



# ANALYTICAL PROCEDURES FOR DEVELOPING LOG AND TREE QUALITY CLASSIFICATION SYSTEMS

by

J. Csizmazia, J. A. McIntosh,  
C. F. McBride and D. C. Gunn

*Résumé en français*

THIS FILE COPY MUST BE RETURNED

TO: INFORMATION SECTION,  
NORTHERN FOREST RESEARCH CENTRE,  
5320-122 STREET,  
EDMONTON, ALBERTA,  
T6H 3S5

DEPARTMENT OF FORESTRY PUBLICATION NO. 1144

1966



Published under the authority of  
The Honourable Maurice Sauvé, P.C., M.P.,  
Minister of Forestry,  
Ottawa, 1966.

## ABSTRACT

Proposed log and tree quality classification systems for Douglas-fir in the Interior of British Columbia have been developed by the Vancouver Forest Products Laboratory. These systems can be used to predict log or tree quality from the measured external log or tree characteristics.

The classification systems have been developed by an analytical procedure involving statistical and numerical techniques in five major steps:

- (1) The preliminary computation of field data.
- (2) The statistical evaluation of field data.
- (3) The interpretation of the statistical evaluation.
- (4) The preparation of quality classification systems.
- (5) The test of the developed systems.

Each step is described in detail and sufficient information is presented to enable this procedure to be employed in the development of similar systems for comparable species and end products.

## RÉSUMÉ

De nouvelles méthodes préconisées pour le classement qualitatif des billes et des arbres sur pied de sapin de Douglas des forêts de l'intérieur de la Colombie-Britannique ont été mises au point au laboratoire de Vancouver. Ces méthodes peuvent servir à estimer la qualité du bois sur pied et du bois abattu d'après la détermination des particularités externes des pièces.

L'élaboration de ces classifications s'est faite selon une technique analytique comportant cinq importantes étapes d'ordre statistique ou numérique, à savoir:

- (1) la compilation préliminaire des données recueillies sur place;
- (2) l'analyse statistique de ces mêmes données;
- (3) l'interprétation de l'analyse statistique;
- (4) l'élaboration des méthodes de classement d'après la qualité; et
- (5) l'épreuve des méthodes élaborées.

Chaque étape fait l'objet d'un exposé détaillé, et la communication renferme suffisamment de renseignements pour permettre d'élaborer des méthodes semblables à l'endroit d'essences et de produits analogues.

## CONTENTS

	<u>Page</u>
ACKNOWLEDGMENT.....	iv
INTRODUCTION.....	1
STEPS OF THE PROCEDURE.....	2
STEPS OF THE ANALYSIS.....	3
(1) Preliminary Computation of Field Data.....	3
(2) Statistical Evaluation of the Field Data.....	5
(3) Interpretation of the Statistical Evaluation.....	6
(4) Preparation of Quality Classification Systems.....	6
Logs.....	7
Trees.....	7
Modification of the System.....	9
(5) Test of the Developed Systems.....	11
REFERENCES.....	12
APPENDICES.....	13
APPENDIX 1 .....	15
"        2 .....	18
"        3 .....	25
"        4 .....	28
"        5 .....	29
"        6 .....	30
"        7 .....	31

### ACKNOWLEDGMENT

The assistance of the Biometrics Research Services, Department of Forestry of Canada, in this report is gratefully acknowledged.

# ANALYTICAL PROCEDURES FOR DEVELOPING LOG AND TREE QUALITY CLASSIFICATION SYSTEMS

- by -

J. Csizmazia, J.A. McIntosh, C.F. McBride, and D.C. Gunn<sup>1</sup>

## INTRODUCTION

The Vancouver Forest Products Laboratory has undertaken the development of log and tree quality classification systems for the major lumber species of the Interior of British Columbia. These systems relate the external log and tree characteristics to the value of the recovered lumber.

An analytical procedure for developing these systems was considered necessary to provide the most acceptable results. However, a literature survey indicated that, although several reports on quality classification systems developed by analytical methods were available for various species (Calvert, 1960; Newport and O'Regan, 1963; Yandle, 1960) very little information was provided on the individual steps involved in the development. Consequently it was necessary to develop a complete method for processing and analysing log and tree quality data, by the application of statistical and data processing techniques.

The steps followed in the preparation of quality specifications for Interior of British Columbia Douglas-fir logs or trees being sawn into dimension lumber are outlined in this report. All data referred to are based on information collected in three of the important fir-producing regions of the interior of the province.

---

<sup>1</sup>Department of Forestry of Canada, Forest Products Laboratory, Vancouver, B.C.

The field information was obtained by a procedure specially developed for wood quality evaluation studies (Jackson et al., 1963). This involved selecting and diagramming the sample trees, following them through all stages of felling, bucking, and transport to the sawmill; diagramming each log, following it through the sawmill and recording the grade and dimensions of each piece of lumber recovered. All information on each tree, log, and piece of lumber was recorded on prepared field sheets (Appendix 1).

It is expected that this field procedure and the steps outlined can be followed for other species when adjustments are made to account for the differences between species.

The objective of the study was to develop log and tree quality classification systems, relating exterior log and tree characteristics to the value of the recovered lumber. In achieving this objective, it was necessary to meet the following requirements (Ellersten and Lane, 1953; Flick, 1955; Newport et al., 1959):

- (a) Express quality of the logs and/or trees by the value of the end-product.
- (b) Establish relationships between value and external characteristics of the logs and/or trees.
- (c) Determine quality class specifications based on these relationships which will separate logs and/or trees into well-defined classes with distinct average end-product values for each class.

The terms quality and value are closely related and, for the purpose of this report, quality will have reference to the logs or trees, whereas value will have reference to the recovered lumber.

#### STEPS OF THE PROCEDURE

To determine the relationships between the exterior log and tree characteristics and the value of recovered lumber,



a systematic selection of the important factors influencing wood quality is necessary. The systematic selection of these variables can be achieved by multiple regression analysis processed by electronic computers. The multiple regression analysis coupled with electronic computer technology is an efficient statistical technique for finding the nature and degree of the relationships between variables. To facilitate the data input format requirements of the regression computer program, the collected field information was transposed to punch cards. The transfer of the field data to punch cards also made possible other unit record processing and electronic computations necessary in the study.

The steps of the procedure of the data transfer, the statistical analyses and the derivation of the quality class systems as outlined in the flow diagram (Figure 1) can be divided into five operations.

#### STEPS OF THE ANALYSIS

- (1) Preliminary computation of field data.
- (2) Statistical evaluation of the field data.
- (3) Interpretation of the statistical evaluation.
- (4) Preparation of quality classification systems.
- (5) Test of the developed systems.

##### (1) Preliminary Computation of Field Data

Field information (Appendix 1) was punched on separate cards for each piece of lumber (Board card), each log (Log dimension card) and each tree (Tree dimension card). Identification numbers (Jackson et al., 1963) punched on each card made possible the assembly of complete logs and trees as desired. The information punched on the cards was sorted and printed for convenience and visual checking.

The computation began with the calculation and printing of the lumber grade recovery for each log from the Board cards, using Program A (Appendix 2). This gave information on lumber grade recovery, lumber volume recovery and served as a check on



the log scale deductions for individual logs.

In the next step the Board cards were grouped into Log Summary cards by Program VI. The Log dimension cards and Log summary cards were used in Program VII to produce Log detail cards and Tree total cards (Appendix 2).

Log and Tree Regression cards were then prepared and printed on IBM sheets by collating Log dimension cards with Log detail and Tree dimension cards with Tree total cards (Appendix 3).

At this point all field information was on punch cards, printed on IBM sheets and ready for statistical evaluation.

## (2) Statistical Evaluation of the Field Data

The multiple linear regression technique (Program C, (Appendix 2)) was used to determine the relationships between log and/or tree characteristics (independent variables) and quality (dependent variable).

At this time it is considered that log and/or tree quality can be expressed by a measure of either the value per unit of log or tree volume, or of unit volume of the recovered product. In the preliminary computations the value of log and tree was calculated by Programs BI and BII (Appendix 2) by applying the average market value of each grade of lumber to the lumber out-turn. The values were then expressed in three ways, as value per cubic foot of gross log or tree scale, value per cubic foot of net log or tree scale, and value per M fbm of log or tree green chain lumber tally.

Preliminary regression analyses were calculated for 14 independent variables for logs and 26 independent variables for trees on each of the above three dependent variables. These analyses showed that only 7 independent variables for logs and 15 independent variables for trees had acceptable statistical correlation with log or tree quality (Appendix 3). Using only these variables, final regression analyses were computed for

sound and defective logs and trees for each of the three sample areas and for the three areas combined. In this report, defective logs are considered as those having log scale deductions, and defective trees as those containing one or more defective logs.

### (3) Interpretation of the Statistical Evaluation

It was expected that the regression analyses would show the nature of the relationships between independent and dependent variables, and would indicate that a set of regression equations composed of practical and statistically important independent variables could be obtained to predict quality adequately.

However, the computed regression equations, although statistically significant, accounted for only a marginal portion of the total variance of the quality. Consequently the regression equations themselves could not be used directly for quality class predictions. However, the regression analyses did indicate the order of importance of the variables in relation to quality. Those variables having the highest correlation in all combinations of sound, defective, and combined sound and defective logs, were used as the basis for further analysis.

### (4) Preparation of the Quality Classification Systems

The log and tree regression data were sorted on the basis of value per cubic foot gross log scale, value per cubic foot net log scale, and value per M fbm of lumber output. The data were then grouped at 5¢ intervals for the cubic foot and \$5 intervals for the M fbm values and the frequency of each of these groups was plotted as a histogram. The histogram of these distributions was examined for any change in the distribution pattern, suggesting possible quality class separations.



However, as illustrated by the value per M fbm histogram in Appendix 4, the frequency distribution followed the normal curve. Because of this and the small range in values, three quality classes were the maximum number considered practical. Therefore, the area under the histogram was divided into three equal sub-areas or divisions to represent the three quality classes, each class containing approximately one-third of the total number of logs (Appendix 4).

However, for practical reasons it was not possible to adhere rigidly to these sub-areas because of the difficulty of splitting the value within the 5¢ and \$5 intervals. Instead, the quality class boundaries were moved to the "frequency breaks" which gave approximately the desired sub-area divisions, with uniformly spaced average values (Appendix 4).

Up to this point the analyses of the log and tree data followed the same pattern; although, as described in the subsequent paragraphs, different approaches were required for logs and for trees to complete the preparation of the quality class specifications.

Logs. The log regression data were grouped into the three divisions and the averages of the log quality characteristics in each division were computed. These averages provided a working base upon which to develop the log quality class definitions (Appendix 5). The minimum or lower borders of the quality characteristics within the quality classes were determined, e.g., in Appendix 5, Class No. 1: "At least 12" top diameter".

In case of extreme differences between these minima and the quality characteristic averages, the reason for the deviations was investigated and allowances or restrictions were established accordingly, e.g. Appendix 5, Class No. 1: "Scale deductions not to exceed 10%".

Trees. Due to the greater variation and irregular distribution of the lumber output values within a tree as compared to a log,

additional statistics were necessary to provide adequate tree quality descriptions. At each 5¢ and \$5 intervals the averages, standard deviations, maxima and minima of the tree variables were computed (Program D, Appendix 2). These statistics indicated that the increase, or decrease, of quality values did not always follow systematically the changes in quality characteristics, e.g., in general the value per unit volume increased with increasing D.B.H., but occasionally both small and very large D.B.H. trees deviated from the pattern. Therefore, the interval averages were adjusted by the standard deviations, or maxima and minima providing upper and lower limits in which the majority of these deviates would fall. These adjusted averages were curved over the 5¢ and \$5 intervals, and curved estimates at each interval were tabulated. The previously established quality class boundaries were then applied to this tabulation to provide a tree quality classification system (Appendix 6) in which the quality of the tree can be determined by a comparison of the measured tree characteristics to the tabulated estimates.

The application of this tree quality classification system can be demonstrated by the following example, and referring to Appendix 6.

The measured tree characteristics are:

Measured Tree Characteristics		Indication of Quality Classes (Appendix 6)
D.B.H. (diameter at breast height)	18"	3
Ht. (tree height)	90'	2
Ht. 1st L.L. (Height to first live limb)	35'	1
S.I. (site index)	70	3
N.C.S. (number of clear sides on butt log)	3	1
TOTAL		10

Predicted quality class ( $10/5 = 2$ ) is Class No. 2.

As illustrated in this example the value of the measured characteristic is compared to that in the table (Appendix 6) and the indicated quality class for that characteristic recorded, e.g., a D.B.H. of 18 inches indicates quality class No. 3, Ht. of 90 feet indicates Class No. 2, etc. The arithmetical average of these indications will be the predicted quality class of the tree.

The above tree quality classification system is flexible; it incorporates five important tree characteristics of which any one can indicate low or high quality, thus making predictions possible even for most of the exceptional cases. Although only five factors are used in this system, additional factors could be considered if applicable, and the table readily extended. It also provides a high degree of precision in predicting quality. When this system was tested using the sample trees, the predicted quality classes corresponded with the known, or calculated classes for approximately 75 per cent of the sample.

However, this system has some features which limit its use under present conditions:

- (a) Several measurements are required for each tree. These measurements are time-consuming and therefore costly.
- (b) It can be used to predict quality on an individual tree basis, whereas the present day requirement of the forest industry is to predict quality on a stand rather than on an individual tree basis.

Modification of the System. Because of these limitations another system more suitable for immediate application was developed.

The regression analyses indicated that when the five variables; Diameter at breast height (D.B.H.); Tree height (Ht.); Height to the first live limb (Ht. 1st L.L.); Number of clear sides on butt log (N.C.S.); and Site index (S.I.), were included in the regression equation, they contributed almost equally to the explained part of the variance. By omitting Ht. 1st L.L. and N.C.S. (factors which are not measured in normal cruising) it was found that the error term of the new equation, including only

D.B.H., Ht., and S.I., did not increase significantly. By stratifying these three variables into S.I. classes, tree quality becomes more homogeneous within S.I. stratas, thereby offsetting part of the increase in the error term.

The tree values were grouped and plotted by D.B.H. classes within the S.I. stratas (Figure 2). The readings of the curves were tabulated and charted to provide the quality classification system (Appendix 7).

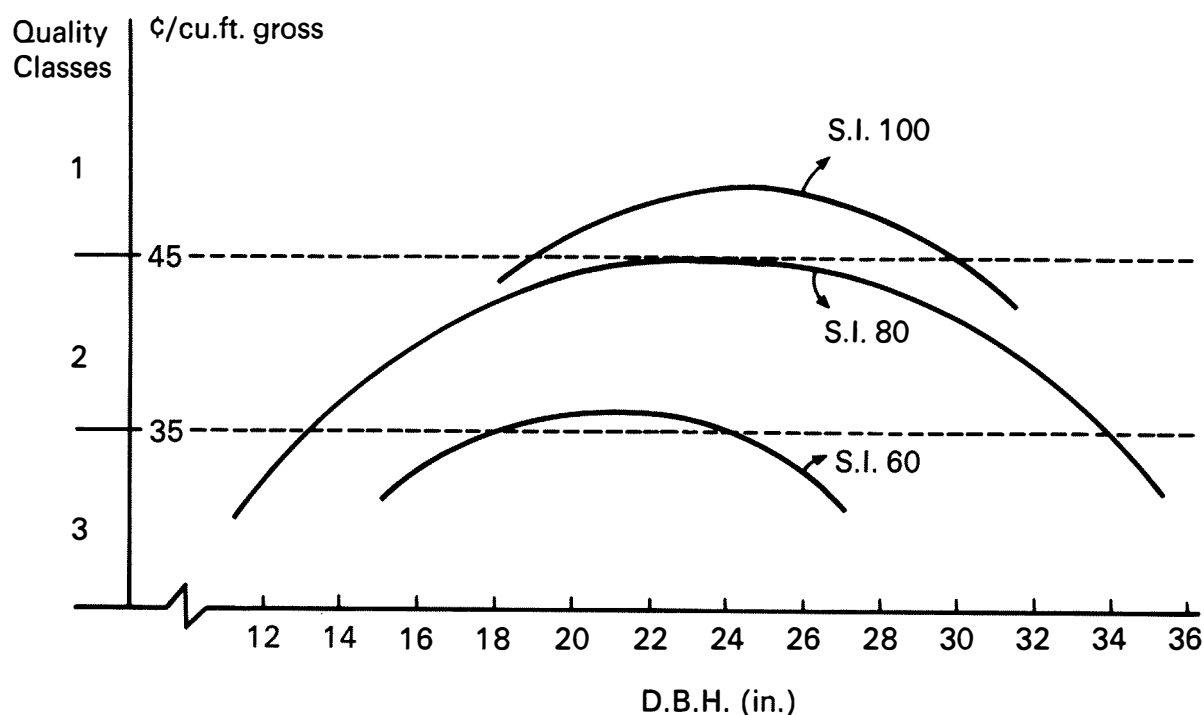


Figure 2.

Tree value (quality) and D.B.H. relationship by S.I. classes  
B.C. Interior Douglas-fir.

In application it is necessary to refer the D.B.H. and S.I. of the tree or stand to the chart and read off the quality classification, e.g., a tree with a D.B.H. of 20 inches and S.I. of 80 would be quality Class No. 2.



This system has the following advantages over the preceding system:

- (1) It is simpler to apply.
- (2) It can be applied with normal cruise data on either an individual tree or stand basis.

The only disadvantage of this system is that quality cannot be predicated as precisely as with the preceding system. In testing, using the sample trees, the predicted quality classes corresponded with the known or calculated classes for approximately 68 per cent of the sample.

#### (5) Test of the Developed Systems

The quality classification systems may be tested in two ways:

(a) Paper testing - This is essentially an "internal" test using only the study data. The quality characteristics of each log or tree are known, and by applying the quality classification system, the quality class of the log or tree can be defined and compared with the known (calculated) quality.

(b) Field testing - Standing trees or bucked logs in the field are classified by the developed systems. After conversion, the realized value (quality) of each log or tree may be compared with that predicted.

## REFERENCES

- Calvert, W.W. 1960. Grading Hardwood Logs for Factory Lumber. Department of Forestry of Canada, F.P.L. Technical Note No. 18.
- Ellersten, B.W. and Paul Lane. 1953. Lumber Price Ratios for Computing Quality Index of Tennessee Valley Hardwoods. Tennessee Valley Authority Division of Forestry Relations, Technical Note No. 15.
- Flick, Frances J. 1955. Grading Logs and Trees for Quality. A bibliography compiled for the Log Grade Committee, Forest Service. U.S. Dept. of Agriculture Library.
- Jackson, George H., J.W. Henley and W.L. Jackson. 1963. Log Diagramming Guide for Western Softwoods. Pacific Northwest Forest and Range Exp. St., U.S. Dept. of Agriculture.
- Newport, Carl A., C.R. Lockard, and C.L. Vaughan. 1959. Log and Tree Grading as a Means of Measuring Quality. U.S. Dept. of Agriculture.
- Newport, Carl A., and William G. O'Regan. 1963. An Analysis Technique for Testing Log Grades. U.S. Forest Service Research Paper PSW-P3.
- Yandle, D.O. 1960. A Method of Indirect Calculations for Use in Log Grade Analyses. U.S. Dept. of Agriculture No. 2194.

# APPENDICES

<u>Appendix</u>	<u>Page</u>
1	15
2	18
3	25
4	28
5	29
6	30
7	31





## Appendix 1

### TREE DIAGRAM FORM

#### GENERAL

Area \_\_\_\_\_  
 T. Sale No. \_\_\_\_\_ X-1  
 Location \_\_\_\_\_ V  
 Mill \_\_\_\_\_ Z  
 Species \_\_\_\_\_ fir

#### TREE DATA

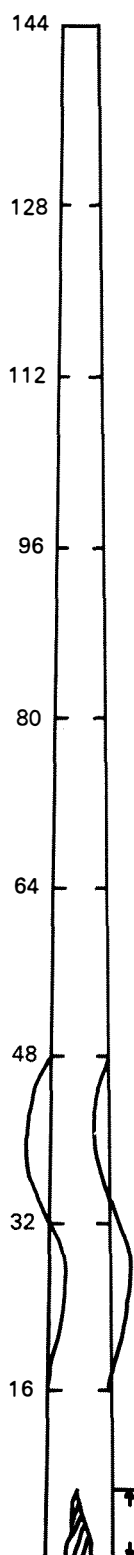
Tree No. \_\_\_\_\_ 15  
 Butt Log Grade \_\_\_\_\_  
 DBH \_\_\_\_\_ 16  
 Tot. Height \_\_\_\_\_ 105  
 Stump Ht. \_\_\_\_\_ 11  
 Ht.—Clear Bole \_\_\_\_\_ 2  
 Ht.—First Dead Limb \_\_\_\_\_ 2  
 Size—First Dead Limb \_\_\_\_\_ p  
 Ht.—First Live Limb \_\_\_\_\_ 10  
 Size—First Live Limb \_\_\_\_\_ m  
 Spiral Grain \_\_\_\_\_ 0  
 Bark Class \_\_\_\_\_ m  
 Crown Class \_\_\_\_\_ d  
 Crown Length \_\_\_\_\_ 70  
 Crown Density \_\_\_\_\_ 80  
 Vigour Class \_\_\_\_\_ g  
 Lean—Amt. \_\_\_\_\_ —  
 Lean—Dir. \_\_\_\_\_ —  
 Tree Age \_\_\_\_\_ 210  
 Pitch \_\_\_\_\_ 0  
 Crown Tip \_\_\_\_\_ p  
 Pruning \_\_\_\_\_ m  
 V.L. Branches \_\_\_\_\_ —

#### STAND DATA

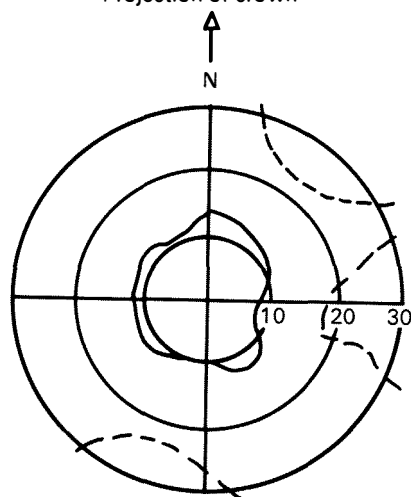
Stand Age \_\_\_\_\_ 200  
 Local Type \_\_\_\_\_ F, PY  
 Stocking \_\_\_\_\_ 100  
 Site Index \_\_\_\_\_ 80  
 Soil Type \_\_\_\_\_ Stony  
 Elevation \_\_\_\_\_ 2000  
 Aspect \_\_\_\_\_ N  
 Slope % \_\_\_\_\_ 10  
 Slope Position \_\_\_\_\_ m

#### CULL INDICATORS

Ht.	Ind.	Amt.
3	f.s.	



Projection of crown



#### Legend

← Orientation Line Location  
 — Tree Crown Outline  
 - - - Adjacent Crown Outline

#### Comments

##### Stand History

even aged, F & PY (50—50)  
 indication of recent (5? years)  
 ground fire, rock outcrops, no  
 decay indications

##### Other

Appendix 1 (cont'd)  
Log Description—Log Grading Study

Log No. 15-1

Length 16.4

Max. Butt Diam. 18

Date Aug 7/62

Species F

Top Diam. 14

Deduction: ft. 2 in. 0

Operation z

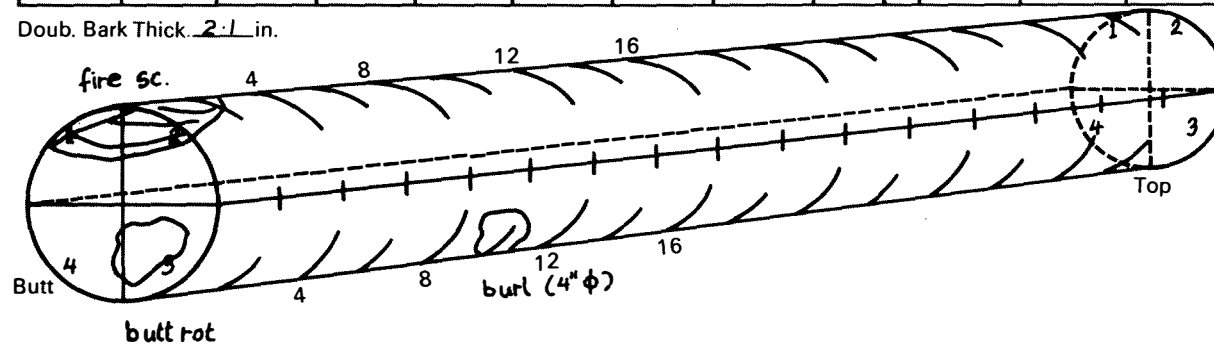
Grade\_\_\_\_\_

Scaled Butt Diam. 16

Butt rot

Grader J. M.[illegible]

Doub. Bark Thick. 2.1 in.

Remarks:

slight sweep  
not sufficient for scale deduct.

# Appendix 1 (cont'd) Lumber tally

Mill **Z**

Species **F**

Grader **X**

Mill Log No. <b>12</b>						Mill Log No. <b>12</b>					
Grade	Thick.	Width	Length	Defect		Grade	Thick.	Width	Length	Defect	
B 09	1" 04	03	06	Wane	1	B 09	1" 04	03	06	Wane	1
C 08	<del>2" 08</del>	04	08	Knots	2	C 08	<del>2" 08</del>	<del>04</del>	08	Knots	2
D 07	3" 12	05	10	Knot Holes	3	D 07	3" 12	05	10	Knot Holes	3
Sel. <del>10</del>	4" 16	06	12	Shake	4	Sel. 10	4" 16	06	12	Shake	4
Const. 20	<del>08</del>	<del>14</del>	14	Rot	5	Const. 20	<del>08</del>	08	<del>14</del>	Rot	5
St'd. 30		10	<del>18</del>	Stain	6	St'd. 30		10	16	Stain	6
Util. 40		12	18	Spiral Grain	7	Util. 40		12	18	Spiral Grain	7
Econ. 50			20	Growth Rate	8	Econ. <del>50</del>			20	Growth Rate	8
1500f 02	Repeats: (circle)		22	Pitch Pocks.	9	1500f 02	Repeats: (circle)		22	Pitch Pocks.	9
1200f 01	<b>(R)</b> R R R R		24	Check	10	1200f 01	R R R R R		24	Check	10
	R R R R R			Twist	11		R R R R R			Twist	11
				Size	12					Size	12

Mill Log No. <b>13</b>						Mill Log No. <b>14</b>					
Grade	Thick.	Width	Length	Defect		Grade	Thick.	Width	Length	Defect	
B 09	1" 04	03	06	Wane	1	B 09	1" 04	03	06	Wane	1
C 08	<del>2" 08</del>	04	08	Knots	2	C 08	<del>2" 08</del>	<del>04</del>	08	Knots	2
D 07	3" 12	05	10	Knot Holes	3	D 07	3" 12	05	10	Knot Holes	3
Sel. 10	4" 16	06	12	Shake	4	Sel. 10	4" 16	06	12	<del>Shake</del>	4
Const. <del>20</del>	<del>08</del>	<del>14</del>	14	Rot	5	Const. 20		08	14	Rot	5
St'd. 30		10	<del>18</del>	Stain	6	St'd. 30		10	<del>18</del>	Stain	6
Util. 40		12	18	Spiral Grain	7	Util. 40		12	18	Spiral Grain	7
Econ. 50			20	Growth Rate	8	Econ. <del>50</del>			20	Growth Rate	8
1500f 02	Repeats: (circle)		22	Pitch Pocks.	9	1500f 02	Repeats: (circle)		22	Pitch Pocks.	9
1200f 01	<b>(R)</b> <b>(R)</b> R R R R		24	Check	10	1200f 01	<b>(R)</b> <b>(R)</b> <b>(R)</b> <b>(R)</b> R		24	Check	10
	R R R R R			Twist	11		R R R R R			Twist	11
				Size	12					Size	12

Mill Log No. <b>15</b>						Mill Log No. <b>15</b>					
Grade	Thick.	Width	Length	Defect		Grade	Thick.	Width	Length	Defect	
B 09	1" 04	03	06	Wane	1	B 09	1" 04	03	06	Wane	1
C 08	<del>2" 08</del>	04	08	Knots	2	C 08	<del>2" 08</del>	04	08	Knots	2
D 07	3" 12	05	10	Knot Holes	3	D 07	3" 12	05	10	Knot Holes	3
Sel. 10	4" 16	<del>06</del>	12	Shake	4	Sel. <del>10</del>	4" 16	<del>06</del>	12	Shake	4
Const. <del>20</del>		08	<del>14</del>	Rot	5	Const. 20		08	14	Rot	5
St'd. 30		10	16	Stain	6	St'd. 30		10	<del>18</del>	Stain	6
Util. 40		12	18	Spiral Grain	7	Util. 40		12	18	Spiral Grain	7
Econ. 50			20	Growth Rate	8	Econ. 50			20	Growth Rate	8
1500f 02	Repeats: (circle)		22	Pitch Pocks.	9	1500f 02	Repeats: (circle)		22	Pitch Pocks.	9
1200f 01	R R R R R		24	Check	10	1200f 01	<b>(R)</b> R R R R R		24	Check	10
	R R R R R			Twist	11		R R R R R			Twist	11
				Size	12					Size	12

## APPENDIX 2

### Program A

Lumber recovery program - 1962

Program language: Fortran II.

Board cards (Format 1) are to be sorted by Mill Log Number or Tree Log Number.

The program reads these sorted cards and prints out the recovered lumber volume by lumber grades, and the total recovered lumber volume for each log (Format 2).

Output is terminated by the printing of the total lumber volume for each lumber grade and the combined volume for all grades.

Format 1 (input)				Format 2 (output)			
Col- umns	Width	Code Name	Name	Col- umns	Width	Code Name	Name
1- 3	3	JCODE	Arbitrary 6 digits	1- 4	4	LTNO	Tree Log Number
4- 6	3	KCODE	Identifi- cation code	6- 9	4	LOG	Mill Log Number
7-10	4	LTNO	Tree Log Number	11-15	5	B	Grade B
11-12	2	LGRA	Lumber grade	17-21	5	C	Grade C
13-14	2	ITH	Thickness (in $\frac{1}{4}$ in.)	23-27	5	D	Grade D
15-16	2	IW	Width (in.)	29-33	5	SEL	Grade Select
17-18	2	LENG	Length (ft.)	35-39	5	CONST	Grade Construction
41-44	4	MLNO	Mill Log Number	41-45	5	STD	Grade Standard

## APPENDIX 2 (cont'd)

### Program BI and BII

Log and tree quality factors - 1962

Program language: Fortran II

### Program BI

Program BI accepts a lumber price array of seven grades and nine sizes. It reads a set of board cards (Format 1, Program A), and punches Log Summary cards (Format 3).

### Format 3 (output)

Columns	Width	Code Name	Name
1 - 6	6		Arbitrary 6 digits identification code
7 - 10	4	LOGT	Tree Log Number
41 - 44	4	LOGNO	Mill Log Number
45 - 49	5	LV	Total log volume (fbm)
50 - 55	6	LC	Total log value (¢)
56 - 60	5	LPR	Average log value (¢/M fbm)

## APPENDIX 2 (cont'd)

### Program BII

This program reads a combined set of Log Dimension cards (Format 4) and the Log Summary cards (Format 3). It computes and punches Log Detail cards (Format 5) and Tree Total cards (Format 6).

Format 4 (input)

Columns	Width	Code Name	Name
1 - 2	2	JI	Arbitrary 6 digits
3 - 6	4	KI	Identification code
7 - 10	4	LO	Tree Log number
12 - 13	2	MT	Top diameter (in.)
14 - 15	2	MB	Butt Diameter (in.)
16 - 17	2	LL	Scale length of log (ft.)
26 - 27	2	LDD	Length deduction (ft.)
28 - 29	2	MTDD	Top diameter deduction (in.)
30 - 31	2	MBDD	Butt diameter deduction (in.)
32 - 34	3	LA	Actual length of log (ft.)

## APPENDIX 2 (cont'd)

## Format 5 (output)

Columns	Width	Code Name	Name
1 -	2		Arbitrary 6 digits
- 6	4		Identification code
7 - 10	4	LO	Tree Log number
12 - 13	2	MT	Top diameter (in.)
14 - 15	2	MB	Butt diameter (in.)
16 - 17	2	LL	Scale length of log (ft.)
18 - 21	4	LVG	Gross log volume (cu.ft.)
22 - 25	4	LVN	Net log volume (cu.ft.)
26 - 28	3	JD	Per cent damaged (volume loss, %)
29 - 31	3	JR	Lumber recovery factor (fbm/cu.ft. volume)
32 - 34	3	LA	Actual length of log (ft.)
35 - 37	3	JT	Taper (in./ft.)
38 - 40	3	LB	Log position distance from tree butt (ft.)
41 - 44	4	MO	Mill log number
45 - 49	5	LV	Total lumber volume from log (fbm)
50 - 55	6	LC	Total log value (¢)
56 - 60	5	LP	Average log value (¢/M fbm)
61 - 63	3	LPG	Log value (¢/cu.ft. gross volume)
64 - 66	3	LPN	Log value (¢/cu.ft. net volume)

## APPENDIX 2 (cont'd)

Format 6 (output)

Columns	Width	Code Name	Name
1 -	2		Arbitrary 6 digits
- 6	4		Identification code
7 - 9	3	NT	Tree number
10 - 11	2	LG	1st digit - 0, 2nd digit - highest log position
12 - 13	2	IT	Tree top diameter (in.)
14 - 15	2	IB	Tree butt diameter (in.)
16 - 17	2	LT	Total scale length of tree (ft.)
18 - 21	4	KVG	Total gross volume of tree (cu.ft.)
22 - 25	4	KVN	Total net volume of tree (cu.ft.)
26 - 28	3	KD	Per cent damaged (volume loss, %)
29 - 31	3	KR	Lumber recovery factor (fbm/cu.ft. volume)
32 - 34	3	LTB	Total actual length of tree (ft.)
35 - 37	3	KT	Taper (in./ft.)
38 - 40	3	KL	Length ratio, scale/actual (%)
41 - 44	4	KG	Number of logs in tree
45 - 49	5	KV	Total lumber volume from tree (fbm)
50 - 53	4	KS}	Total value of tree
54 - 55	2	KC}	
56 - 60	5	KP	Average tree value (¢/M fbm)
61 - 63	3	KPG	Tree value (¢/cu.ft. gross volume)
64 - 66	3	KPN	Tree value (¢/cu.ft. net volume)



## APPENDIX 2 (cont'd)

### Program C

Correlation and regression with automatic reduction.

Standard self-contained Fortran II program.

Library number S3-4A, December 1962.

Computing Center, University of British Columbia.

## APPENDIX 2 (cont'd)

### Program D

Tree summary program - 1962.

Program language: Fortran II.

Tree regression cards (Format in Appendix 3/B) are to be sorted by ¢/cu.ft. or \$/M fbm. The computer accepts these cards and calculates the averages, standard deviations and determines the maxima and minima of the variables by any pre-specified ¢/cu.ft. or \$/M fbm division. This information is printed out with the count of trees found in each division (Format 7).

Format 7

Columns	Width	Code Name	Name
1 - 5	5	DBH	Diameter breast height
6 - 12	6	HT	Tree height
13 - 17	5	HTDL	Height to first dead limb
18 - 22	5	HTLL	Height to first live limb
23 - 26	4	CWC	Crown closure
27 - 32	6	CWDSY	Crown density
33 - 37	5	AGE	Tree age
38 - 41	4	TIP	Crown tip
42 - 45	4	VLB	Very large branches (over 3.0" Ø)
46 - 50	5	SI	Site index
51 - 54	4	SLP	Slope of terrain
55 - 58	4	FSC	Fire scar
59 - 62	4	CWW	Crown width
63 - 66	4	NCS	No. of quarters clear of knots on butt log
67 - 72	6	\$/MFB	\$/M fbm
73 - 77	5	C/GG	¢/cu.ft. (gross)

# APPENDIX 3

## Log Regression Card

Merritt, Vernon, Williams Lake, Douglas-fir - 1962-63

Columns	Width	Name
1- 4	4	Log number
5- 6	2	Sub-sample area
7- 8	+ 2*	Diameter (top)
9-11	+ 3	Lth
12-15	+ 4	Gross log volume (cu.ft. x 10)
16-18	+ 3	% damaged (volume loss)
19-21	+ 3	Lumber recovery factor (fbm/cu.ft. x 10)
22-24	+ 3*	Taper (in./ft. x 100)
25-27	+ 3	Distance from tree butt
-28	+ 2*	No. of clear sides or less than 3 pin knots (N.C.S.)
29-30	+ 2*	No. of large knots ( $1\frac{1}{2}$ " - 3")
31-32	+ 2	No. of total knots
33-35	+ 3*	Rot (cu.ft.)
36-38	+ 3}	Ring shake (cu.ft.)
39-41	+ 3}*	Shake (cu.ft.)
42-44	+ 3	Crook (cu.ft.)
45-47	+ 3*	Log value (¢/cu.ft. gross) )
48-50	+ 3*	Log value (¢/cu.ft. net) )
51-54	+ 4*	\$/1000 fbm )
Dependent variables		

+ Included in preliminary regression.

\* Included in final regression.

(1000/DT was calculated as independent variable)

# APPENDIX 3 (cont'd)

## Tree Regression Cards

Merritt, Vernon, Williams Lake, Douglas-fir - 1962-63

Columns	Width	Name
1- 4	4)	Disregard (only for point checking)
5- 8	4)	
9-11	3	Tree number
12-13	2	Local area
14-16	+ 3*	Diameter at breast height (D.B.H.)
17-19	+ 3*	Total height (Ht.)
20-21	+ 2	Ht. clear bole
22-23	+ 2*	Ht. first dead limb
24-25	+ 2*	Ht. first live limb (Ht. 1st L.L.)
-26	+ 1	Bark class
-27	+ 1*	Crown class
28-29	+ 2	Crown length
30-32	+ 3*	Crown density
33-34	+ 2	Lean amount
35-37	+ 3*	Tree age
-38	+ 1	Pitch
-39	+ 1*	Crown tip
-40	+ 1*	Very large branches (0, 1)
-41	+ 1	Stand type
42-44	+ 3*	Site index (S.I.)
45-46	+ 2	Elevation

# APPENDIX 3 (cont'd)

## Tree Regression Cards (cont'd)

Columns	Width	Name
47	+ 1	Aspect
48 - 49	+ 2*	Slope
- 50	+ 1	Slope position
- 51	+ 1*	Fire scar
- 52	+ 1	Sweep
53 - 54	+ 2*	Crown width
- 55	+ 1*	No. of clear sides on butt log (N.C.S.)
56 - 59	+ 4*	\$/1000 fbm (green chain))
60 - 62	+ 3*	¢/cu.ft. (gross) ) Dependent variables
63 - 65	+ 3*	¢/cu.ft. (net) )
66 - 68	+ 3**	Shake (fbm) ) Special run
69 - 71	+ 3**	Rot (fbm) } (Dependent variables)

+ Included in preliminary regression.

\* Included in final regression.

(1000/D.B.H. was calculated as independent variable)

\*\* Special run.

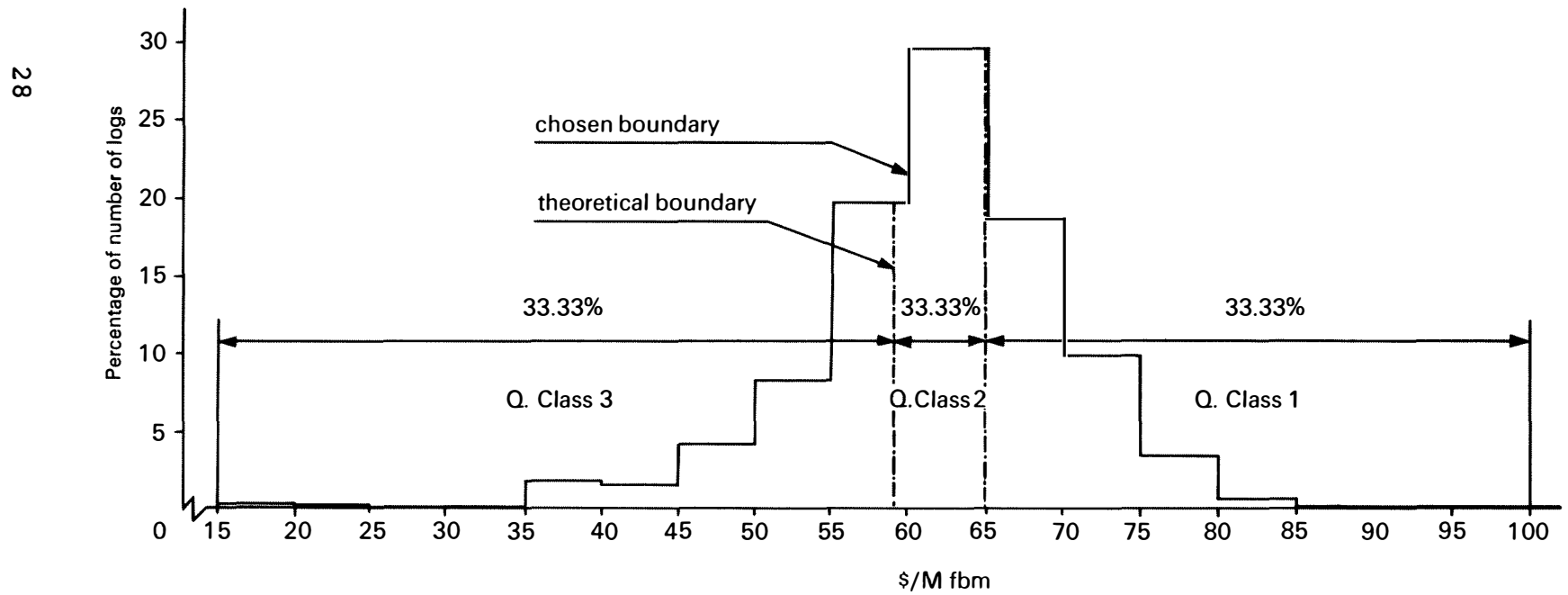
## Appendix 4

### Distribution of sample logs

Percentage of number of logs by \$ 5/M f b m value intervals

Cumulative percentages:

0.47 0.78 0.86 1.25 3.06 4.79 8.97 17.32 37.02 66.81 85.25 95.18 98.73 99.52 99.76 99.92 100.00



## APPENDIX 5

### Proposed Log Quality Classes - October, 1963

#### Interior Douglas-fir

##### No. 1 Logs

- At least 12 in. top diameter and 12 ft. in length.
- At least one face\* clear of knots over the entire log length.
- One large knot,  $1\frac{1}{2}$ "- 3", permitted per 4 ft. of total log length.
- Free of visible incipient rot or stain.
- Scale deductions not to exceed 10% of the gross log volume.
- Logs with knot clusters containing medium or large knots not permitted.
- The top diameter may be reduced to 10 in. on small sound straight logs which have at least two faces clear of knots over the entire log length.

##### No. 2 Logs

- At least 8 in. top diameter and 12 ft. in length.
- Two large knots permitted per 4 ft. of total log length.
- Logs with knot clusters containing medium or large knots not permitted in logs less than 18 in. in diameter.
- Scale deductions not to exceed 20% of the gross log volume.
- The diameter may be reduced to 6 in. on small sound straight logs free of large knots and containing fewer than 10 smaller knots per 4 ft. of total log length.

##### No. 3 Logs

- Lower in quality than No. 2 but will cut out at least one-half of their gross scale volume in merchantable lumber.

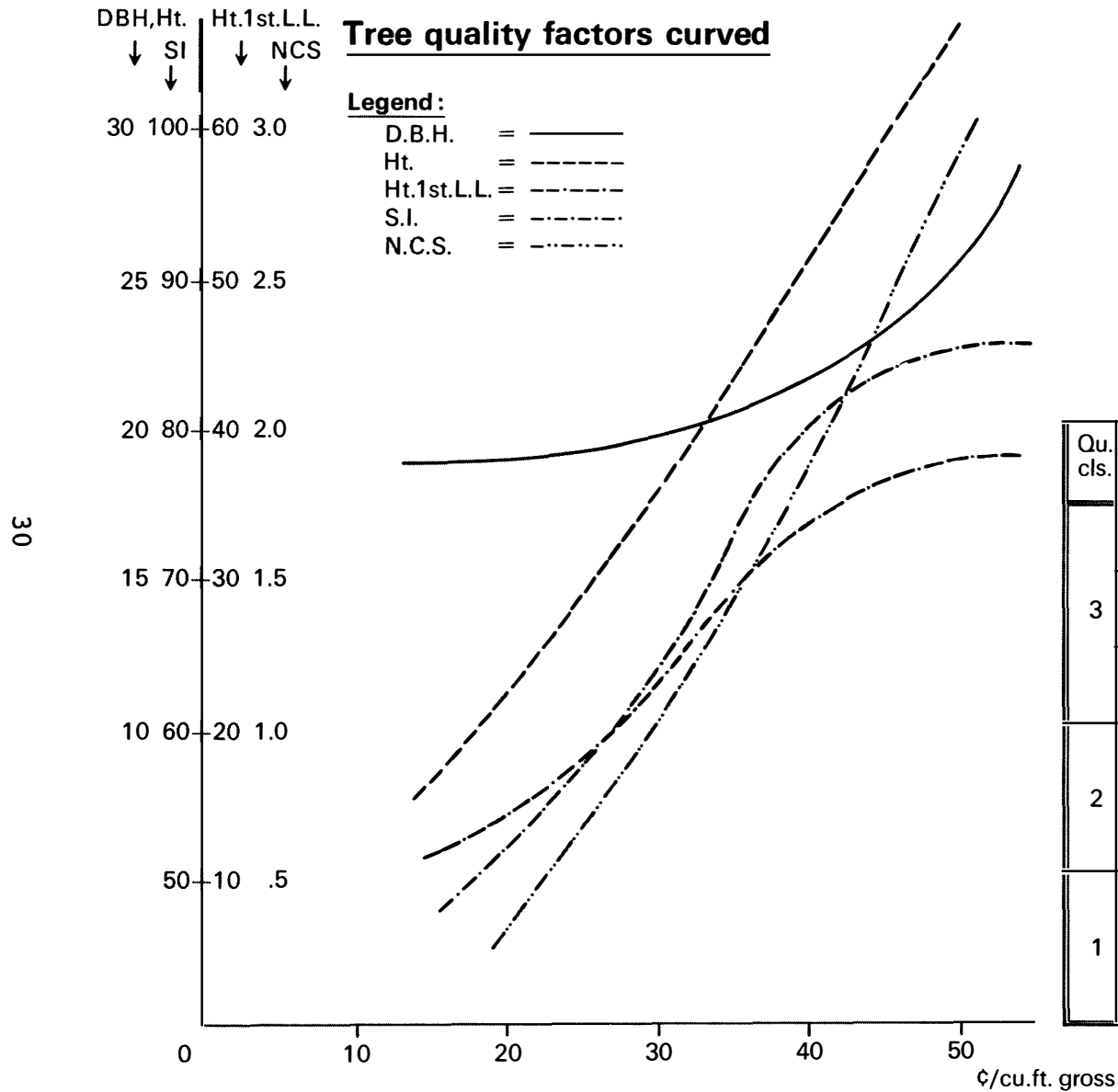
##### Cull Logs

- Lower in quality grade than No. 3.

---

\* The log surface is divided into four faces, each face extended over one-quarter of the log circumference and the full length of the log.

## Appendix 6



### Tree quality classification chart

Charted curve readings are adjusted to fit the distribution within an interval.

Qu. cls.	¢/cu.ft.	D.B.H.	Ht.	Ht. 1st L.L.	S.I.	N.C.S.
3	25	any	65	15	55	0
	30	15	75	20	60	0
	35	18	80	25	70	1
2	40	22	85	30	75	1
	45	23	90	35	80	2
1	50	24	100	35	80	2
	55	24	110	35	80	3



## Appendix 7

Tree quality classification

Douglas-fir, Interior B.C.

D.B.H. inches	Site index						
	50	60	70	80	90	100	110
10							
11							
12							
13		Class 3					
14							
15							
16							
17							...
18							...
19							...
20							...
21				Class 2		...	...
22						...	...
23						...	...
24						...	...
25						Class 1	...
26					...	...	...
27					...	...	...
28						...	...
29						...	...
30						...	...
31							
32							
33							
34							
35							
36							
37							
38							