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A Data Bank System

For Forest Tree Disease And Growth Plots In British Columbia

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ABSTRACT

Growth and disease measurement data over periods up to 47 years and coordinates for 22,000 trees in seven natural stands and three plantations on eastern Vancouver Island are stored on magnetic tape. A system has been developed for rapid data retrieval by using standard formatting, sequential ordering and cross-indexing of data files. A data analysis program allows choice of compilation and statistical analysis procedures to be applied to selected data subsets, including calculation of total, mean, mode, median, range, frequency distribution, and tests of conformity to normal, random or patchy distribution. Stem maps are also produced. Data subsets can consist of any logical combination of up to 37 tree growth or disease parameters. The analysis program is in modular form, allowing the addition of compilation or statistical options. Procedures for using the system are described.

RÉSUMÉ

On a emmagasiné sur bandes magnétiques des données sur la croissance et les malladies deș arbres touchant 22,000 sujets au cours d'une période de 47 années, dans sept peuplements naturels et trois plantations, sur la partie est de l'Île de Vancouver. Un systéme fut mis au point pour le recouvrement rapide des données à l'aide d'un format standard, d'un ordre séquentiel et des index multiples des dossiers contenant les données. Un programme d'analyse des données permet un choix de compilation et des processus d'analyse statistique pour être appliqués à des sous-séries de données choisies, y compris les calculs de totaux, de moyennes, de modes, de médians, d'aires de répartition, de distribution de fréquence et de tests de conformité a des distributions normales, au hasard ou irrégulière. Des cartes sur les tiges sont aussi produites. Les sous-séries de données peuvent comprendre toute combinaison logique allant jusqu'à 37 paramètres de croissance d'arbres ou de maladies. Le programme d'analyse, de forme modulaire, permet d'y ajouter des compilations ou des statistiques, au choix. L'auteur décrit le processus à suivre pour utilizer le systéme.

INTRODUCTION

Increased use of modelling techniques in forestry research has created demands for large amounts of data covering a wide range of forest growth parameters and conditions. Concurrently, the trend toward multidisciplinary research has emphasized the need for collecting and compiling data in a form compatible with the needs of, and readily accessible to, scientists in various disciplines. This implies a rapid, simple retrieval process for specified records based on a consistent, well-indexed data file system. For large data collections, rapid retrieval can only be accomplished by computer; therefore, the necessary data storage transfer and retrieval system must be developed. Simplicity in use of a file system generally requires re-arrangement of records to allow more direct retrieval commands and may involve creating intermediate work files before final user files can be produced. Index files may be needed to minimize the amount of searching necessary for individual records, and these should be cross-referenced.

Compiling and statistical testing of data usually follows data retrieval, e.g. grouping, summing, mapping, plotting. In view of the fractional time required for computation and printing-out compared with that for retrieval, it is efficient to incorporate data-processing options in the retrieval operation. However, since simplicity in system use decreases with increasing number of options, a balance must be struck around the average requirements of the user group. It may, therefore, be advantageous to design the retrieval and data processing system in a modular structure, each option consisting of a separate module which can be added or deleted without causing structural changes to the others. Thus, changing user requirements can be accommodated with minimum disruption.

At the Pacific Forest Research Centre (PFRC), development of multidisciplinary research in simulation of forest growth and pest impact caused us to review part of our data resource and to maximize its usefulness. This data had been collected by scientists at PFRC and the British Columbia Forest Service over a period of 47 years in the coastal Douglas-fir zone. A variety of plot sizes, shapes, measurement variables and periods had to be accommodated. Specialized interests of mensurationists and pathologists had to be satisfied, while meeting the limitations of an in-house mid-size computer. We hope that the following description of the approaches used at PFRC to meet these requirements will be helpful to other groups facing the same problems. In addition, by providing a full account of the system, we hope to encourage use of, and addition to, the existing data bank.

DATA STORAGE

Data Sources

The data comprise growth and disease measurements in three plantations and seven natural stands (ca 22,000 trees) growing on Vancouver Island, from Lake Cowichan (48° 50′ N, 124° 07′ W) to Campbell River (50° 00′ N, 125° 20′ W). Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) is the main species in all installations. At installation establishment, the natural stands ranged in age from ca 15 to 65 years and plantations were ca 15 years old. All trees were mapped and coordinates were recorded for each tree in plantations. Pertinent data are summarized in Table 1. Site and establishment details have been described by Wallis (1976). The oldest installations (47 years) were established by the B.C. Forest Service to study growth and yield of Douglas-fir. Mortality caused by root rot, particularly *Phellinus (Poria) weirii* (Murr.) Gilbertson, became apparent following establishment, so the plots and records were made available to PFRC for studying the disease. Installations established by PFRC are of more recent origin; up to 20 years of growth records are available.

Data recorded varies among installations and measurement dates. For most installations, diameter at breast height (dbh) and crown class are recorded from date of establishment. An adequate sample of heights is also available for most areas. Diagnosis of disease and natural mortality is considered reliable, particularly in the last 20-30 years when the installations were inspected by forest pathologists. Stem maps, available for all installations, appear to be sufficiently accurate to allow their use in estimating competitive stress indices.

Installations varied greatly in layout and measurement procedure. Excepting Tsable River, Block 3, plantation installations comprised square or rectangular blocks of varying size. These blocks were subdivided into plots 20.86 x 20.86 ft (1/100 ac.) and subplots 10.43 ft square (1/400 ac.). Coordinates within each plot, based on a 16 x 16 grid (1 grid unit = 1.3 ft or 0.4 m), were measured in units from a point of origin at the lower right-hand or left-hand corner of each plot. Natural stand installations consisted of single plots or clusters of plots, rectangular or circular in shape, ranging in size from .25-1.0 ac. Trees were mapped but their coordinates were not computed.

Measurement data varied according to type of installation and year of measurement. A list of plantation variables and their code values is shown in Table 2. Natural stand records were less detailed and their format varied considerably. They were re-recorded using a standard format based on that for plantations (Table 3).

Many data compilations at PFRC require a record of horizontal coordinates (e.g. calculation of competition indices, modelling disease spread); therefore, it was essential to include coordinates in each tree record based on as large an area as possible. For plantations, tree coordinates based on individual plots were converted to coordinates based on the whole installation. For natural stands, individual tree coordinates were computed from stem maps, then added to tree records.

File Creation

Plantations - The method used to convert the data to computer storage can probably be best described by the use of Tsable River, Block 1, as an example. Orientation of individual plots within the plantation is shown in Fig. 1. As a first step, written records of tree coordinates and measurement data, formatted as in Table 2, were transferred to punch cards, then to magnetic tape (Magtape) from which a print-out was made for error-checking. Tree records, as stored on Magtape, are shown in Fig. 2.

Tree coordinates on the original Magtape file had origins of 0,0 corresponding to the lower left corner of each plot. This coordinate system was converted to an overall installation system with origin 1,1 (to make data handling in FORTRAN simpler), the conversion being accomplished in two steps.

1) The Tsable River Block coordinate system, 24 plots long x 12 wide, has 384 and 192 units along the X and Y axes, respectively, coordinates being numbered 1-385 and 1-193 (16 x 24 units + 1 unit and 16 x 12 units + 1 unit). Accordingly, a matrix (array) 385 x 193 was created and placed on disk in a direct-access work file for coordinates (grid file). Tree records for each year of examination were extracted from the Magtape; at the same time, the plot coordinates were converted and written with the associated data on disk in a direct-access work file for measurement data. The location (file record number) of each record in the data work file was cross-referenced in the grid file, e.g. if the 300th consecutive record written into the data work file had converted coordinates X = 126, Y = 58, position 126,58 in the grid file matrix was set to 300. At the completion of this step, the matrix in the grid file contained a record number for every record in the data work file.

2) To allow more efficient data retrieval,

the tree data work file was re-ordered so that the first and last records pertained to the tree with the minimum X and Y coordinates (lowermost, left-hand tree) and the one with the maximum X and Y coordinates (uppermost, right-hand tree), respectively. The re-ordered records were then transferred to a finalized data (FD) file, sequentially ordered so that the records 1 to i, the right-most tree along the coordinate Y=1, appeared in order of increasing X coordinate. Along the coordinate Y=2 were the trees represented in records i+1 to j, the right-most tree along Y=2, and so on. The relationship between the tree data work file and the physical area is shown on the left in Fig. 3; the FD file is shown on the right.

Although the FD file was thereby ordered in a sequential manner, searching for coordinates in such lengthy files on disk required excessive time. Therefore, two indexing files were created for rapid in-core searching of specific coordinates, allowing a reduced number of disk-reads to retrieve a tree record at a particular grid point. These files, consisting of simple arrays, were stored as one-record direct-access files. The "last record number" (LRN) file contained, in locations 1-193, the last tree record on each Y row. That is, the entry in location 1 was the FD file record number of the right-most tree along the Y coordinate 1. Location 2 gave the record number of the right-most tree on Y=2, and so on. Thus, all trees with Y coordinate = 10 are found in the FD file under record numbers corresponding to LRN locations 9 (+1) to 10.

The "X-coordinate" (XC) file allowed further in-core searches of coordinate points. This contained the X coordinates of all trees ordered as in the FD file. Thus, the coordinates X=100, Y=10 could be inspected in the XC file at locations 9 (+1) to 10 of the LRN file. The relationship between the FD, LRN and XC files is shown in Fig. 4.

Natural Stands - Owing to varying formats in field data recording, the procedure for creating natural stand files differed from that for plantations. Files were created in three steps, as follows:

1) Tree coordinates, relative to the plot grid origin (1,1) at lower left-hand corner, were derived from stem maps by Gradicon digitizer. Coordinates, to the nearest 1/100th inch, map scale, were automatically punched on cards with their tree identification number. The origin of non-rectangular plots was set at that of a circumscribing rectangle. Coordinates for each tree number were transferred to Magtape work files (grid file) and a list printed out for error-checking. Change of coordinates to a more convenient map scale, if desired, was made on the grid file. In most stands, the scale in 1/100th inch was unnecessarily large and was therefore reduced by a factor of 6. The original coordinates were replaced by recalculated ones.

2) Tree data work files were created on Magtape from field records, formatted as in Table 3.

3) Grid and data files were merged to form a final data file.

Natural stand files were much smaller than those for plantations and disk-reading time was not excessive; therefore, indexing files were not created.

File Identification

Plantations - The number and length of tree records for plantations necessitated separation according to year of examination. Each file, i.e. grid, LRN, XC, work files and final data files were named systematically, as shown in Table 4. By this system, the first five letters identify the type of file; the first number indicates the installation to which it pertained, and the last two numbers following the period indicate the year of examination.

Natural Stands - Because of their small size, natural stand files were not separated by examination year; this operation was performed by the retrieval and analysis program (see below). Names for natural stand files are shown in Table 4. Letters preceding the period identify the type of file; the first number after the period identifies the installation; the last numbers are the plots within the installation.

DATA RETRIEVAL AND ANALYSIS

Current requirements of the PFRC scientist group using the data bank include the following procedures:

Inspection of selected portions of the files.

Summaries, including totals, means, frequency distributions.

Basic statistical summaries, including range, median, mode, conformity to normal distribution.

Map of all or selected portions of installations.

Special statistical tests for non-randomness and patchiness of tree distribution.

To allow choice among these procedures and to accommodate additions or deletions as requirements change, the retrieval and analysis computer program was constructed in modular form, each procedure being entered as a subroutine. The function of the main program was restricted to entering the installation identity, delimiting coordinates, specifying year of examination and variables of interest. Choice of subroutines (options) are also entered in the main program.

File Specification

Following designation of the required files for mounting on the computer (see Operation of System), a check is made by the program to ensure that the file mounted on the computer matches that specified. A message is produced and the job is aborted if they do not match. The area to be examined must be specified by its delimiting coordinates either in its entirety or as a subdivision. This may be of any rectangular dimensions. An option permits the random selection of a number of individual subareas of specified dimensions.

File Inspection

Any number of records may be printed out for inspection by specifying the initial and final record number desired and the interval between them, e.g. every 10th record from records 1 to 100. Consecutive records are requested by setting the interval at 1. The record is printed out before constraint selections are made (Fig. 5).

Record Retrieval

Selections of particular trees for record retrieval are made by specifying subset(s) of the total population (constraint variables) and the selected population (test variable). For example, diameter classes of suppressed Douglas-fir with root rot are obtained by specifying the following values for the respective constraint variables: code 5 (species), value 1 (Douglas-fir); code 11 (disease class), value 1 (root rot); code 7 (crown class), value 4 (suppressed). The test variable and values are code 6 (diameter class) and values of the individual diameter classes. Any combination of constraint variables may be specified, provided they are logically consistent. If one of the specified variables was not recorded in the year of examination, a message is generated and the job is aborted. Codes for all variables and values are shown in Tables 2 and 3.

Certain features of the program increase ease and flexibility in variable selection. All values of constraint and test variables may be specified by using the value 100, rather than naming individual values. The "zero value" option allows selection of trees that do not belong to the constraint variable specified, e.g. trees without root rot can be selected using the zero value for the root rot variable. Another option allows the program to deal with either the plantation or natural stand data.

Another type of constraint option selects the population from one examination year for analysis in a subsequent year. For example, to examine diameter change over 10 years, all trees in diameter class 1 in 1960 are regrouped by diameter class in the 1970 examination. By systematic extraction of each 1960 diameter class into a pass-record file, the 10-year diameter growth of each tree can be summarized.

Only one test variable may be specified for each run, but any number of test values may be used. If a test value does not occur in the file, a message is produced but the job is not aborted. As its name implied, the test variable is the one on which statistical tests are performed and its numerical values are plotted on the stem map. For example, if the test variable is diameter class and test values include all classes, a map will show its diameter class at the location of each tree.

Data Analysis Options

The following compilation and statistical procedures may be applied to each data subset.
Summary - This option prints out subtotals and totals for constraint and test variables. Frequency distributions are plotted if there are three or more levels in a variable (Fig. 6).

Stem Maps - Stem maps may be requested for an entire installation or subdivisions thereof. The title of each map identifies the installation, date of examination, test variable plotted and map scale (Fig. 7). A further option produces a map of all test levels, followed by maps of individual test levels. For example, a stem map by diameter will show the locations of all diameter classes. Additional maps show the locations of each diameter class alone.

Descriptive Statistics - This option, based on Myers and Wilson (1969), provides print-outs of population values and sample estimates for the test variable (Fig. 8).

Tests for non-random distribution - This test (Pielou 1959), adapted by Bloomberg (1974), returns a value for index of non-randomness, number of trees in the population tested and number of samples drawn (Fig. 9). An optional print-out shows coordinates of every random point selected and those of the nearest tree. Number of samples to be drawn must be specified. Another option specifies the minimum number of individuals that must be present, thus preventing execution of the test if the population is too small for realistic results.

Test for Distribution of Patchiness - This test (Pielou 1964), adapted by Bloomberg (1974), returns a chi-squared value for conformity of patches to a random distribution, percentage of the area in patches and their average size (Fig. 10). Optional print-outs are: 1) coordinates of the centres of each plot-pair and the angular bearing from first to second, and 2) number of plots in which test individuals are present or absent, distance separating plot-pairs and computed transitional probabilities. Number of samples to be drawn, radius of plots and number of incrementations of inter-plot distance must be specified.

Conformity to Normal Distribution - This test, based on Snedecor (1959), returns a summation chi-squared value for deviation of observed from expected frequency in each test variable value class (Fig. 11).

OPERATION OF SYSTEM

This section provides detailed instructions for operation of the PFRC data bank system. Organization parallels that outlined in preceding sections, though not necessarily in the same order. Job commands are assumed to be by punched cards, using the Digital PDP-11 DOS Batch operating system.

File Specification and Creation

Files are specified by the following commands. Each command is punched on a separate card and must be in the exact order given. The first is always the JOB card:

JOB name (account number)

where "name" is any 6 alphanumeric characters, the first of which must be a letter. The job name can be conveniently used to identify the purpose of the retrieval, e.g. DEAD60 to indicate trees which died in 1960. The account, and all other numbers, are specific to the installation and can be obtained from the local data center supervisor.

The data retrieval program is stored on disk and is obtained by the following command:

$ME PLEASE MØUNT number ØN DK1:

where "number" identifies the disk.

Whenever the user data files, stored on Magtape, are changed, they are obtained by the following command:

$ME PLEASE MØUNT number ØN MT1:

where "number" identifies the Magtape.

Mount commands are followed by a wait:

$WAIT

User files must be transferred from Magtape to a corresponding job file on disk by the utility program:

$RUN PIP

Each plantation file transfer is accomplished by three commands. For the final data file:

#DK1:A<MT1:TDATAn.yy[number]/RW:NØ

where "number" is the file originator's account. File names are given in Table 4.

#DK1:TREC/CØ<DK1:A

#DK1:A/DE

For the LRN file:

#DK1:B<MT1:INDXAn.yy[number]/RW:NØ

#DK1:INDEX/CØ<DK1:B

#DK1:B/DE

For the XC file:

#DK1:C<MT1:XCRDAn.yy [number]/RW:NØ

#DK1:XCØØRD/CØ<DK1:C

#DK1:C/DE

Natural stands do not require LRN and XC files. In place of the preceding 9 commands, use:

#DK1:CRDAT.Nnn<MT1:CRDAT.Nnn

$AS DK1:CRDAT.Nnn,3

The retrieval and analysis program (PLANTØ) is executed by the command:

$RUN DK1:PLANTØ

This is followed by the variable selection and analysis card deck.

Variable Selection and Analysis

Variables are selected for retrieval and analysis by specifying their code values (Tables 2,3) on punched cards in the order indicated below. Each card consists of 16 fields, five columns wide. Code values must be entered so that they are "right-justified" in the fields, i.e. the last digit must fall in the fifth column from right in each field. The first variable selection card follows immediately after the $RUN command.

Card No.	Column No.	Values
1	5	1 for natural stand data, 0 for plantations.
	10	1 if file inspection required, otherwise leave blank.
2		Card is left blank if no record inspection required.
	1-5	Initial record number to be inspected.
	6-10	Final record number to be inspected.
	11-15	Interval of record numbers (every nth).
3		Card is left blank if no Pielou tests required.
	1-5	Number of samples to be drawn for test of population non-randomness (Pielou No. 1). Leave blank if test is not required.
	6-10	Number of samples to be drawn for test of patchiness. (Pielou No. 2) Blank if not required.
	15	1 for optional print-out for Pielou No. 1. Blank if not required.
	20	1 for optional print-out (1) of Pielou No. 2. Blank if not required.
	25	1 for print-out (2) of Pielou No. 2. Blank if not required.
	26-30	Number of distance incrementations in Pielou test No. 2. Blank if not required.
	31-35	Plot radius in Pielou No. 2. Blank if not required.
	36-40	Minimum number of trees on which to base Pielou tests. Blank if not required.
4	1-5	Code value of test variable.
	6-10	Number of test variable values.
	11-60	Values of test variable in ascending order of magnitude, one value per five-column field.
5	1-5	Installation identification number.
	6-10	Plot identification number (natural stands only). Blank if not required.
	11-15	Year of examination.
	16-20	Number of constraint variable values.
	25	1 for random selection of subareas. Blank if not required.
	26-30	Scale of map (ft per unit).

Card No.	Column No.	Values
6		This card must be included if indicator for random selection of subareas is 1, otherwise it must be excluded.
	1-5	Minimum X coordinates of selected area (in units).
	6-10	Minimum Y coordinates of selected area.
	11-15	Maximum X coordinates of selected area.
	16-20	Maximum Y coordinates of selected area.
	21-25	Length of random subareas, in units.
	26-30	Width of random subareas, in units.
	31-40	Initializers for random number generator.
	41-45	Number of subareas to be randomly selected.
7		Card is left blank if no constraints required.
	1-5	Code value of first constraint variable selected.
	6-10	Number of constraint variable values.
	11-60	Values of constraint variable in ascending order of magnitude, one per five-column field.
	65	1 for zero record option. Blank if not required.
	66-70	Assigned code value for zero record.
7(1) 7(2) . . . . 7(10)	Additional constraint codes and values as required, one constraint variable per card.	
8		Indicators for data analysis options. Value is 1 if required, otherwise left blank.
	5	Summary.
	10	Frequency distribution.
	15	Maps of all test variable values.
	20	Maps of each test variable value.
	25	Basic statistics.
	30	Normal distribution test.
	35	1st Pielou test.
	40	2nd Pielou test.

Card No.	Column No.	Values
	45	Pass File option. Blank if not required. 2 to create the pass file. 1 to use the pass file.
9	5	1 for test variable zero record option. Blank if not required.
	6-10	Assigned code value for zero record.
10	1-5	Installation identification number.
	6-10	Plot identification number (natural stands only). Blank if not required.
	11-15	Minimum X coordinates of area to be examined, in units.
	16-20	Minimum Y coordinate of area.
	21-25	Maximum X coordinate of area.
	26-30	Maximum Y coordinate of area.
11	5	−1 for termination (end of data).

The following card must come immediately after the termination card:

$EØD

Following each run, job files must be deleted as follows:

$RUN PIP
DK1:TREC/DE
#DK1:INDEX/DE
#DK1:XCØØRD/DE

If no further runs follow, the disk must be dismounted by the command:
$ ME PLEASE DISMØUNT number
$ WAIT

The job is terminated by
$FI

Notes on Inputs

Pass File - The pass file is created by selecting tree records from one year of examination file, then used by comparing the same tree numbers with their records in another, usually later year file. The change of file must be executed as a separate, later job, complete with all file specification commands.

File Inspection Option - If this is the only option requested, variable selection cards 3-9 should be blank cards.

Constraint Variables - If no constraints are placed on the inclusion of records, i.e. all records are included, one blank card should be inserted as the first constraint variable.

Normal Distribution Test - This test must be preceded by the Descriptive Statistics subroutine. Failure to include indicator for the latter generates a reminder message but does not abort the program.

Program Specification

The program PLANTØ consists of approximately 1100 FØRTRAN statements partitioned into subroutines. Working core requirements, excluding buffers, drivers, etc., are 17K words. Direct-access (disk) job file requirements are for files totalling 565K words. Current version of the program is fitted on a Digital PDP11, 24K word available core machine by "overlaying" subroutines.

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TABLE 1. Summary of installation establishment data and recording dates

	Natural Stands[1]								Plantations		
Installation No.	193 C	PW. 1	60	61	364 Thinned	364 Unthinned	395	200	1	2	3
Location	Cowichan Lake	Cowichan Lake	Parksville	Parksville	Cowichan Lake		Port Alberni	Cowichan Lake	Robertson River	Campbell River	Tsable River
Year established	1930	1939	1928	1928	1950	1950	1950	1945	1957	1958	1959
Year terminated	cont.[2]	1949	1975	1975	1975[5]	1975[5]	1963	1954	cont.	cont.	cont.
Establishing agency	BCFS[3]	CFS[4]	BCFS	BCFS	BCFS	BCFS	BCFS	BCFS	CFS	CFS	CFS
Number of Plots	1	3	1	1	7[6]	7	14	1	1	1	1
Plot size (ac)	0.69	0.25	0.4	1.0	0.5	0.5	0.1	0.1	9.0	7.2	4.8
Length (X axis) in grid units	376	334	174	245	138		83	112	480	960	Block 1,384 Block 2,192
Width (Y axis) in grid units	127	334	175	244	111		83	109	480	192	192
Length of grid unit (m)	.24	.11	.23	.26	.37		.24	.18	0.40	0.40	0.40
Year Recorded: D.B.H.	30,45,54, 57,75	39,45 49,51	28,33,37,42, 47,52,55,57, 67,75	28,33,37,42, 47,53,54,55, 57,67,75	51,57,60,63,68,70, 75		46,50, 55,57	35,40, 45,49, 50,54	63,68,75	64,69,75	65,70,75
Crown Class	30,42,57,75	39,51	28,33,37,42 47,53,57,75	28,33,37,42 47,55,57,75	51,75		46,50 55	35,40 45,49 54		69,72	70,73
Height[7]	30,57,75	49	55,67,75	54,67,75	51,57,63,68,70,75		50,55,	35,49, 54	59,75	58,75	59,75
Disease	45,54,57,60, 63,64,66,68, 70,72,75	35,40,43,45, 48,49,51	33,37,42,47, 55,61,66,70 75	33,37,42,47, 54,57,61,66, 68,70,73,75	51,53,54,57,60,63, 60,63,64,66,70,75		46,50 55	40,45, 49,54	57,60,63 68,71	58,61,64, 69,72	59,62,65, 70,73

1 = natural established stand
2 = measurements still continuing
3 = British Columbia Forest Service
4 = Canadian Forestry Service
5 = measurements on some plots terminated in 1970
6 = plots 10,11,12 destroyed in 1971.
Not all plots measured in same year.
7 = sample trees only measured

Table 2. Variable Codes and Values (Plantations)

Variable	Code No.	Value 1	2	3	4	5	6	7	8	9	10
Installation	1	Robertson R.	Campbell R.	Tsable R. Block 1	Tsable R. Block 2						
Block	2	Numbers can be obtained from original maps									
Plot	3										
Tree No.	4										
Species	5	Douglas-fir	W. Hemlock	W.R. Cedar	White Pine	Lodgepole Pine	Alder	Maple	Balsam Fir	Other Hardwoods	
DBH Class (inches)	6	0.1-1.0	1.1-2.0	etc.							
Crown Class	7	Dominant	Codominant	Intermediate	Suppressed						
Age	8	As recorded									
Tree Condition	9	Living	Dead								
Foliage Color	10	Green	Yellow	Green-yellow	Yellow	Red					
Disease Class	11	Rootrot									
Disease Class	12		Frost lesion								
Disease Class	13			Foliage Dis.							
Disease Class	14				Dieback						
Disease Class	15					Terminal Bud Injury or Leader Breakage					
Disease Class	16						Sunscald				
Rootrot Class	17	Healthy with symptoms	Green & Pitch exudate	Yellow-Green	Yellow-Green & Pitch ex.	Green (confirmed disease)	Yellow (confirmed disease)	Apparent Healing	Apparent Healing	Dead	Healthy no symptons
Year of Death	18	Last 2 digits of year									

Table 2. (Continued)

Variable	Code No.	Value 1	2	3	4	5	6	7	8	9	10
Apparent Healing	19	Pitch exudate	Pitch, ex. & mycelium	Lesions	Pitch, ex. & lesions	Pitch, ex., mycel. & lesions					
Root-rot identification	20	Armillaria mellea	Phellinus weirii	A. mellea & P. weirii	Fomes annosus	A. mellea & F. annosus	Poria subacida	Polyporus schweinitzii	Other	Undiagnosed	
Years of decline	21	No. years									
Girdling (% of circum.)	22	25	50	75	100						
Sunscald internodes	23	No. of internodes involved									
Sunscald color	24	Red	Bronze	Copper							
Sunscald lesions	25	No. lesions									
Frost lesion internodes	26	No. internodes involved									
Frost lesion	27	No. lesions									
Foliage Disease	28	% Crown Thinning									
Foliage Disease Identification	29	Rhabdocline	Needle Curl								
Cause of death (other than root rot)	30	Suppression	Breakage	Other							
Years since dieback	31	Year of dieback to last living node									
Dead leader growth	32	Whole feet									

Table 2. (Continued)

Variable	Code No.	Value									
		1	2	3	4	5	6	7	8	9	10
X coordinate	33	Original Plot coordinates.									
Y coordinate	34										
Year of examination	35	Last 2 digits of year.									
X coordinate	36	Computed Installation coordinates									
Y coordinate	37										

TABLE 3

Variable Codes and Values (Natural Stands)

Variable	Code No.	Value: Identification No.	193C	PW.1	60	61	364	395	200
Installation[1]	1		1	2	3	4	5	6	7
Plot No.	2		1	1	1	1	1-14	1-14	1
Tree No.	3	Values obtained from Stem maps.							
Species	4	Values as for Plantations.							
DBH	5								
Height	6	Values in whole feet.							
Age	7								
Crown Class	8								
Tree Condition	9								
Year of death	10								
Cause of death (other than root rot)	11	Values as for Plantations							
Root rot identification	12								
Year of examination	13								
X coordinate	14								
Y coordinate	15								

[1] See Table 1 for location of installations.

Table 4

Names of computerized plantation and natural stand data storage files

File Name	Purpose	Example
GDATAn.yy	Plantation data work file	GDATA1.59 (data work file for plantation no. 1 (Robertson River), in examination year 1959)
GRIDAn.yy	Plantation coordinate work file	GRIDA1.59
TDATAn.yy	Plantation final data file	TDATA1.59
INDXAn.yy	Plantation LRN file	INDXA1.59
XCRDAn.yy	Plantation XC file	XCRDA1.59
TDAT.Nnn	Natural stand data work file	TDAT.31 (data work file for installation no. 3., plot no. 1)
CØØRDS.Nnn	Natural stand coordinate work file	CØØRDS . 31
CRDAT.Nnn	Natural stand final data file	CRDAT. 31

p12	p13	p36	....	p276	p277
p11	p14	p35	....	p275	p278
p10	p15	p34	....	p274	p279
.	.	.		.	.
.	.	.		.	.
.	.	.		.	.
.	.	.		.	.
p02	p23	p26	....	p266	p287
p01	p24	p25	....	p265	p288

Fig. 1. Plot orientation in Tsable River, Block 1.

A	B	P1	Tree	---- tree data ----	X	Y	Yr
3	1	20	138	....	5	2	59
3	1	20	138	....	5	2	62
3	1	20	138	....	5	2	65
3	1	20	138	....	5	2	70
3	1	21	140	....	1	9	59
3	1	21	140	....	1	9	62

Fig. 2. Tree records as they appear on original Magtape file, arranged by Area (A), Block (B), plot (P1).

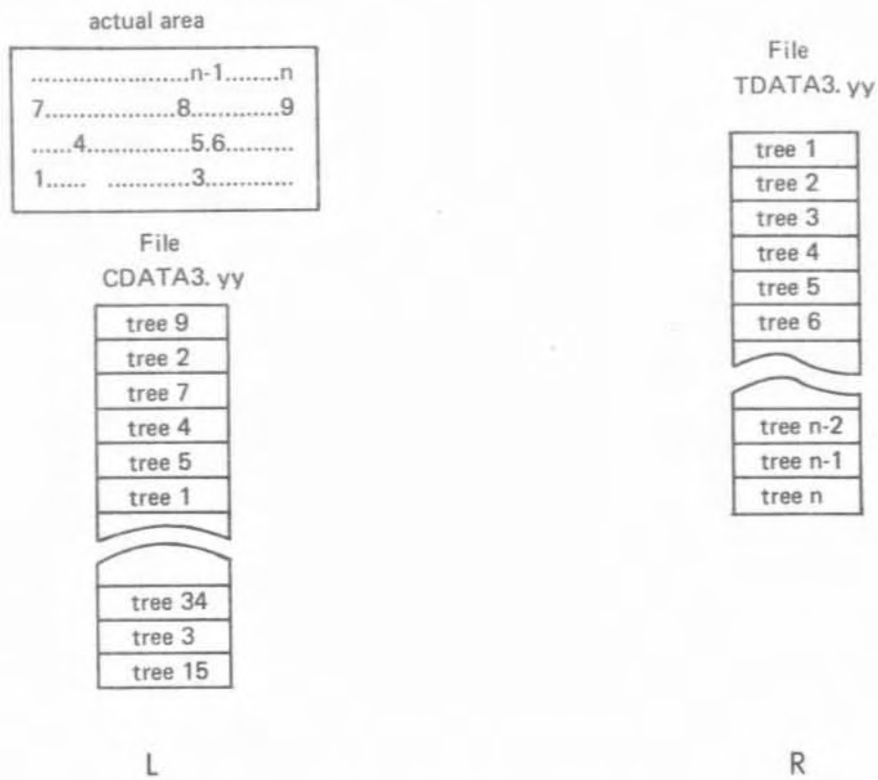

Fig. 3. (L) Unordered arrangement of work file in relation to position of trees in plantation.
(R) Re-ordered finalized work file.

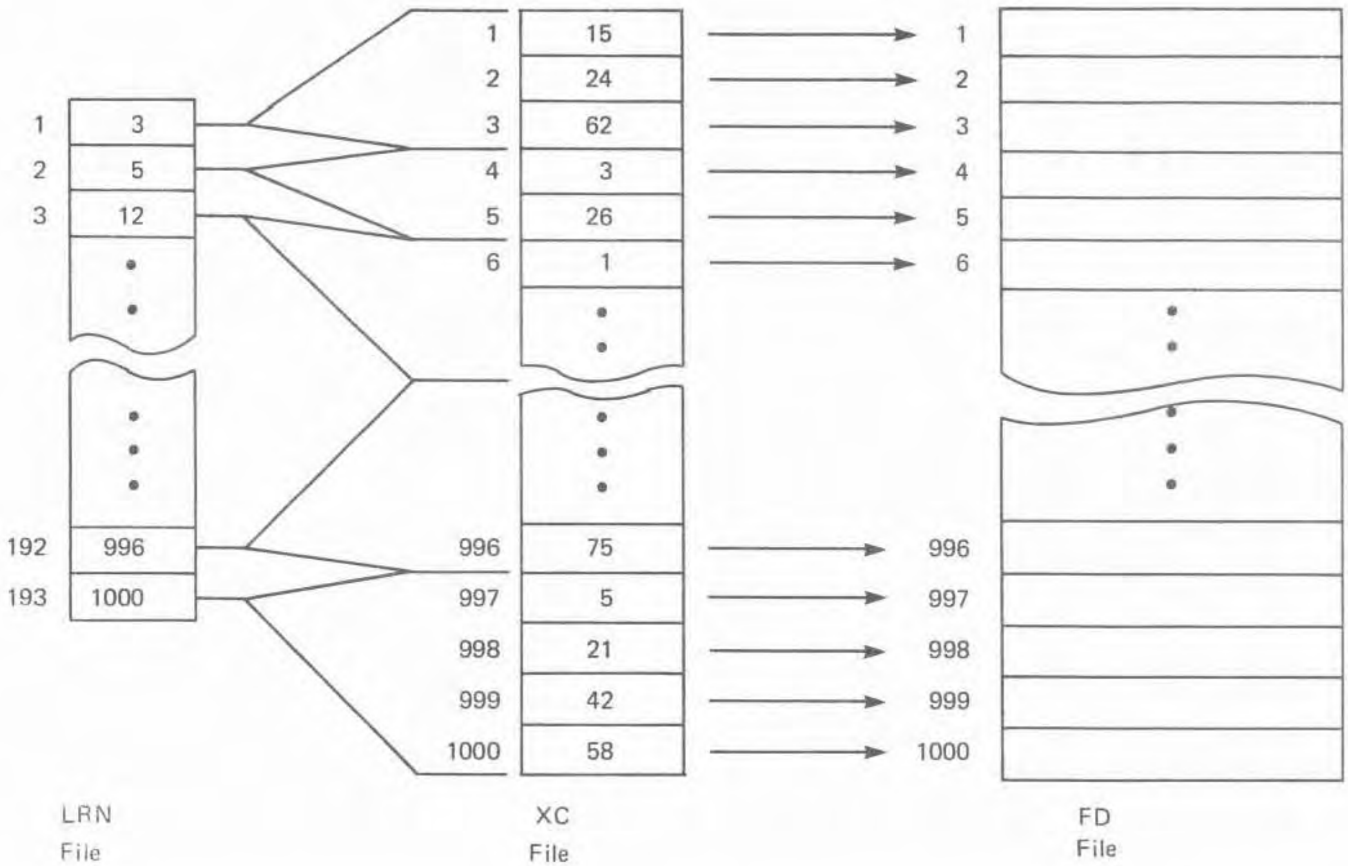

Fig. 4. Relationship between LRN, XC, and FD files for 1000 trees, 75 X, and 193 Y coordinates. The right-most tree record on Y = 1 is no. 3, and on Y = 193, no. 1000, Trees on Y = 1 have X coordinates 15, 24 and 62, those on Y = 193 5, 21, 42 and 58. Tree records are arranged serially in the FD file.

PLANTATION NO. 2 YEAR OF EXAMINATION 69

BOUNDED BY COORDINATES 1, 1 TO 52, 60

PARTIAL PRINT-OUT OF TREE RECORD FILE FROM RECORD NO. 1TO 1000 BY INTERVALS OF 10

VARIABLE NO.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2	2	720	6313	1	8	1	0	1	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	6	0	69	7	1
2	2	697	6011	1	5	0	0	2	0	2	0	4	0	0	0	0	64	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5	69	17	6
2	2	697	6013	1	6	3	0	1	1	0	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	6	69	32	7
2	2	673	5731	1	7	2	0	1	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	13	69	49	14
2	2	719	6305	1	8	1	0	1	1	0	0	3	0	5	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	1	1	69	2	18
2	2	695	5993	1	3	4	0	1	1	0	0	3	0	5	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	1	2	69	34	19
2	2	695	5495	1	7	2	0	1	1	0	0	3	0	5	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	9	3	69	42	20
2	2	695	5969	1	5	3	0	1	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	6	10	69	39	27
2	2	719	6301	1	6	3	0	1	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0	0	0	6	13	69	7	32

Fig. 5. Example of print-out obtained by specifying file inspection option. Variable code numbers and values are explained in Tables 2 and 3.

```
                              PLANTATION NO.  2      YEAR OF EXAMINATION  69
              BOUNDED BY COORDINATES   1,   1 TO  50,  60


                          NO. OF TREES IN SELECTED VARIABLES AND LEVELS

     CONSTRAINT               CONSTRAINT
     VARIABLE                 LEVEL

         5   1   2   3                                                            TOTAL

           105   0   0                                                             105

                     P  E  R  C  E  N  T    O  F     T  R  E  E  S
.........10........20........30........40........50........60........70........80........90.......100
.                                                                                                   1

.

.

     CONSTRAINT               CONSTRAINT
     VARIABLE                 LEVEL

         9   1                                                                    TOTAL

           105                                                                     105

       TEST                   TEST
     VARIABLE                 LEVEL

         6   1   2   3   4   5   6   7   8   9  10  11                            TOTAL

             2   7  15  16  20  13  13  10   7   1   1                             105

                     P  E  R  C  E  N  T    O  F     T  R  E  E  S
.........10........20........30........40........50........60........70........80........90.......100
.1

.   2

.          3

.           4

5               5

.        6

.        7

.      8

.   9

1010

.11
```

Fig. 6. Example of print-out obtained by specifying summary option. Number of trees in each level of first constraint variable is shown in tabular form, followed by frequency distribution graph if three or more levels have been specified. Table and graph is repeated for each constraint and test variable. Variable code numbers and values are explained in Tables 2 and 3.

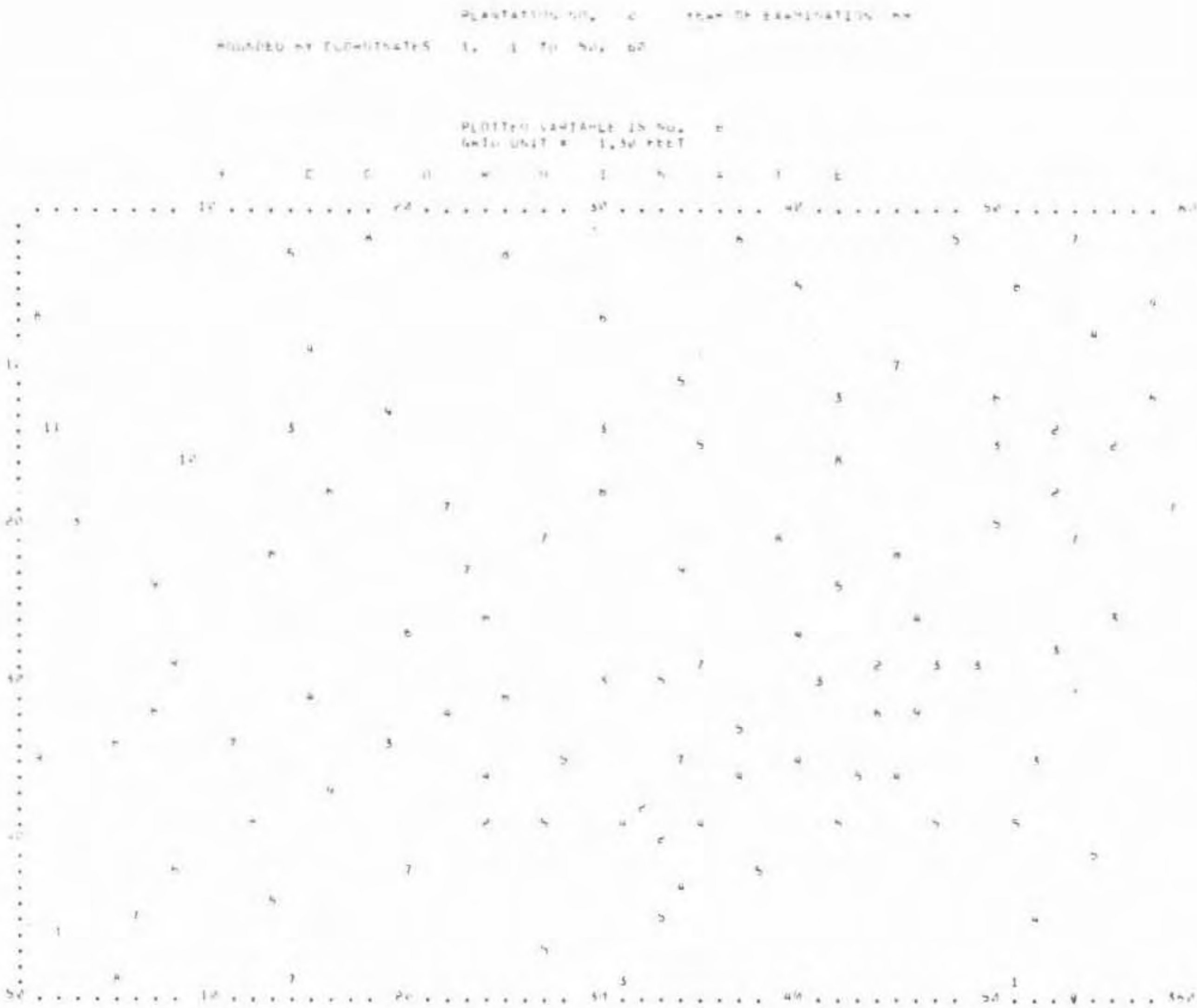

Fig. 7. Example of print-out obtained by specifying stem map option. Position of each tree is shown by a numeral representing the value of the test variable, in this case variable code 6 or DBH, by one-inch diameter classes.

```
                                        PLANTATION NO.   2      YEAR OF EXAMINATION  69

                  BOUNDED BY COORDINATES   1,   1  TO  50,  60


                                        TEST VARIABLE IS    6


                  DESCRIPTIVE STATISTICS

     FOR CALCULAT   ION OF THE RESULTS IN PART A, THE DATA SET IS
TREATED AS AN ENTIRE POPULATION, FOR CALCULATION OF THE RESULTS
IN PART B, THE DATA SET IS TREATED AS A SAMPLE FROM A MUCH LARGER
POPULATION.  IN ALL CASES, IT IS ASSUMED THAT NO CORRECTIONS ARE
REQUIRED FOR MEASUREMENT OR GROUPING INTERVALS.

                  PART A - POPULATION VALUES

PARAMETER                VALUE                  SYNONYMS
---------                -----                  --------
MEDIAN                  5.0000
1ST MODAL VALUE         5.0000
MODAL FREQUENCY             20
RANGE                  10.0000
MEAN                    5.3143               EXPECTED VALUE, 1ST MOMENT,
                                             1ST CUMULANT.
SUM OF SQUARED
DEVIATIONS FROM       486.6267
THE MEAN
VARIANCE                4.6536               2ND MOMENT, 2ND CUMULANT

                  PART B - SAMPLE ESTIMATES

STATISTIC                VALUE                  SYNONYMS
---------                -----                  --------
MINIMUM                      1
MAXIMUM                     11
TOTAL                 558.0000
NO. OF OBSERVATIONS        105               TOTAL FREQUENCY
VARIANCE                4.6984               2ND K-STATISTIC.
DEGREES OF FREEDOM        104.
STANDARD DEVIATION      2.1676
STD. ERROR OF MEAN      0.2115
```

Fig. 8. Example of output obtained by specifying descriptive statistics option. The data comprises all values of the test variable, treated as a total population and as a sample.

```
                              PLANTATION NO.   2   YEAR OF EXAMINATION  69
              BOUNDED BY COORDINATES   1,   1  TO  50,  60


VARIABLE AND LEVEL BEING TESTED FOR DISTRIBUTION ARE     6/100

RANDOM POINT    DISTANCE TO  NEAREST INDIVIDUALS

 10, 34              1.0
 41,  2              5.0
 42, 54              1.4
 43, 12              1.4
 25, 21              2.2
 34, 60              8.1
  7, 45              3.0
 21, 51              1.4
 23,  6              1.4
 34, 20              1.0

PIELOU"S TEST OF RANDOMNESS BY POINT TO PLANT DISTANCES

NO. OF INDIVIDUALS  OMEGA      ALPHA      NO. OF SAMPLES

          105       114.00     1.301           10
```

Fig. 9. Example of output obtained by specifying option for 1st Pielou test on test variable no. 6, all values (indicated by 6/100). Optional print-out shows random points and distances. Alpha value indicates index of non-randomness which must be compared with a table value (Pielou 1959).

```
AREA    2  BOUNDED BY COORDINATES  121,121  TO  180,180

VARIABLE AND LEVEL BEING TESTED FOR DISTRIBUTION OF PATCHINESS ARE    6/  9


CHI-SQUARED FOR RANDOM DISTRIBUTION =   43.42  WITH   10  DEGREES OF FREEDOM
MEAN DIAM.        OF PATCHES =      2.1
MEAN DIAM. OF GAPS     =      37.2
PERCENT AREA  OCCUPIED BY PATCHES =   1.2  VARIANCE =  0.002
```

Fig. 10. Example of output obtained by specifying Pielou test no. 2. Significant patchiness is indicated by a chi-squared value exceeding the table value.

PLANTATION NO. 2 YEAR OF EXAMINATION 69

BOUNDED BY COORDINATES 1, 1 TO 50, 60

TEST VARIABLE IS 6

GOODNESS OF FIT TEST FOR THE NORMAL DISTRIBUTION

CLASS	OBSERVED FREQUENCY	EXPECTED FREQUENCY	(O-E)(O-E)/E
1	2	1.666811	0.06660339
2	7	4.144356	1.96766067
3	15	8.302714	5.31235409
4	16	13.597604	0.42445037
5	20	17.944849	0.23536813
6	13	19.175625	1.98889709
7	13	16.591776	0.77754509
8	10	11.624228	0.22694972
9	7	6.594087	0.02498688
10	1	3.028562	1.35876977
11 +	1	2.289368	0.72616953

SUMMATION CHI SQUARE = 13.10975456
WITH 8 DEGREES OF FREEDOM

Fig. 11. Example of output obtained by specifying option for testing conformity of test variable data to a normal distribution.