really has any information. It's possible. So, Jerry, what did you do and how did you do it here?

Outslay. This area is still part of the same block–notice the trails that have been located. We marked this initially for one of our conventional thinnings–a crown thinning. You can still see blue paint on some of the trees. After some discussion we decided to try something different. One of our goals for the year was to develop a new method for harvesting, for mechanizing the harvesting process. Earlier this afternoon, you saw skidders yarding logs that had been felled to lead, so that when a machine pulls a log out of the timber it will slip out of the stand fairly easily. With this concept in mind, we located strips here just as we locate trails–by tying flags on a tree. Our fallers cut these strips 12 feet wide in the timber stands (Figure 4). Probably at about a 60-degree angle to the cat trail, with the

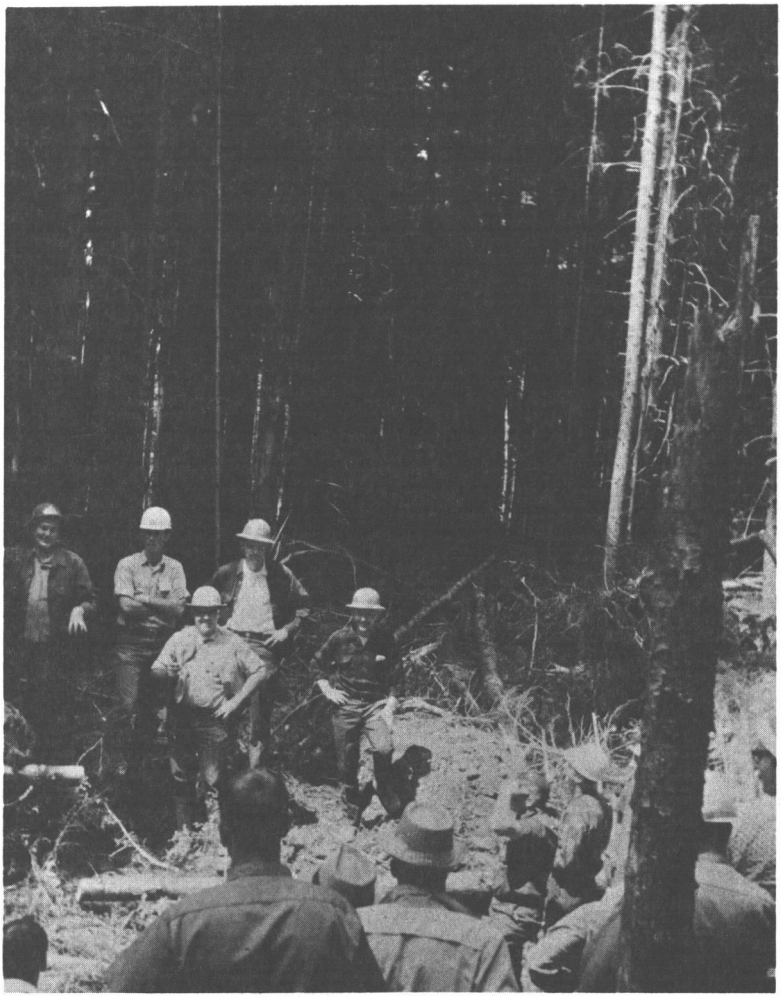

Figure 4. Foresters from Crown Zellerbach discussing corridor thinning by tractor. A corridor is visible in the background.

hope that this would make yarding easier and would help the faller reduce hang-ups from the numerous limbs. As you walk up through this stand you'll see the trails that have been cut into the timber. In this block, the trails are spaced 27 feet apart, from center line to center line, with the strip cut 12 feet wide.

We'll cross over to one of the cat trails to see how the timber is lying. Would this material be easy to yard? On the other side of the road, we spaced the trails 54 feet apart, center line to center line. Then we'll walk through some of the timber that has not been thinned yet so you can get an idea of what it looks like. So we are suggesting now that this is actually a thinning, but not a conventional silvicultural thinning. We say it doesn't hurt the stand. And we say that there are 300 to 400 trees left per acre right now between the trails. I think those are the main points, unless there is something you want to add, Karl?

Foeste. No, other than to mention that the 300 to 400 trees left per acre still gives us a lot of trees, even though the trails may be as much as 15 feet wide. We still have trees from which to select our crop trees.

Malmberg. There's one thing that might be misunderstood. We mentioned pretrailing as the first cut, waiting a year, and then thinning a second time. As Jerry said, the strips are 54 feet on centers, which leaves about 42 feet of standing green. It doesn't say we couldn't come back a second time and put a second corridor in there. On this side, we purposely put in corridors spaced on 27-foot centers. If you want a heavy cut, 40 to 45 percent of the volume per acre, this is what you are going to get. Or to illustrate for you what the other side of this project would look like 3 years from now if we put corridors into the remaining stand and cut more corridors leaving 15-foot strips of standing timber. So there is a chance for confusion. But remember, there is a way to get logs three times, maybe four, including a heavy, low thinning with a diameter limit such as we talked about Monday, without marking trees individually. On this side, it would be all over until the heavy low thinning and we wouldn't need to mark it. It could be a diameter limit cut. So in that way you'd have pretrailing, a heavy corridor cut, wait until some time in the future, a heavy low thinning–no marking. That's three times on this side. The other way you'd get through four times without marking. And that's the key–mechanization. Find a way to do it without marking trees to cut or to leave. Find a way that's safer. The hang-ups in this dog-haired stuff are serious and are a source of injury to loggers.

This way, there are no hang-ups. Fundamentally, we found a safer way to log. We offer this for your consideration. There have to be problems in it. Somewhere there are some serious bottlenecks. But we want to weigh the plus and minus factors. Right now we are pretty high on this thing. We think that we have measured timber long enough to recognize an opportunity. There is a way to get wood without spending the time marking the trees. And then you will not pay the penalty. But we can't prove it till several years from now. We can't make a conclusion today, because we haven't got the evidence. We are thrilled that it is a possibility.

Audience. Have you tried shears?

Malmberg. Yes, but without much success here.

Audience. I was at Chemult a week ago looking at the shears that Boise Cascade is using in lodgepole pine. That wouldn't be applicable here, but I was thinking about reducing the labor cost of felling. It looks like equipment similar to this could be developed for west-side conditions.

Malmberg. If you gather in here now, we'll get started. We do have one message for you from our faller who has been doing this kind of work in young timber—that is, felling trees in young stands and limbing them the hard way for years. The message is that if you fellows are going to get at it, you have to remember one thing; to stand on a little log and walk all the way along it and limb it and cut the top off, you need feet shaped like a bluejay's! Then you can hang on to that darn little log. So there's a little piece of wisdom for you. And with that, we better give it back to Jerry.

Outslay. I hope you have been noticing the low stumps. This is the way our fallers have been cutting the timber, leaving about a 6-inch stump. I tell them to cut it 6 inches below the ground and then they come out just about right. If you look down this skid trail that we built over a year ago, you can see how the trees are felled to lead. The second road over you can see the logs. If I recall correctly, there should be about 10 trees on that strip (Figure 5). I believe the average was 10 trees per strip. You can notice how the strips were located 27 feet apart and felled at about a 60-degree angle to the skid trail.

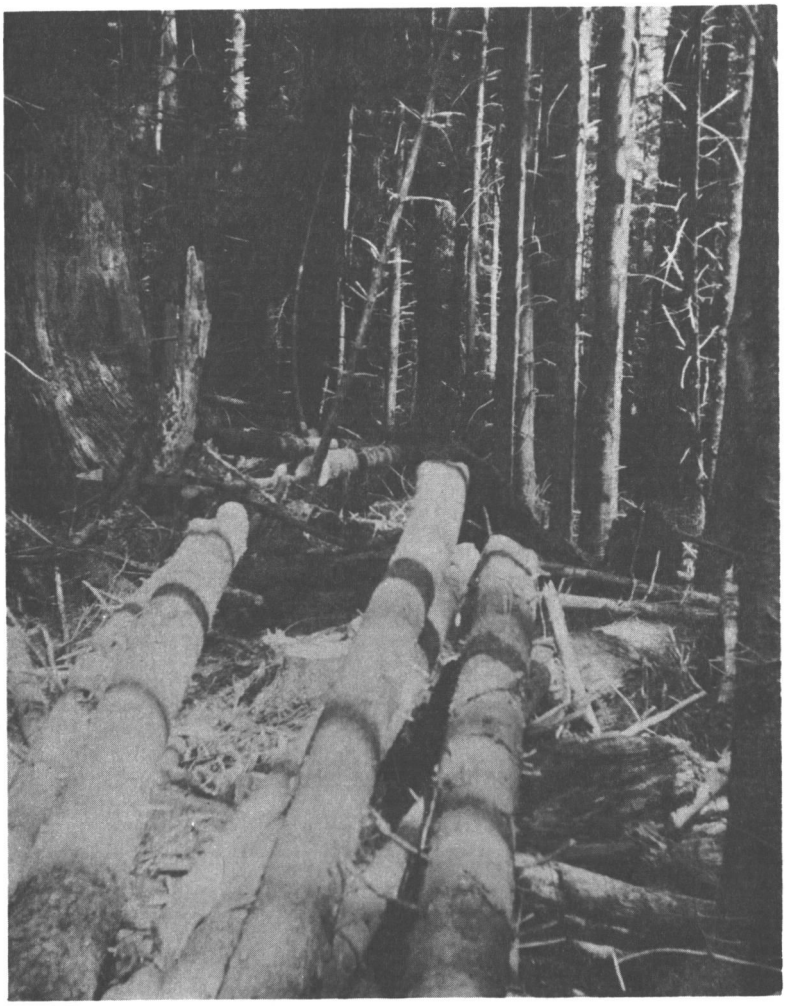

Figure 5. Logs ready for yarding in corridor thinning.

It seems to me and to the rest of our crew that having logs bunched in these corridors should make yarding easier. The choker setter will benefit by having to pull very little line to hook on to the trees. Some of the trails have the butts of the log facing the trail–this may require the logger to pull a little more line. Notice that the logger does not need to go more than

10 or 15 feet to hook onto the last top on these strips. This may facilitate the use of a grapple on the back of a tree farmer or a track vehicle. Operating with a rubber-tired rig on this soil in the winter is difficult. We would favor the track yarding machines—no real proven track yarding machines are available yet, but we are getting very close. There is the possibility of wedging the trees, even if they are leaning the wrong way, wedging in the direction that will make yarding operations easier.

Audience. Is the concentration of limbs and debris in the cat trails going to give any trouble?

Outslay. I don't believe it will with the track yarding machines we have. We have blades on the machines to get the tops out of the way. This is one of the reasons for recommending a blade on the front. It doesn't have to be a big blade to push a lot of dirt, but just to kick these tops out of the way. Karl, you followed some of the felling operations on the 30 trails in this area. Would you like to make a comment or two on what you have noticed?

Foeste. I think we have discovered something here that is quite significant. The amount of time that a man spends actually felling the trees in this method as compared to the conventional method of thinning. For instance, in our previous time studies on conventional thinning methods, the faller spends only 27 percent of his time in felling the trees. Ten percent of his time is spent fighting hang-ups and 16 percent of his time in moving. Here we have almost doubled the percentage of time felling trees. As much as 47 percent of logging time is spent in felling. Moving time has dropped from about 16 to 4 percent of the time. That's quite significant. In 4 hours of felling, I recorded 43 seconds spent fighting a hang-up. We don't have enough information yet to say we are going to reduce our felling costs, but it looks as though we might. And as Jerry said, we certainly see the possibility for yarding these logs with something like a grapple.

Audience. What is your opinion on felling the trees either away from or towards the main trail?

Foeste. I think this is the faller's choice. If there is a hole at the end of the trail, then the faller should fell with butts

toward the skidroad. I know that Don likes to grab ahold of the butts usually. It helps him a little. But right now, don't you think, Don, it is better to fell them into the trail? Except when the trees are all leaning back that way and a lot of wedging would be required. Then you might start a hole or you might have one already made and then just fell them away. It's kind of faller's choice, don't you think, Don?

Malmberg. I agree. Don't wedge a tree if you can avoid it. Work with Nature, not against her. But you are going to fight tops and butts depending on how much adverse and how much favorable slope you have, together with the mix of trees in the stand. Where you can, yarding butt end first saves fighting the top. On a slope, most of that timber is set–it wants to go with the slope. When you yard from above, you have favorable yarding. Yarding down hill means a lot of top-end yarding. When timber is this short it's no trouble. A little longer, a little bigger, a little heavier tree and sometimes you get to the landing with a little piece in the choker and the log is still down the slope.

These are excellent questions. We don't have all the answers but we do have ideas. Any more questions?

Audience. What should be the distance for skid roads? Are they a little close right in here?

Foeste. In my opinion, they are about right. You must be able to reach the tree. This is as close as you want to be, from this distance on up to 150 feet. Look back through this stand and you see some areas that have been thinned. When you stand on a strip that has been cut, it looks like the treatment has been harsh at that one point, but, when you look **through** the stand, it just looks as if it has been thinned. There are some advantages. For instance, in a normal thinning this stand would have more scarring on the trees. Many foresters claim scarring creates favorable conditions for *Fomes annosus*. This system will help reduce or eliminate scarring and reduce the potential for disease in the stand.

Now, let's look at the high-lead strip and that will terminate the tour.

Malmberg. How do you get logs from young timber like this? What can you do? We were desperate. We looked at several

alternatives. And the safest and easiest way to log is by strips such as these (Figure 6). We can argue about how wide the strips should be. We didn't know how much wood we could get. Well, this strip illustrates the width we are hanging our hat on—20 feet. Then we do it again, one more time, in between. Will the herringbone idea fit? Not as well as another clearcut

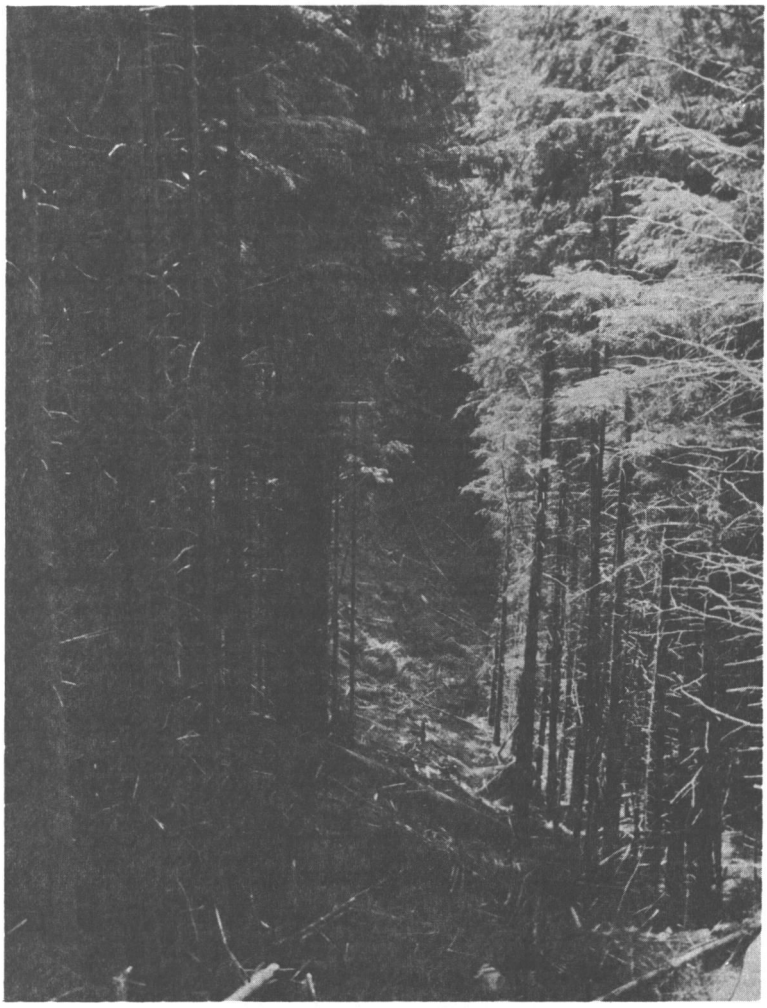

Figure 6. High-lead strip thinning in 40-year-old hemlock.

strip would. So I think the reason the cost per C-unit (100 cubic feet) of wood was high was not the system, it was the fact that we moved so much–the cost of moving here is all in this one setting. The first thing you know, all the logs were here, and we had to let go the tail-hold and move to the next one.

Well, here is trail number 4 mentioned in Table 2. It is 394 feet long from landing to tail-hold; that isn't very far. Well, we yarded the trees up to the landing whole, and limbing and topping was done on the landing. This procedure is much easier and safer than working on the steep sidehill where the log is likely to run down the hill past you. The faller, on the average, in this stand cuts 16 trees per hour. The highest number felled was 28. That's pretty good with a saw. But the average of the good and the bad, the fast and the slow worker, is 16 trees an hour. The actual yarding cost is good. The moving time got us, because we had some 200-foot strips. Yarding time is good, but it's over with soon and we have to move–so four men are out of work, waiting to get set up to log again. What about damage? We have invited people to see if they can find scarring here. If I can't thin a hemlock forest on my property because I skin trees, that's sad. Go find scarring damage here. Foresters will say you can't work this timber and ground in my watershed because you dirty up the creek. Go find soil disturbance here. Wildlife? Yes, they hang around all the time. We think we have a good system here. But is it thinning? I don't know. Jerry Outslay says, "Yes, it is thinning." We did do something beneficial. We put the strips close together like he just showed us. He says,"You bet it's thinning." And I can agree with him whole-heartedly. But I say, "Let's get logs! You fellows figure out what to call it." If you can't get permission to manage young-growth timber because it is not thinning, change your argument and suggest that you can get logs by partial cuts that favor mechanization in the harvesting process. If it doesn't come out thinning, maybe that's too bad. If it is thinning, all right. Maybe we can tie what we know together with this unproven idea and get landowners started on young-growth management. We know of no other way to work in this forest and make a profit. We can't work this forest with a cat and make a profit. Not under our circum-

Table 2. Results of High-Lead Strip Thinning in Hemlock, Age 40 Years, with a Four Man Crew on Their First Try with a Schield-Bantam Yarder.

Item measured	Trail number								
	1	2	3	4	5	6	7	8	Total
Length of trail, *feet*	490	304	345	394	448	280	633	208	--
Width of trail, *feet*	20	20	20	20	20	20	20	20	--
Time to fall trees, *hr*	4.2	3.2	4.3	3.7	8.9	3.3	10.9	1.5	40.0
Trees felled per hour	28.3	18.4	13.3	19.7	12.5	19.0	10.4	26.6	16.0
Logs to a 4 in. top	119	59	57	73	111	62	113	40	634
Avg log, *cubic feet*	11.3	14.0	16.4	14.6	16.5	15.4	18.6	14.6	15.2
Time to yard and deck, *hr*	4.9	2.2	2.5	2.7	3.5	2.4	2.9	1.2	22.3
C-units produced[1]	13.4	8.2	9.4	10.7	18.3	9.5	21.0	5.8	96.3

[1]Powersaw cost ranged from $1.54 to $3.08 per C-unit roadside, by the full-tree system with limbing and topping at the landing. Yard and deck cost ranged from $9.44 to $15.32 per C-unit roadside, which included the time lost in moving and rigging tail-holds. The moving and rig-up time was excessive because of the many short trails, which raised costs.

stances. Maybe you can on your ground, but we can't on ours. We have to have some way of harvesting, and this looks possible. It is possible–we did it!

Operation of the Washington 98 Thinning Yarder

The Washington 98 thinning yarder has a swing capability and is mounted on a tank undercarriage (Figure 7). This is one

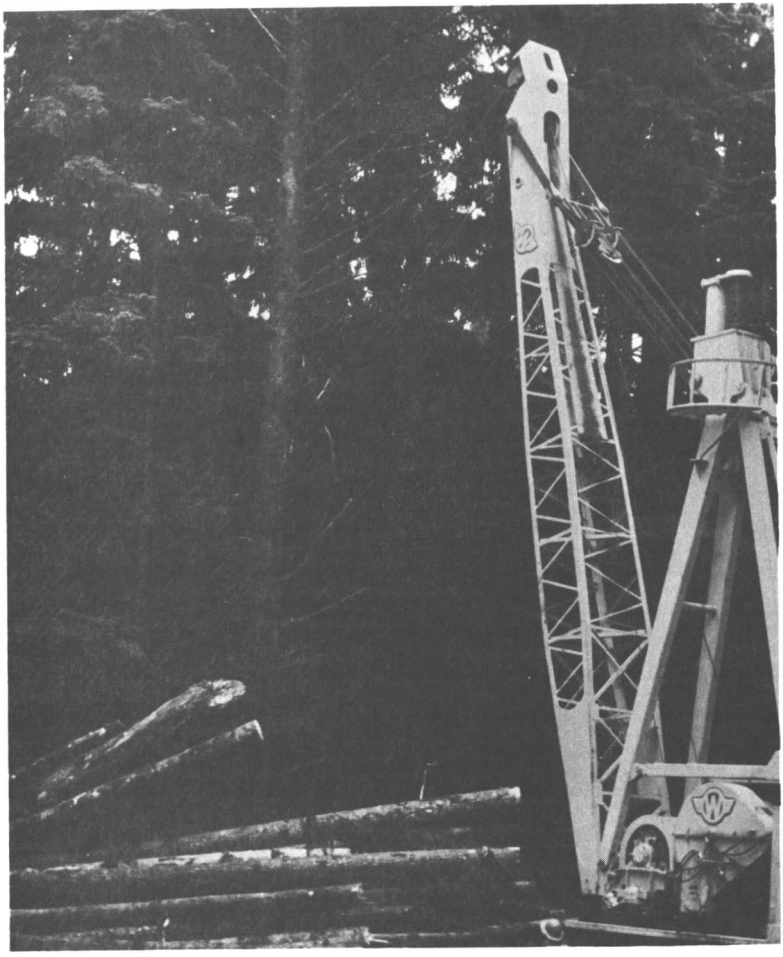

Figure 7. The Washington 98 thinning yarder bringing in a turn of logs from a steep hillside.

of a series of units to be developed for harvesting with grapples instead of chokers or both in combination. The Washington 98 is expected to be followed by the Washington 78. The first unit developed of this line is known as the Skylok 108. Speed, flexibility, power, efficiency, and performance are the main advantages in the design of the 98 yarder.

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