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Timber Measurement Problems

IN THE DOUGLAS-FIR REGION OF WASHINGTON AND OREGON

by

DAVID BRUCE and
ROBERT W. COWLIN

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
U.S. DEPT. OF AGRICULTURE · FOREST SERVICE
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FOREWORD

This analysis of timber measurement problems in the Douglas-fir region of Washington and Oregon was made by members of the Station staff under the leadership of Consultant Robert W. Cowlin. Available literature was reviewed to help identify the measurement systems used in the region, to gain familiarity with the background in which these systems were developed, and to make a preliminary determination of the problems encountered by users of the present systems.

Next, representatives of different user groups were consulted to determine their experience with and opinions about timber measurement problems and their objectives and standards of performance in use of measurements.

Station staff participating in these conferences were David Bruce, Paul H. Lane, Melvin E. Metcalf, Robert B. Pope, Donald R. Gedney, John W. Henley, Marlin E. Plank, and Richard Woodfin. In addition, Thomas C. Adams reported on timber measurement problems encountered in his field studies of timber sales arrangements, Walter H. Lund prepared a report on timber measurement systems now in use by Region 6 of the U.S. Forest Service, and Carl A. Newport prepared a report on timber measurement systems in use by private timber owners in the open market sale of standing timber.

About 120 people were consulted in over 70 separate conferences. This report does not attempt to describe all the small variations of measurement systems now used, to present all the varying viewpoints, or to tally up the votes for or against any features of the present measurement systems. It also does not include analyses of timber appraisals, sales contracts, or sales administration other than the problems of measurement, although other phases of these subjects were discussed in some conferences.

Since this report may be read by people not familiar with forest management and the timber industry, many details will be included that may seem unnecessary to some readers, although no attempt will be made to avoid all forestry and trade jargon.

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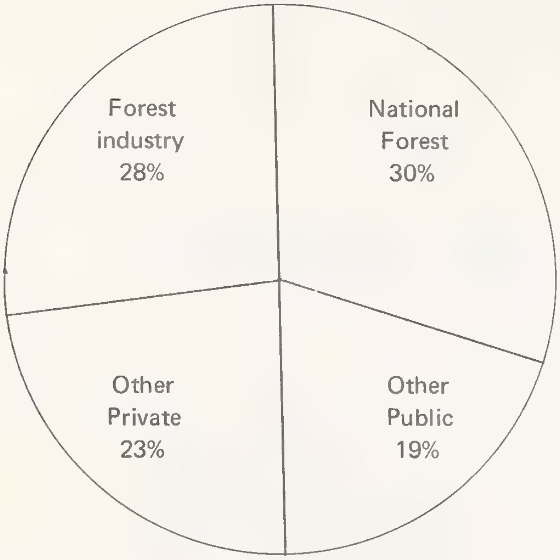
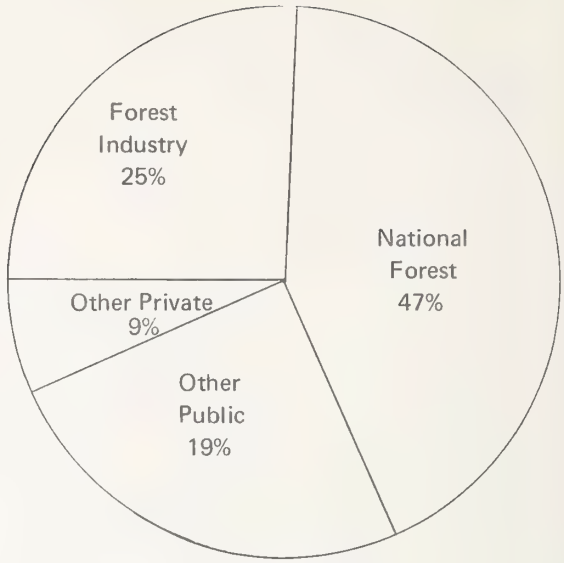
INTRODUCTION

Owners and managers of timberlands and timber processing plants are vitally concerned with measurement of trees and logs. Timberlands are the source of raw materials for the industry, and their best management requires knowledge of the quantity and value of present supplies and forecasts of the effect of this management on future supplies. These raw materials insure continued operation of timber processing plants if they can be procured at costs commensurate with the value of the products. An essential step in procurement is the estimation of volume and grade of trees or logs. Investment in new processing plants and equipment depends in part on forecasts of raw material availability. These forecasts are based on forest survey. Timber measurements are also needed in the industry's financial reports, records, and control systems. Many taxes paid by timberland and plant owners are based on some measurement of trees or logs.

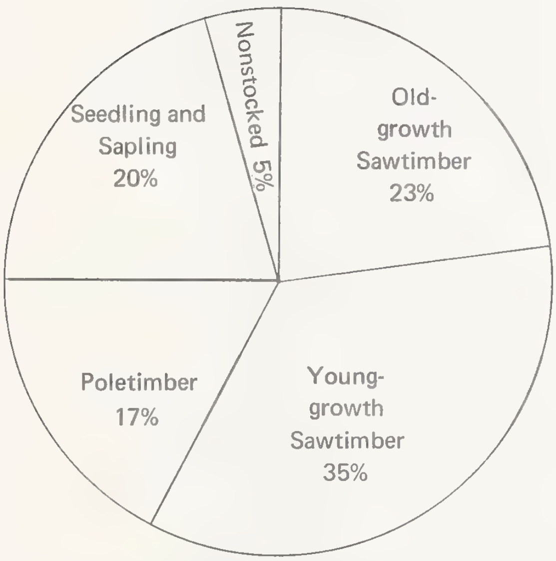
Many communities in the Douglas-fir region are largely dependent on the timber industry, which is one of the major contributors to the wealth of the region. Therefore, the many people employed in timber and related industries are affected by the results of these measurements. Also interested are a large group of people not too well versed in the intricacies of timber measurements, including bankers, legislators, newspapermen, members of the transportation industry, and taxpayers in general.



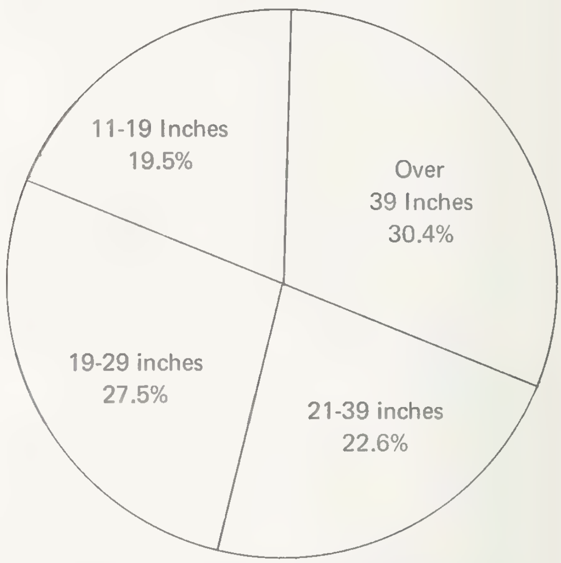
1a. Ownership of commercial forest land.



1b. Sawtimber volume on commercial forest land.



1c. Type of forest on commercial forest land.



1d. Sawtimber volume by diameter class.

Figure 1.--Commercial forest area and sawtimber volume in Douglas-fir region of Oregon and Washington, January 1, 1963.

In the Douglas-fir region of Washington and Oregon, 66 percent of the present sawtimber supply is on the 49 percent of commercial timberland in public ownership; 25 percent of the supply is on the 28 percent owned by timber industries; and 9 percent of the supply is on the 23 percent in other private ownerships (Figure 1). Of the 1966 annual cut of 12 billion board feet, 45 percent was from public lands. Most of this public timber was sold directly or indirectly to local mill operators. Much of the private timber was logged by industrial owners, mostly for processing in their own plants. In the last 3 years, the Japanese export market for logs has become increasingly important, accounting for over 8 percent of the harvest in 1966.

Practically all of the timber cut is scaled and graded as logs once, and some of it is scaled two or more times. Scaling may be by the seller, the buyer, or by a third-party log scaling and grading bureau.[1]

The sale of public timber on the stump has, in the past 20 to 30 years, largely replaced the log market where there was open bidding for rafts of logs harvested mostly from private lands. This has changed the main function of log scaling and grading bureaus. Where formerly their primary job was scaling and grading rafts of logs before the rafts were auctioned, now about half of their work is scaling and grading timber cut from public forests under sales contracts.

In the same period, there has been increasing harvest in second-growth stands. This has been accompanied by changes in harvesting and milling equipment and practices. More important to the present study, this change in timber source has reduced the size of trees and logs considered merchantable and changed the kind and amount of defect.

Another recent change in the Northwest is use of sorting and concentration yards. In these, logs whose species and quality do not make their end use obvious are measured and sorted for shipment or sale to different plants (for example, pulpwood logs are sorted and loaded separately at the woods landing). Since measurement itself adds nothing to the intrinsic value of the log and since sorting will assign most logs to the most profitable use, the sorting or concentration yard introduces the value-producing sorting operation for what otherwise would be only an operating expense. There is also much exchange of logs between plants which serves the same purpose, although possibly less efficiently. When log prices increase, more use of sorting or concentration yards may be stimulated to match logs to plant requirements.

Further change in the last 10 to 20 years has been the increasing concentration of the timber processing plants and industrial timberland ownership. With plant capacity remaining about the same, number of plant and timberland owners is decreasing. This reduction appears to have had little or no effect on competition in public timber sales. An important effect has been more multiproduct industries and industrial tree farms, and increased incentive for determining the most profitable use of each log.

Most trees and logs sold in the Douglas-fir region of Washington and Oregon are measured in board feet, Scribner Decimal C rule.[2] Some export sales are based on the Brereton rule[3] and some pulpwood sales on cubic feet. Both pulp logs and culls may be

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[1]*There are now four scaling and grading bureaus in the Douglas-fir region of Washington and Oregon: Columbia River, Grays Harbor, Puget Sound, and Southern Oregon.*

[2]*A description of the Scribner rule is on page 6.*

[3]*Brereton scale is 12 times the cubic-foot content of a cylinder with diameter equal to the average of the two end diameters and length equal to that of the log.*

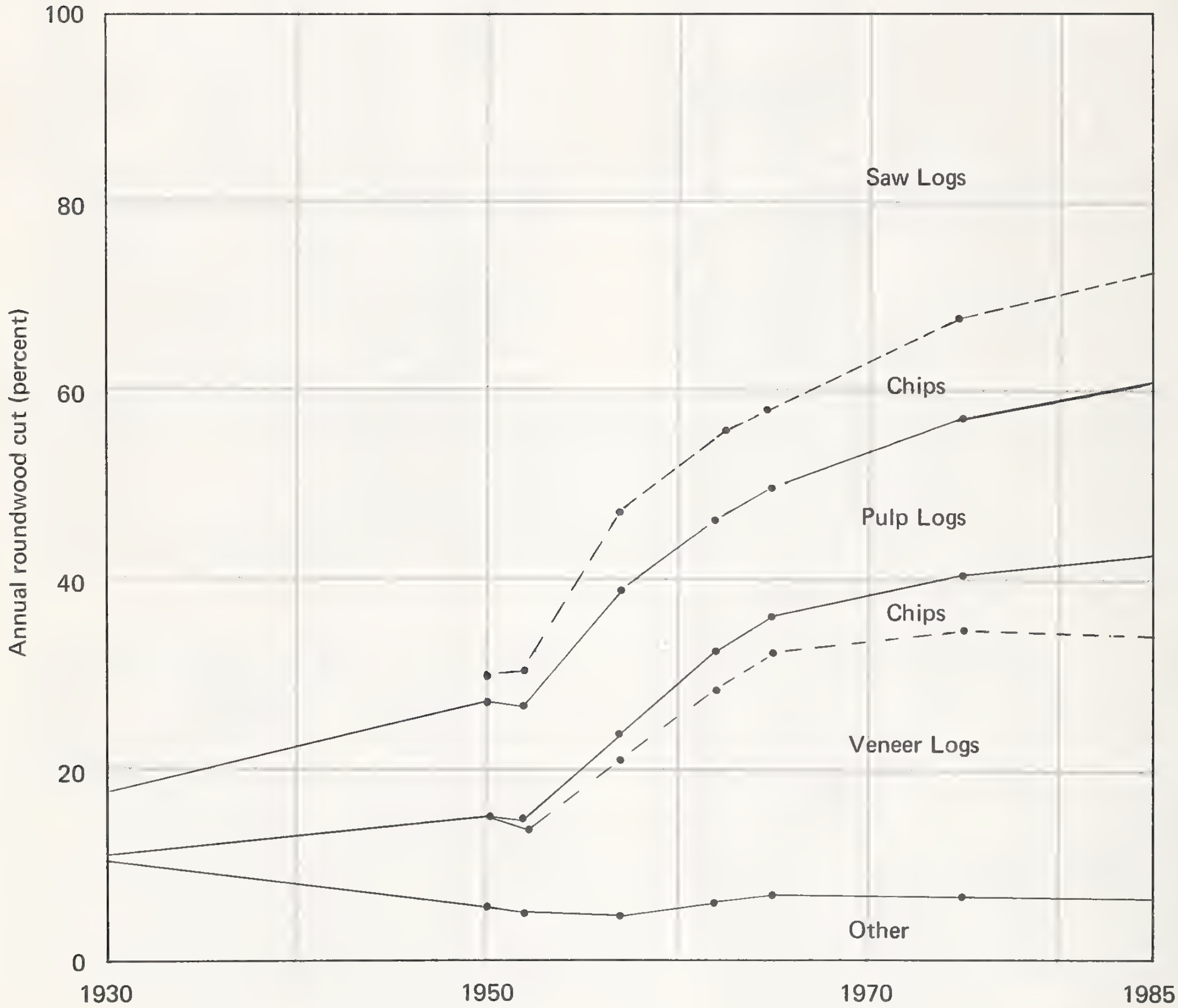

Figure 2.--Roundwood use in Douglas-fir region.

weighed. Poles and piling are sold by the lineal foot or piece.

Procedures for using the Scribner rule in the Douglas-fir region differ in several ways from methods common elsewhere: no allowance for taper is made on logs up to 40 feet long; fractional inches of diameter are dropped; in water scaling, a single (usually smallest) diameter is measured; and defect deductions are made only by reducing scaling diameter or length.

The annual costs of cruising and measuring trees and logs in the Douglas-fir region are about $15 million, slightly over $1 per thousand board feet harvested.

Apparently, this large expenditure does not produce all the estimates of potential product volumes needed by the timber industry because there are repeated requests for accurate and up-to-date conversion factors. These factors usually are used to convert estimates of volume or weight of logs to estimates of their potential products, but also may be used to convert from one log measurement to another. The list of conversion factors is long, reflecting the many different uses of wood.

Today, about half the logs harvested in the Douglas-fir region are sawed into lumber, one-fourth are peeled into veneer, and the rest are either chipped for pulp or used as poles, piling, or other wood products (Figure 2).[4] A large proportion of the residues from sawmills and veneer mills is chipped for pulp.

If present trends in production continue, even larger proportions of the logs will be made into veneer and pulp chips and smaller proportions will go into sawmills.

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[4]*Data from:*

Andrews, H. J., and Cowlin, R. W. Forest resources of the Douglas-fir region. U.S. Dep. Agr. Misc. Pub. 389, 169 pp., illus. 1940.

Gedney, Donald R., Newport, Carl A., and Hair, Dwight. Prospective economic developments based on the timber resources of the Pacific Northwest. V. 2, pt. 6, Forest Industries. 174 pp., illus. 1966. (Prepared under cooperative agreement with Bonneville Power Administration as part of their "Pacific Northwest Economic Base Study for Power Markets.")

THE STUDY

In October 1966, the Pacific Northwest Forest and Range Experiment Station's Advisory Committee urged that research be started to develop log and tree measurement systems with adequate accuracy in conversions from one unit of measure to another. A first step toward this undertaking is the present study which has as its objective an analysis of timber measurement systems now in use in the Douglas-fir region of Oregon and Washington. This analysis includes consideration of the objectives and standards of performance of the many different classes of users.

Specific objectives are to: (1) determine what information about tree or log dimensions, defect, quality, and other characteristics is now being used to estimate tree, log, and product volume, weight, or value, and how it is acquired and summarized; (2) look into the problem of accurate conversion factors; (3) define the criteria by which different classes of users judge present systems and by which they would judge any changes in present systems; (4) use these criteria to appraise the strengths and weaknesses of existing systems.

The accomplishment of these objectives should furnish the basis for consideration of changes and improvements needed in the measurements systems and for the further development of a program of specific studies to solve identified problems.

The authors believe that a complete timber measurement system should supply all the information about tree and log dimensions, defect, quality, or other characteristics needed to estimate: (1) volume or weight of wood in trees or logs, (2) quantity of one or more products that can be made from trees or logs, and (3) value of trees or logs. It should also include the means of acquiring, summarizing, and using this information.

Many timber measurement systems have limited objectives and therefore are not complete systems as defined above. However, a characteristic of most systems is that a unit of estimated volume or weight is used as the basis for sale of wood. Establishing prices for the sale of trees or logs requires estimates of their quality – hence, quality is usually assayed when trees and logs are measured.

SOME HISTORY OF LOG SCALING AND GRADING

In the United States before 1805, if log volumes were measured at all, the unit of measurement apparently was cubic feet. Sometime during the next 20 years, estimation of number of superficial feet (square feet of surface area) of 1-inch boards in logs started. This was done either by direct estimates of board feet or by comparing the estimated cubic volume of the log with that of a "standard" log. The oldest surviving publication of the Scribner log rule is dated 1846. It includes logs 12 to 44 inches in diameter and 10 to 24 feet long. It may be the first log rule based on diagrams of the boards that might be cut from the log. Various extensions of the Scribner rule were made. The one now generally accepted – the Decimal C – was first published in 1910 after 4 years of use by the Forest Service (for logs 6 to 120 inches in diameter and 6 to 16 feet long by even feet). This extension appears to have accepted the Lufkin Rule Company's Decimal C extension from 11- to 6-inch diameter, rounded Scribner's original values to the nearest 10 board feet from 12 to 44 inches, rounded Spaulding values from 48 inches to about 72 inches in diameter, and established higher values by extending the Spaulding curve using the International 1/8 inch as a guide to shape of curve.[5] The Spaulding rule was developed in California in 1868 for logs 10 to 96 inches in diameter and 12 to 24 feet long. It was based on diagrams, but values appear to have been smoothed. From 12 to 44 inches, the Spaulding values look like smoothed Scribner values.

[5] *A footnote to the 1910 Forest Service table adds confusion by stating "the original rule did not extend beyond a diameter of 60 inches." This implies that some venerable table attributed to Scribner extended to 60 inches. In 1903, the Forest Service published a Scribner rule table that extended only to 44 inches.*

It is not certain what log rules were first used in the Douglas-fir region. The fact that the Scribner rule was used for many years around Puget Sound and the Spaulding around the Columbia River is suggestive. The Drew rule, formerly used in western Washington, was based on diagrams for logs over 20 feet long (adjusted for mill tally) and was developed by Fred Drew, log buyer for Pope & Talbot, Inc.

Early use of log rules was to determine wages to be paid fallers and buckers, payments to logging contractors, and price to be paid for logs delivered to mills by settlers. Timberland usually was acquired for a fixed price per acre (under the Timber & Stone Act of 1879 for $2.50 per acre). In 1900, 900,000 acres in western Washington were sold at a rate of about 10 cents per thousand feet ($6 per acre). However, census reports show the average value of Douglas-fir stumpage was 68 cents in 1890 and $1.05 in 1904. These price differences were probably largely a matter of accessibility, competition, and quality.

Early records (back to 1860 for Puget Sound) suggest that most logs were purchased camp run (ungraded). From 1902 to 1908, "Flooring" logs were selling for $8 to $14 in Puget Sound, "Merchantable" for $6 to $11, and "No. 2" for $3.50 to $7. In the record for 1909 to 1916, No. 1, No. 2, and No. 3 replaced these earlier grades but maintained the $3 differential between grades. In 1910, the manager of the Columbia River Scaling Bureau stated that under the old system of scaling the scaler took enough off the diameter to make a knotty log the same in value as a log without black, loose, spiked, or large knots, but that under the grading system, the price takes care, to a great extent, of the knot problem. He also said that scalers should not be required to deduct for defects they could not see, but that these should be price considerations.

In the early days of the plywood industry, veneer logs were selected from rafts of sawmill logs. In 1924, plywood mills were reported to take only 1-1/2 percent of the logs they looked at and every log was rolled a dozen times before being accepted. In 1926, a scaling book mentioned payment of a premium for selected No. 2 sawmill logs and selection of No. 3 sawmill logs for core stock.

Changes in manufacturing technology have caused changes in log grades and end use of logs. Currently, Selects are logs too small for a regular Peeler grade. Veneer mills often cannot compete with sawmills for Peelers. Fir Wood logs are no longer classed as No. 1 and No. 2. Special Culls (logs with white pocket rot that will make at least mill-certified plywood) are regularly peeled. Peewees, or gang-mill logs, are not recognized by scaling Bureau rules but are by gang-mill operators.

A relatively recent change in the Douglas-fir region is the use of cubic-foot log scaling by industries that operate pulpmills. Some of these industries have made the cubic foot the basis of all their inventories, business control records, and transfers of wood from one division to another. In 1948, cubic-foot scaling was adopted as the official log measurement in British Columbia. Methods of determining cubic-foot content vary, some using two-end diameter measurement and some small-end with taper allowance. The most notable inaccuracies of cubic-foot scaling are associated with butt swell. Some criticism of British Columbia cubic-foot scale is aimed at underallowance for butt swell. Another criticism of cubic-foot scaling and grading in coastal British Columbia is that the three grades used do not adequately segregate logs into value classes.

Another change has been the partial substitution of weighing for other wood measurement. This is done in one of two ways. Either weight is the unit of sale or a subsample of weighed truckloads is measured in some volume unit and an average conversion ratio is calculated. Experience elsewhere suggests that if reasonably accurate conversion to board feet, log scale, is wanted, both weight and total length of logs must be measured. Weight scaling is most popular for low- or uniform-value logs. Weight-to-volume ratios vary if percent sapwood changes, if species are mixed, and if small material is left on the ground after felling for varying periods. High-value logs with highly variable defect are seldom weighed, because this precludes individual log examination.

It is sometimes stated that the United States and Canada are the only parts of the world where board-foot estimates are used and, hence, implied that these are the only countries that use log measures incompatible with those used in other nations. This is far from true. Some South and Central American countries and Liberia use board feet, and in parts of the world where there formerly were British colonies, the "super" foot and quarter girth measure (Hoppus) are common. Elsewhere, cubic feet or cubic meters are used to measure logs, but the rules for determining them are bewilderingly various. Logs may be measured inside bark or outside bark; diameters may be small end, two end, or midlog; and fractions may be dropped or rounded to the nearest whole number.

TREE MEASUREMENT

Inventories of standing timber are made for at least four general purposes. National and regional inventories of timber resources are made to provide broad guides to public and private forest policy. More detailed inventories are made to appraise market values of large blocks of timberland for sale, purchase, or exchange. Diagnostic inventories provide a basis for such management decisions as which specific areas to include in the annual cutting budget and which are highest in priority for cultural investments. Timber sale inventories are made to estimate the volume and quality of stumpage offered for sale.

In all these kinds of inventory, estimates of tree volume and quality are important, although amount of detail and standards of accuracy vary widely. Each kind of inventory will be discussed to examine the measurement systems used and some of the problems encountered.

TIMBER RESOURCE INVENTORIES

An example of timber resource inventory in the Douglas-fir region is the Forest Survey, conducted on a continuing basis by the U.S. Forest Service under authority of the McSweeney-McNary Forest Research Act of 1928. Forest Survey also is responsible for preparation of timber resource analysis reports. Because Forest Survey is a national effort, basic information is gathered and summarized according to national standards. The standard units for reporting timber volume are cubic feet and board feet, the latter estimates based on the International 1/4 inch rule (a log scale rule that allows for taper and closely approximates sawmill production). In the Douglas-fir region, Forest Survey data are also summarized in board feet estimated by the

Scribner rule (based on tree volume equations giving 32-foot log formula Scribner values for trees with measured d.b.h., total height, and Girard form class) to facilitate regional reports in units similar to those now used by the Douglas-fir timber industry.

Forest Survey starts with land classification on aerial photographs, systematically choosing points for interpretation at a density of about 1.3 per square mile. Then the points that fall nearest a 3.4-mile-square grid are ground checked if their land class is not obviously nonforest. If the ground check shows the area to be commercial forest, a cluster of 10 prism points and 1/300-acre plots is installed that covers about an acre. On these plots, diameter, quality, and stocking are tallied and a subsample of height and growth is taken. Provision is made for reidentifying the plots at the time of the next survey, thus making possible a direct measure of growth, mortality, and other changes. These records are the basis of survey reports of acreage by land type, timber volume and growth, and forest condition. Sampling errors at one standard deviation are 3 percent per million acres and 10 percent per billion cubic feet.

Forest Survey's major problems with measurement arise from the need to translate estimates of standing-timber volumes into units of potential product – tons of pulp, board feet of lumber, and square feet of veneer or plywood. Forest Survey is also faced with the problem of translating reports of product output and log production into estimates of drain on the timber resource. A large part of the difficulty comes from the fact that accurate conversions to and from Scribner board-foot estimates depend on knowledge of length and diameter of the logs in question. However, part comes from lack of specificity of the term Scribner scale. It may mean long logs, bureau net scale (without taper allowance on logs up to 40 feet); or it may mean 8-foot veneer blocks, gross scale. It may imply water, truck, or rollout scaling, which often produce different estimates. Other Survey measurement problems are those common to all tree and log measurement systems.

The 10-point plot design is standard for both Forest Survey and National Forest inventories and provides data useful for both Survey reports and National Forest planning. National Forest crews intensify the sample by using a 1.7-mile grid instead of a 3.4-mile grid. In 1966, the Bureau of Land Management in its reinventory work also started using Forest Service field procedures on an intensified grid.

Survey processes these field data to Survey standards, and the two agencies process them to the standards used in their management planning and allowable cut calculations. For the past 3 years, National Forest inventory estimates have been based on net local tree volume estimates derived from log measurements on active timber sale areas. (National Forest Douglas-fir scaling and grading rules closely resemble those of the Puget Sound Bureau.) This gives a volume estimate based on local defect and current utilization and scaling practice. The Bureau of Land Management bases its inventory on volume of 16-foot logs by the Scribner-formula rule and estimates of defect deductions for each sample tree.

No other agency or industry was found to be using current Forest Service sampling design in inventory, although quite similar field measurements are made by the timber industry on CFI (continuous forest inventory) plots. These CFI plots are established in second-growth stands. They attempt to sample directly stand changes due to growth, damage, mortality, cutting and cultural practices. Such inventories provide more accurate estimates of growth than can be derived from yield tables. They are similar in most respects to regional surveys and the inventories on which public agencies base their calculation of allowable cut.

Some of the problems arising from Forest Service and Bureau of Land Management inventories center around public statements about allowable cut. Some people appear to ignore and others to not understand differences between the board-foot estimates of the two agencies, others make invalid comparisons of log or finished product data with allowable cut, and still others restate allowable cut as percent of inventory without qualifications. Some of these are not strictly measurement problems and some are due to differences among Forest Survey, National Forest, and Bureau of Land Management board-foot estimates and to the differences between log scale estimates and lumber volumes.

National Forest inventory estimates should come closest to log scale on sales, provided the local sample base is truly representative.

TIMBERLAND VALUATION

Timberland valuation inventories are made for sale, purchase, or exchange of timberland, to assess taxes, to appraise damages, to determine compensation under condemnation, or to determine value when timber property is offered as collateral. Such valuation assumes there is an open market for the property.

Inventory intensity varies with the size of the property, value per acre, uniformity of the stands, and with the purpose of the valuation. A common procedure is to map or estimate areas in types that are classified by major species, five size classes, three densities of stocking, plus indications of site, minor species, age of origin, and condition class. Noncommercial forest or nonforest land types are estimated separately. Basal area and age of poletimber stands is sometimes estimated and compared with normal yield tables.

To complete the valuation, an assay of current and future accessibility and operability is included with the inventory to establish present market value.

Merchantable sawtimber volume usually includes sound trees, 11 or 12 inches d.b.h. and over, estimated by the Scribner rule on the basis of 32-foot logs to a top 40 percent of d.b.h. or 8 inches. Quality may be assessed on basis of butt log grade, or estimates of grades of all logs may be made. Visible defect is deducted tree by tree, and hidden defect and breakage may be deducted tree by tree or on an area basis. Trees suitable for poles and piling are usually tallied separately as is dead merchantable material.

Most estimates make use of volume tables such as the Mason, Bruce, and Girard form class tables; the Washington tarif tables; or local volume tables. However, ocular estimates of total net volume ("volume direct") for samples or entire stands are still occasionally used.

The measurement problems in timberland valuation are of two classes. The first is determination of the species, tree size, top diameter, defect, quality, etc., that differentiate trees or portions of trees that have positive stumpage value. The second is accurate estimation of volume to these merchantable limits. This estimate is usually based on one of the various kinds of volume tables made from detailed measurements of felled trees to merchantable limits selected by the table's author. Single-entry tables based on d.b.h. alone are quite likely to be unrepresentative of the area being inventoried. Double- and triple-entry tables provide more safeguards against this kind of bias. A greater source of inaccuracy in estimation of net volume than volume tables is the deduction for defect. The cruiser tries to estimate the amount that will be deducted when logs are scaled. The ends of a log expose its interior defect, hidden from the cruiser. Surface indicators of defect usually can be examined closely during the scaling but are often hard to see on the standing tree. Knowledge of defect typical of the species, locality, and stand condition is helpful but not infallible in estimating hidden defect.

DIAGNOSTIC INVENTORIES

A diagnostic inventory involves inspection of many acres with enough volume estimation to determine relative operability and management needs. Often this is done in the course of other travel in extensively managed timberland. However, with intensive management, this type of survey should cover the entire property at a minimum of 10-year intervals. This inspection is needed to determine current accessibility, operability, and opportunities for stand or site improvement by scheduled commercial cuts or cultural treatments. (There appear to be no specific timber measurement problems in this type of survey not encountered in other inventories of standing timber.)

TIMBER SALE AND PURCHASE INVENTORIES

Measurement systems used for timber sales or purchases differ more widely than those used in other timber inventories. The measurement procedures and problems are different for partial cutting than for clearcutting. They also are quite different for old-growth than for young stands. Sales arrangements also differ. For example, some sales are lump sum, some have flat rates by species for all net volume scaled, and some have different rates for log grades within species. Some sales are negotiated, some are by sealed bid, and some are by oral auction. These different sales arrangements impose different inventory problems on both the seller and the prospective buyer.

A major difference between buyers and sellers is that in a locality where there is competition each buyer has to examine many more sale areas than the sellers. (Average number of bidders per sale is four to five.) On the other hand, the seller makes detailed plans for road location and standards, silvicultural treatments, fire control, and slash disposal for each sale area; these become part of the sales prospectus and sales contract and assist the buyer in deciding whether or not he is interested in the sale.

Rather than examine each of these possible variations individually, we will discuss the general measurement system, with comments on major differences in procedure.

The purpose of the sale or purchase inventory is to establish a price the seller will accept or a price the buyer will pay for the specific timber under whatever restrictions or requirements (roads, fire protection, and cutting methods) the seller establishes. These prices ideally approach fair market values, although there is seldom an open market to confirm these values.

Studies of logging and milling costs and product value or studies of logging costs and log values may be used to establish stumpage values. The former is customary in Federal sales and the latter in State and private sales. Some private stumpage prices are in part based on knowledge of bid prices in recent public auctions. In any of these approaches, the generally applied test of accuracy of the net volume estimate is the log scale and grade of the timber removed from the sale area. Where the seller incorporates current scaling and grading rules and practices into his sales inventory and uses an allowance for breakage, the scale tests his ability to foresee breakage, bucking

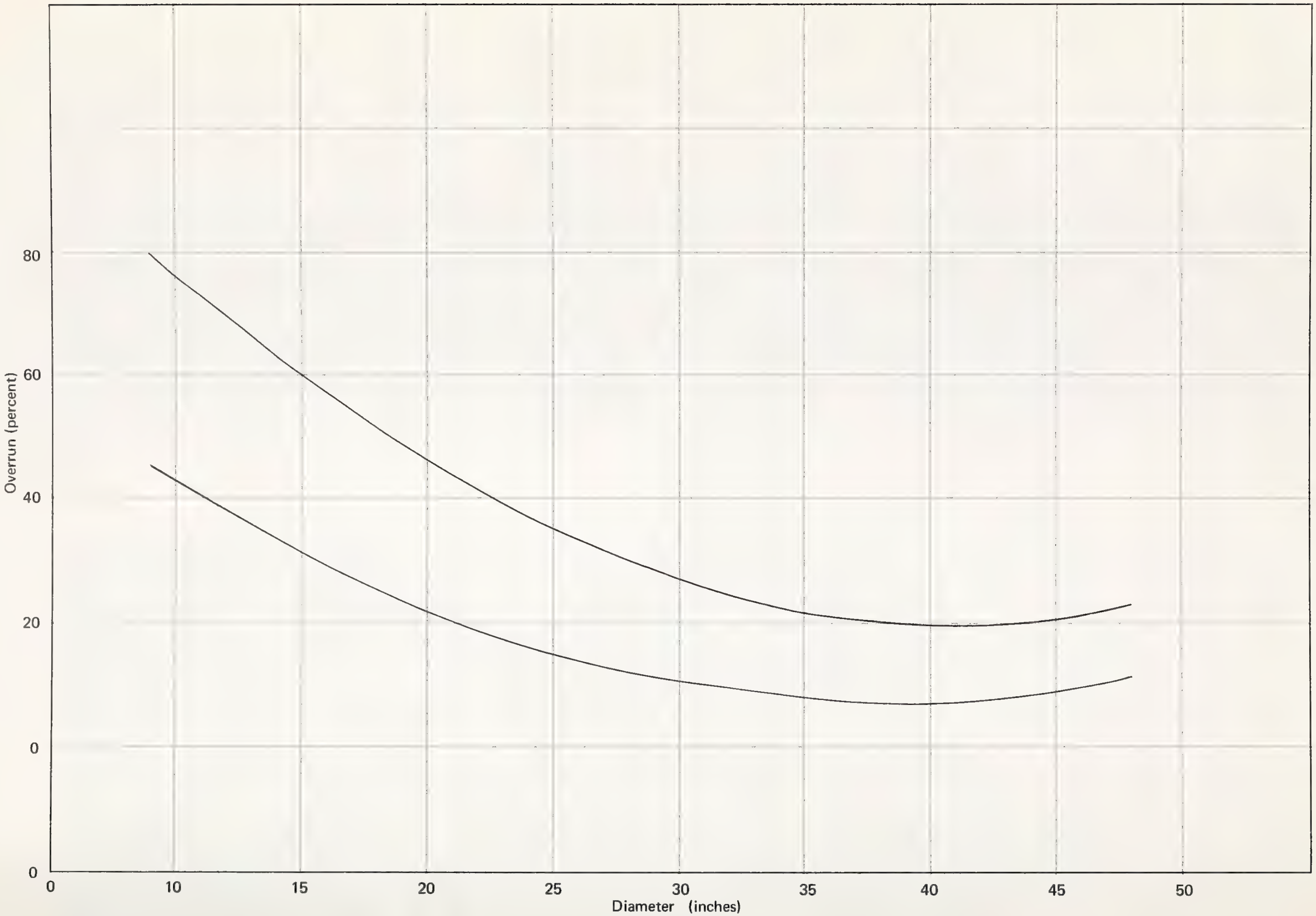


Figure 3.--Overrun; same logs, long-log scale (40-foot maximum), dropping fractional inches, applied to woods-length logs, compared with short-log scale (20-foot maximum) applied to mill-length logs.

practice, utilization, and unseen defect as well as to estimate gross tree volume and log grade. Where the seller estimates sale volume according to other scaling or grading practices, the volume and value estimates must be adjusted before a meaningful comparison with scale can be made (Figure 3). In scale sales, both buyer and seller get copies of the scale tickets. In lump sum sales, the buyer usually has the logs scaled and can compare this scale with the sales inventory, but the seller gets no independent estimate of the scale.

Usually, in the Douglas-fir region, the estimate of net volume is based on a line-plot inventory using either fixed-area or prism plots. Sampling rates of 5 to 20 percent are common. Often, diameters of all sample trees and the total or merchantable heights of a subsample of trees are measured. Sometimes all heights are estimated. Grades are assigned to all logs of sample trees. Visible defect is deducted, and hidden defect and breakage are estimated on an area basis.

An important variation in this procedure is the 100-percent inventory used by the Bureau of Land Management for lump sum sales. Here an attempt is made to record the height and diameter of each tree in the sale. Hidden and visible defect are estimated tree by tree. Every 10th tree is graded by 16-foot logs.

Some partial cut sales are thinnings in young stands, some are thinnings in stands near rotation age, and some are sanitation-salvage cuts in overmature stands. Either trees to be cut or trees to be left are marked. Either arrangement makes it difficult for the buyer to sample cruise the timber, since he cannot be positive that marking is uniform throughout the sale area or that his standards of merchantability (both size and cull) are identical with the seller's.

As in other inventories, various volume tables are available or can be prepared for use in sales and purchase inventories. Sampling errors are calculated to estimate the probable limits within which the volume estimate would fall if all trees had been measured by the same procedures as sample trees. However, sampling errors are not valid estimates of the limits within which the scale will actually fall.

The buyers interviewed generally felt that the seller's volume estimate and scale should agree within 10 percent on scale sales and 5 percent on lump sum sales. Many examples of failures to meet these or similar standards were cited. It was not always clear how recent these examples were or whether needed adjustments had been made for the cruiser's assumptions about utilization, unseen defect, and scaling practice.

These same standards usually were applied to comparisons of buyer's and seller's cruises. Generally, it was felt that tree counts and gross-volume estimates were satisfactory, although one or two instances were mentioned where the buyer's and seller's cruisers apparently disagreed on limits of merchantability. Major discrepancies were almost always attributed by purchasers to failure to make accurate allowance for defect. Sellers pointed out that it is not possible for them to predict bucking practice, which can affect gross scale, grade, and cull, when the purchaser is not known before the sale. On the other hand, the buyer's cruiser usually knows by experience the bucking practice and utilization to expect. Occasionally, it may be difficult for the buyer's cruiser to identify exact sale boundaries.

Two recent developments in sales inventories should be mentioned here. Both are being used on some Bureau of Land Management sales. One is 3-P sampling (probability proportional to prediction); the other is tree measurement with an optical dendrometer (Figure 4). The 3-P sampling scheme ensures heavier sampling of large, more valuable trees and lighter sampling of small, less valuable trees than conventional plot samples. (Prism cruising also selects a heavier sample of large trees.) The 3-P system substitutes a sampling error based on a kind of continuous stratification of volumes for one based on little or no stratification. This sampling error is based on the volume of trees as directly measured, rather than on some volume table value with attendant possible bias and usually unspecified error of estimate. The optical dendrometer makes possible accurate unbiased direct estimates of gross volume and can be used to examine the stem for defect indicators.

Figure 4.--Optical dendrometer used to measure upper-stem diameters and heights on standing trees.

LOG MEASUREMENT

The major purpose of log measurement is to estimate grade, volume, or weight as a basis for payment in sales. Sometimes logs are scaled and not graded. Log scale may be the basis for payments to logging contractors and for log transportation. Today, practically all fallers and buckers are paid on hourly rates, and log measurements are no longer the basis for wages. Logs are also measured to update or check yard or pond inventories and to measure daily or shift input into mills.

The first time logs are measured is when trees are marked for bucking. At this time, decisions are made that affect grade and volume of the logs produced from the tree. With high-value trees and variable defect, this marking should be done by well-trained and experienced men. In low- or uniform-value material, this job is less critical. Each operator has his own set of decision guides for bucking.

Most logs in the Douglas-fir region of Washington and Oregon are measured by scaling bureaus. The aggregate volume scaled by the four bureaus each year is about 10 billion board feet. It is not known what proportion of the yearly cut of 12 billion board feet is scaled more than once.

Largely because of the efforts of the Northwest Log Rules Advisory Group, the log scaling and grading rules of different scaling bureaus are identical in all but a few respects (such as descriptions of No. 3 peelers and pulpwood logs). The Forest Service has incorporated these rules into its scaling manual for the Douglas-fir region in Washington and Oregon. The Bureau of Land Management uses procedures that are customary elsewhere in the United States (short-log scaling and scaling to nearest inch). Industrial landowners and mill operators use other scaling and grading rules internally, but generally use scaling bureau rules for purchase and sale of logs. In southwestern Oregon, logs from east of the Cascade divide and from California are scaled by short-log rules, and some plants use short-log scale.

Although published scaling and grading rules are the same in most respects, instructions for application vary somewhat among bureaus, and some people commented on local variation in application of the rules. These variations apparently are greater between bureaus and agencies and between localities than within agencies and locations. Many people stated that grades, defect indicators, or both meant different things in different parts of the Douglas-fir region. Most important of all, the problem of variation between individual scalers appears to plague all those concerned with accuracy of scale and grade determinations.

Standards of check scaling are generally 5 percent of net volume and value for batches of 100 logs or 100,000 board feet. If a rescale of a raft of logs by one of the bureaus is requested and is less than 5 percent different in volume from the original scale, the requesting party pays for the rescale and the original estimate is accepted. If the difference is greater than 5 percent, the rescale is accepted and is not charged for. With truck and rollout scaling, there seldom can be a rescale, and the dissatisfied party can only request an early check scale. The Forest Service scaling manual sets as its standards 2 percent for sound logs and 5 percent for defective logs. It is generally recognized that scalers can' be far apart in grade, defect, and gross volume on individual logs, and that the only reasonable check is on large batches of logs, where two or more scalers are expected to "average out."

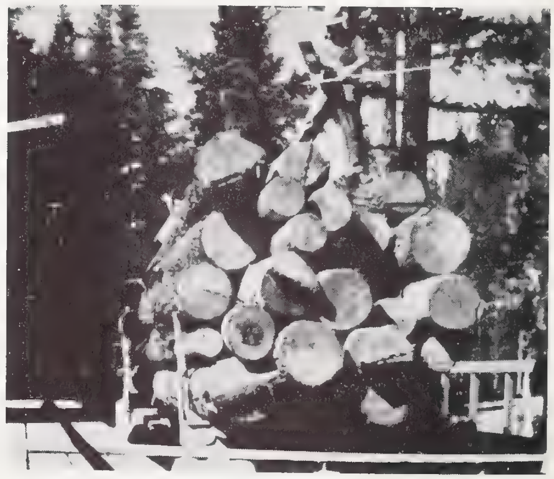
Generally, people recognize that there will be differences between water, rollout, and truck scale, although there is no concensus on what the percentage differences will be (Figure 5). Most consider truck scale highest and most erratic, particularly with eight or more logs on the truck. Defect indicators are hidden, and lengths of interior logs are hard to estimate. Occasionally, it is difficult to identify the small end of some logs. Rollout scale, where there is room to turn logs, is generally most accurate for sound or small logs. Rollout scale, with measurement of average diameters, is somewhat higher than water scale where a single diameter is measured. Some kinds of defect indicators show up best in water scale. For these reasons, scale and grade of one batch of logs will vary with scaling conditions; to be a valid comparison, the check scale should be made under the same conditions as the original scale.

Some of the difficulty in yard and pond inventory and tally into the mill is caused by differences in scaling conditions. Log tagging is used in some instances to maintain tight control of volume in storage and volume used by the mill. Most mill operators find this too expensive, and some rely on individual raft or deck total volumes. Some use net scale into storage and gross scale adjusted by average defect out of storage. Others calculate average net log volume going into storage from scale tickets, and count logs going into the mill. Where logs are bucked in yard or pond and the segments do not go directly to the mill – or where part goes to a veneer mill and part to a sawmill – storage inventory commonly becomes quite inaccurate. A discrepancy of about a million feet in inventory, with some 20 million feet moving through storage, was mentioned.

The Scribner Decimal C rule is generally used in the Douglas-fir region for scaling logs. Some export logs are scaled net

a: Rollout or yard

b: Water

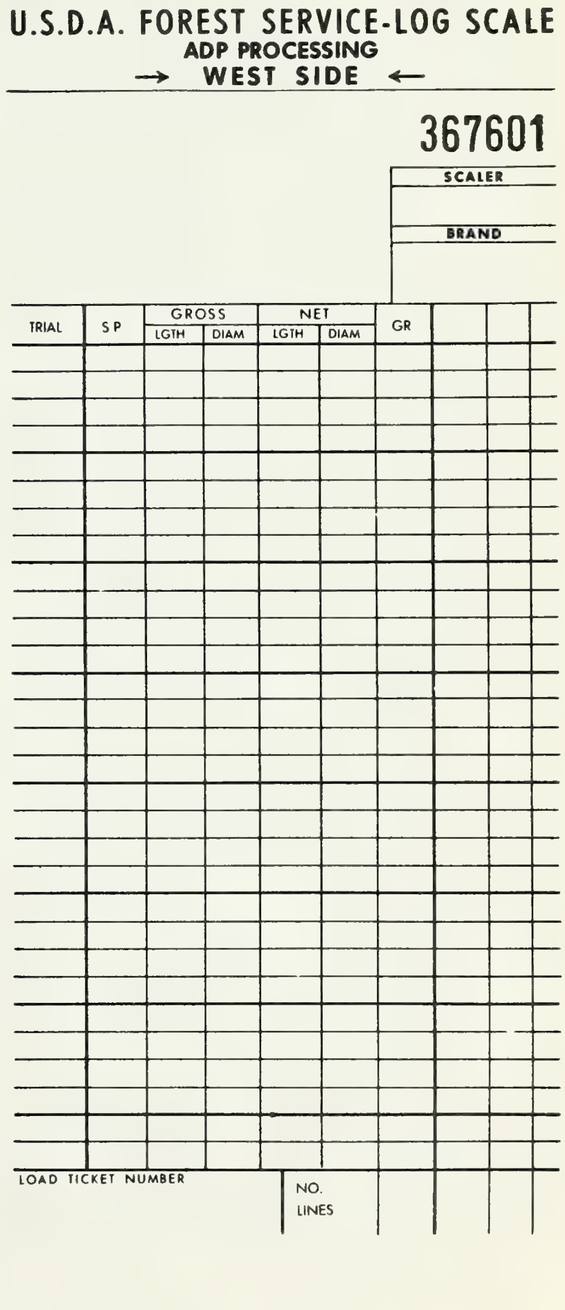


c: Truck

Figure 5.--Log scaling conditions

Scribner by scaling bureau rules and others are scaled net or gross Brereton. Since about a billion board feet are exported, there is considerable familiarity with Brereton scaling procedures. The use of weighing has already been mentioned. Even though weight scale might seem to be an ideal way to pay for log hauling, one operator who tried it stated that truckers wanted to know how many board feet they were hauling.

Total net scale is seldom accepted as a full measure of value. Either the detailed scale bill is examined, a sample of logs is inspected, or both (Figure 6). Thus, knowledge of how the logs run is an important part of the valuation process. Range of diameters and lengths, kind and variability of defect, and whether the logs are high or low within grades are all important considerations in establishing value. Knowledge of source locality and past experience with logs from the area also help in log valuation.


U.S.D.A. FOREST SERVICE-LOG SCALE
ADP PROCESSING
→ WEST SIDE ←
367601
SCALER
BRAND

TRIAL	SP	GROSS LGTH	GROSS DIAM	NET LGTH	NET DIAM	GR			

LOAD TICKET NUMBER
NO. LINES

Figure 6.--Type of log scale bill used with automatic data processing.

PRODUCT STUDIES

Studies relating product output to log input are made for various reasons. These can be classed as operating efficiency studies, batch studies, and individual log studies. The most frequent and least accurate of these studies is the comparison of weekly or monthly records of input and output for management control. Operating efficiency of a mill is judged on estimates of volume and value of log input compared with volume and value of product output.

Somewhat better controlled are batch studies run for a day, a shift, or part of a shift. In these, there is usually little question of the input and output not representing identical logs – all logs going into the mill are scaled – and the green chain or chipbin is cleared before and after the run. However, these studies usually consider only total input and total output by green grade and dimension or, if chips, by dry weight. Grade recovery of lumber and veneer may be studied by assembling logs of a single grade, and usually of a limited diameter and length range, in batches large enough to keep the mill operating for the duration of the study.

The most refined studies are those in which each log is numbered and its products are measured individually. This is a more expensive study to make, and may slow mill operations and challenge sawyers to maximize output. Sometimes, dimensions of the products are prescribed and are not identical with those produced in normal mill operation. For these reasons, results of such studies are sometimes not considered representative of regular mill operations. However, such studies have provided the clearest insights into the important effect of log size on production costs and of log dimensions and grade on product volume and grade. These studies provide the basis for some operation research analyses and sometimes, in conjunction with the results of batch studies, are part of the basis for appraising timber values.

In periodic control studies and batch studies, the usual estimate of input is number of board feet, Scribner Decimal C. In sawmills, this is compared with green chain lumber tally. The difference is overrun or underrun. As long as overrun remains fairly constant, the production process is considered to be under control. The amount of variation in overrun that causes concern varies tremendously. In some mills, large deviations for several months will be expected to average out before the year is over. In others, a change of less than 5 percent for a 2-week period has to be examined and explained to be sure operating efficiency has not changed. These varying standards are partly a result of differences in tightness of control of measurement of logs into the mill; differences in defect, grade, and size of logs processed; and dimensions of lumber produced. A mill that can stick to a uniform grade mix and constant average log diameter is expected to have more uniform overrun than a mill with frequent changes in average log quality and size. Mill experience usually suggests the overrun typical of log source localities. When new sources are tapped, a batch of logs may be run through the mill to get an idea of what overrun to expect.

Veneer mills appear to use a similar control process, although most use as their control the ratio of number of square feet of 3/8-inch plywood to a board foot, log scale. Ratios ranging from 2.2 to 2.9 were mentioned.

Larger industries have used operation research studies to analyze their production. Some plywood plants use the grade mix in their order file to control log input to the mill and log inventory. Advantages of minimizing inventories of logs or finished plywood of unneeded grades are obvious. This type of study can be based on grade recovery studies of large batches of logs. Another application of operations research is the determination of product mix that maximizes profit when operating capacities of mill equipment and potential sales volume of various dimensions and grades of plywood are imposed as constraints. A study of this kind can be based on average grade and size of log input in the recent past.

To determine the most profitable use of logs by grade and size, more detailed recovery studies are required. In these studies, the board-foot Scribner volume estimate for the log by itself is practically useless. Important variables are diameter, length, taper, quality; and defect of the log. Some recovery studies suggest that present methods of estimating quality and defect are inadequate. These findings should not surprise mill operators who feel that the No. 2 sawmill grade is too broad or who have observed that product recovery often has a more constant relation to gross scale than to net scale. In using the results of such recovery studies, an integrated industry can consider several alternatives for logs – saw, peel, chip, or sell. A single-product industry has a simpler alternative – process or sell logs.

Accurate studies of product recovery require different applications of basic log dimensions and different defect deductions for various products. Pulp yield is based on the cubic volume and density of wood in the log. The only defect deductions are for missing or rotten wood. (Possibly volume of knots and compression wood should be considered, but no studies were found that did this.) Veneer yield is related to small-end diameter, amount of necessary round-off, effect of taper on fishtail production, and core diameter. Core diameter may be determined by chuck size, core market, or log characteristics. The standard saw-log defect deductions are not appropriate for veneer, with some defects being more severe and some less severe for veneer. The value of logs for poles and piling depends on small-end diameter, taper, length, and defect. Lumber yields also are related to small-end diameter, taper, length, and defect. Published results of some lumber recovery studies using Scribner log rule estimates show high overrun for small diameters, a minimum overrun at 28 or 30 inches, and increasing overrun for larger logs. These studies usually eliminate effect of length on overrun by limiting the range of log length in the study. Where defective logs are separated from sound logs, overrun usually is greater for defective logs. These studies also demonstrate that each mill must make its own product recovery studies because overrun varies so greatly among mills (Figure 7).

No studies were encountered that tested the three basic units – length, surface area, and cubic volume – suggested by L. R. Grosenbaugh in the Davis report[6] on allowable cut. Limited tests at the Pacific Northwest Forest and Range Experiment Station show that these basic units are effective estimators of lumber and veneer volume production. However, this trio of units is no better than the basic log dimensions from which they were derived. Their advantage lies in the ease with which they are measured and cumulated in standing trees.

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[6] *Davis, Kenneth P., Briegleb, Philip A., Fedkiw, John, and Grosenbaugh, Lewis R. Determination of allowable annual timber cut on forty-two western National Forests. Rep. Board Rev., U.S. Forest Serv., Washington, D.C., M-1299, 38 pp., 2 tables. 1962.*

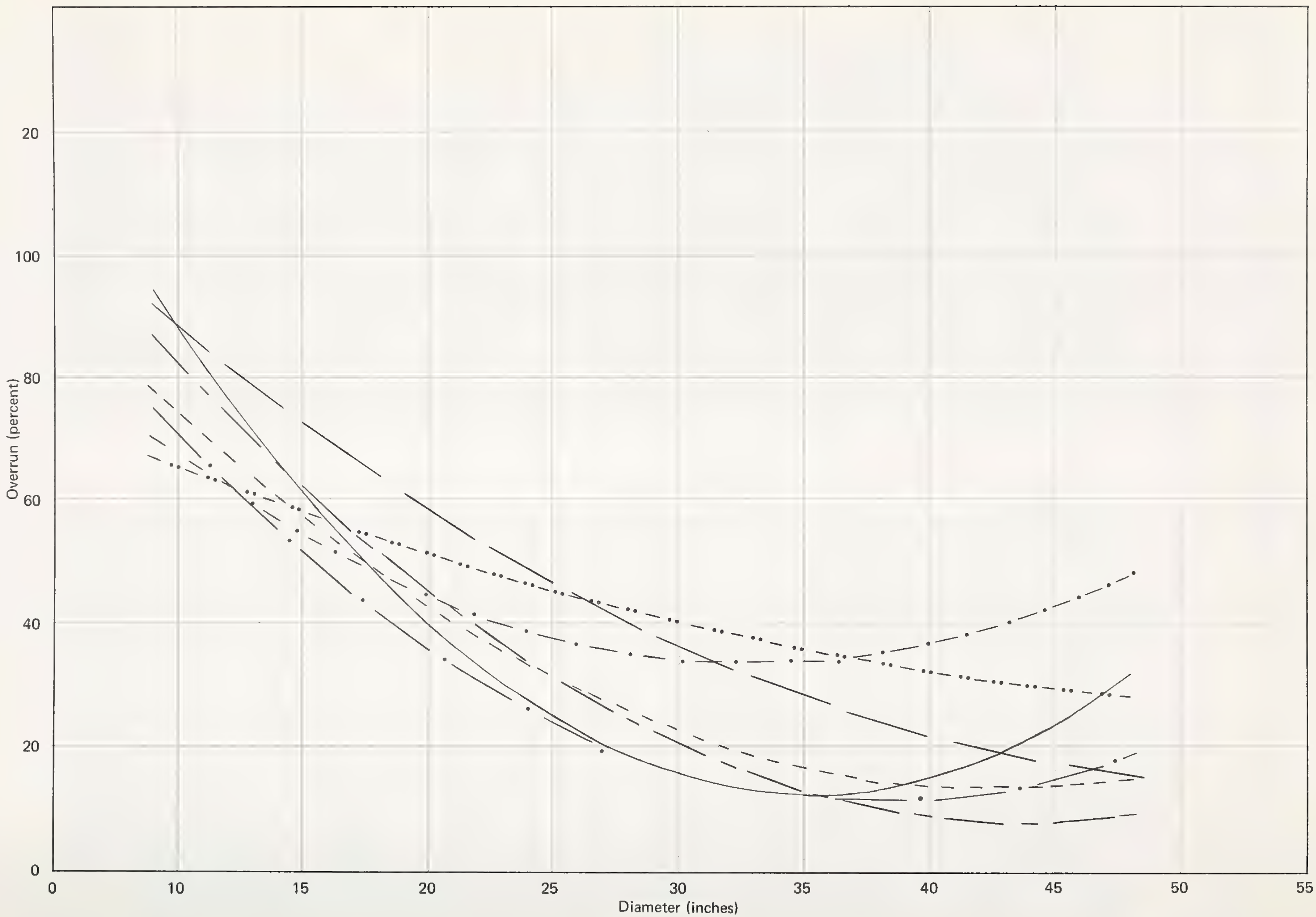


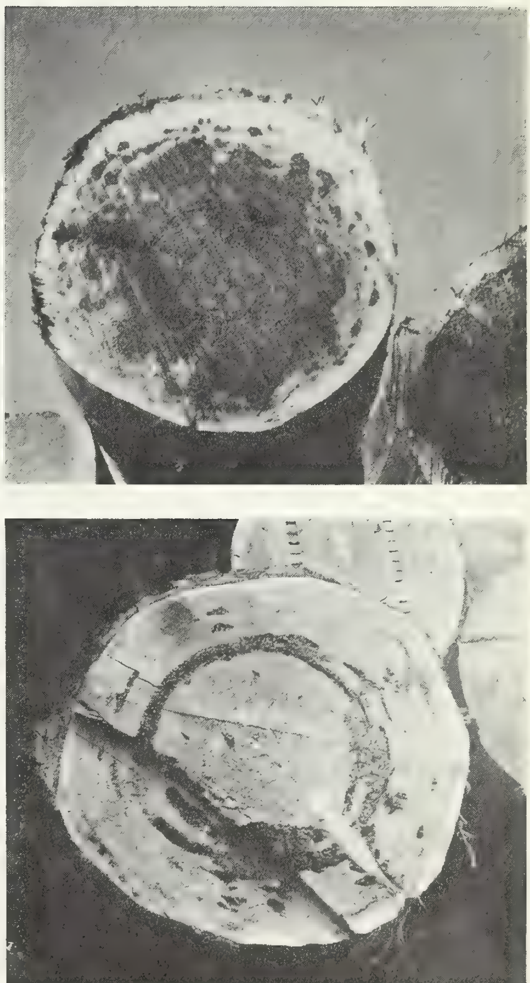
Figure 7.--Variation in overrun among seven mills, log scaled by scaling bureau rules.

There may be advantages in cumulating them for batches of logs, but these have not been demonstrated. Apparently, no tests have been made in the Northwest of the utility and accuracy of log weight and length as cumulated measures for batches of logs to estimate product recovery. However, the operator of a dimension mill reported that the closest way to estimate lumber yield is to weigh logs. On the basis of 10 loads of 30-percent defective Douglas-fir, he found that he got 1 board foot of lumber for each 6.3 pounds of logs. He used this factor for a year with good results.

SOURCES OF TIMBER MEASUREMENT PROBLEMS

There are several ways measurement problems can be classified. Consideration of problem source is important because some measurement problems will remain to annoy all concerned, no matter how many changes are made or refinements added to the present systems. Measurement problems typical of old-growth timber will disappear in time. However, others are generated by the way records are kept or sales are made and can be reduced only by changing record keeping or sales procedures, not by adjusting measurement systems.

Figure 8.--Defective logs.



DEFECTIVE TREES

Defect is a major source of problems, particularly in the approximately 500 billion board feet of old-growth timber in the Douglas-fir region. Since high-value old growth will be with us in commercial amounts for 30 to 50 years, any system for measuring timber in the Douglas-fir region must be adapted to good defect estimation. In standing trees, external indicators of defect must be used; those high in the tree are hard to see, and many defects have no external indicators. After trees have been bucked, the cut sections give samples of the inside of the tree (Figure 8) and external indicators can sometimes be examined closely. However, if logs must be measured on trucks or in decks, these external indicators may be hidden. It is generally agreed that unless the cruiser or scaler frequently has watched logs being sawed or peeled he cannot interpret defect indicators correctly under current scaling rules. Some studies suggest that to get the same accuracy, sampling rates in defective timber must be several times greater for net-volume estimates than for gross-volume estimates.

SHAPE OF LOGS AND TREES

Many measurement problems would disappear if trees were circular in section and tapered uniformly. Since neither of these conditions is often found in nature, there are problems of diameter measurement and variations in rules for making diameter measurements on logs. A common rule is to measure the greatest diameter and one at right angles to it. Because of shape and abnormal swellings or knots, it is often unlikely that two scalers will agree on either direction or magnitude of the greatest diameter.

Accurate estimates of cubic-foot volume are easy to make on logs with uniform taper. However, Brereton scale, which assumes there are 12 board feet in each cubic foot, is usually more than 1 percent low when the small end is less than 70 percent of the diameter of the large end. If nominal rather than actual length is used, there will be an additional low bias averaging about 2 percent. Scribner scale neglects taper and becomes progressively more biased as either taper or length increases. The amount of bias usually is expressed as overrun. Nonuniform taper and butt swell present many problems in determining cubic-foot and Brereton scale, whereas long-log Scribner scaling ignores the existence of these problems. Nonuniform taper also creates problems of form-class estimation in cruising and in selecting appropriate conversion factors after logs have been scaled in any unit.

HUMAN ERRORS

Human errors will be present as long as timber is measured. If the errors due to carelessness and lack of experience in determination of length, diameter, and defect of trees and logs were reduced to a minimum, there would still be other errors in the measurement systems. These include selection of inappropriate volume tables or equations, incorrect determination of form class or utilization limits, wrong choice of breakage deduction, use of incorrect conversion factors, selection of inadequate sampling intensity for high variable populations, and a host of other erroneous decisions.

VARIATION IN LOG AND TREE SIZE AND VALUE

The Douglas-fir region may have the distinction of having the greatest average variation in log and tree size and value of any part of the United States. Single logs scaling 6,000 board feet are still cut (and larger could be, except for highway weight limits and capacity of logging equipment). Obviously, cruising and scaling systems, geared to recognizing value of No. 1 peelers, are too expensive for low-grade material. Variation in value requires flexibility in measurements; it can define the acceptable accuracy of weight scaling and sample scaling and cruising. Change in size of logs and trees causes variation in product recovery ratios and reduces accuracy of converting factors.

COST OF MEASUREMENT

Since measurement itself adds nothing to the intrinsic value of the product, costs of measurement should be held to a minimum. This could result in choice of conditions for measurement that minimizes measurement costs but adds to other production costs such as truck delays at scaling ramps. On the other hand, attempts to minimize effect of measurement on other production costs could result in scaling conditions that don't permit accurate measurement, such as in large storage decks.

VARIABLE LENGTH LOG EXTRACTION

Cutting logs in variable lengths appears to be the most efficient way to get timber from the forest to the mill. However, in truck scaling, accurate determination of volume is easier when logs or bolts are uniform in length. Long logs have more hidden defect than short logs. Butt swell on long butt logs causes trouble in cubic-foot or Brereton scaling and in taper determination for board-foot segment scaling. Cruisers can't predict exactly where trees will be bucked and, under present systems, can't estimate accurately what the aggregate scale of the logs will be.

MULTIPRODUCT UTILIZATION

The value of a log depends on the products that can be made from it. Many people seek accurate factors for converting from one way of expressing volume of logs to other ways so that they can determine the most profitable use of the logs. Another approach is to seek more efficient means of estimating product potentials of each log than catalogs of conversion factors. Other measurement problems attributed to the multiproduct potential of logs are that defects affect usable volume differently for various products and that log lengths and trim requirements differ for each process. Also, minimum diameter limits of merchantability vary among products, making it difficult for cruisers to predict how much of each tree will be used.

CHANGING PRODUCTION TECHNOLOGY AND CONSUMER DEMAND

Changes in production technology include development of new products as well as changes in processes or equipment in making timber products. The measuring system should provide information on volume or raw material available and also accurate estimates of product output. An example of change is the recent expansion of chipping facilities. Several observers reported that after chippers were installed in sawmills, the production of No. 4 lumber and hence overrun was reduced.

Another area where changing technology and consumer demand generate perplexing problems is in allowable cut calculations. These calculations are based on even flow of timber products. This even flow should be susceptible to measurement. But the term is not well defined – no one proposes even flow of masts for sailing ships, yet historically this was once the most valuable product of American forests. More recent problems in assaying even flow are those generated by diminishing use of logs for lumber and increasing use of mill residues in pulpmills.

USE OF LOGS IN TIMBER VALUATION

The intermediate step of valuing logs is so deeply entrenched in the way timber business is conducted in the Douglas-fir region that it may seem natural or necessary. However, there are those who point out that timberland produces trees, that timberland owners sell trees, and that the value of trees is determined by the useful products into which they can be converted. From this point of view, log measurements and log values should be considered only if they are useful in establishing the value of trees. This, in theory, is what is done in lump sum sales. However, the way things work today, the check of accuracy of a timber cruise applied in practice is the log scale. It already has been noted that sampling error of the cruise is not the same as accuracy measured by this means.

Another problem related to use of logs in timber valuation is the implicit requirement that some or all of the logs be scaled, which is a cost of doing business. Also, where the sale contract requires log measurement, it is possible that utilization practices in the woods may be poorer because payment is made only for logs scaled as merchantable, whereas in lump-sum sales the purchaser can use as much of the tree as is profitable at no extra cost.

USE OF A SINGLE UNIT OF ESTIMATE FOR CONTROL

Although volumes of trees and logs are estimated in various units, accountants insist that only one unit be used in the financial records of each business. When production costs are being studied, it is helpful to use a unit that is related to the physical job of harvesting, transporting, and processing wood. However, studies of product recovery and logging and milling costs all show that except for chips a single unit of volume does not serve. Almost all such studies show the important effect of log size—often as indicated by scaling diameter. Accountants who insist on a single unit readily accept a limited classification scheme (i.e., different dollar values for different grades and species). All these things suggest that a single unit of volume does not really serve the needs of the timber processing industry. The problem is how to supplement it to get the information needed for business control.

CONVERSION FACTORS AND AN ALTERNATIVE

Industry's request for development of more accurate conversion factors suggests two obvious things. The first is that modern industry is interested in accurate estimates of varied product potentials of trees and logs. The second is that existing conversion factors do not serve this interest. When a conversion factor is stated, the statement should show the conditions under which it was developed and mention sources of difference that will reduce its accuracy. For product converting factors, these conditions include methods and equipment in the manufacturing plant and species and size of logs. Other variables that may affect conversion accuracy are bark thickness, taper, and amount and kind of defect.

Although variation in manufacturing methods and equipment must be considered somehow, there appear to be two approaches to solving the conversion problem. One is to accumulate long lists of converting factors suitably qualified so that one appropriate for each occasion can be found. The other is to develop a means of recording and cumulating information about the size and shape of batches of trees or logs that can be used to estimate recovery of any product or probable scale by any rule. This latter approach is not so extreme as it may seem, for there would be no particular problem in keeping track of both volume (in any unit) and length of all logs in a batch. These two totals give an estimate of average volume per unit length, which describes average log size. Whether additional derived units should be cumulated or some measure of the range and variability of the log dimensions would be more useful is open for study.

Results of product recovery studies, expressed as equations showing either change in overrun or in percent of log volume converted to the product as a function of log diameter, can be considered continuously varying conversion factors. However, this concept can be applied only to certain special equation forms; many other predicting equations can be viewed only as direct estimates of product recovery based on measured log dimensions.

CRITERIA FOR MEASUREMENT SYSTEMS

Throughout the discussions of measurements, statements were made that explicitly or implicitly set up standards of performance and accuracy deemed desirable. Some of these were mentioned by most of those interviewed, others by but a few. Because this study was not an opinion poll, the relative popularity of most criteria will not be discussed.

UNIFORMITY

Nearly everyone mentioned uniformity as the outstanding desirable characteristic of measurement systems. Uniform systems are wanted that can be applied consistently to all trees and logs.

STABILITY

Measurement systems should not be subject to frequent minor changes. People want to know by experience how the systems work.

ECONOMY

Costs of measurement should be appropriate to value of the trees or logs and to degree of accuracy needed for efficient business operation.

UNDERSTANDABILITY

Dimensions, volume, quality, and defect should be expressed in terms understandable to both buyers and sellers of logs or trees and to others concerned with timber measurement.

OBJECTIVITY

The systems should avoid so far as possible all subjective individual judgment. This implies maximum use of direct linear measurements and counts and detailed specific instructions for each part of the determination of dimensions, quality, or defect.

CONVERTIBILITY

Accurate converting factors are wanted – from one unit of volume to another – and from any measure of raw material to any end product.

REPRODUCIBILITY

Each part of the system should be designed so that two or more people will get the same result. This makes possible direct checks on accuracy of application.

PRECISION

Various standards of precision were mentioned. Generally, in the measurement of 100 pieces or 100,000 board feet, acceptable standards 95 times out of 100 are: value or net volume of trees, 5 to 10 percent; value or net volume of logs, 5 percent; and gross volume of logs, 2 percent.

LACK OF BIAS

Precise measurements are not necessarily accurate. Measures of precision test reproducibility of measurement with a given instrument and by a specified method. Accuracy requires lack of bias in both instrument and method.

COMPLETENESS

Measurements should include examination or sampling of all dimensions and indicators of quality and defect needed to determine values of trees or logs for each product. The measurements should be adaptable to changes in technology of wood processing.

ADDITIVITY

Additivity affects many parts of the measurement systems. It should be possible to deplete inventories of standing trees by records of logs measured and logging residue. It should be possible to deplete records of storage inventory by simple measurements of logs into the mill. The sum of log and chunk volumes should equal tree volume, and this should not vary with bucking lengths. The tree and log measures should be linearly related to product quantities of major interest, so that when scale and resulting product of two or more batches are added, the sums stay in constant proportion.

HOW PRESENT DOUGLAS-FIR REGION TIMBER MEASUREMENT SYSTEMS MEET THE CRITERIA

Rather than to test all current timber measurement systems against all criteria, it seems more efficient to consider a few features common to most systems. There are at least six major headings here: systems of measurement, estimate, or exchange; rules of application for log measurement; grading rules; conditions of measurement; means of summarizing data; and possibilities of improvements that will better meet the criteria.

SYSTEMS OF MEASUREMENT, ESTIMATE, OR EXCHANGE

Six systems have been identified: Scribner log scale (board feet), Brereton log scale (board feet), cubic (feet), weight (pounds), linear (feet), and piece. Although the vast majority of logs are measured in Scribner, the use of other units violates the criterion of uniformity. These other units have been used long enough that none can be considered a recent minor change. They appear to be understandable to most buyers and sellers, but not necessarily to others interested in timber measurements. None of the units are directly convertible to estimates of product recovery without more information, particularly about diameter of logs. Most of the units may be generally additive, although they are not linearly related to all product quantities. However, the Scribner rule, because it does not allow for taper, cannot be considered additive. Overrun, and hence bias, may vary from 0 to 100 percent for the Scribner rule as applied here. Also, because it assigns no volume to 5-inch logs and relatively little to other small logs, it is not easily convertible to other units of estimated volume or to product yields of small logs.

RULES OF APPLICATION FOR LOG MEASUREMENT

As already noted, the log scaling and grading rules of the scaling bureaus and the Forest Service are quite uniform, but the supplemental instructions to scalers are said to be somewhat less so. Individual application of these rules and instructions can be erratic. Part of this trouble can be traced back to the rules which are so written that subjective judgment is a requisite of scaling and grading. Wherever subjective judgment is called upon, reproducibility is lowered. Apparently, the rules are stable because many persons commented on how difficult it is to get the rules changed.

Defect deductions appear to be not additive, because lumber recovery or overrun is usually greater for defective than for sound logs. However, scaling logs up to 40 feet without taper allowance appears to be the biggest source of failure of the rules of application to meet the criteria. There is lack of uniformity both because Bureau of Land Management uses short-log scaling and because east-side and California logs are used in the Douglas-fir region. Data on board feet from the Douglas-fir region based on Scribner long logs cannot be added to board-foot estimates from other parts of the United States and cannot be compared directly with lumber production records. The results of long-log scaling are understandable to buyers and sellers but apparently not to many others interested in the timber industry. Long-log scaling without taper allowance is neither complete nor additive and requires knowledge of log length and taper before accurate converting factors can be found.

GRADING RULES

Grading rules are not uniform. Diameter limits and other characteristics vary among species. This makes grading rules difficult to understand. Practically all these rules require subjective judgment of what grades of products the log will produce. This reduces reproducibility of grades for individual logs. They appear to be quite stable, since names, indicative of former utilization, have lingered on after manufacturing technology has made these names obsolete.

CONDITIONS OF MEASUREMENT

Because conditions of measurement are not uniform, measurements are not necessarily reproducible and bias and accuracy may vary. Where parts of logs are hidden during measurement, subjective judgment is inevitable. Only occasionally do conditions make complete measurements possible, although they are not required by most present scaling rules.

MEANS OF SUMMARIZING DATA

Some log and tree measurement data still are worked up by hand and use of log scale or the volume tables – others are summarized on electronic computers. Hand calculation is less accurate, once records have been edited, than electronic, is more expensive, and leads to omission of much detail that can be summarized cheaply on electronic computers. This suggests that hand computation prevents the completeness of record that is available today and that can be used to get good estimates of multiproduct potential yields. However, many machine programs have been written merely to replace rather than to improve hand summaries.

POSSIBILITIES OF IMPROVEMENT

In view of the failure of present measurement systems to fully satisfy the standards of performance, it is pertinent to ask if systems can be improved so that they will. It is obvious that some criteria call for performance limited by other standards. For example, there must be a balance between economy and precision. However, the criteria are compatible and present knowledge is sufficient to supply many of the parts of measurement systems that would meet these standards. However, there are still difficult questions of objective assessment of grade, defect, and accurate and additive estimates of product recovery standing as obstacles to completely satisfactory measurement systems. Some research has been done on these questions but more is needed.

DISCUSSION

Present timber measurement systems in the Douglas-fir region have developed gradually in the last century. Most logs are measured by the Scribner log rule without taper allowance for logs up to 40 feet long. This rule probably gave reasonably good estimates of lumber recovery when mills cut nothing smaller than 12-inch logs and considered low-grade lumber unmerchantable. However, with current sawmill utilization it gives high overrun, and when average log size varies it gives highly variable overrun. Use of Scribner long-log scale creates difficult converting factor problems for the half of the logs that are not used in sawmills.

Although most buyers and some sellers seem satisfied to use Scribner long-log scale as the basis for sale and purchase of trees and logs, the standards of accuracy for 100-piece lots suggest the acceptance of large errors in individual log measurements. If errors were random, 5 percent in 100 pieces would be equivalent to 50 percent in each individual. If all errors were in the same direction (bias), the average individual error would be 5 percent. Actually, the 5 percent in 100 pieces is partly an allowance for random variation and partly for bias. Although great variation in piece measurements is recognized, it is usually claimed that these fluctuations average out and that estimates of experienced cruisers or scalers agree quite well. This undoubtedly is true for small and uniform-value logs, but is somewhat questionable for large logs with highly variable defect. It is this latter kind of logs that requires greatest accuracy in measurement. A scaling bias of 5 percent on a 2-million-foot sale at $40 a thousand costs $4,000. A major source of complaint and dissatisfaction among users of the present systems is the employment of inexperienced cruisers or scalers – and most recognized the need for training.

Despite the familiarity of buyers and sellers with the measurement systems, these systems are certainly not well understood by those not active in the timber market. Outstanding sources of confusion are differences between long- and short-log scale, between net and gross scale, and between scale and product recovery. Even amongst insiders there appear to be some misconceptions, such as an assumed independence of log price from the scaling and grading procedures. However, the greatest weakness in current systems is implied by the remark that even an experienced man could "lose his shirt" if he tried to enter a market 200 miles from the area in which he gained experience. The weakness is obviously in recognition of quality and defect, not in log dimensions. The requirement that cruisers and scalers gain experience by watching logs being sawed or peeled is further evidence of the local and subjective nature of grades and defects in present systems.

SUMMARY

Many problems in timber measurement in the Douglas-fir region have been discussed. A problem of great concern to many forest managers is lack of understanding of the measurement systems by those not active in the timber market. This is not strictly a measurement problem. However, some specific measurement problems can be noted:

1. The Scribner rule, which assigns little volume to small trees or logs, is not well adapted to estimation of value of second-growth stands.
2. Long-log scaling without taper allowance makes conversions to any other unit of volume inaccurate unless lengths and tapers of logs are known.
3. Estimation of grade and defect is based to a large extent on subjective judgment.
4. Different defects reduce yields of various products to a different degree.
5. Most volume estimates for standing trees depend on volume tables that have undetermined bias and unspecified error of estimate.
6. When cruising standing trees, sellers cannot predict accurately the utilization and bucking lengths and, hence, the probable scale.

An additional problem is the present need for the timber industry to be able to accurately determine the value of each log for alternative products. This requires either a large catalog of precise converting factors or good means of estimating potential yields of each log – information not furnished by present systems.

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1968. Timber measurement problems in the Douglas-fir region of Washington and Oregon. U.S. Forest Serv. Res. Pap. PNW-55, 29 pp., illus. Pacific Northwest Forest & Range Exp. Sta., Portland, Oregon.

Timber measurement problems in the Douglas-fir region were studied by consulting users of these measurements. This report summarizes current practices and the objectives and standards of performance of various users and discusses adequacy of current systems in light of these requirements.

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Headquarters for the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is in Portland, Oregon. The area of research encompasses Alaska, Washington, and Oregon, with some projects including California, the Western States, or the Nation. Project headquarters are at:

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