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Many centers of population in the Pacific Northwest are dependent upon employment in the forest based industries. Many of these timber dependent communities look to the public forests for their raw wood requirements. In some localities the installed capacity has outstripped the local wood supply. This necessitates reaching into other areas within the same subregion or into areas, such as the pine subregion, east of the Cascade Range.

This interchange of logs between subregions creates problems, in log scaling, grading, and marketing, that are not of common knowledge nor fully understood by those affected by them. This is the problem we are concerned with in this study.

A public timber sale purchased on the east-side was partitioned into three subsales. One subsale, representative of the timber on the east slope of the Cascades, was used for a source of a log population

for the model in this study.

From a population of 999-log loads a sample of 105 loads was selected. Each truck load was scaled by the rules of the east- and west-side at the same time, location, and conditions. Loads from each day of operation were included in the sample.

These paired loads were analyzed using the Student's "t" to test the null hypothesis, that no difference existed between scaling practices, at the five percent significance level for length, gross, and net volume. The hypothesis was rejected for there were significant differences between practices for all categories.

There were 1514 logs in this study model with a gross volume of 705 MBF and 827 MBF for the west- and east-side practices respectively. These volumes were expressed as a ratio of .853.

Every load was examined and each log was paired by the two lengths as determined by the two scaling practices.

All logs that were unpaired because of mismatched lengths were discarded. The remaining 1029 paired logs represented 68 percent of the original log count and 80 percent of the original gross volume. The gross volumes of 568 MBF and 658 MBF for the west- and east-side practices respectively were expressed as a ratio of .864.

The difference between the gross volume ratios from the original 1514 logs and the 1029 paired logs were (.864) - (.853) = 1.1 percent. This 1.1 percent was attributable to length and piece accountability.

The difference between the paired logs gross volume ratio of .864 and unity was 13.6 percent. This percentage was attributable to the differences that were a result of taper scaling on the east-side.

The net/gross ratio differences between the east- and west-side scaling practices was 3.9 percent. This was attributable to the subjective judgment of the individual scalers.

The study model logs were scaled, graded, and log prices assigned to each grade. These volumes and values were weighted by log grade and species and a single value was expressed in dollars per net MBF Scribner scale for each subregion.

The log value, stumpage values, and operating costs expressed in dollars per MBF were placed on an equivalent basis by dividing the operating costs and stumpage values by the total west-side/east-side net volume ratio of .813. An additional charge was added to the operating costs for the greater haul mileage.

The logs from the model were placed into both the east- and west-side markets and profit ratios were determined to be .069 for the former and .085 for the latter. This was expressed as net dollars per MBF Scribner scale of $6.26 for the west-side and $3.84 for the east-side market.

The highest net dollar return clearly emphasizes that marketing, grading and scaling are ranked in that order in the overall economic-mensurational picture.

A Comparative Economic Analysis Between Log Scaling Practices

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INTRODUCTION

The Problem

The forest products industry faces many problems, several of which are associated with the increasing population. The population pressures are making demands which affect the lands that sustain the wood resource needed by the industry. The net effect of any land use change is that some segments of the industry are displaced and must shift to a new source of supply to meet their roundwood requirements.

Many centers of population in the Pacific Northwest are dependent upon employment in the forest-based industries. In some of these communities, the wood-using plants there look to the public forests for approximately one-half of their raw material supply. These economic areas located in the Douglas-fir subregion from northern Washington, throughout western Oregon and into northern California consume nearly 14 billion board feet annually.

Some of these timber-dependent communities must reach beyond their own locality for logs to satisfy the demands of their installed capacity. Approximately three-fifths of these economic areas satisfy over 70 percent of their needs locally, however, Salem imports about two-thirds of its needs, while the Seattle demand exceeds one-half of its local supply. Portland requires approximately 40 percent of its total wood requirements to be supplied from outside of its borders. Portland qualifies for the title of being the most diversified geographically, marking ten different economic areas in the Douglas-fir subregion plus eastern Oregon and Washington as sources for timber (Austin, 1969).

With the increasing demands on the resources within the Douglas-fir subregion it is natural that some of the timber supply on the east-side of the Cascades is being harvested for sale on the outside.

When these logs move from these east-side timber sheds, the differences between scaling practices do cause difficulties for the forest industry.

It is this problem of log measurement, quality and markets with which this study is concerned.

Objectives

The objectives of this study are:

1) To quantify the differences between scaling practices for the log length, taper, and piece accountability for the gross volume, and defect and breakage for the net volume.
2) To examine the reasons for the log scale volume (Scribner) differences, that occur between scaling practices in the Pacific Northwest.

3) To qualify all species of roundwood by a grading classification appropriate for each subregion's scaling practice. The Columbia River Bureau Grading Rules will be used for the logs placed in the west-side market and a general "woods-run" grade will be used for logs entering the east-side market.

4) To determine the maximum net dollar income for each thousand board feet, Scribner log scale weighted by grade, species, and scaling practice for each market.

Scope

Geographically this study is limited to the Pacific Northwest. It is further restricted to those areas where there is a flow of logs from one area to another having a dissimilar scaling practice. The focal point of interest here is the interaction caused by the exchange of logs between the two subregions. This study, from the practical aspect, is concerned with the several economic areas embracing both the east- and west-side market centers. This primary region can be depicted as triangular in shape, with one point at Puget Sound, another at the south end of the Willamette Valley, and the third at the confluence of the Columbia and Snake Rivers in the vicinity of Pasco, Washington.

Method of Analysis

An east-side public timber sale was the source for the log population that was used in this study.

This sale was of sufficient volume to create several subsales, each one in excess of five million board feet Scribner log scale.

A subsale, designated as II, was selected as the source for the study model samples. This selection was made from a choice of several subsales and was done for these reasons: It was representative for the timber species and size in the primary sale. It was the median subsale, for the entire sale contract, in position, operation time span, number of loads, number of logs, and volume. The operational contract was geared to a fully integrated west-side operation, allowing complete flexibility for log length manufacturing. The market location was a primary consideration for this not only transitioned the log from one scaling practice to another, but transportability and translocation of the commodity was geographic and economic as well. The measurement and quality evaluation was performed by the respective scalers for both practices under exact conditions in time and place. The information from each scaler was recorded on a separate scale sheet.

The Columbia River Bureau scale tickets indicated length, diameter, species, grade for gross, and net volume and the number of logs on each load. The public agency scale ticket information was given for length, gross, and net volume and the number of logs on each load. The log volume was determined from the taper difference and was entered on the ticket at the time of scaling. No diameters were included on the ticket. Diameters were determined through the use of volume taper tables. A "woods-run" grade was considered on the east-side, for all logs, regardless of species. Each load had two sets of records identified by ticket, truck, scaler, location, and market numbers, and the buyer, seller and haulers names.

A ten percent sample consisting of 105 loads was selected from these load tickets. Each load was averaged for length and these mean lengths were tested, by the null hypotheses, for a significant difference at the five percent level using the Student's "t" Test for paired observations. The gross volume was used to analyze the differences between practices for length, taper, and piece accountability. Net volume was used in the analysis for differences due to defect and breakage.

These logs were placed in both the east- and west-side markets. The location and economic conditions, of each market, were indicated by the operating costs, log market values, and profit ratios. Differences between practices involving values were adjusted by using the differential ratio to place costs and prices on a comparable basis.

Definition of Terms

West-Side

The Douglas-fir subregion embraces the geographic area west of the crest of the Cascade Range in the Pacific Northwest and is regionally referred to as the west-side. Here the scaling practice accepts the 40-foot log segment as the maximum scaling length.

The scaling diameter is measured at the small end of the log inside the bark. Fractional measurements are always taken to the next lower full-inch mark.

Taper allowance is arbitrarily considered to be one-inch per 10-feet of length when the log exceeds the single log maximum of 40-feet. This permits the assigning of an interior diameter inside bark for other than singular segmentation at the time of scaling.

Grade is assigned from descriptive lists which enumerate the external surface characteristics and overall size dimensions.

All log scaling and grading in this Douglas-fir subregion is done by one of five bureaus who act as a third-party referee for log sale transactions.

East-Side

The ponderosa pine subregion embraces the geographic area east of the Cascade Range in the Pacific Northwest and is regionally referred to as the east-side.

The scaling practice in effect occasionally accepts a 16-foot, but most frequently the 20-foot is the maximum log scaling segment called for in contracts.

Diameters are measured inside the bark at both ends of the log (butt logs excepted) to determine the rate of actual taper for: 1) determination of internal diameter for other than single segmentation scaling; 2) the proper selection of both diameter and rate of taper table by log length so the gross board-foot volume can be correctly determined. Butt logs are considered for taper individually or an average taper is established by a study for specific sales or areas. Diameter measurements for single segment logs are taken inside bark at the small end of the log as on the west-side.

Multiple diameter measurements resulting in fractional inches are rounded to the next higher inch, if the measurement falls on the one-half inch mark or greater, and conversely if the fractional inch measured is less than the one-half inch mark. When diameters are averaged and the resultant falls at the fractional one-half inch mark, then that measurement is rounded down to the next lower full inch and is recorded as the scaling diameter.

The log grade determination for species other than pine is minimal on the east-side.

There are no accredited bureaus on the east-side. Usually the public agency is the timber seller and does the scaling. This information usually does suffice for all transactions affecting the scaled logs.

The National Forest Handbook and supplement sets forth the scaling practice rules for each subregion in the Pacific Northwest for the federal agencies. Third-party bureau scaling is the accepted practice on the west-side.

The Scribner log rule in the form known as the Scribner Decimal C is used throughout both of the subregions. In this form the board-foot volumes are rounded to the nearest 10 board-feet and the zero is dropped.

The log volumes are determined by diameters measured inside bark, and lengths are measured to the even 2-foot multiples in a similar manner. The maximum segmentation is 40-feet on the west-side and 20-feet (occasionally 16-feet) on the east-side. The log grade is determinable in both subregions, through the use of the "bureau" grading system in the Douglas-fir subregion on the west-side and a "woods-run" grade for each species in the pine subregion on the east-side.

The term "woods-run" simply indicates that the general quality of the timber is considered and a price for the entire volume on a net MBF scale is considered. This is most appropriate on the east-side for species other than pine. On the west-side log grade lists are set down as guide lines for log scaling and grading to be used as such by the scalers.

MBF means thousand board-feet as determined using the Scribner log rule.

Installed capacity refers to the production capabilities. In this paper it refers to the volume of wood needed to run the installed wood manufacturing equipment at full production for one year.

Piece accountability refers to accounting for each log from the time it is loaded on the truck in the woods until it has arrived and is unloaded at its terminal destination. A system of tickets, records, and recounts are used. This is a most important feature of the log scaling, grading, and marketing system.

LITERATURE REVIEW

History of Log Measurements

Throughout history the wood products industry has been continually searching for a satisfactory solution to its raw resource measurement problems. An excellent bibliography on measurements has been assembled to be used to help resolve this dilemma (Bruce, 1968).

Some of the vagaries of the Scribner log rule should be reviewed. When the Reverend Scribner first diagrammed this rule in 1846, he was only concerned with logs in the range from 12 to 44 inches in diameter and lengths between 10 to 24 feet. Various extensions have been projected over the years and today this rule embraces diameters from 6 to 120 inches and lengths from 4 to 100 feet.

The Decimal C part of this rule was first published in 1910 after having been used by the U.S. Forest Service for several years prior to this. The Scribner rule apparently was extended downward to the 6-inch diameter class, using the Lufkin Company's Decimal C Rule. The original Scribner values were then rounded to the nearest 10 board-feet for those diameters from 12 to 44 inches. The Spaulding log rule was the source for the Scribner rounded values from 48 to 72 inches. The upper limits of the Scribner Decimal C version were patterned from an extension of the Spaulding curve using the

International 1/8 inch log rule as a guide to shape the curve to give these higher values. The exact derivation of this Decimal C version over its entire range is still a matter for conjecture (Bruce and Cowlin, 1968).

While both the commercial and research results are given practical meaning by the Scribner Decimal C rule, the research results are less than satisfactory because of irregularities present. This difficulty was partially resolved by Don Bruce (1925) who published a mathematical formula for 16-foot logs: $V = .79D^2 - 2D - 4$, in which V is the volume in board feet and D is the diameter inside bark in inches at the small end of the log. For diameters from 12 inches and up, volume is largely a function of D^2 while in the lower diameters the $2D - 4$ becomes the more effective factor upon the computed volume, by lowering the rate of volume change in relation to diameter change. This formula, while approximating the published volumes very closely, has the advantage to indicate measured, logical increments of volume from diameter to diameter and from length to length for any given log. One-sixteenth of the log volume by this formula is that volume for a one-foot segment. The volume of any length log is simply an exercise in multiplication.

Staebler (1953) and Hoyer (1965) used this version of the Scribner rule in their individual studies in which the volumes of long logs bucked and scaled as two short logs were compared under various rates of taper.

Log Form

The merchantable product that is manufactured from the log is dependent upon four variables: diameter, length, form, and defect (Dilworth, 1970).

Of these variables, probably log form is the most difficult to work with. Logs having the same scaling diameter inside bark at the small end, but each with a different diameter at the butt end, will show a wide range of individual volumes of the end product manufactured (Dobie, 1964).

The rate of taper does vary from the stump to the tree tip. This rate of taper is quite variable but is uniform over a fairly wide range. Through the production function of "bucking," the tree is manufactured into logs. Each log assumes the form of a truncated section of the tree bole from which it originated. These truncated sections are named for the frustrum of the geometric figure that each one resembles (Dilworth, 1970).

The log originating in the butt section of the tree is of a neiloidal configuration with the average diameter occurring in the lower half of the log. Conoids develop from the mid-tree bole with the average diameter being equidistant from either log end. High form old growth will develop logs of a cylindrical form from this mid-bole location, the diameters here are uniform throughout the entire log. Top logs are considered a paraboloid with the average diameter occurring in the upper half of the log (Dilworth, 1970).

Log Size

Ker (1962) compared the board foot differences between long and short log bucking to show the change in the lumber recovery factor. The overrun factor for recovered lumber was reduced when the logs were bucked and scaled as short logs. The lumber recovery factor indicates that full tree length logs had 132 percent overrun as opposed to 26 percent overrun when bucked as short logs.

Overrun is due in part then to the use of taper sawing, better manufacturing, and utilization techniques. Staebler (1953) further notes that in the measurement of long logs under the bureau scaling practices on the west-side, no allowance for taper is made for logs under 42 feet in length. The portion of any log that is outside of the scaling cylinder (scaling diameter inside bark at the small end of the log) is the taper. The amount of taper is proportionately greater in long logs with small diameters. This wood outside the scaling cylinder is actually used in the conversion to the end product thus contributing to the overrun.[1]

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[1]See Figure 1 in the Appendix.

The focus of concern, while not directed toward the recovery of the log's cubic volume specifically, does point up the comparative gross differences between scaling practices. As the length and diameters inside bark on each end of the log vary in their related ratios, the log form changes in its ratio. As these changes are taking place, the rate of taper is responding in a like manner as the log is reduced in length. The lumber-recovery factor does show the necessity for qualifying the scaling practices applicable. Only through this identity can an analysis be made which evaluates diameters, lengths, rates of taper and volume records (Wright, 1969).

Scaling Practices

Variations due to geographic source of logs are considered to be of less importance than the differences arising from the factors of scaling practices and the age of the timber (Row and Guttenberg, 1966).

Making comparisons between long and short log scaling are, in reality, difficult to accomplish for standardization between practices is lacking. Scaling will vary with cutting practices, physical location (woods, landing, truck or water), geographical location (east- or west-side of the Cascade Mountains) (Bruce and Cowlin, 1968). Historically, short logs have been scaled on the east-side, but today there is an increasing number of short logs being scaled on the west-side (Bruce, 1961; Hopkins, 1966).

Systematic errors from the book scale are introduced by differences between the actual scaling practices. One type of error is the result of rounding the scaling diameter to the nearest inch (Bruce, 1961) and length to the nearest foot (Laver, 1951). If the rounding is always downward, the biased measurement of all logs (e.g., 12.0 to 12.9) is recorded as 12.0 inches.

Bruce (1961) suggests the difference in log scale volumes arising from measuring to the nearest and to next lower inch amounts to 10 percent for a 10-inch log and 5 percent for a 20-inch log. These differences are highly correlated to the scaling diameter. Hoyer (1965) in his taper studies in second-growth Douglas-fir found the volume differences were greater for long logs developed from low form timber. For extremely high form trees and scaled as long logs, the volume differences were much lower.

Bruce (1961) found, in a direct comparison between tree volumes in long (32-foot) and short (16-foot) log ratios, that long log second-growth Douglas-fir was 90 percent of the short log scale volume. Hoyer (1965) shows the 32-foot, in relation to the 16-foot volume, has a range from 82 to 89 percent. The upper range of the percentages represents the larger diameter trees (logs). These latter data are based upon a 6-inch top while the former is based upon total height. When Bruce (1961) used merchantable height, the results in both studies, for all practical purposes, were the same.

In the comparison of the coefficients of variation for each ratio equation for short logs over long logs the coefficients are substantially lower for short logs. Doubt is cast whether the log length or the uniformity of species can be attributed to the lower variation. It is suggested where short logs are scaled, a table of a given degree of accuracy can be obtained from a smaller number of measured trees (Bruce, 1961).

There are recent comparisons involving long log-short log scale and are of current interest. The North West Timber Operators (Ewing, 1969) compiled a study of defective old-growth federal timber sales that failed to sell. The short range objective of this study was to identify the basic cause for the sale rejection, analyze and correct the problem and place the sale again on the market. The long range objective was to test and evaluate the 3-P cruising system for its accuracy, reliability, and practicality. The testing of this latter objective was accomplished by projecting the log volumes and log grades for a stand of timber by using sample trees. This study comprises several timber sales with a net volume in excess of 40 million board feet. A scaling sample of approximately 3 million board feet is involved in the comparison. To really develop a true "woods-run," long-log short-log differential, it was necessary to reduce the bias in the gross and net log measurements. On logs exceeding 22 feet, the lengths were measured in even two-foot multiples for each one-inch diameter class, inside the bark, at each end of the log (e.g., 34 feet-

20 inches-26 inches). The log scale volume was then recorded for the shorter, smaller diameter (16 foot-20 inch) top log, and the longer, larger diameter (18 foot-23 inch) bottom log. The volume of these two log segments was combined and made up the total short log scale volume. The long log (34 foot-20 inch) volume was recorded from the published tabular list for Scribner Decimal C rule. These volumes were then compared for the long-log short-log differential based on "woods-run" bucking practices. This in turn was representative of the actual, not a theoretical application, of bucking practices.

The comparative differences between the government short log scale and the scaling bureau's long log scale ranged between 5.9 percent to 10.3 percent for the gross and 5.9 percent to 9.6 percent for the net volume. The short log scale, without exception, was the larger volume (Ewing, 1969).

Further comparisons were drawn between the long log scaling practices. Ewing (1969) reported these apparent differences were spread over a wider range than were the long-short log comparisons. The gross volume ranged from -9.5 percent to +2.2 percent difference and the net volume a -11.0 percent to a +0.5 percent difference. The government scale exceeded the third party scale in all but two instances for the gross volume and once in the net volume.

A study made by Hopkins (1969) for the Northern California Log Scaling and Grading Bureau compared the gross scale on 9804 logs.

These logs were a representative sample of a normal "woods-run," with approximately 25 percent of the lengths being 20 feet or less. The scale was tallied on the mill deck as these logs entered the head-rig storage. The short-log (20 foot segment) volume was 5380 MBF and 4760 MBF long-log (40-foot segment). The short-log scale consistently exceeded the long-log scale by 13 percent. There was little variation between species where a representative sample of logs was scaled.

Thompson (1964) did a taper study on western Oregon second-growth Douglas-fir. His results for long-log short-log bucking were similar to those experienced by the scaling bureau in northern California. After bucking the long-logs into short segments the volume in butt logs 20 inches or less in diameter increased 12 percent, while those logs with diameters 30 inches and over showed a 16.1 percent increase. The logs ranging between these diameter limits showed very little variation. In the second cuts, the volume increased by 10.6 percent for logs 20 inches or less. This increase dropped to only 7.6 percent for logs in the 20 to 30 inch range. Top logs 20 inches and under showed a 14.7 percent volume increase for short-logs over long-logs.

Additional observations by interested agencies, corporate bodies, and individuals indicate similar experiences in volume differentials as a result of long-log short-log scale comparisons. Crane (1964) reported some variances were spread by 30 percent. These differences were subject to variation because of species, form, location, and the scaling practice in effect. Elmgren (1970) and Alexander (1962) indicate that in net scale the volume tends toward wider differences due to the highly subjective judgment procedures involved in defect deductions.

Some of the wood products industry on the east-side have been using a low intensity yard and truck scale, endeavoring to stratify for species, quality, utilization, and size (Hubbard, 1969).

Thomas (1969) and Hubbard (1969) report that the variation within their own scaling practices under the east-side rules, ranges between 10 and 15 percent. On some samples usually this will average out to under three percent over the specific operation.

The difference was measured between the yard and mill deck scale. This factor approaches a minimal difference as experience between the yard and deck scale is reached. The mill deck scale was the final volume used for purchase and accountability for volume input conversion (Hubbard, 1969).

The British Columbia legislature (1946) discussed the variation between logs of different sizes. The point of argument centered on the measurement of small logs being 20 to 30 percent in variance between scale volume and actual converted volume.

According to the study on measurement problems (Bruce and Cowlin, 1968) the variations in log scaling are not so much the fault of the published version of Scribner, but of the local application based on the interpretation of these rules. These variations are greater between agencies and bureaus and between localities. To say there is no variation within agencies, bureaus, and localities under identical scaling practice rules is unrealistic. The human element, the variation between individual scalers, is present wherever measurement and grade evaluations are made. Errors are also made.

Log Grades

In a paper on the evaluation of log and tree quality for wood products, Lane (1963, p. 89-93) states that:

> Basic to success in any primary processing business is a thorough knowledge of the raw material being used. In industries that process raw materials, such as agricultural crops, basic chemicals, or minerals generally have sufficient information about the quantity and quality of these raw products, prior to manufacture to make a reliable estimate of the products to be produced.
>
> By contrast, most producers of wood products do not have available the kind of information needed to estimate the product potential of the trees or logs they process.

Log grading in the Pacific Northwest began prior to 1910. At that time, Douglas-fir logs were graded for sawmill use only. As the wood products industry expanded into veneer manufacturing the number of grades increased as they were needed. Today the demand for quality is paramount. The log grades are separated into several peeler, sawmill, pulp, and cull subdivisions.

On the west-side the highest quality veneer logs are priced in excess of $160 per thousand board feet with a proportional decrease for each grade to a low of about $25 per thousand board feet for the minimum merchantable quality log (Dilworth, 1970).

On the east-side log grading is basically approached on an averaged "woods-run" basis. Research on log and tree grades are currently being conducted by industry, universities and public agencies alike in an effort to satisfactorily qualify a grading system for this subregion (Lane, 1963).

It is important for not only the log scaler to know the log grading systems, but the timber cruiser must have detailed knowledge of the log grading systems if quality cruising (determining log grades in the standing tree) is to be satisfactorily incorporated into any appraisal analysis.

Since log grades are based primarily upon the recovery of the end product. It is essential for the log grader to be thoroughly acquainted with the manufacturing process and product (Dilworth, 1970).

The primary purpose for log scaling is to estimate the net usable content of the timber product in acceptable units of measure (Idaho Vo-Ed Manual No. 38, 1968). Grading then is the relative suitability for a given product as determined by a classification of the physical, mechanical, or chemical properties of the log (Lane, 1963) placing each individual piece within the qualifying category (Dilworth, 1970).

The grade assigned to any log will be the highest possible within the diameter and length requirements for that grade and species (Official Log Scaling and Grading Rules for the Columbia River Log Scaling and Grading Bureau, 1969).

The lack of basic knowledge of many log and tree characteristics has greatly hindered the development of adequate grades especially on the east-side. Trees being a biological material, are heterogeneous with no two being exactly alike. The product and value from given log grades are widely divergent and are somewhat misleading. A thorough study of the relationship between the tree characteristics, the product yield and values is necessary before any meaningful grading system can be developed. There is a wide gap between the knowledge of the quality of the end product and the less sophisticated log grades (Lane, 1963).

Defects

Defect present in the log certainly has a bearing upon the quality and the conversion of the end product. The natural defects which exist in the log before the tree is felled are sometimes difficult to evaluate. If it is of a pathological origin the defect may well be entirely obscured within the tree bole. Other natural defect, such as sweep, crook, or knots, etc. may be less obscure but can be reduced by good bucking procedures. The harvest process may well contribute to the list of additional mechanical defects such as breakage, brooming, and slabbing to name but a few (National Forest Log Scaling Handbook, n.d.).

Factors such as out of roundness, pitch spiral grain, taper, sweep, etc. have a significant effect upon the strength, specific gravity, chemical properties, and seasoning therefore certainly must have a correlation with the grading system (Lane, 1963).

Lane, Plank and Henley (1970) known for their persistent efforts to promote better grading systems have recently presented a new way to estimate quality on inland Douglas-fir sawtimber. This along with Gaines (1962) improved grading system for ponderosa and sugar pine sawlogs in standing trees, Estep and Hunt (1964) white fir log values and lumber yields, Levitan (1969) study on log scale on knotty logs, and Oregon Forest Products Research Laboratory (1958) log grade studies in the ponderosa pine subregion does much to reinforce the wood-products industry, association, public agencies, scaling bureaus, and the universities joint endeavors to promote uniformity and standardization in the quality as well as in the quantity measurements.

Log Values

The importance and reasoning for the establishment and improvement of existing log grading systems cannot be over emphasized. The log grading system that is predicated upon the manufactured end product can be equated, over time, with a monetary value, referenced quantitatively and qualitatively for each species represented.

The end product selling value within each grade, dimension, and form is dependent upon the input volume of logs of varying sizes, and the cost of converting these logs into that product. The harvesting and transportation costs by log size are added to this. An analysis of the net value of logs, by size and quality, can then be completed (Chapman and Meyer, 1947).

These analyses are related directly to the forest economy and in turn allude to the overall economic problems of society. Taking a closer look at the total economic picture, it can best be described as a flow of resources (inputs) into the economic mechanisms and from this an outflow of goods and service (outputs). The inputs are the costs and the outputs are the income from the product (Duerr, 1960).

Economic activities revolve about several elements. Human wants are varied and insatiable. Resources are limited, versatile, and capable of being combined into production commodities and finally, resources are utilized through techniques to produce goods and services to satisfy these wants (Leftwich, 1962).

Market Price

Differences in institutional arrangements are used to solve economic problems for various types of societies. The society that involves the forest products industry is classed as modern and industrial and is organized on a capitalistic base. We can divide this society further into four sectors: government, households, non-profit institutions, and the market. It is this latter sector that is held in special interest, for here is the very essence of the free-enterprise economic system. In this sector, cooperation is achieved through the voluntary exchanges of services and goods for money, and money for services and goods. These exchanges take place between enterprises and individuals or between an enterprise and an individual (Friedman, 1962).

The money equivalent of a single commodity unit is price, and value is the total aggregate of wealth, which is the sum of the unit quantity multiplied by the price (Chapman and Meyer, 1947). The proposition that the price of a commodity (logs) is determined then by the interaction of headings, termed "supply" and "demand," as the forces that affect the price (Friedman, 1967). Price is related to supply and demand, each affecting and being affected by price. Individual exchanges affect prices and prices are influenced by the quoted prices of previous sales. The market (demand) price is set, not by the urgent or average purchaser, but by the indifferent (marginal) purchaser. The minimum (supply) price is the one required that assures that production costs will be covered and still retain sufficient working resources to perpetuate the business enterprise (Chapman and Meyer, 1947).

Prices serve as guideposts, indicating where resources are wanted, providing incentives for people to follow. Factor prices serve to distribute the product, while product prices serve the function of setting standards and organizing production. Over any short period of time, when the product quantity is rigidly fixed, a need for adjusting consumption to production is called for. By being free to bid, prices will adjust, for goods in short supply, to the quantity wanted, at market prices equal to the quantity available. Prices therefore do transmit information effectively and efficiently, to provide an incentive to the users of resources to be guided by, and to follow this information. This presupposes the existence of effective competition in translating the common wishes into productive activity (Friedman, 1967).

Duerr (1960, p. 339) defines

> Marketing is that branch of production in which the title to commodities is transferred and the related function of information, exchange, physical supply, and financial services are performed. Its importance in forestry stems from its growing costliness and from its role in setting material rewards and expenses in economic life.

Types of Markets

The market in which the forest products industry is involved is comprised of comparatively few firms. Technically competition is lacking, rivalry is intense, and price is established through price leadership. Since the number of firms is few, each has a significant share of the market and can exert an influence upon it. This type of market where sellers are limited is termed an oligopoly, where the buyers are involved in like numbers the market is termed an oligopsony (Ferguson, 1966). There are two underlying reasons that can be attributed to the limited number engaged in the forest products industry; one is an aggregation within and the other is due to a geographic barrier (Duerr, 1960).

A large part of the commercial activity within the forest economy is conducted through imperfect competition. This is to say there are imperfections present in the buyers' and sellers' knowledge, their numbers, and in the commodity, or products (Duerr, 1960).

Mead (1966, p. 177) has resorted to using the theory of oligopoly to define oligopsony in the timber markets. He suggests that the oligopoly theory cannot be transferred without modification for the following reasons:

> First, the tools of analysis differ between product and factor markets. Second, markets in which oligopsonists buy tend to be geographically narrower than markets in which oligopolists sell. And, third, price is a more significant variable

in the former, whereas non-price competition is relatively more significant in the latter.

On this third point of price the oligopolist frequently sells to consumers with imperfect knowledge. While the oligopsonist, being comprised of but a few in number (by definition) are professionals with (perfect) knowledge of product quality and price.

Transportability

The physical supply function of marketing includes the concentration-dispersion, transportation, and storage of the raw wood resource. In the Pacific Northwest the concentration of wood resources is moved from the public and private sales through contractors to the processors. Aggregations occur in the system where large, private, integrated timber owners bypass some detail in the market functions. The flow of the resource follows the same movement from forest owner, through the concentrating dealer, to the principal concentration, through the dispersing dealers to the ultimate consumer. The firms engaging in these marketing transactions are limited in number by the geographical dispersion of the timber sheds. The interrelation between timber sheds and sales areas can be analyzed in terms of comparative advantage. Grade prices are determined in the process of geographic sorting and follow the principle of relative transportability. The lower the transportation rate, per unit of value, of any commodity, the farther it can be shipped (Duerr, 1960).

The very fact that logs are bulky and expensive to transport is self evident. The more an area's economy is timber dependent, the more self sufficient is the area in terms of timber supply. Some areas now have installed capacity that exceeds the productive potential of their receding timber sheds. To perpetuate business and community their raw wood resource must be obtained in some part beyond their local environs. Some logs in the Douglas-fir region come from outside the region. The areas around Puget Sound and Portland, Oregon, are timber deficient areas. Portland is the most diversified area in terms of geographical sources of timber. Logs are obtained from the areas tributary to the Columbia River Drainage eastward, in Idaho, and from the area immediately adjacent to the east slope of the Cascade Range (Austin, 1969).

Modern transportation (truck, rail, and water) with high powered equipment and better accessibility, has moved distant timber sheds to within the operable periphery of the processing centers (Gedney, 1963). In these areas with untapped timber supplies, development will take place and industries will grow. Some of this expansion will occur in the subregion east of the Cascade Range (Wall, 1969).

Cost Trends

The average stumpage prices sold in the Douglas-fir region from public sales have continued to show a long run increasing trend. Any fluctuation from this trend has been of short duration and matched the general economic activity (Hamilton, 1970). Log prices have been following the same trend as the stumpage prices. These log prices have historically reflected the local area market of which they were part and parcel. Today the trend is to a regional pricing which finds a leveling of the price range throughout the Douglas-fir subregion (Hair and Ulrich, 1970).

In the areas of the Pacific Northwest where there is competition for Federal timber, bid prices rise substantially above the appraised prices. Approximately 70 percent of the sale volume exceeded the appraised price on the west-side while only approximately one-half of the volume on the east-side was sold above the appraisal. The timber and log buyers, manufacturers of wood products, and exporters are interested in obtaining raw wood resources (including Federal stumppage) for the least cost possible. The variables that they hold in some control are the log mix and the logging and manufacturing costs. The principal cost is the raw material stumpage or logs. These areas, where competition has been limited, have become attractive to potential purchasers from the more competitive areas and they have moved in. Initially the sales are purchased close to the appraised prices but soon the area becomes competitive. This movement has been within and between the subregions (Mean and Hamilton, 1968).

THE STUDY

Sales and Subsales

A public agency timber sale, purchased competitively in the market, was the source for the log population that was used as a model in this study.

This sale was located on the east-side but had access to either the east- or west-side economic centers as alternate markets.

The total sale was divided into three smaller sales, unequal in size, each in excess of five million board-feet Scribner log scale. Each subsale was an individual unit separated from the others by a time and market factor.

When these subsales were contractually activated, the production from each was effectively tied into one specific type of conversion facility, located in only one of the alternate market centers. No deviation was made from this practice throughout the life of each subsale.

This timber sale composition was approximately four-fifths Douglas-fir and the bulk of the remainder was hemlock and white-fir. The pattern of log dimensions were equally distributed within both practices. The diameters were also equally distributed, with 25 percent of the logs under 11 inches, 50 percent under 16 inches, 75 percent under 21 inches, 95 percent under 31 inches, and the remaining five percent scattered among the 40-plus-inch diameter classes.

The lengths were somewhat more diversified. At the 16-, 17-, and 18-foot mark, the first two lengths were very evident in the west-side practice. The 18-foot length predominated in the east-side practice for the 17-foot log was not a recognized scaling length. There was some shifting at the 26- and 30-foot length. When the adjacent lengths are considered, the measure evens. A disproportionate difference between practices occurred at the 44-foot mark; here the east-side scaling practice exceeded the west-side by several percentage points. If the 40- and 42-foot lengths are combined, parity is achieved.

The measurements and grading for the total sale log population was performed by two scalers each representing his respective organization for the life of the entire sale contract.

The Model

The subsale, designated II, was used as the source of the log samples for the model in this study. It was the second subsale sold and was logged during the second contract year of the total sale. Scaling was performed on 45 separate days during this operation. This subsale comprised over one-third (34.2 percent) of the total sale population. This subsale II, total net board foot volume, Scribner log scale, was 7.215 million for the east-side and 6.029 million for the west-side.

This subsale was selected from a choice of three subsales that comprised the total sale population. Subsale II was representative of the timber species composition and size for the primary sale and for much of the timber on the east slope of the Cascades as well. These logs were cut under the specifications for an integrated west-side firm that manufactured lumber, plywood, and pulp. These end products permitted considerable flexibility in the log production in the woods without unreasonable length restrictions.

The entire production from this subsale was scaled on the truck. The measurements for each practice were performed by the scalers at one location at the same time, and under like conditions.

The other two subsales were rejected. On one the logs were measured by each scaler at separate locations and on the other the logs were cut as long as permissible which resulted in a very narrow range of lengths.

Sampling

All the load tickets for the entire sale contract were recorded chronologically on microfilm. These films were viewed and samples were drawn for each production date that scaling occurred. The scale ticket number for each load was used as a sample index and the numeral 5 was the selector. The first ticket with the numeral 5 appearing as the right-hand digit was the first load selected, and every tenth load thereafter was drawn for that date. If a 5 did not appear, the median load for that date was the first sample and the selection proceeded as before. If ten loads were not produced for that date and no numeral 5 appeared, the median loan was picked as the starting point, with a coin toss, indicating the beginning direction of the count, which was alternated until the tenth load was identified as the only sample for that date. When the entire sale population was sampled, the loads were matched with the comparative scaling practice. The loads that could not be positively identified were eliminated.

The calculation for the number in the sample (sampling rate) for a given level of sampling can be determined by an iterative procedure when the number in the whole population and the coefficient of variation is known. This requires an estimate of the number in the sample to find an appropriate value of the Student's "t" to use in the calculations. This may need to be repeated to find the proper sample size.

Sample sizes can be determined from this formula found in Dilworth (1970).

$$n = \frac{Nt^2C^2}{NA^2 + t^2C^2}$$

where

n = estimated sample size

N = number in population

A = desired accuracy in percent

C = coefficient of variation of sample units in percent

t = tabular values of Student's t.

This formula was derived by combining an infinite population formula with a limited population multiplier $(N - \frac{n}{N})$. Without this correction factor the number of samples tend to be overestimated in a finite population. The calculations for sample size can be minimized by referring to tables, charts or graphs (Johnson et al., 1963; Bruce, 1969).

The application of these tables, charts, and formula to this study with the data from Subsale II, Table 1, and using the Dilworth formula we find:

$$n = \frac{Nt^2C^2}{NA^2 + t^2C^2}$$

where

n = number of sample loads

N = 999 loads of logs

A = 3.4 percent

C = 37.17 percent

t = 1.99 standard errors

then n = 32 loads of logs were satisfactory for a 3.4 percent acceptable error (A).

The number of load pairs needed to detect a true mean difference of size D was found in Freese (1967):

$$n = \frac{t^2 \, S_d^{\,2}}{D^2}$$

The data from Table 1 for the gross and net volumes were used. The number (n) paired loads needed were 55 for the gross and 72 for the net.

The sample drawn was satisfactory.

COMPARATIVE ANALYSIS

The "t" Test

The comparative testing was based on the null hypothesis that no difference exists between scaling practices. The "t" test for paired log loads at the five percent level of confidence was implemented by using this formula found in Freese (1967):

$$t = \frac{\overline{X}_A - \overline{X}_B}{\sqrt{\frac{S_d^2}{n}}} = \frac{\overline{d}}{\sqrt{S_d^2}}$$

where

n = the number of pairs of log loads

S_d^2 = the variance of the individual differences between A and B.

The public agency's east-side scaling practice data were held in the dominant position $\overline{X}_A$ with the west-side Columbia River Scaling Bureau assuming the subordinate position $\overline{X}_B$ in the formula which enabled a consistent relationship to be maintained throughout this study.

Testing the Model

These differences were first categorized, then compared, and the results examined to determine if there was any significant difference between each truck load of logs.

These paired loads were tested at the five percent level of confidence using the hypothesis there were no real differences between scaling practices.

The results indicated there were significant differences for log lengths, and gross and net volumes. The null hypothesis was rejected.

As shown in Table 2 there were 1514 logs in the Subsale II study model. The gross board-foot volume, Scribner log scale was 705 MBF and 827 MBF for the west- and east-side scaling practices respectively. The difference between these two practices for the gross volume was expressed as a ratio of .853.

Every load was then examined and each log was matched for length with its counterpart in the opposing scaling practice.

All logs that were unpaired because of unmatched lengths were discarded. The remaining 1029 paired logs represented 68 percent[2] of the total sample log count. The volumes of 568 MBF and 658 MBF for the west- and east-side respectively represented 80 percent[3] of the total gross volume in the study model sample. The difference between these two practices for the gross volume was expressed as a ratio of .864.

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[2]Rounded to closest whole number.

[3]Rounded to closest whole number.

The differences between the total sample and the matched pairs of logs amounted to 32.03 percent for the log count and 1.08 percent for the gross volume.

These differences were separated into two additional categories attributable to length and piece accountability. The log count break-down was 31.90 percent for length and 0.13 percent for piece accountability. The gross volume was 0.97 percent for length and 0.11 percent for piece accountability.

The ratio between the scaling practices for the paired logs was .864. This 13.64 percent was attributable to the differences that were a result of taper scaling on the east-side.

The west-side/east-side ratios for the total study model sample volume were .853 gross and .813 net. There was a difference of 3.97 percent between these two practices that was attributable to the subjective judgment of the scalers.

Log Values

When the net scale of the log had been determined, the log was graded and classified as a marketable commodity. The quality was assigned by the official rules of the Columbia River Log Scaling and Grading Bureau for the west-side. A general "woods-run" grade was assigned for the east-side. The graded log was now associated with a monetary value, indicated by a unit price, per MBF Scribner net log scale. A unit price was designated for each grade level in each economic center.

Marketing

The alternate choice of markets sometimes available to the basic log commodity was usually within, rather than between, sub-regions. Recent history has shown that modern transportation technology was responsible for the elimination of many geographic, economic, and institutional barriers. The freedom of choice in market selection and the maximization of profits were the fundamental tenets that perpetuated the business enterprise. The market demand and resource supply were the mechanisms that operated the market price levels that allocated the resource.

The enterprising manager caused the forest resource under his control, to be placed in a timber dependent economic center, with a high volume need. This roundwood demand frequently was caused by the over installed productive capacity that had outrun its local log supply.

Here was a highly competitive situation that attracted, with a commodity price level a net return commensurate with the incursion costs for participation in that market.

This was the economic framework the timber industry in the

Pacific Northwest operated within in the past and continues to do so today. This study was held within these same guidelines.

This subsale was geographically situated so the markets on either slope of the Cascade range were equivalent in accessibility. The log commodity price was considered to be the primary factor for entry into any specific market.

This subsale did enter, as a unit, into both of the subregions. The log was manufactured as a commodity under the specifications for the particular conversion facility receiving it. This market transaction was established as a result by a buyer who required a resource to satisfy a production schedule. The counterpart to this transaction was a seller with the available forest resource to supply the quantity demanded. A price was determined, confirmed, and the market cleared.

For continuity, Subsale II log samples were used as an economic study model for a comparative demonstration to show what occurs when a sale was made either within or outside of the original subregion. The difference in scaling practices, price levels, and quality evaluation were quite apparent between subregions.

This model was placed within an economic center, on equivalent market levels, net MBF, and grade price for the same time period. Costs per MBF and grade were adjusted to the respective scaling practices, as well as the stumpage price, so the comparisons made were directly one to one.

Marketing Analysis

The log markets for the east- and west-side centers were determined by selecting the log prices from the 1969-1970 OSU cooperative extension log market reports.

The west-side values were established in Table 3 using these log prices and the official rules of the Columbia River Log Scaling and Grading Bureau. The volumes, grades, and species were extended for the study model. To determine the weighted species value, it was multiplied by the species total composition percentage which was summed and resulted in a single weighted dollar net MBF value for all grades and species. This was comparable to the single value in Table 3 per MBF "woods-run" grade and species for the east-side. The values were $79.81/MBF west-side and $59.04/MBF east-side.

The operating (logging, transportation, road construction) costs in Table 4 were selected from actual costs appropriate for the conditions simulated in the Subsale II study model. These costs were weighted for each subregion so they were comparable. There were some additional costs for transportation to the west-side market. While the origin and derivation of these costs were not pertinent to this study they did point to salient features that were most important. From Table 5 the west-side market profit ratio was .085 and the margin for profit was $6.26. This west-side net return was 163 percent the east-side net return where the profit ratio was .069 and the margin for profit was $3.84. The west-side market gives the greater net return.

SUMMARY AND CONCLUSIONS

Summary

The objectives of this study were: to quantify the relationships between scaling practices, to examine the reasons for the differences between the practices, to qualify all species of logs by the appropriate scaling and grading rules for each subregion, and to determine the maximum net income in dollars per MBF, Scribner log scale, from each alternate market choice. The effective area of the study touched upon the economic centers in the ponderosa pine and Douglas-fir subregions along the Columbia River basin to the feasible economic limits of transportability in eastern Oregon and Washington.

A public agency timber sale purchased on the east-side in the auction market was partitioned into three subsales. A subsale designated as Subsale II was selected as a source for the log population which was used as a study model.

There were 105 truck loads of logs selected from the 999 loads in Subsale II for the use as a study model. These loads were paired and tested against the null hypothesis at the five percent level of significance using the Student's "t" test. There were significant differences and the null hypothesis was rejected.

All 1514 logs in the study were examined and the gross volume ratio determined the west-side practice was .853 of the east-side gross scaled volume.

These logs were then paired by length from each scaling practice. The gross volumes from each scaling practice for these 1029 paired logs were expressed as a ratio .864 for the west-side 568 MBF/east-side 658 MBF gross volume.

These differences between .864 and .853 amounted to 1.1 percent which represented the gross volume differences for length. This volume difference represented the 485 logs that were not paired. Much of these length differences can be attributed to the scaling practice method of handling trim allowance on log lengths. On the east-side where trim is permissive a log is measured for its actual length. On the west-side trim is mandatory, if the required trim is missing, the log is reduced two-feet in length on the scale record. The preponderance of logs in this study were longer under the east-side scaling rules. The percentage differences between the original 1514 logs and the 1029 paired logs was 32.03 percent by log count.

These percentages were separated into two categories for length and piece accountability. This latter category refers to two logs unaccounted for in the west-side log count. The gross volume breakdown was 0.97 percent for the length and 0.11 for the piece accountability. The number of logs involved was expressed as 31.90 percent which was attributable for length and 0.13 percent for the missing two logs under piece accountability.

The difference between the west-east gross volume ratio of .864 and unity was 13.64 percent. This percentage was attributable to the scaling practices under the east-side rules pertaining to the extension of log diameters from both ends of the log into volume through the use of taper tables.

The net/gross ratio differences for the east- and west-side scaling practices was 3.97 percent which was due to the subjective judgment of the individual scalers.

When these volume differences between scaling practices for this study model were completed and totaled they were as listed in the following categories.

Categories[4]	Percent
Net Volume	81.31
Piece Accountability	0.11
Log Length	0.97
Diameter and Taper	13.64
Defect and Breakage	3.97
Total	100.00

[4]These categories are all expressed as volume difference percentages between the west-side and east-side scaling practices.

The study model was scaled and graded, prices were assigned to each log grade. These volumes and values were weighted by log grade and species. A single value was expressed in dollars per MBF net Scribner scale for each subregion.

From Table 4 in the Appendix, the log values, operating costs, and stumpage values in MBF Scribner scale are \$79.81, \$34.00, and \$39.55 for the west-side and \$59.04, \$23.05, and \$32.15 for the east-side. The west-side stumpage values and operating costs were weighted by dividing the east-side values by the total west-side/east-side net volume ratio of .813. The west-side operating costs include additional transportation charges for the greater haul mileage.

Thelogs from the model were placed into markets on both the east- and west-side. The profit ratios were .069 for the east-side and .085 for the west-side.

The economics of marketing was emphasized when the net dollar returns were compared from each market. The west-side net profit of \$6.26 per MBF was 163 percent of the \$3.84 per MBF from the east-side net return. These differences were most apparent when they were expanded using the total net volume from Subsale II. The net return was \$27,805.60 for the east-side market and scaling practices, and \$37,741.54 for the west-side market and scaling practices.

The significance of the volume differences between scaling practices based on mensurability is diminished by the advantage of an alternate choice of markets.

Conclusions

This study was conducted under somewhat unusual circumstances, however, the practices suggested here are realistic and duplicable under normal operating conditions in the Pacific Northwest.

The greatest net dollar income was obtained by placing the logs from this study into a west-side marketing center. These logs were scaled under the west-side scaling practices by a third-party bureau using the Columbia River Log Scaling and Grading Rules.

The scaling and grading practice selected should be based upon the most definitive rules. These rules should apply fully to both log quality and measurements.

The application of these rules is wholly dependent upon the ability of the scaler. He must determine the quality and quantity of the raw wood resource and he must account for the total number of logs scaled.

Log quality is equated with the monetary values for specific markets. Marketing is an integral part of this total measuring and grading process. Without the enterprising management and market placement of the log commodity, log scaling and grading would be an exercise in futility.

BIBLIOGRAPHY

Adams, Thomas C. 1968. Price trends of open market Douglas-fir logs in western Washington and northeast Oregon. Portland. 14 p. (U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station. Research Note PNW 74)

Alexander, L.B. 1962. The muddled maze of many methods of measuring timber. In: Loggers Handbook. Vol. 22. Portland. Pacific Logging Congress, p. 8-9, 114-115.

Austin, John W. 1969. Timber flows and utilization patterns in the Douglas-fir region. 1966. Portland. 89 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 89)

_______________ 1970. Production, prices, employment and trade in northwest forest industries. Portland. 48 p. (U.S. Pacific Northwest Forest and Range Experiment Station. First Quarter 1970)

Berger, John M. 1968. Timber resource statistics for central Oregon. Portland. 38 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Resource Bulletin. PNW 24)

Beylea, Harold C. and T.R. Sheldon. 1938. Some anomalies in the board foot measurement of logs. Journal of Forestry 36:963-969.

Bruce, David. 1968. Literature on timber measurement problems in the Douglas-fir region. Portland. 28 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 67)

_______________ 1969. Charts for determining sampling rate and number in sample. Portland. 6 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Note PNW 97)

_______________ 1970. Estimating volume of Douglas-fir butt logs. Portland. 5 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Note PNW 117)

Bruce, David and Robert W. Cowlin. 1968. Timber measurement problems in the Douglas-fir region of Washington and Oregon. Portland. 29 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 55)

Bruce, Donald. 1925. A formula for the Scribner rule. Journal of Forestry 23:432-433.

________________ 1961. Prism cruising in the western United States and volume tables for use therewith. Mason, Bruce and Girard, Portland, Oregon. 61 p.

Bruce, Donald and James W. Girard. (n.d.). Tables for estimating board foot volume of trees scaled in 16-foot logs based on diameter, form class and total height. Mason, Bruce and Girard, Portland, Oregon. 46 p.

Chapman, Herman H. and Walter H. Meyer. 1947. Forest valuation. New York, McGraw-Hill. 521 p.

Columbia River Log Scaling and Grading Bureau. 1969. Official log scaling and grading rules. Portland, Oregon. 43 p.

Cowlin, R.W., P.A. Briegleb and F.L. Moravets. 1942. Forest resources of the ponderosa pine region. Washington, D.C. 99 p. (U.S. Pacific Noarthwest Forest and Range Experiment Station - miscellaneous publication 490)

Cowlin, Robert W. and Robert M. Forster. 1965. The timber situation and outlook for northwest Oregon. Portland. 56 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Resource Bulletin PNW 12)

Crane, James R., Forester. 1964. Edward Hines Lumber Co. Comments on scaling differences. Westfir, Oregon.

Cunia, T. and H. Simard. 1967. Tree-length logging and wood measurement by sampling. In: Conference Proceedings on Wood Measurements. Technical Report 7, ed. by F. Buckingham. University of Toronto, p. 47-72.

Davis, Vern. 1966. Scaling small logs. In: Loggers Handbook, Vol. 24. Portland. Pacific Logging Congress. p. 67-68.

Dilworth, J.R. 1970. Log scaling and timber cruising. Rev. ed. Corvallis, Oregon. State University Book Stores. 466 p.

Division of Economic Research. 1963. Timber trends in western Oregon and western Washington. Portland. 154 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 5)

Dobie, J. 1964. Log taper related to lumber production. British Columbia Lumberman 48(5):80, 84-85.

Duerr, William A. 1960. Fundamentals of forest economics. New York, McGraw-Hill, 579 p.

Elmgren, Roy C., Forester. 1970. Boise Cascade Timber Products, West Oregon Region. Unpublished log scale comparisons. Medford, Oregon.

Estep, Eldon M. and Douglas L. Hunt. 1964. Lumber yield and log values of white fir. Portland. 35 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 20)

Ewing, Arnold D. 1969. Sales analysis and evaluation of cruise techniques, for accuracy, reliability and practicality. Euguene, Oregon, North West Timber Operators. 3 p. (10 addendum reports)

Fedkiw, John. 1964. Forest industry capacity, production and available log supplies in the Douglas-fir subregion. Portland. 63 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 11)

Ferguson, C.E. 1966. Microeconomic theory. Homewood, Illinois, Richard D. Irwin, Inc., 439 p.

Freese, Frank. 1967. Elementary statistical methods for foresters. Madison, Wisconsin. 87 p. (U.S. Forest Products Laboratory. Agriculture Handbook 317)

Friedman, Milton. 1967. Price theory. Rev. ed. Chicago, Aldine, 285 p.

Gaines, Edward M. 1962. Improved system for grading ponderosa pine and sugar pine saw logs in trees. Berkeley. 21 p. (U.S. Pacific Southwest Forest and Range Experiment Station. Technical Paper 75)

Gedney, Donald R. 1963. Toward a complete use of eastern Oregon's forest resources. Portland. 71 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Resource Bulletin PNW 3)

Gedney, Donald R., Carl A. Newport and Dwight Hair. 1966. Prospective economic developments based on the timber resources of the Pacific Northwest. Portland. 174 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Cooperative Publication on Forest Industries for Bonneville Power Administration)

Grosenbaugh, L.R. 1967. Tree form: definition, interpolation, extrapolation. In: Conference Proceedings on Wood Measurements, Technical Report 7, ed. by F. Buckingham. University of Toronto. p. 1-16.

Guttenberg, Sam. 1970. Economics of southern pine pulpwood pricing. Forest Products Journal 20(4):15-18.

Hair, Dwight and Alice H. Ulrich. 1970. The demand and price situation for forest products 1969-70. Washington, D.C. 79 p. (U.S. Division of Forest Economics and Marketing Research, Forest Service. Miscellaneous Publication 1165)

Hamilton, Thomas E. 1970. Stumpage price responses to changes in volume of timber sold. Portland. 19 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper 92)

Hopkins, C.J., Manager. 1969. Northern California Log Scaling and Grading Bureau. Personal communication. Arcata, California.

Hoyer, G.E. 1965. Variable log-length and traditional scaling practice: two problems in applying Scribner volume to second growth stands. Olympia. 16 p. (Washington State Department of Natural Resources. Resource Management Report 1)

Hubbard, Art. 1969. Confusion in the woodpile: log measurements. In: Proceedings of the 31st Oregon Logging Congress. Eugene, Oregon, The Reporter Co. p. 5-6.

Idaho State Board for Vocational Education. (n.d.). A manual of instruction for log scaling and the measurement of timber products. Boise, Idaho, 112 p. (VO-ED 38)

Johnson, Floyd A., Robert H. Ruth and Robert W. Madison. 1963. Sample scaling for timber sales. Journal of Forestry 65(5):360-364.

Ker, J.W. 1962. The theory and practice of estimating the cubic content of logs. Forestry Chronicle 38(2):168-172.

Lane, Paul H. 1963. Evaluating log and tree quality for wood products. Forest Products Journal 13(3):89-93.

_______________ 1964. Grades for inland Douglas-fir saw-logs in standing trees. Portland. 4 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Note PNW 19)

Lane, Paul, Marlin E. Plank and John W. Henley. 1970. A new and easier way to estimate the quality of inland Douglas-fir sawtimber. Portland. 9 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 101)

Larson, Kenneth R. 1967. You, too, can use sample scaling. In: Loggers Handbook, Vol. 27. Portland. Pacific Logging Congress. p. 35-38, 164, 167, 168.

Laver, C.F. 1951. Principles of log measurements. London, Ernest Bern Limited. 200 p.

Leftwich, Richard H. 1962. The price system and resource allocation. Rev. ed. New York, Holt, Rhinehart and Winston, 381 p.

Levitan, Jack. 1968. Should log scale be reduced for knots. Portland. 149 p. (U.S. Pacific Noarthwest Forest and Range Experiment Station. Research Note PNW 3)

McIntyre, R.W., et al. 1936. Log scaling. Portland, The Timberman, 157 p.

Mead, Walter J. 1966. Competition and oligopsony in the Douglas-fir lumber industry. Los Angeles, University of California Press. 276 p.

Mead, Walter J. and Thomas E. Hamilton. 1968. Competition for federal timber in the Pacific Northwest - an analysis of forest service and bureau of land management timber sales. Portland. 63 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 64)

Metcalf, Melvin E. 1965. Timber resource statistics for the Pacific Northwest. Portland. 38 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Resource Bulletin PNW 9)

Newport, Carl A. 1969. Confusion in the woodpile: log measurement as a basis for timber management. In: Proceedings of the 31st Oregon Logging Congress. Eugene, Oregon. The Reporter Co. p. 9-12.

Objections raised to scaling methods. 1946. Timberman 47(8):114.

Oregon Forest Products Research Center. 1958. Log grade studies in the ponderosa pine region. Corvallis. 24 p. (State of Oregon Bulletin 7)

Row, Clark and Sam Guttenberg. 1966. Determining weight-volume relationship for saw logs. Forest Products Journal 16(5)39-47.

Smith, Douglas S. 1967. A quantitative analysis of log volume concepts and product derivatives. Master's thesis. Corvallis, Oregon State University. 80 numb. leaves.

Smith, Richard C. and Donald R. Gedney. 1965. Manpower use in the wood-products industries of Oregon and Washington 1950-1963. Portland. 48 p. (U.S. Pacific Noarthwest Forest and Range Experiment Station. Research Paper PNW 28)

Staebler, George R. 1953. Long logs or short logs with the Scribner scale. The Timberman, LIV(10):66-68, 70.

Steel and Torrie. 1960. Principles and procedures of statistics. New York, McGraw-Hill, 481 p.

Stroup, Eldon D., Forester. 1968. Log marketing. Paper presented to the Rural Area Development Committee, Bend, Oregon, July 26.

Thomas, Frank, Forester. 1969. Tygh Valley Lumber Co. Interview on log scale differences. Portland.

Thompson, Gene, Forester. 1964. Unpublished log scale differences between long and short scaling practices on identical logs. Corvallis, Oregon.

Turnbull, K.J. and G.E. Hoyer. 1965. Construction and analysis of comprehensive tree-volume tariff tables. Olympia. 63 p. (Washington State Department of Natural Resources. Resource Management Report 8)

Turnbull, K.J., G.R. Little and Gerald E. Hoyer. 1963. Comprehensive tree-volume tariff tables. Olympia. 23 p. (Washington State Department of Natural Resources)

U.S. Comptroller General. General Accounting Office. Report to the Congress of the United States. 1966. Review of procedures for measuring national forest timber in the Pacific Northwest Region (Region 6) Portland. 35 p.

U.S. Congress. House. Committee on Banking and Currency. Hearings before the committee on the rising costs of housing: lumber price increases. 91st Congress, 1st session, March 24-28, 1969. 894 p.

U.S. Dept. of Agriculture. n.d. National forest log scaling handbook. Washington, D.C. 193 p.

U.S. Dept. of Agriculture. 1970. Timber appraisal R 6 amendment 152. In: Forest Service Handbook. Washington, D.C. p. 414. 22g--1.

Wall, Brian R. 1969. Projected developments of the timber economy of the Columbia-North Pacific Region. Portland. 87 p. (U.S. Pacific Northwest Forest and Range Experiment Station. Research Paper PNW 84)

Wright, D.M. 1969. A comparison of the British Columbia cubic scale with three log-scale rules used in western North America. Vancouver. 4 p. (Canadian Forestry Service. Department of Fisheries and Forestry, Forest Products Laboratory. Information Report VP-x-52)

APPENDIX

Table 1. Subsale II study model log loads. Gross and net (Decimal C) volume differences between east-side and west-side scaling practices.

		Gross Volume	Net Volume
d	=	12,162	14,702
d^2	=	1,601,442	2,427,348
$\bar{d}$	=	115.830	140.020
S^2d	=	1,853.220	3,546.030
Sd	=	43.050	59.550
CV	=	37.170%	42.530%
$S\bar{d}$	=	4.200	5.810
$S\bar{d}\%$	=	3.626%	4.150%
FPC	=	.895	.895
FPC $S\bar{d}$	=	3.974	5.498
FPC $S\bar{d}\%$	=	3.431%	3.927%
"t"(5)	=	29.172	25.105
N	=	999 loads	
n	=	105 loads	
Av. logs/load = 14.51			

Table 2. Subsale II study model logs, volumes and ratios.

Log Category	Scaling Practice	Number of Logs	%*	Net Scribner MBF	%*	Gross Scribner MBF	%*
Original sample	West	1512	100	633	100	705	100
	East	1514		778		827	
West/East ratios		0.998		.813		.853	
Paired logs	West	1029	68	510	80	568	80
	East	1029		623		658	
West/East ratios		1.000		.820		.864	
Discard logs	West	485	32	122	20	137	20
	East	485		155		169	
West/East ratios		1.000		.787		.811	

*Rounded

Table 3. Weighted percentage, log grades by species, dollars per MBF, Scribner log scale, Columbia River Rules for west-side and "woods-run" for east-side.

Log Grade	Douglas-fir			Hemlock-White Fir			Pine			Larch			Other Species			Total Weighted FOR ALL GRADES AND SPECIES $ MBF NET
	% Grade	$ MBF	Weighted $ MBF	% Grade	$ MBF	Weighted $ MBF	% Grade	$ MBF	Weighted $ MBF	% Grade	$ MBF	Weighted $ MBF	% Grade	$ MBF	Weighted $ MBF	
1 P																
2 P	.6	125	.75													
3 P	7.4	107	7.92				19.5	106	20.67							
SM	23.2	93.50	21.69	11.4	75.06	8.56	26.4	93.50	24.68	43.2	93.50	40.39	20.4	76.15	15.53	
2 S	37.1	83.50	30.98	39.3	65.06	25.57	26.9	83.50	22.46	38.4	83.50	32.06	22.7	66.15	15.02	
3 S	31.7	70.50	22.35	49.3	55.06	27.14	27.2	70.50	19.17	18.4	70.50	12.97	56.9	56.15	31.95	
Weighted by grade value MBF			$83.69			$61.27			$86.98			$85.42			$62.50	
Percent of total			77.8%			16.3%			2.6%			1.7%			1.6%	100%
Weighted by species and grade			$65.12			$ 9.97			$ 2.27			$ 1.45			$ 1.00	$79.81
East Side, all species, all grades																$59.04

Table 4. Operating costs* and log values by subregions and scaling practices.

	East-side[1]	West-side[2]
Logging costs	$11.64	$14.31
Transportation	6.97	14.23
Road construction	4.44	5.46
Total operating costs	$23.05	$34.00
Stumpage		
Weighted average all species	$32.15	$39.55
Log selling price		
Weighted average all species and grades	$59.04	$79.81

* All costs, stumpage values and selling prices have been weighted, combined and factored to reflect the cost, price or volume appropriate to the specific scaling practice or subregion. All figures are dollars per MBF Scribner log scale.

1/ 778 MBF net Scribner east-side scaling rules.

2/ 633 MBF net Scribner west-side scaling rules. Difference ratio 633/778 = .813.

Table 5. Market prices, values, cost and ratios in MBF net Scribner log scale.

Factors	Markets	
	East Side	West Side
1. Selling price	$59.04	$79.81
2. Total operating costs	23.05	34.00
3. Conversion return	35.99	45.81
4. Stumpage	32.15	39.55
5. Profit and risk	3.84	6.26
6. Operating ratios	.934	.922
7. Profit ratios	.069	.085

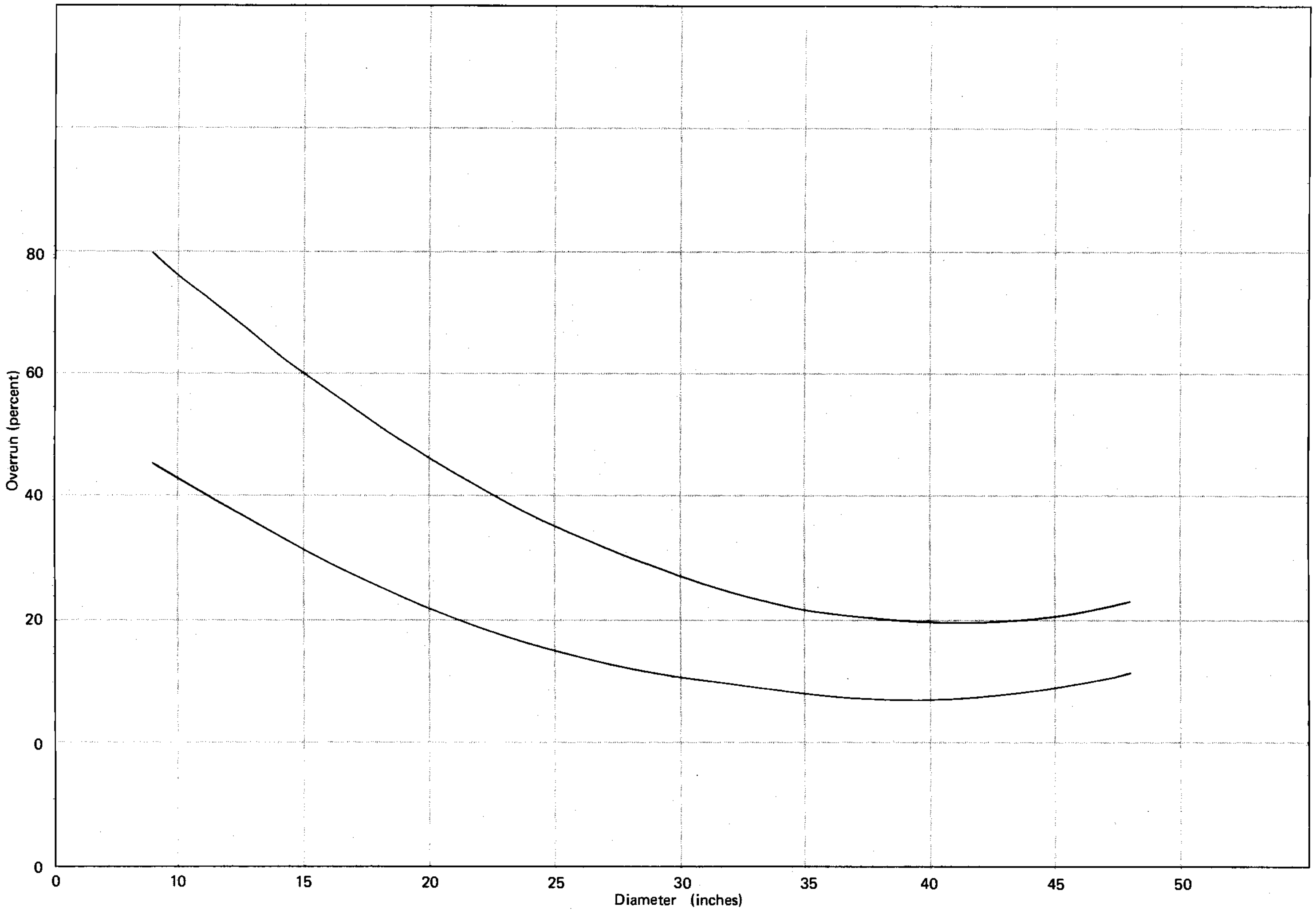

Figure 1. Overrun long logs compared with the same logs as short logs. (Reproduced from Timber Measurement Problems in the Douglas-Fir Region of Washington and Oregon (Bruce & Cowlin, 1968).)

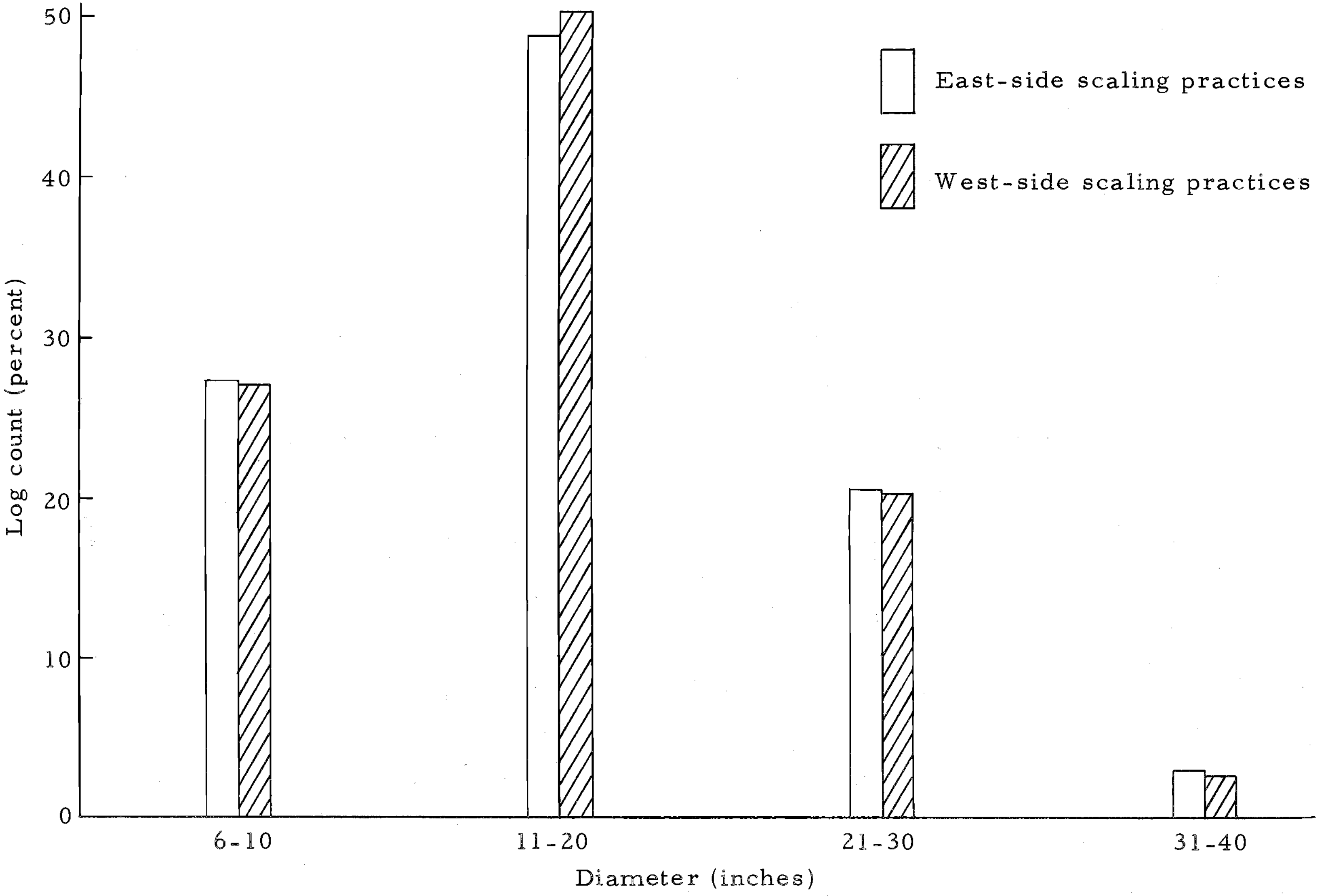

Figure 2. Subsale II study model log count by diameter (inches) in percent.

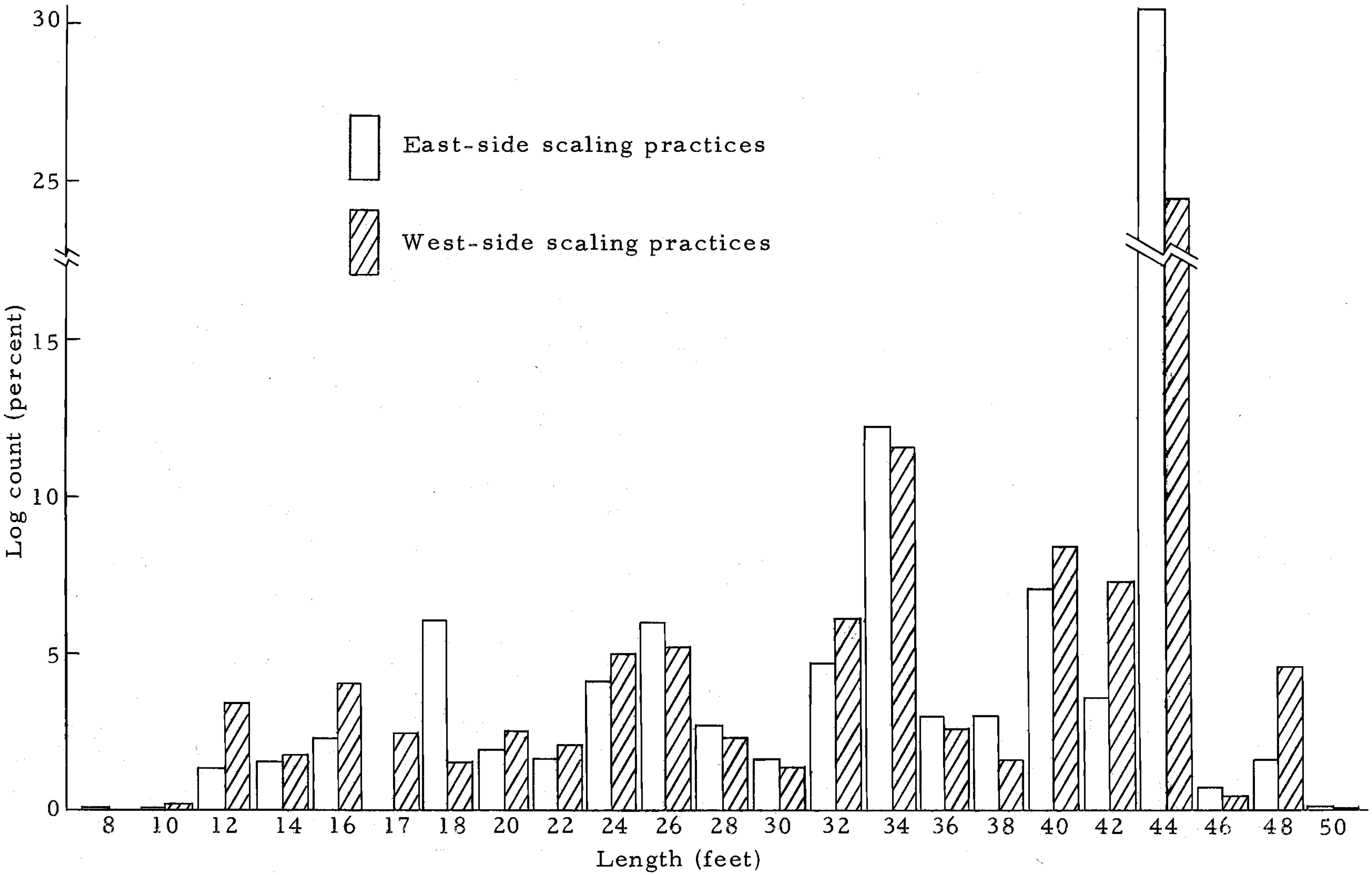

Figure 3. Subsale II study model log count by length (feet) in percent.