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FIELD MANUAL FOR MEASURING DECAY AND CULL IN FORESTS

by D.G. Bryant and K.S. Richardson

NEWFOUNDLAND FOREST RESEARCH CENTRE
ST. JOHN'S, NEWFOUNDLAND
INFORMATION REPORT N-X-119

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I. INTRODUCTION

The major causes of cull[1], the major decay types, and the principal decay organisms were identified in a recent global forest inventory in Newfoundland (Richardson 1973). However, the information obtained was too general to relate volume losses to site characteristics, stand age classes or stand types. Such detailed information is essential to obtain reliable estimates of net merchantable volumes and to prepare precise management plans. In addition, the detailed information may be used for developing systems of forest protection, for evaluating and modifying, if necessary, existing cull specifications, and for establishing acceptable limits of decay in trees in relation to the utilization of a variety of forest products such as pulpwood, sawlogs, plywood, chipboard, etc.

Decay and cull studies require stem analyses of a large number of trees and include from 25 to 125 measurements and observations for each tree. This amount of data must be systematically collected and recorded to minimize errors, and to expedite the processing and analysis of data and finally the reporting of results. This manual describes the methods required for dissecting trees, and for classifying and measuring defects and decay, and in addition, it describes a systematic method for recording data.

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[1]Hudak, J., J. Meades, and K. Richardson. 1971. Cull survey of the forests of Newfoundland. Canad. For. Serv., For. Res. Lab. Intern. Rep. N-42.

II. SITE AND STAND MEASUREMENTS

Observations and measurements of site and stand conditions and selection of plot location and size will vary with the agency concerned with inventory and cull surveys. In the system described in this manual, site and stand data will be recorded in the two lines of the header of the tally form (Fig. 1). However, the same information does not need to be repeated for every tree measured in a plot; it is necessary only to record the site and stand data on the tally form that includes the information for the first tree in each plot.

The method of recording observations and measurements of site and stand characteristics are listed below. The abbreviations on the left side of the page correspond to headings on the form.

IN FIRST LINE OF HEADER

Reg - Inventory number. Obtained from user's inventory instructions.

FS - Forest Section number according to Rowe (1972). Codes for sections are printed at the bottom of tally form.

Map - Inventory Map Number. Obtained from inventory instructions.

Plot - Inventory Plot Number. Obtained from inventory instructions.

Tree No. to Age BH: - See section III for recording tree data.

LC - Land capability class, numbered 1 to 7, as described by McCormack (1967) as follows:

1 - No limits to commercial forest growth: over 1.11 cunits/year.

2 - Slight limits to growth: 0.91 to 1.10 cunits/year.

3 - Moderate " " " : 0.71 to 0.90 " "

4 - Moderately-severe limits: 0.51 to 0.70 " "

5 - Severe limits to growth: 0.31 to 0.50 " "

6 - Very severe limit : 0.11 to 0.30 " "

7 - No commercial growth : less than 0.11 " "

Note: The capability class for forested areas may be obtained from published maps.

TALLY FORM FOR DECAY AND CULL

RECORDED BY ____________________

DATE ____________________

Reg	FS	Map	Plot	Tree	Tree I.D. No.	Spec.	Tot. Ht.	Ht. 3" Dob	Crown L	CC	No. bolts	St. Age	Age B H	LC	CT	HC	CD	

Tree I.D. No.	FT	Top	S	A	Elev.	SO	SM	ST	

Bolt No.	Dob	Dib	FD	section 1	2	3	4	FD	section 1	2	3	4	Ind. sec.	Ind. sec.	Decay description & measurement P	A	I	D/W-A	D/W-I	L-A	L-I	Density wood	Density decay	Decay organism	DT	Tree I.D. No.	

Forest section		Crown class	
B1b	1	Broken top	0
B12	2	Dominant	1
B13a	3	Codominant	2
B28a	4	Intermediate	3
B28b	5	Overtopped (suppressed and advanced growth)	4
B29	6		
B30	7		
B31	8		
B32	9		

Form defect		External indicator		Section affected
None	0	None	0	No decay
Fork	1	Fork	1	1st ft.
Crook	2	Crook	2	2nd ft.
Sweep	3	Rot. branch	3	3rd ft.
		Broken top	4	4th ft.
Section affected		Open scar	5	
		Closed scar	6	
Not	0	Conk	7	
1st ft.	1	Canker	8	
2nd ft.	2	Frostcrack	9	
3rd ft.	3			
4th ft.	4			

Decay Description and Measurement

Position (P)		Advanced (A)		Incipient (I)
No decay	0	None	0	None
Butt-heart	1	Yellow stringy	1	Yellow
Trunk-heart	2	Yellow spongy	2	Brown
Sapwood	3	Brown stringy	3	Red
Trunk rot outside butt rot or another trunk rot	4	Brown spongy	4	Pink
		Brown cubical	5	Green
		White stringy	6	Purple
		White spongy	7	Black
		Red stringy rot	8	Yellow-green
		Red stringy pocket rot	9	red-brown

Species	
Tremblg aspen	311
White birch	168
Yellow birch	166
Balsam fir	003
White spruce	043
Black spruce	045
Larch	032
White pine	062
Red maple	110
Willow	400

Fig. 1. Tally form for recording measurements of decay and cull in trees.

CT - Cover type expressed in code as

1 - over 74% softwood (conifers)

2 - 51% to 74% softwood (conifers)

3 - 26% to 50% softwood (conifers)

4 - less than 26% softwood (conifers)

HC - Height class expressed in code as follows for four dominant stems in the plot area

1 - up to 10 feet

2 - 11 to 20 feet

3 - 21 to 30 feet

etc.

CD - Crown density expressed in code as follows

1 - 71% to 100% crown closure

2 - 41% to 70% " "

3 - 11% to 40% " "

4 - 0 to 10% " "

IN SECOND LINE OF HEADER

TREE ID NO. See section III

FT - Forest type will be coded per user's instructions. They are, for western insular Newfoundland,

1. Pleurozium-balsam fir

2. Black spruce-moss forest

3. Dryopteris-balsam fir

4. Clintonia-balsam fir

5. Sphagnum-balsam fir

and for central and eastern insular Newfoundland,

6. Kalmia-black spruce

7. Sphagnum-Kalmia-conifer

8. Pleurozium-balsam fir

9. Hylocomium-balsam fir

10. Sphagnum-balsam fir

11. Carex-balsam fir

12. Rubus-balsam fir

13. Lycopodium-Dryopteris-balsam fir

14. Black spruce-moss forest

15. Bog

and for Labrador Newfoundland (Wilton 1965)

16. Spruce/lichen

17. Spruce-fir/feathermoss

18. Fir-spruce-birch/rich herb

19. Spruce-fir/Dwarf shrub

20. Spruce/sphagnum

TOP - Topographic position will be coded in five classes

1 - Ridge top
2 - Upper slope
3 - Middle slope
4 - Lower slope
5 - Valley bottom

S - Slope in five classes

1 - 0 to 5% slope
2 - 6 to 15% slope
3 - 16 to 30% slope
4 - 31 to 60% slope
5 - over 60% slope

A - Aspect will be coded in nine classes

1 - N
2 - NE
3 - E
4 - SE
5 - S

8. Pleurozium-balsam fir

9. Hylocomium-balsam fir

10. Sphagnum-balsam fir

11. Carex-balsam fir

12. Rubus-balsam fir

13. Lycopodium-Dryopteris-balsam fir

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3 - 16 to 30% slope
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5 - over 60% slope

A - Aspect will be coded in nine classes

1 - N
2 - NE
3 - E
4 - SE
5 - S

6 - SW

7 - W

8 - NW

9 - FLAT

ELEV - Elevation will be recorded in feet or meters per instructions.

SO - Soil order will be coded in eight classes per The System of Soil Classification for Canada (1970) as follows:

1 - Chernozenic (deep A horizon)

2 - Solonetzic (degraded)

3 - Luvisolic (clayey)

4 - Podzolic (leached)

5 - Brunisolic (brown)

6 - Regosolic (indeterminant)

7 - Gleysolic (water-logged)

8 - Organic

SM - Soil moisture will be coded in six classes per The System of Soil Classification for Canada (1970) as follows:

1 - Moisture seldom exceeds soil capacity.

2 - Well-drained; no mottling in upper 3 feet

3 - Moisture present for small part of year; mottled below 2 feet

4 - Moisture in excess of field capacity for long periods; mottling sometimes in A horizon.

5 - Moisture in excess for most of year; poorly drained

6 - Free water within 1 foot of surface for most of year.

ST - Soil texture will be coded as follows:

1 - Silt

2 - Sand

3 - Loamy sand

4 - Sandy loam

5 - Sandy clay loam

6 - Loam

7 - Silty loam

8 - Clay loam

9 - Silty clay loam

10 - Sandy clay

11 - Silty clay

12 - Clay

III. TREE MEASUREMENTS

The methods for dissecting trees and recording data are described in the following four subsections. The measurements obtained are used for stem analyses of trees in the plot.

A. Marking and falling trees

Within each plot, all trees 3.6" diameter at breast height (dbh) and over will be numbered consecutively with a felt-marker on an exposed wood surface below the 0.5 foot (stump height) level of the stem. All numbered trees will be felled at stump height and the stem of each felled tree will be marked at 4 foot intervals, commencing at the butt and extending to a top diameter of 3.0" diameter outside bark (dob). The length of the last bolt may be equal to or less than four feet because of the top diameter limit.

B. Recording tree information on the header of the tally form

The header information will be recorded on the top line of the tally form (Fig. 1). The following abbreviations at the left hand side of the page correspond to the headings on the form.

IN FIRST LINE OF HEADER

Reg, etc. - see section II.

Tree - Tree number. Assigned sequentially starting with number 1 in each plot.

If a tree is forked below 4.5 feet and both stems are 3.6 inches dbh or over, treat each stem as a tree (Fig. 2A), each with its own tree number.

If a tree is forked above 4.5 feet (Fig.2B), a different tally sheet is used for each stem but all stems have the same basic tree number, for example as follows:

00012 for the main stem

10012 for the lowest secondary stem

20012 for the next " "

30012 " " " " "

etc.

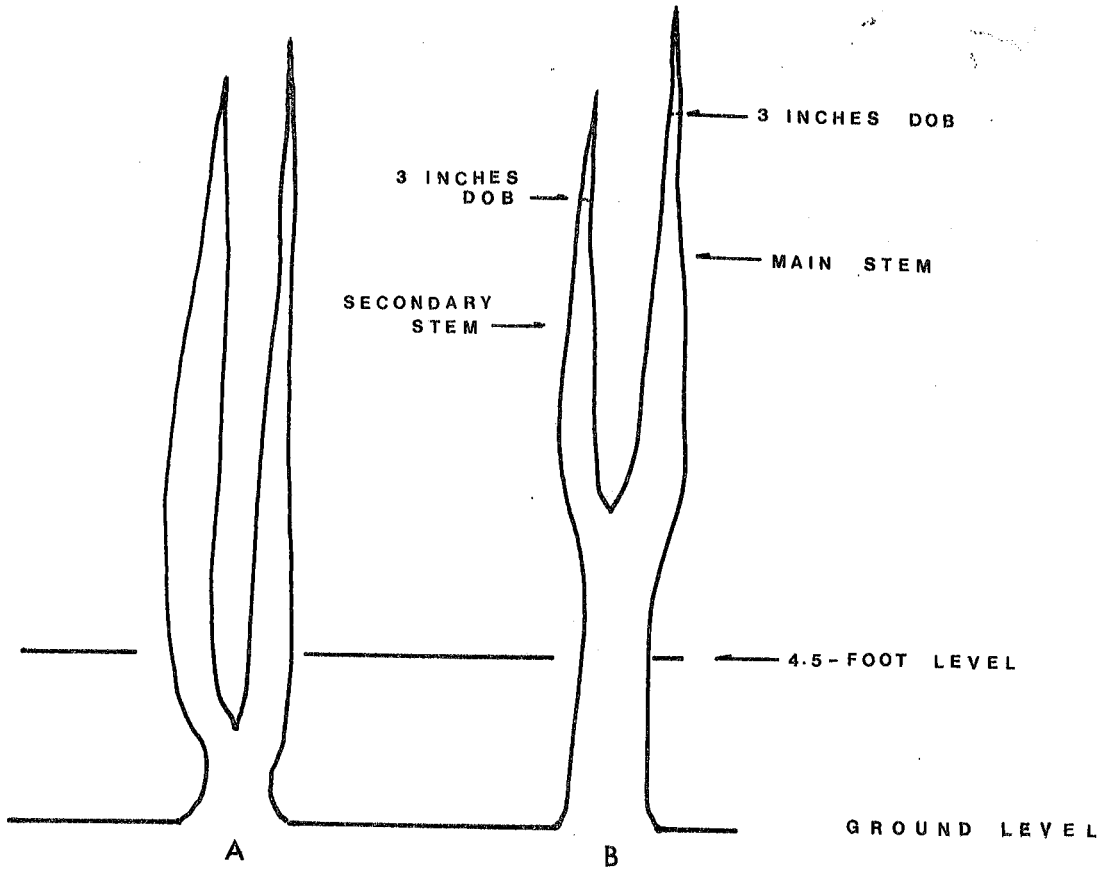


Fig. 2. Diagram of trees forked (A) below 4.5 feet and (B) above 4.5 feet.

Note that the digits 1 to 9 at the beginning of the five-digit number denote secondary stems of a forked tree. The main stem includes the stem below the fork as well as the highest stem above the fork to 3 inches dob (Fig. 2B).

Tree I.D. No. - Tree Identification Number. Each tree will have a unique number that is needed in computer operations to identify all data which pertain to one tree and which are contained on several punched cards. This number will be recorded once in both lines of the header and for each bolt as it is recorded.

An example of a Tree I.D. No. is

741056

where 74 is the year of tree measurement

1 is the crew number, and

056 is the 56th tree measured by crew #1 that year.

The same Tree I.D. No. is used for both the main stem and the merchantable stems arising from a fork.

Spec. - Tree species; see code at bottom of tally form.

Tot. Ht. - Total height of the tree including stump height of 0.5 feet.

Ht. 3" dob - Height to 3.0 inches dob including the 0.5 ft. stump height. If top of tree is broken below 3.0 inches dob enter 777.7. For secondary stems of forked trees, the height is from the fork to 3.0 inches dob.

Crown L. - Crown Length. If top of tree is broken below the crown, enter 777.7.

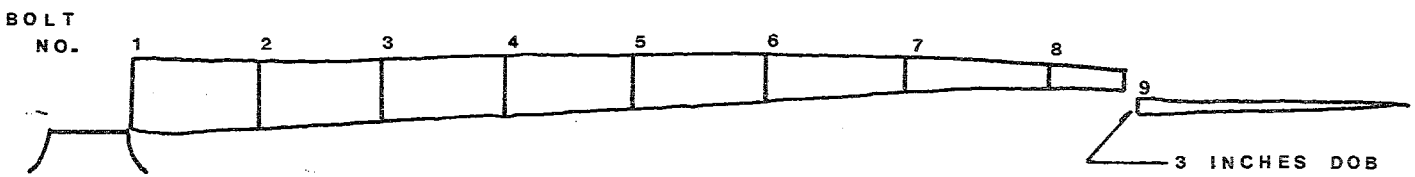
CC - Crown Class. See code at bottom of tally form. If top of tree is broken enter 0.

No. Bolts - Number of 4-ft. bolts in the tree below 3.0 inches dob. For secondary stems, the number of 4-foot bolts from 3.0 inches dob to the fork.

St. Age - Stump age.

Age BH - Breast height age.

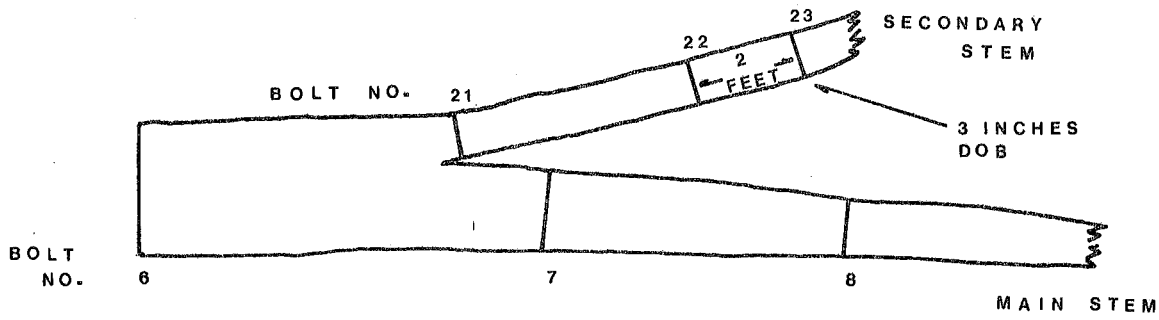
Examples of header data for single and multiple stem trees are given in Figs. 3 to 5. Note that the data for each stem is recorded on a separate sheet.



Reg	FS	Map	Plot	Tree	Tree I.D. No.	Spec.	Tot. Ht.	Ht. 3" Dob	Crown L	CC
03	06	0541	0003	0012	741056	003	041.3	30.7	014.8	1

No. bolts	St. Age	Age B H
07	72	52

Fig. 3. Diagram of a single stem tree and the number data for the tree.



SHEET 1 OF 2

Tree	Tree I.D. No.	Spec.	Tot. Ht.	Ht. 3" Dob	Crown L	CC
00012	741027	003	043.9	031.7	015.6	2

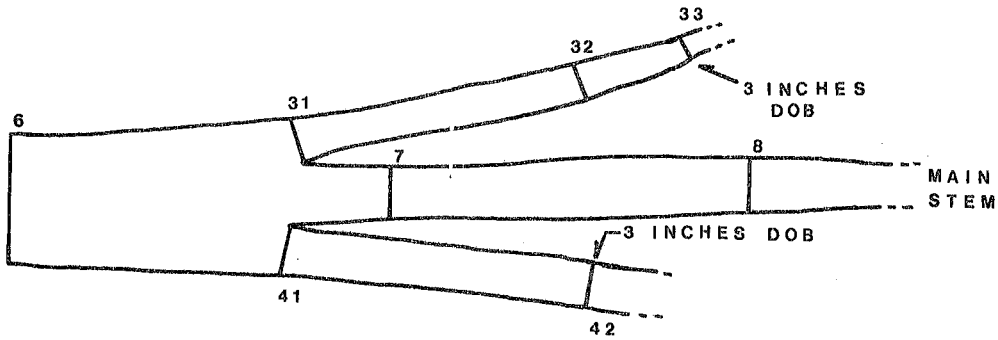
No. bolts	St. Age	Age B H
08	062	046

SHEET 2 OF 2

Tree	Tree I.D. No.	Spec.	Tot. Ht.	Ht. 3" Dob	Crown L	CC
20012	741027	003	.	006.0	.	

No. bolts	St. Age	Age B H
01		

Fig. 4. Diagram of a fork and the header data for the main stem (sheet 1 of 2) and for the secondary stem (sheet 2 of 2). Note that the digit 2 in the tree number denotes a secondary stem.



SHEET 1 OF 3

Tree	Tree I.D. No.	Spec.	Tot. Ht.	Ht. 3" Dob	Crown L	CC
00007	74 1 1 25	168	044.5	029.5	018.1	2

No. bolts	St. Age	Age B H
07	085	072

SHEET 2 OF 3

Tree	Tree I.D. No.	Spec.	Tot. Ht.	Ht. 3" Dob	Crown L	CC
30007	74 1 1 25	168	.	005.0	.	

No. bolts	St. Age	Age B H
01		

SHEET 3 OF 3

Tree	Tree I.D. No.	Spec.	Tot. Ht.	Ht. 3" Dob	Crown L	CC
40007	74 1 1 25	168	.	004.0	.	

No. bolts	St. Age	Age B H
01		

Fig. 5. Diagram of double fork and the header data for the main stem (sheet 1 of 3) and two secondary stems (sheets 2 and 3 of 3)

C. Bucking trees

a. Buck tree at each 4-foot mark.

b. Cut a 2-inch thick disc from the lower end of each bolt. This disc will be used for density analysis (see section VII). Label the disc as follows;

741056 / 8

Bolt number

Tree I.D. No.

c. If decay is present, cut another disc, 2" - 3" thick for later examination (see section VI.A.).

d. If a fork occurs below 4.5 feet and both stems are 3.6 inches dbhob or over, the stems are treated as two trees.

e. If a fork occurs above 4.5 feet, the secondary stem, similar to the main stem, is bucked at 4-foot intervals to 3.0 inches dob beginning at the fork as illustrated in Fig. 6.

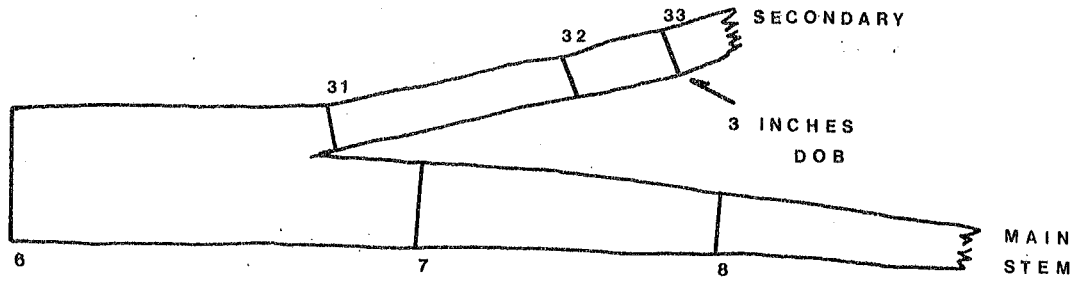


Fig. 6. Bucking the main and secondary stems of a forked tree.

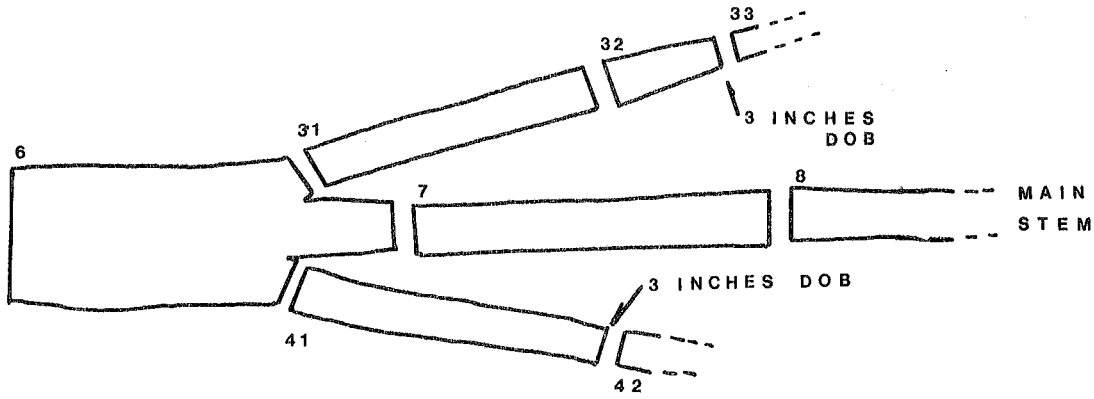
D. Measuring and recording bolts

In the absence of defects, i.e. form defects and decay, the bolt numbers and diameters outside and inside bark (dib), measured at the lower end of each bolt, will be recorded under the columns headed Bolt No., Dob and Dib. The diameters will be measured to the nearest tenth of an inch by taking the average of two measurements made at right angles to one another. Measurements of bolt length are not required. Figure 7 illustrates a tree bucked at 4-foot intervals to 3.0 inches dob.

Bolt No.	Dob	Dib
1	9.0	8.7
2	7.9	7.7
3	7.1	6.9
⋮	⋮	⋮
7	3.4	3.2
8	3.2	3.0
9	3.0	2.7

Fig. 7. Diagram of a bucked, single stem tree and the numbers and diameters recorded for the bolts.

On forked trees and in the absence of decay, the bolt numbers and diameters will be recorded under the columns headed Bolt No., Dob, and Dib on their respective tally sheets as illustrated in Fig. 8.



ON SHEET 1 OF 3

Bolt No.	Dob	Dib
06	05.6	05.4
07	03.4	03.2
08	03.2	03.0
09	03.0	02.7
	.	.

ON SHEET 2 OF 3

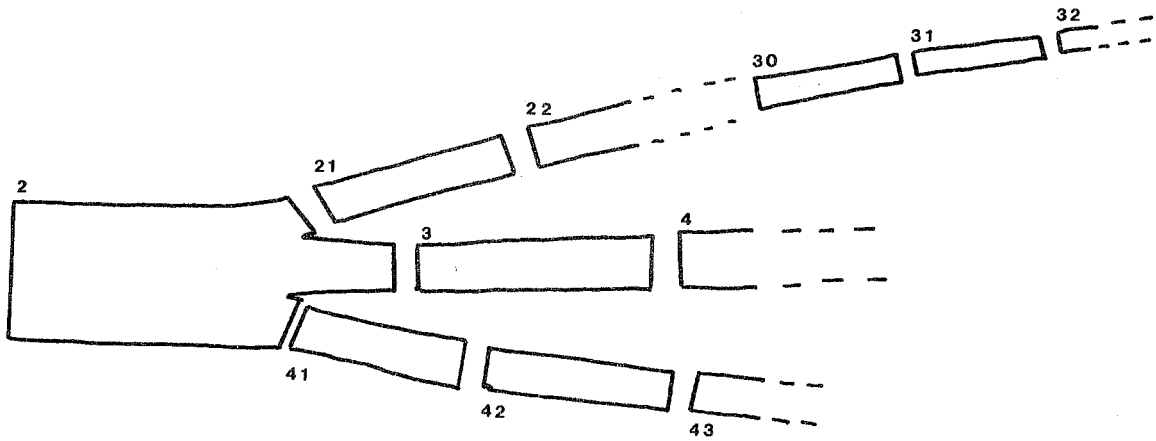
Bolt No.	Dob	Dib
31	03.3	03.1
32	03.1	02.9
33	03.0	02.7
	.	.

ON SHEET 3 OF 3

Bolt No.	Dob	Dib
41	03.4	03.1
42	03.0	02.8
	.	.
	.	.

Fig. 8. Diagram of a bucked, forked tree and the numbers and diameters of bolts for the respective stem. See Fig. 5 for details of header data and note the digits 3 and 4, which signify secondary stems, in both the tree number and the bolt numbers.

If there are 10 or more diameter measurements in a secondary stem, then the numbering is continuous, for example as follows 21, 22, 23 ... 29, 30, 31 and 32; note that this series assumes there were more than 10 diameter measurements in the main stem. In this series the number 31 does not mean another secondary stem. If there is another secondary stem in the tree, then its tree number and bolt numbers are preceded by the digit 4 (Fig. 9); the digit 3 was pre-empted by the above series of bolts.



ON SHEET 1 OF 3

Bolt No.	Dob	Dib
	.	.
02	.	.
03	.	.
04	.	.

ON SHEET 2 OF 3

Bolt No.	Dob	Dib
21	.	.
22	.	.
⋮	⋮	⋮
30	.	.
31	.	.
32	.	.

ON SHEET 3 OF 3

Bolt No.	Dob	Dib
41	.	.
42	.	.
43	.	.
	.	.

Fig. 9. Diagram of a tree with secondary stem having more than 10 bolts and the method of recording bolt numbers for the main stem and the two secondary stems.

If defects are present, then bolt numbers and their respective diameters are not recorded successively until all observations and measurements for these defects are completed and recorded for each bolt. The methods of recording numbers and diameters and location and dimensions of defects and decays for bolts are given in sections IV to VI.

IV. FORM DEFECTS

A. Classifying

Form defects are crook, fork and sweep (Fig. 10). The first two result from a damaged or killed leader or stem: crook represents the situation where one new leader has formed and fork represents the case where two or more new leaders have formed. Sweep is curvature in the stem and is recognized as a defect only if the curvature is more than 4 inches in a 4-foot bolt. Codes for these defects are listed on the bottom of the tally form.

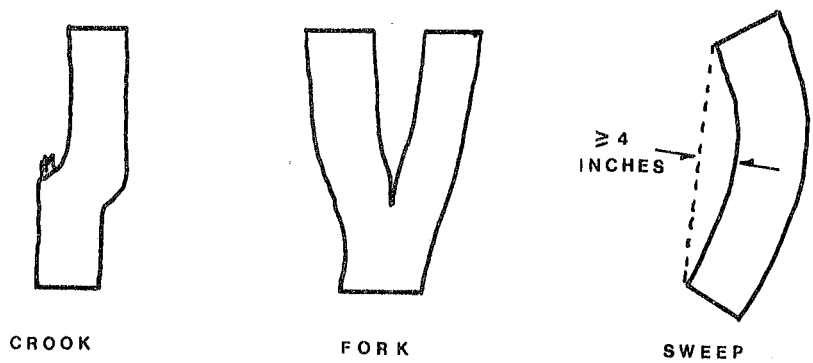


Fig. 10. Examples of form defects.

B. Measuring

A bolt with form defects is marked into four one-foot sections. The basal one-foot section is given the code "1" and the succeeding one-foot sections "2", "3" and "4" (Fig. 11). These codes are listed on the bottom of the tally form and are used to measure the location of the form defect.

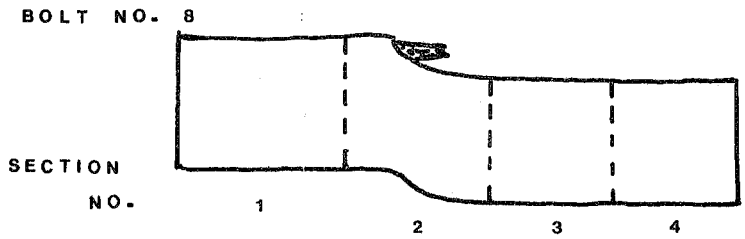


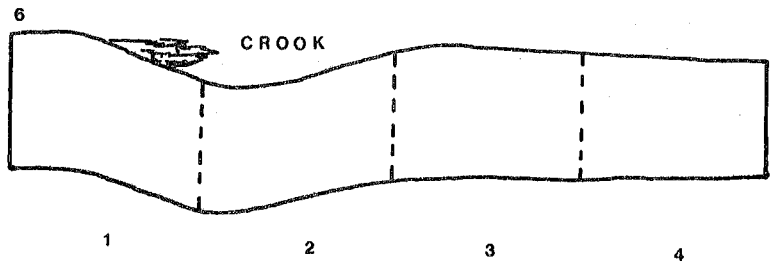
Fig. 11. Diagram of a 4-foot bolt marked into 1-foot sections.

C. Recording

There are two places on the tally form for recording form defects in a bolt (Fig. 1). Each place has five columns and allows the recording of one kind of form defect. If there are no form defects, a "0" is recorded in the column headed "FD" and the remaining four columns are left blank. The code for a form defect is recorded in the first column (Fig. 12). The next four columns represent the successive one-foot

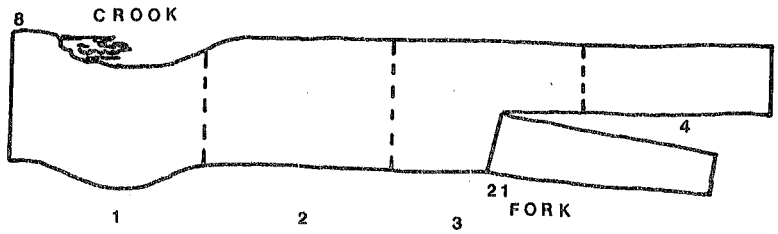
sections of a bolt. The number of the section affected by the form defects is recorded in its respective column. Zero is recorded if, within a defective bolt, a one-foot section is not affected. The presence of sweep in a bolt eliminates the need to record the presence of either crook or fork as form defects.

Examples illustrating the procedures for measuring and recording form defects are given in Figs. 12, 13 and 14.



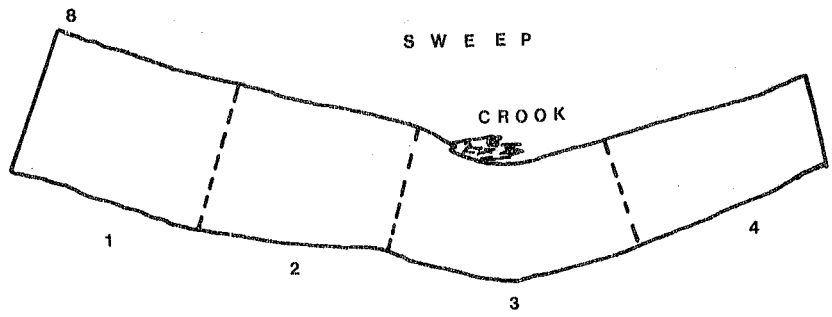
Bolt No.	Dob	Dib	FD	section 1	2	3	4	FD	section 1	2	3	4
06	07.3	06.9	2	1	2	0	0	0	0	0	0	0

Fig. 12. Diagram of one type of form defect (crook = code 2) affecting one or more 1-foot sections of a bolt and the method of recording observations on the tally form.



Bolt No.	Dob	Dib	FD	section 1	2	3	4	FD	section 1	2	3	4
08	05.6	05.2	2	1	0	0	0	1	0	0	3	0
	.	.										

Fig. 13. Diagram of two types of form defects in a bolt and the method of recording observations on the tally form.



Bolt No.	Dob	Dib	FD	section 1	2	3	4	FD	section 1	2	3	4
08	07.6	07.2	3	1	2	3	4	0	0	0	0	0
	.	.										
	.	.										

Fig. 14. Diagram of sweep and another form defect in a bolt and method of recording observations. Note that sweep takes precedence over the crook.

V. EXTERNAL INDICATORS OF DECAY

A. Classifying

Nine external indicators of decay are recognized. Two of them (Fig. 15), conk and canker, are definite signs of disease.

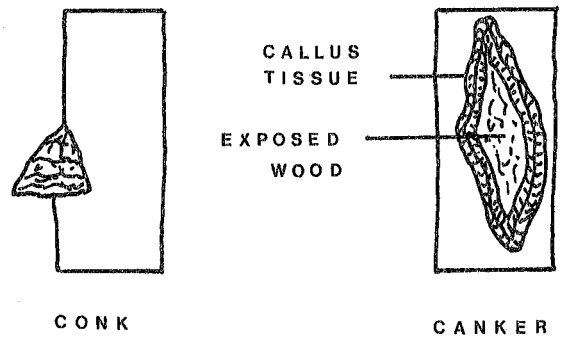
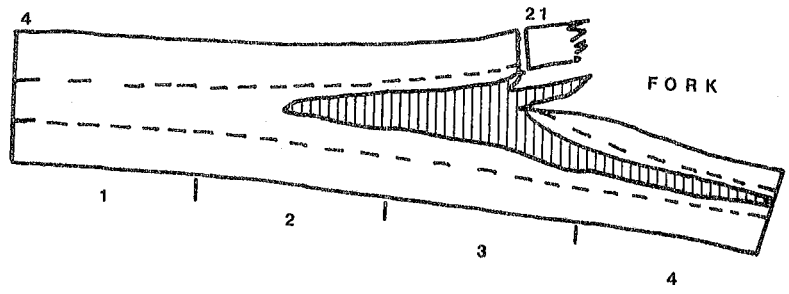


Fig. 15. Diagrams of external indicators which are signs of disease.

The remaining seven indicators, viz. fork, crook, rotten branch, broken tip, open and closed scars, and frost crack as well as cankers are potential infection courts for decay organisms. Codes for these indicators are listed on the bottom of the tally form.

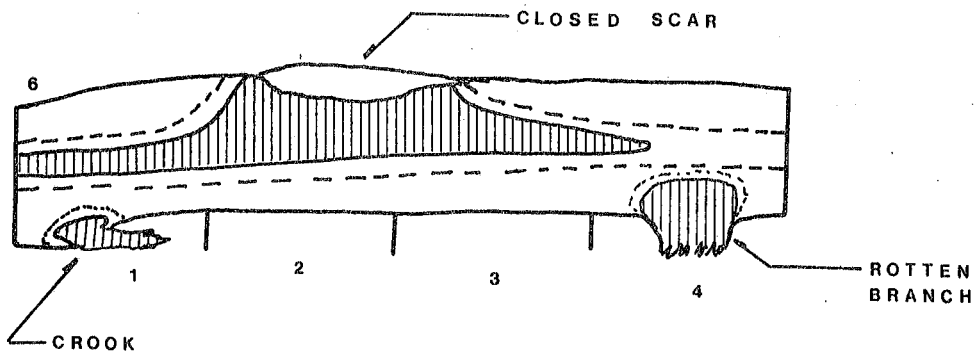
B. Dissecting

A bolt with an external indicator must be dissected if decay is present at either end in order to determine if the decay is associated with the indicator (Fig. 16). In bolts with an external indicator but with no decay present at either end, dissection is not required as it is assumed that there is no decay.



A

Bolt No.	Dob	Dib		Ind. sec.	Ind. sec.
04	05.2	04.9		13	0
	.	.			



B

Bolt No.	Dob	Dib		Ind. sec.	Ind. sec.
06	07.9	07.5		62	20
06	.	.		30	0

Fig. 16. Diagrams of decay associated with external indicators and method of recording data. A. One external indicator and associated decay. B. Three external indicators one of which is associated with the decay.

C. Measuring

A bolt with external indicators of decay is marked into four, 1-foot sections. The basal one-foot section is given the code "1" and the succeeding one-foot sections, "2", "3" and "4". These codes are listed at the bottom of the tally form and are used to measure the location of the external indicators of decay.

D. Recording

There are two places on the tally form for recording external indicators of decay (Fig. 1). Each place has two columns and allows the recording of one kind of indicator. When no indicators occur, "0" is recorded in the first column and the second column is left blank. When an indicator occurs the code for the indicator will be marked in the first column. If it is associated with decay, the numeral for the 1-foot section, on which the centre of the external indicator occurs, will be recorded (Fig. 16A). If the indicator is not associated with decay, "0" is recorded in the second column (Fig. 16B).

If three or more external indicators of decay occur on a bolt (Fig. 16B) the bolt number is repeated in the succeeding line. This allows the recording of the presence of the additional indicators. Note that in this succeeding line only the bolt number is repeated.

Note that in the following and subsequent diagrams a cross-hatched area represents advanced decay and an area delineated by a dotted line represents incipient decay.

VI. DECAYS

A. Classifying

Decay is recognized by the presence of discoloured wood. All decay will be classified according to its position in the tree, its stage of development, and its colour and texture as follows:

Position - Decay in the heartwood will be classified as butt rot or trunk rot. Butt rots are caused by fungi that enter the main stem through the root system. Trunk rots are caused by fungi that enter the tree through external injuries or through dead or wounded branches on the main stem. Fungi causing sapwood decay enter the tree through wounds in the stem and roots. The codes for describing these positions are listed at the bottom of tally form. Note that whenever code 4 is used that there is a measurement for code 1 or 2.

Stage - Two stages of decay development will be recognized, viz. incipient and advanced. Incipient decay is discoloured wood that is not noticeably softer than sound, normal wood. Advanced decay is discoloured wood that is softer than sound, normal wood.

Colour & Texture - The 2 to 3-inch disc cut during bucking will be split to expose a radial face. On this face, the observer will use the point of a knife to determine the softness of the decay. Incipient decay will be described according to one of the nine colours listed at the bottom of the tally form. Advanced decay will be described according to one of the nine colour-textures, listed at the bottom of the tally form.

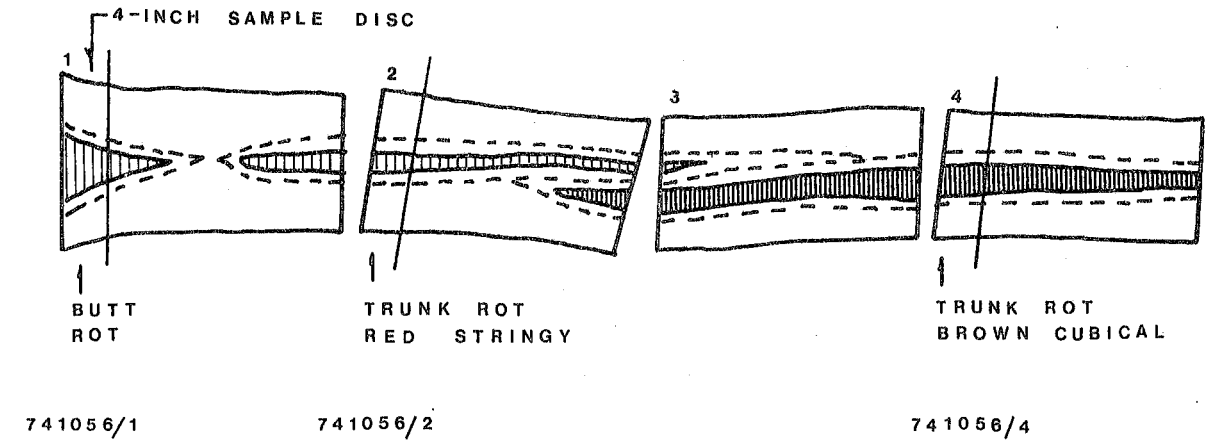
B. Collecting decay samples

One 4-inch thick disc will be taken for each decay type or zone of decay in a tree. Figure 17 illustrates where these disc samples will be taken. As noted, each disc will be labelled with the Tree I.D. Number and bolt number and sent to the laboratory for culturing decay organisms (see section VII).

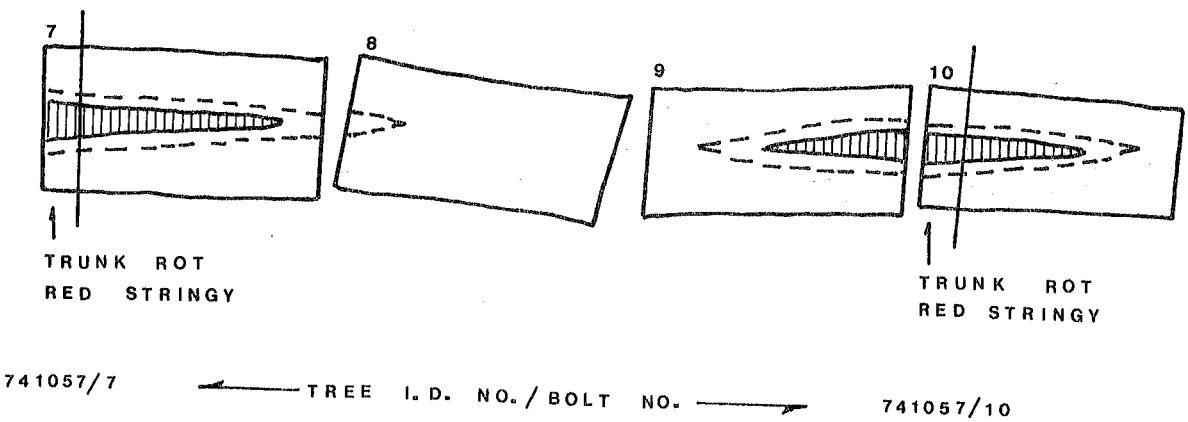
C. Measuring

1. Diameter of butt and trunk rots

Diameter of butt and trunk rots will be measured to the nearest tenth of an inch by taking the average of two measurements made at right angles to one another. Decay does not always occur in a regular pattern and the following diagrams (Figs. 18-21) show the methods for determining the diameter for several decay patterns.



A



B

Fig. 17. Diagrams of bucked trees showing locations to obtain samples (4-inch disc) of each decay type (A) and for each zone of the same type (B).

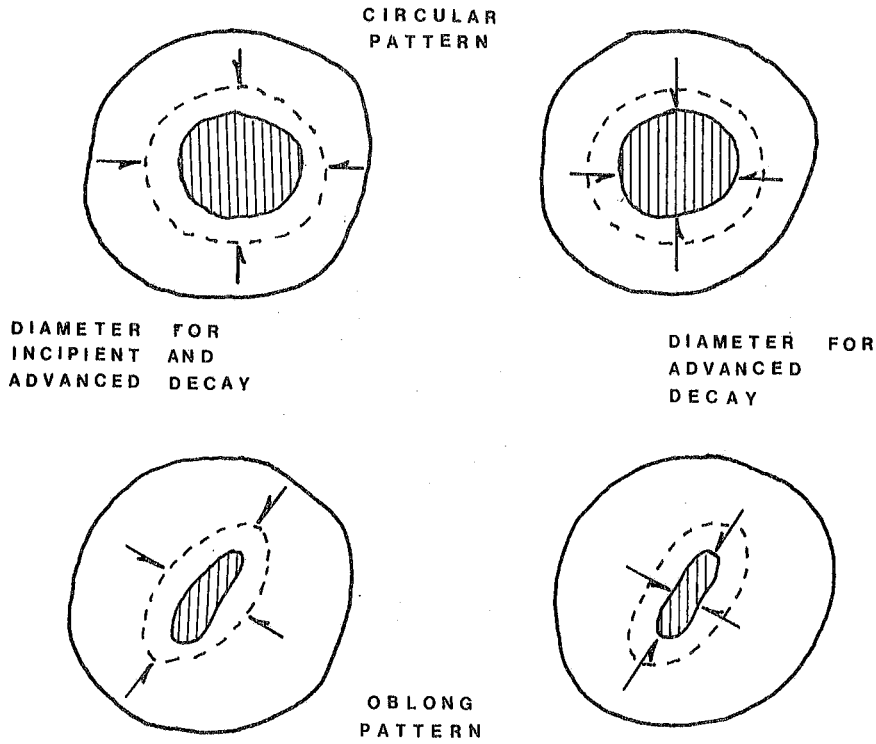


Fig. 18. Diagrams of heartwood decay patterns and methods of measuring diameters.

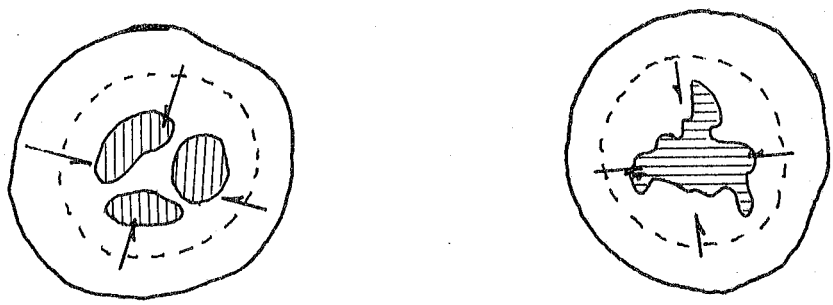


Fig. 19. Diagrams of irregular, advanced heartrot and methods of measuring diameters.

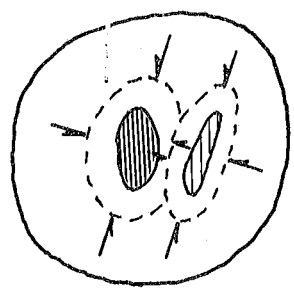


Fig. 20. Diagram of two adjacent decay types and method of measuring diameters.

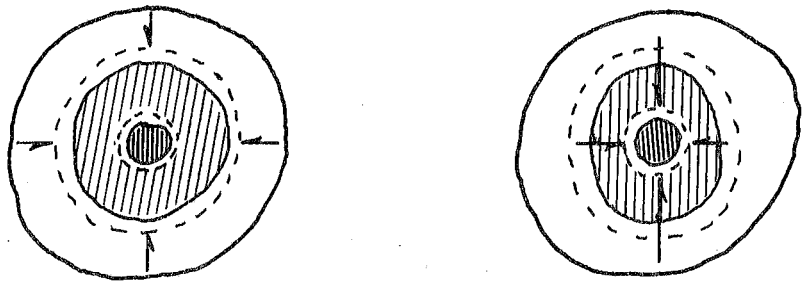


Fig. 21. Diagram of trunk rot outside butt rot or another trunk rot and methods of measuring diameters.

2. Width of sapwood decay

Sapwood decay advances from the outer margin towards the centre of a tree and accordingly the width of decay penetration will be the average of two measurements taken to the nearest 0.1 inch and made at right angles to each other (Fig. 22). For sapwood decay in part of the circumference, say 2/3 of the circumference, then 2/3 of the average width is the recorded value (Fig. 23). For example, 0.8 inches would be recorded for an average measured width of 1.2 inches when 2/3 of the circumference is affected.

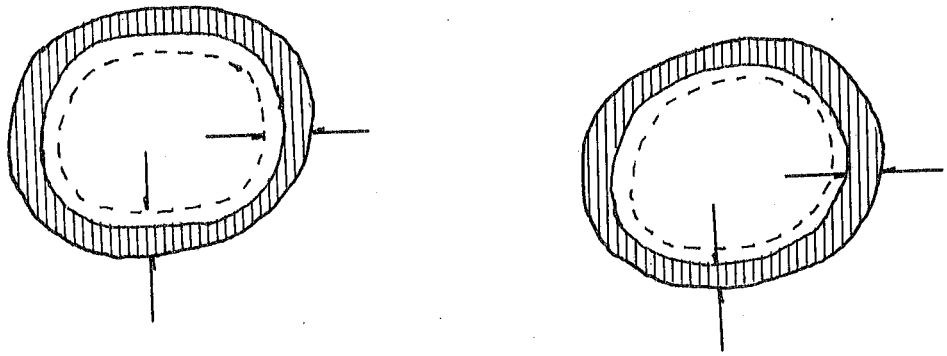


Fig. 22. Diagram of sapwood decay throughout the circumference and methods of measuring widths.

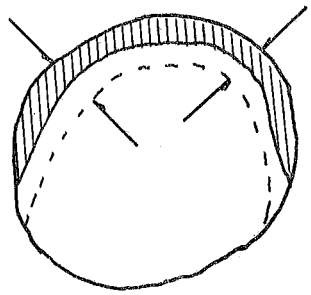


Fig. 23. Diagram of sapwood decay in part of the circumference and method of measuring width.

3. Length of decay

The length of both incipient and advanced decay is measured to the nearest 0.1 foot. The observer will assume that the decay column is 4 feet long if the same decay is present in the same stages at both ends of the bolt, as illustrated in bolt 4 of Fig. 17A.

However, where either the stage or type of decay is not the same at both ends, the bolt must be dissected to measure the length of the respective conditions. The method of dissecting bolts is different for butt and trunk rots and sap rot. For sap rot, surface notching of the bolt is sufficient to locate the end (or beginning) of advanced or incipient decay in a bolt. For butt rots and trunk rots, the bolt should be dissected in the sequence indicated in Fig. 24 which shows decay that has progressed from the base of a bolt. Decay that has progressed from the top of the bolt is the reverse of these illustrations.

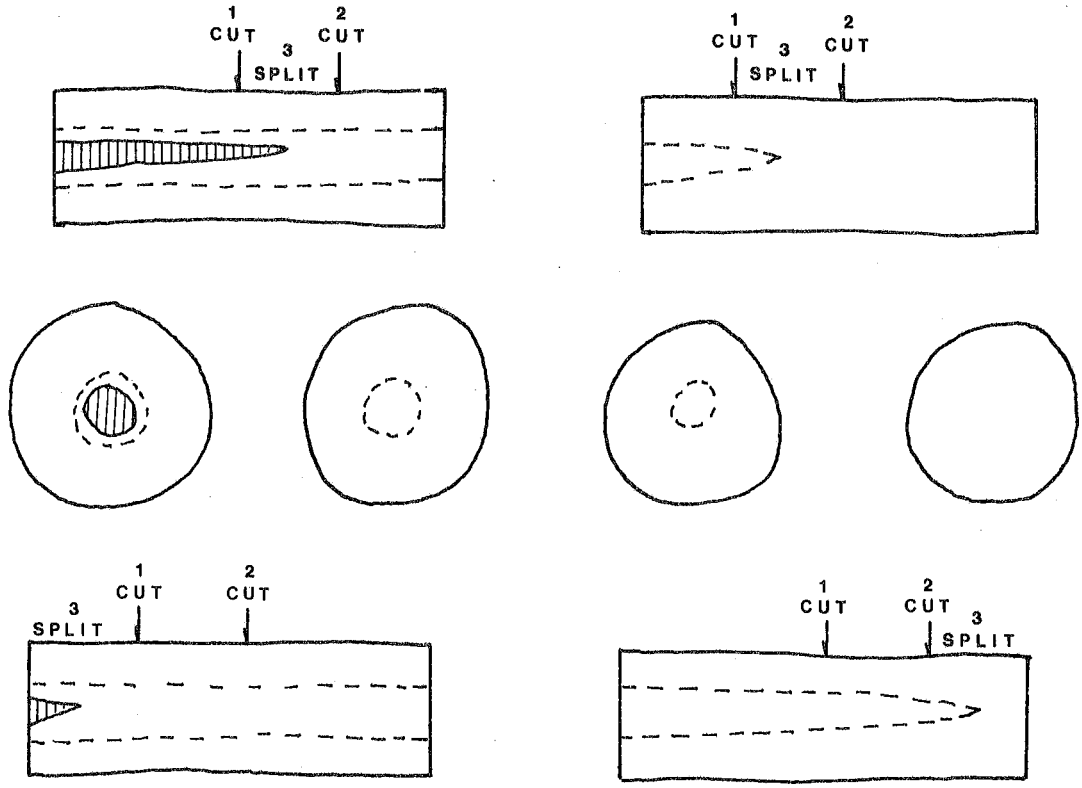


Fig. 24. Diagrams showing the methods for dissecting bolts to determine lengths of decays that have terminated within bolts.

The sequence of cuts and splits for two decay types that had progressed from opposite ends of a bolt is illustrated in Fig. 25.

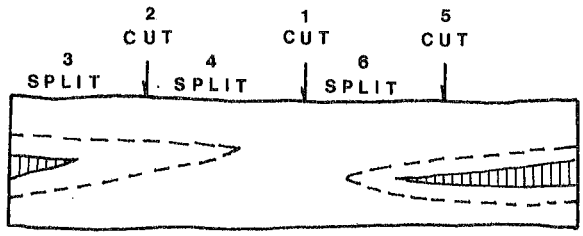


Fig. 25. Diagram showing the method for dissecting a bolt that has two types of decay - one at each end and both terminating within the bolt.

D. Recording

1. Bolt numbers and diameters for bolts with decay

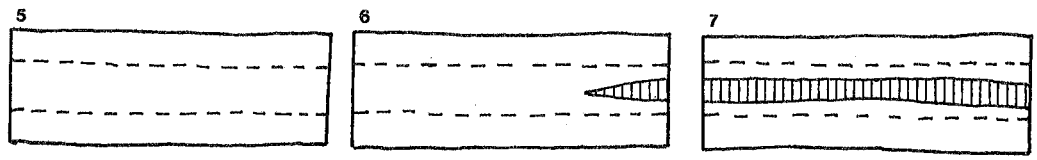
Bolt numbers and diameters inside bark and outside bark are recorded as described in section III D. However, if there is a change in decay position or type, e.g., a butt rot and a trunk rot in the same bolt or two trunk rots in the same bolt, the bolt number is repeated in the succeeding line to allow recording of both decays. In the repeated line, columns for dob, dib, form defect and external indicators of decay are left blank. Note the recorder must always inspect the base of succeeding bolts to detect changes in decay types or position.

2. Decay descriptions and measurements

There are seven columns on each line of the tally form for descriptions and measurements of each decay type. The code for the position of decay is recorded in the first column which is headed by the letter P. The code for the texture and colour of advanced decay is recorded in the second column headed A, and the code for the colour of incipient decay in the third dolumn headed I. The diameter of advanced butt rot or trunk rot, or width of advanced sap rot is recorded in the column headed D/W-A. Similarly, the diameter or width of incipient stages of decay is recorded in the column headed D/W-I. The length of advanced or incipient decay is recorded in the column headed L-A or L-I, respectively. If more than one type of decay occurs within a bolt, the bolt number must be repeated and each type recorded on successive lines of the tally form.

It is essential that each decay type is fully coded for all bolts in which it occurs. For example, if only incipient decay is evident in a bolt, then the decay column must be examined at other levels in the tree to determine if there is any advanced decay associated with the incipient. If advanced decay is present at other levels, its code must be recorded with that of the incipient, although only the incipient decay may be present at the point of measurement. Fig. 26 illustrates this point: advanced decay is not present at the base of bolt #1 but code 3 describing it is given along with code 2 which describes incipient decay that is present.

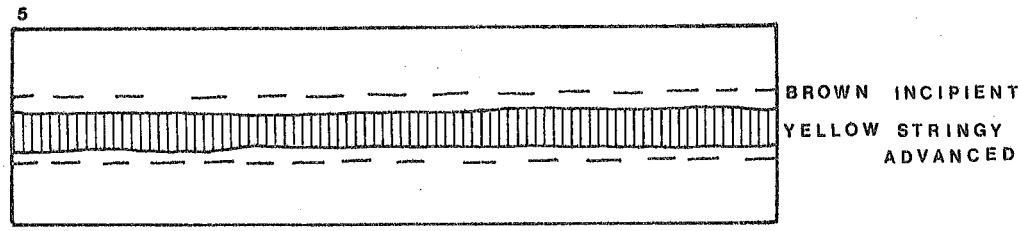
Where one heart rot is present at the base of a bolt or at both ends of a bolt, diameter (or width) and length of the decay are recorded in the respective columns (Figs. 27 and 28). However, where decay is present only at the top end of a bolt (Figs. 29 and 30) a "0" is entered in the diameter (or width) columns, and the length of the decay measured from the top end, is recorded. The method of recording observations and measurements for one sap rot are illustrated in Fig. 31.

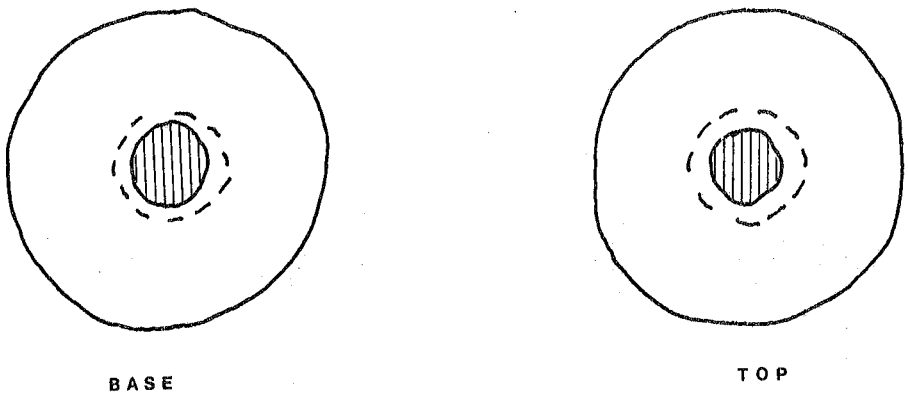


Bolt No.	Dob	Dib
05	.	.
	.	.
	.	.

Decay description & measurement						
P	A	I	D/W-A	D/W-I	L-A	L-I
2	3	2	.	.	.	.
			.	.	.	.
			.	.	.	.

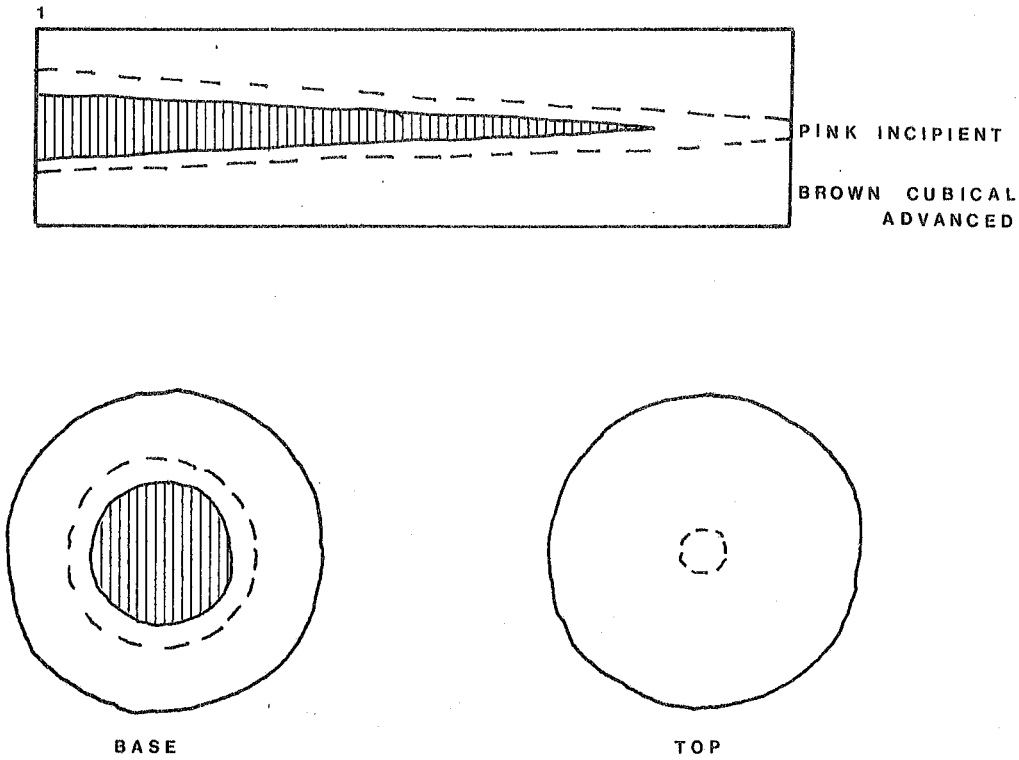
Fig. 26. Diagram of incipient decay, its associated advanced decay in other bolts and method of recording observations.





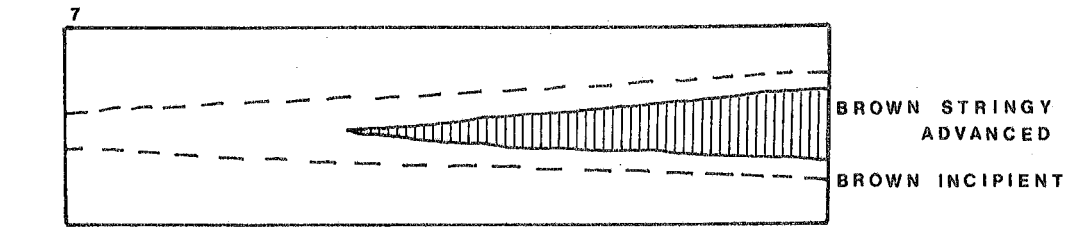
Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
05	08.3	07.8	2	1	2	02.1	03.3	4.0	4.0

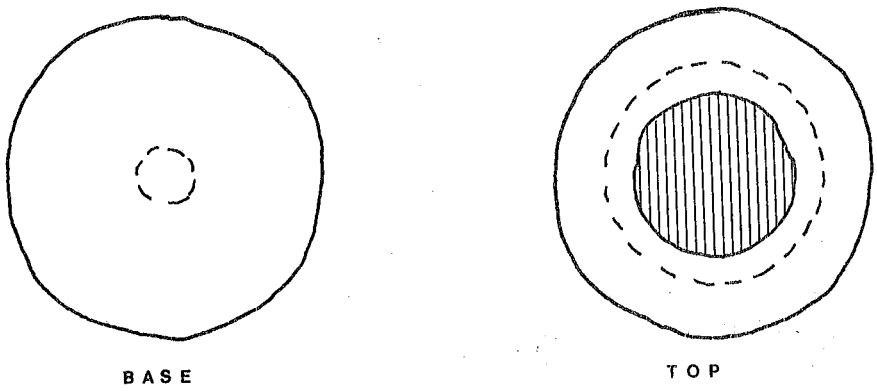
Fig. 27. Diagram for recording one decay type at both ends of a bolt.



Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
01	10.6	10.0	1	5	4	04.0	05.2	3.3	4.0

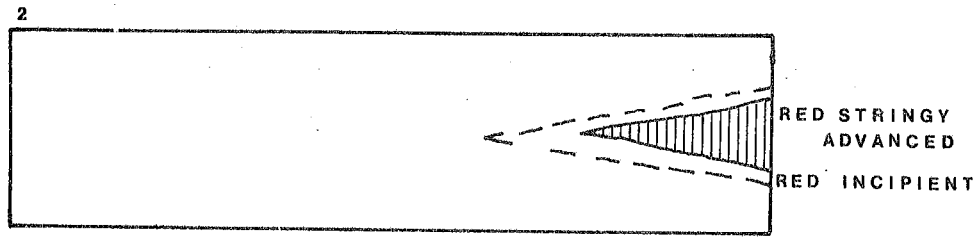
Fig. 28. Diagram for recording one decay type at both ends of a bolt; advanced decay at the base only.

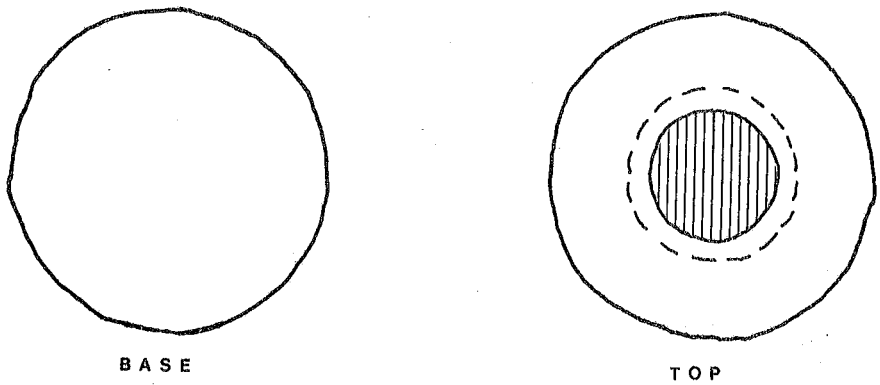




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
07	08.9	08.5	2	3	2	00.0	02.0	2.5	4.0

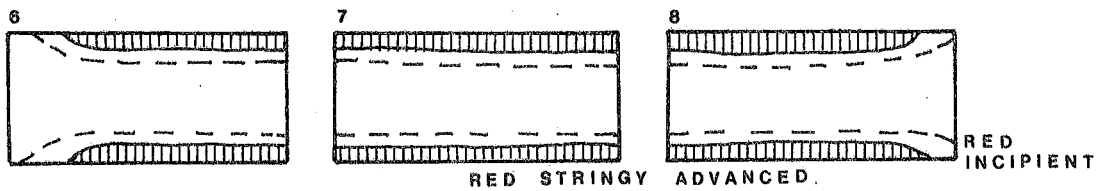
Fig. 29. Diagram for recording one decay type at both ends of a bolt; advanced decay at the top only.

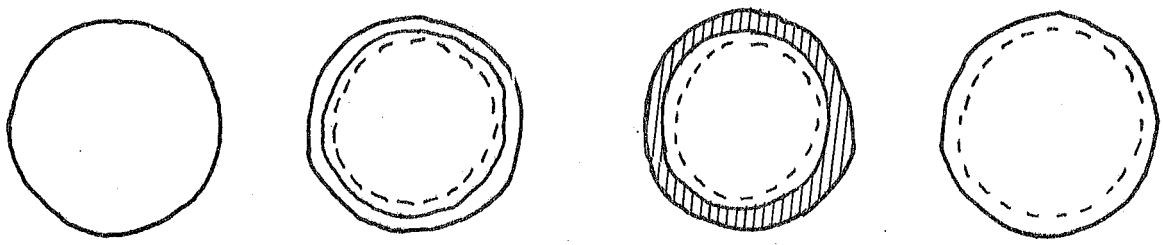




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
02	06.3	05.9	2	8	3	00.0	00.0	1.0	1.6

Fig. 30. Diagram for recording one decay type at only the top of a bolt.



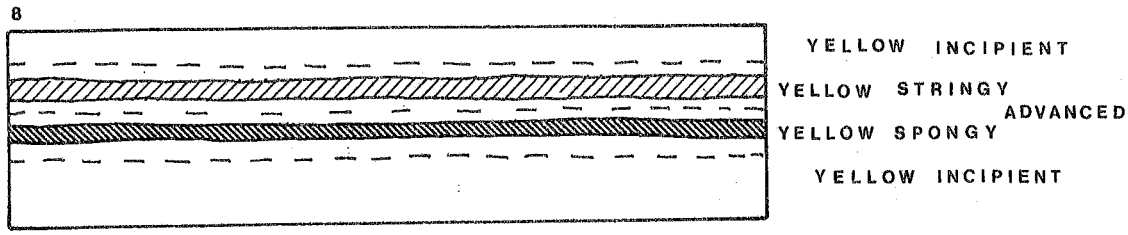


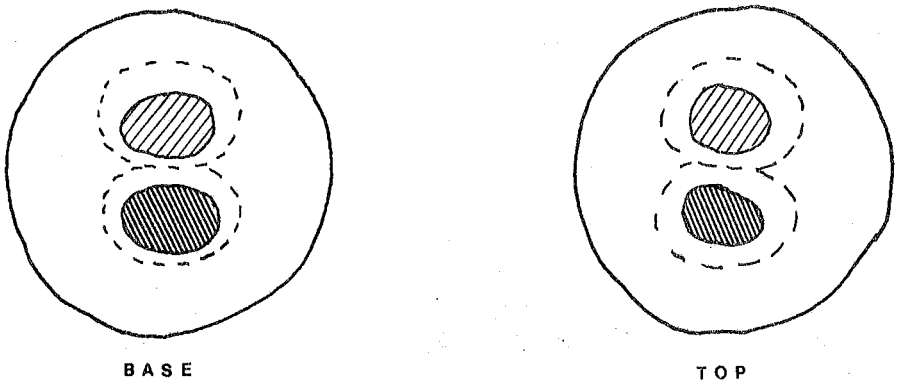
Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
06	08.7	08.2	3	8	3	00.0	00.0	3.3	3.8
07	08.3	07.8	3	8	3	00.3	00.6	4.0	4.0
08	07.9	07.4	3	8	3	00.2	00.5	3.5	4.0

Fig. 31. Diagram for recording sap rot in a tree.

Where two decays are present either at opposite ends of the bolt, or adjacent to each other at one or both ends of a bolt, or a trunk rot surrounds a butt rot, then the observations and measurements are recorded as illustrated in Figs. 32 to 38. Note the special code number 4 for trunk rot; it is only used when trunk rot surrounds another rot (Fig. 38). The code number 2 is used at all other times, i.e. when trunk rot is adjacent to butt rot (Fig. 39) or when only trunk rots occur as illustrated in Fig. 37 and bolt #2 in Fig. 38.

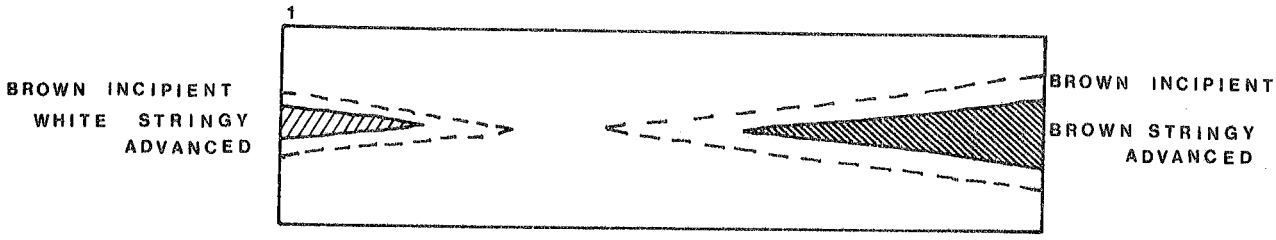
Fig. 40 illustrates the method of recording observations and measurements for three decay types in a bolt.

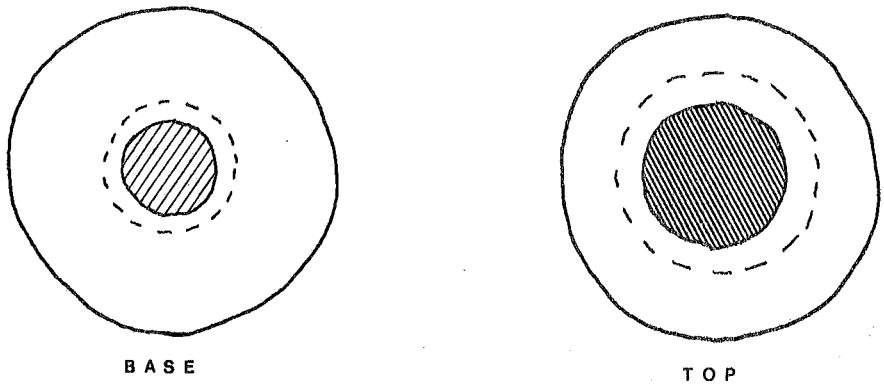




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
	.	.				.	.	.	.
08	07.9	07.7	2	1	1	02.1	02.5	4.0	4.0
08	.	.	2	2	2	01.9	02.2	4.0	4.0
	.	.				.	.	.	.
	.	.				.	.	.	.

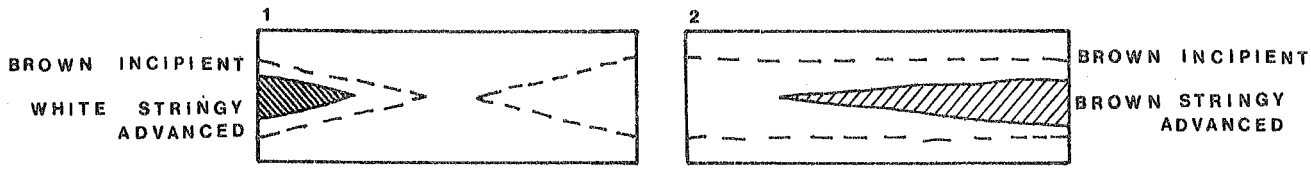
Fig. 32. Diagram for recording two decay types side-by-side occurring at both ends of a bolt.

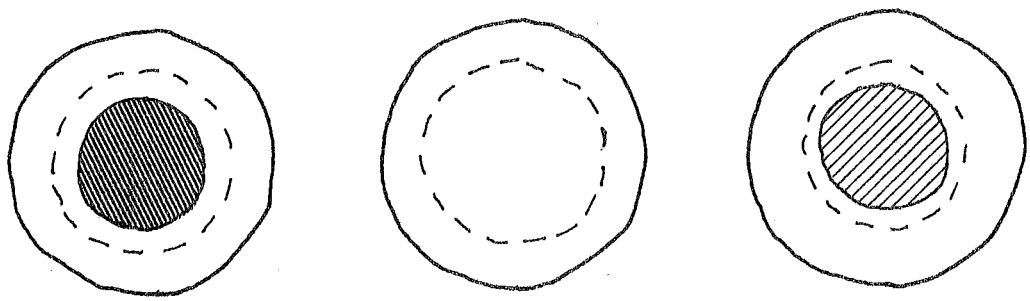




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
01	10.2	09.4	1	6	2	04.3	05.1	0.8	1.2
01	.	.	2	3	2	00.0	00.0	1.6	2.3
	.	.				.	.	.	.
	.	.				.	.	.	.
	.	.				.	.	.	.

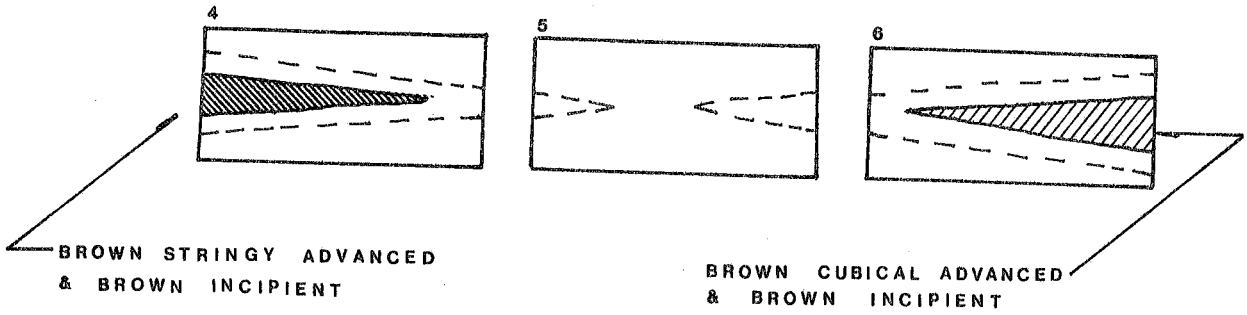
Fig. 33. Diagram for recording for two decay types, one at each end of a bolt.

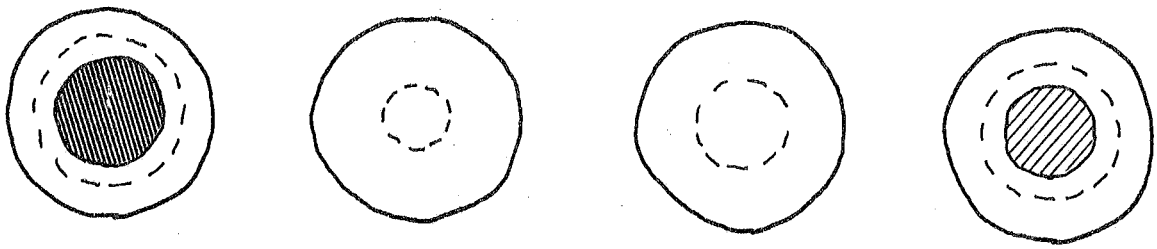




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
01	09.7	09.0	1	6	2	03.9	04.5	1.1	1.9
01	.	.	2	3	2	00.0	00.0	0.0	1.8
02	09.2	08.8	2	3	2	00.0	04.8	3.1	4.0
	.	.				.	.	.	.
	.	.				.	.	.	.
	.	.				.	.	.	.

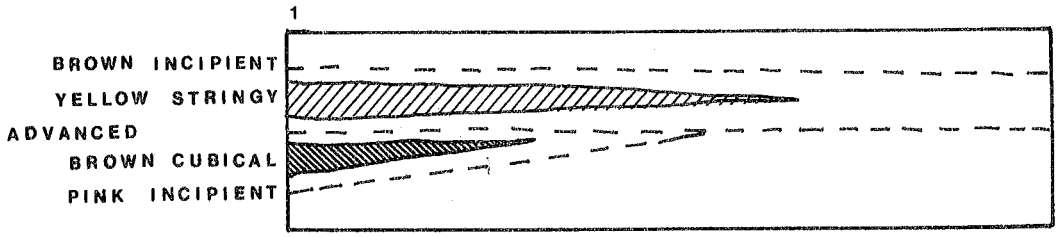
Fig. 34. Diagram for recording two decay types; both stages of one type at the bottom of the first bolt only; the incipient stage of the second type at the top of the first bolt only; both stages of the second decay type in the succeeding bolt. Note that the second incipient decay is identical to the incipient stage of the first type and described fully to allow the computer to associate it with the correct advanced decay.

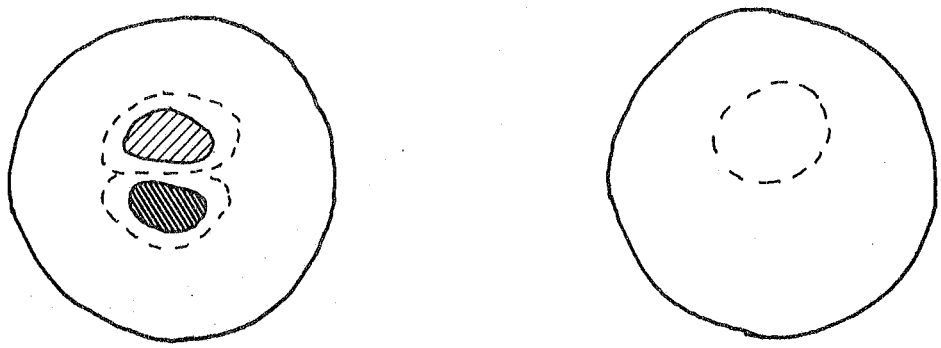




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
	.	.				.	.	.	.
04	05.4	05.2	2	3	2	01.8	02.3	3.2	4.0
05	05.2	05.0	2	3	2	00.0	00.4	0.0	1.9
05	.	.	2	5	2	00.0	00.0	0.0	2.0
06	05.0	04.8	2	5	2	00.0	01.8	3.5	4.0
	.	.				.	.	.	.
	.	.				.	.	.	.

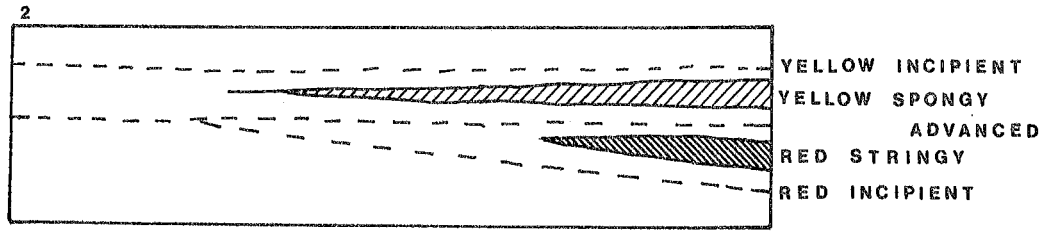
Fig. 35. Diagram for recording two decay types; one type in bolt 4; the incipient stages of both types in bolt 5 and both having the same description (brown); the other decay type in bolt 6.

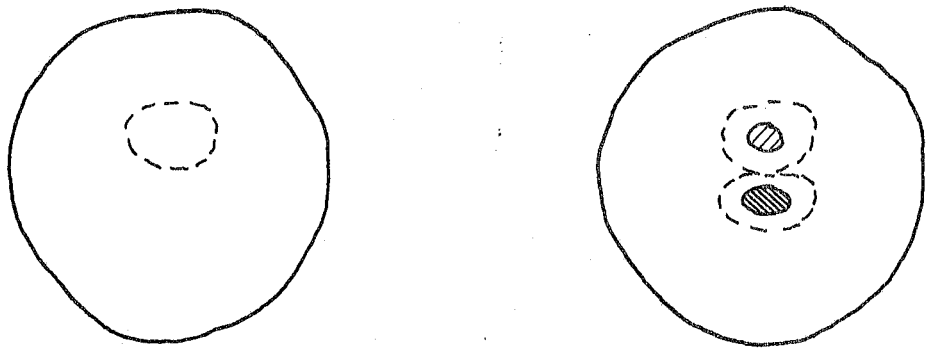




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
01	1 1.7	1 1.1	1	1	2	0 4.1	0 5.2	2.7	4.0
01	.	.	1	5	4	0 2.2	0 3.1	1.1	2.0
	.	.				.	.	.	.
	.	.				.	.	.	.

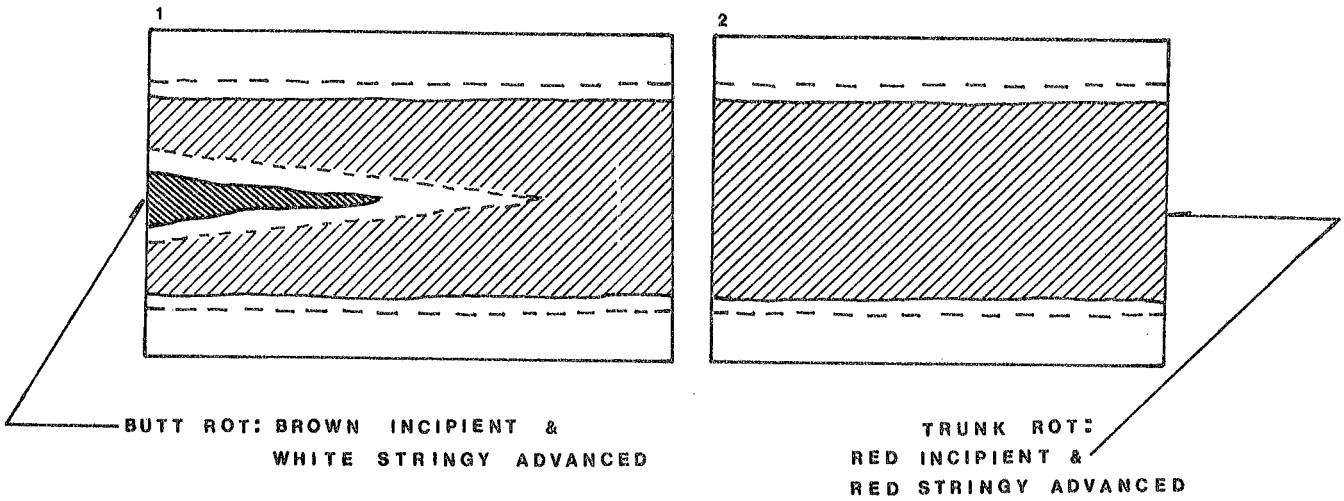
Fig. 36. Diagram for recording two decay types side-by-side in a bolt; both progressing upwards.

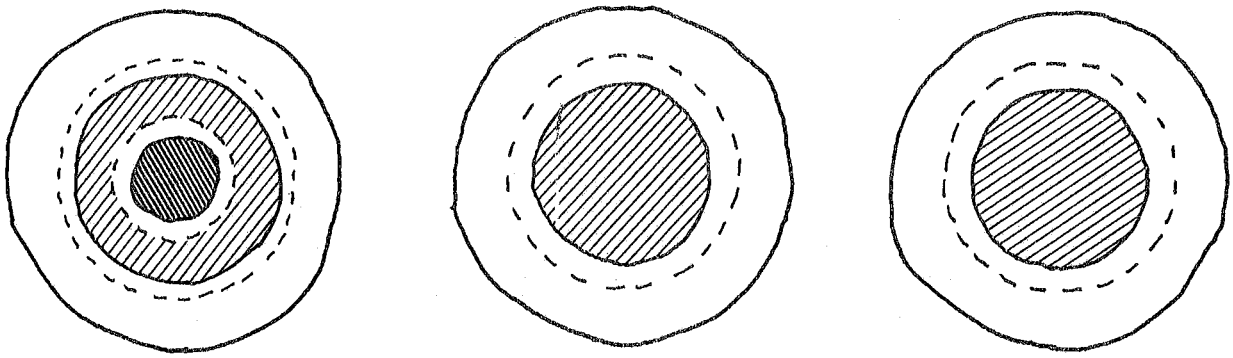




Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
02	06.7	06.3	2	2	1	00.0	03.1	2.9	4.0
02	.	.	2	8	3	00.0	00.0	1.3	3.0
	.	.				.	.	.	.

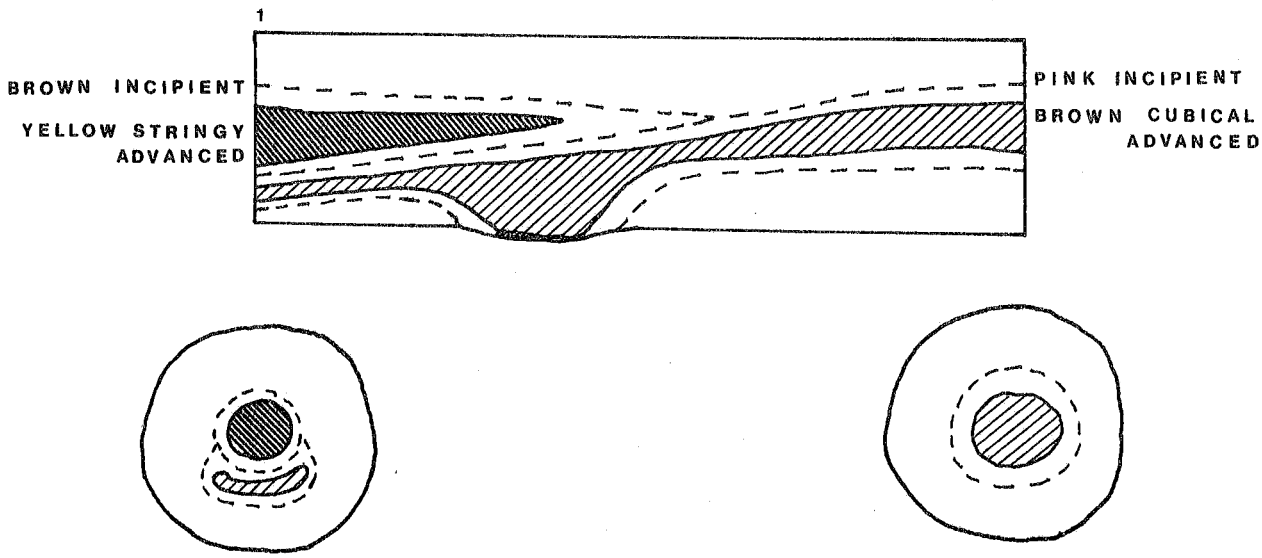
Fig. 37. Diagram for recording two decay types side-by-side occurring at the top of a bolt; both progressing downwards.





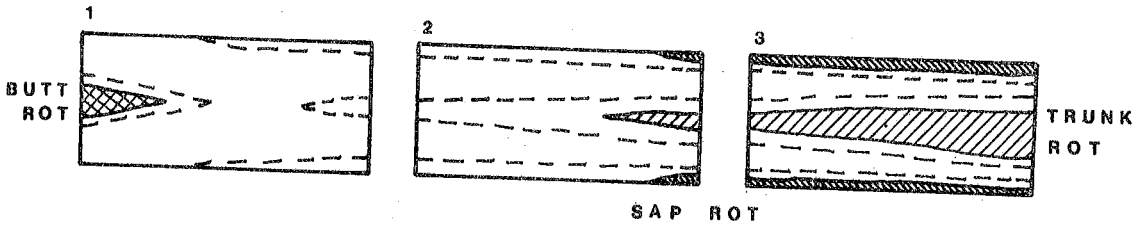
Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
01	10.2	09.6	1	6	2	02.3	02.7	1.8	2.9
01	.	.	4	8	3	05.9	06.6	4.0	4.0
02	10.0	09.4	2	8	3	05.8	06.4	4.0	4.0
	.	.				.	.	.	.
	.	.				.	.	.	.

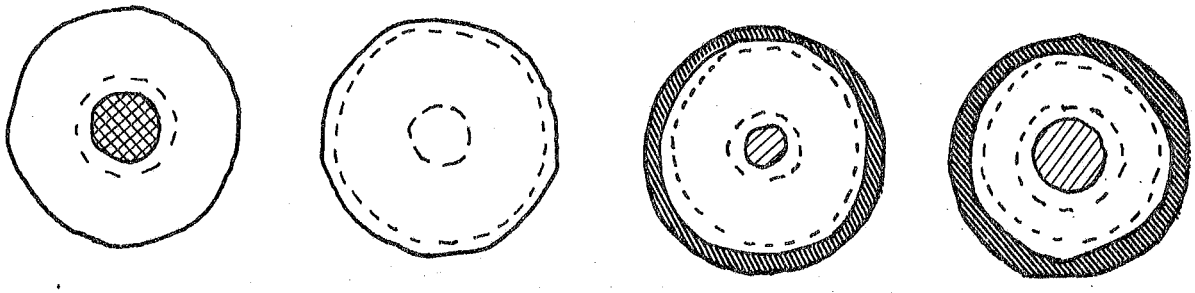
Fig. 38. Diagram for recording trunk rot outside butt rot. Note the use of code 4 for trunk rot in bolt #1 and code 2 for the same trunk rot in bolt #2.



Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
01	12.6	12.3	1	1	2	03.6	04.2	1.8	2.4
01	.	.	2	5	4	02.1	03.0	4.0	4.0
	.	.				.	.	.	.

Fig. 39. Diagram for recording a trunk rot adjacent to a butt rot.





Bolt No.	Dob	Dib	Decay description & measurement						
			P	A	I	D/W-A	D/W-I	L-A	L-I
01	09.8	09.3	1	5	2	02.1	03.3	1.2	1.7
01	.	.	2	7	2	00.0	00.0	0.0	1.0
01	.	.	3	8	3	00.0	00.0	0.0	2.2
02	09.4	08.7	2	7	2	00.0	00.9	1.5	4.0
02	.	.	3	8	3	00.0	00.9	0.8	4.0
03	08.5	07.9	2	7	2	00.9	02.1	4.0	4.0
03	08.5	07.9	3	8	3	00.3	00.9	4.0	4.0
	.	.				.	.	.	.
	.	.				.	.	.	.

Fig. 40. Diagram for recording three decay types in a tree or bolt; i.e. butt rot, a trunk rot, and a sap rot.

VII. LABORATORY ANALYSES OF DISC SAMPLES

The measurement of density and culturing of decay organisms will be done in the laboratory on the 2-inch and 4-inch thick discs respectively, collected from the sample trees. The density of both sound and affected wood will be measured on the 2-inch discs according to prescribed methods.

Small cubes of affected wood will be cut from the 4-inch discs and cultured for identification of the decay organism. Culturing will be done in the prescribed manner, and the causal organism will be identified to species and the type of decay it causes. The code for each species and decay type is on file in the laboratory and some examples are as follows:

Identifications		Codes	
Causal organism	Decay type (DT)	Decay organism	DT
Stereum sanguinolentum	White trunk rot	031	1
Coniophora puteana	Brown butt rot	041	4
Peniophora polygonia	White trunk rot	003	1

VIII. PROCESSING OF TALLY FORMS

The tally forms will be examined in the office and blank columns will be filled with zeros and repeated numbers and digits, e.g. Tree I.D. No., will be indicated by a vertical arrow. Any discrepancies will be checked with the field crews for correction.

The edited tally forms will then be ready for card punching and preparation of the data for computer calculation. The flow charts for analyzing the decay and cull data have been completed, and the calculation programs are now being written to estimate the volume losses attributable to the various decay types and ultimately to determine the net merchantable volume of stands. The data and analyses will also permit evaluation of the factors influencing the incidence of decay and cull and the development of methods for providing remedial action.

ACKNOWLEDGEMENTS

We would like to thank John Marshall for his help in the development and testing of the tally form.

We also thank Mr. M. Airth, Statistician, Computing and Applied Directorate, Dept. of Environment, for his continuing review of the system.

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