CULL FACTORS FOR SITKA SPRUCE, WESTERN HEMLOCK AND WESTERN REDCEDAR IN SOUTHEAST ALASKA

JAMES W. KIMMEY, PATHOLOGIST

STATION PAPER NO. 6

AUGUST - 1956

ALASKA FOREST RESEARCH CENTER

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE

JUNEAU, ALASKA

R. F. TAYLOR, FORESTER IN CHARGE

Station Paper No. 6 August 1956

CULL FACTORS FOR SITKA SPRUCE, WESTERN HEMLOCK, AND WESTERN REDCEDAR IN SOUTHEAST ALASKA

James W. Kimmey
Pathologist

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Alaska Forest Research Center

Agriculture--Forest Service, Berkeley, Calif.

CONTENTS

	Page
Introduction	1
Study Methods and Bases	2
Adequacy of bases	4
Computation Procedure	4
Tree classification	4
Stump heights	4
Log lengths	5
Top diameters	5
Log rules employed	6
Causes and Types of Cull	6
Fungi causing cull	10
Cull Indicators	13
Reliable indicators of cull	13
Sitka spruce	13
Western hemlock	13
Western redcedar	14
Non-indicators of cull	14
How to use indicators	14
Cull Factors	19
Flat factors	19
Indicator factors	21
Elevation-Cull Relationship	25
Age-Cull Relationship	26

TABLES

Page

Table 1.--Number of study trees by species 3

Table 2.--Percent of white rot and brown rot in each stage of decay by tree species 9

Table 3.--Percent of total cubic cull volume caused by each type of rot and stage of decay in each tree species 9

Table 4.--Fungi causing decay by type rot and species 11

Table 5.--Flat factors for gross board-foot and cubic-foot volumes 20

Table 6.--Indicator factors for Sitka spruce 22

Table 7.--Indicator factors for western hemlock 23

Table 8.--Indicator factors for western redcedar 24

Table 9.--Percent cull in three tree species by elevation above sea level 25

Table 10.--Tree diameter, volume and cull by age class and species 30

FIGURES

Figure 1.--Average utilized top diameter 5

Figures 2, 3, 4, 5.--Types of cull 7-8

Figures 6, 7, 8, 9.--Some conks that are reliable indicators of cull on Sitka spruce 15

Figures 10, 11, 12, 13.--Injuries on trees that are reliable indicators of cull 16

Figures 14, 15, 16, 17.--Some conks and injuries that are reliable indicators of cull in western hemlock 17

Figures 18, 19, 20, 21.--Non-indicators of cull and one indicator 18

Figure 22.--Relationship of tree age to board-foot cull 27

Figure 23.--Relationship of tree age to cubic-foot cull 28

Figure 24.--Relationship of tree age to occurrence of rot 29

CULL FACTORS FOR SITKA SPRUCE, WESTERN HEMLOCK, AND WESTERN REDCEDAR IN SOUTHEAST ALASKA

By James W. Kimmey [1]

INTRODUCTION

An unknown quantity has for many years been one of the principal problems in inventorying the timber of Southeast Alaska. The unknown is the extent of defect in the region's vast timber stands. This publication presents a tool for estimating the defect; cull factors are given here for the three principal tree species as determined by a study made at eight locations in these stands.

Cull is that part of a living tree which is not merchantable because of defect. When the amount of cull is expressed as a percent of the gross volume of a tree, the percentage is termed the cull factor.

Within a species the average amount of cull in a tree increases with its age. However, it is impossible or impracticable to determine the age of each sample tree when cruising. Since tree size is ordinarily correlated with age and is readily measured by cruisers, tree diameter has been employed in the preparation of these cull factors.

Cull was studied in Sitka spruce (*Picea sitchensis* (Bong.) Carr.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), and western redcedar (*Thuja plicata* Donn). Cull discount factors for each of these species were prepared for trees of various diameters. They were based on both board-foot and cubic-foot gross volumes to fixed top-diameter limits and to average top limits utilized in the logging areas. Besides these flat factors similar discount factors were prepared for the amount to be expected when certain indicators of cull, such as conks or wounds, are found on the outside of the trees. Cull factors of this latter type are termed cull indicator factors.

All of the various cull factors were prepared primarily for use in the Forest Survey in Southeast Alaska. They are published here for use of other workers in the forests of this area.

---

[1] This project carried out by James W. Kimmey, Pathologist of the California Forest and Range Experiment Station, with the cooperation of the Alaska Forest Research Center. This report is distributed by the Alaska Forest Research Center, Juneau, Alaska.

STUDY METHODS AND BASES

The study was conducted on logging operations in 1953 and 1954. Trees felled for logging at eight locations were used. Not many such areas were available, but those used were selected to give as nearly as possible a representative distribution in Southeast Alaska. Five of the study areas were located south of Wrangell where most of the current logging was being done, and three of the areas were further north.

Sampling was distributed to all available elevations within a study area. The only selection of sample trees was for a good basis in all representative diameter classes. Western redcedar was not present in all study areas, and all of the felled trees of this species on two areas were used as samples.

The basis of study trees, by diameter classes, at each study area is given in table 1.

When possible, general notes were recorded on trees before they were felled, and detailed notes were taken on all study trees after they had been felled and bucked into logs. The extent and types of cull, the causal fungi, and all associated cull indicators were determined and recorded on scale diagrams of each study tree.

Table 1.--Number of study trees by species and 10-inch d.b.h. classes, Southeast Alaska.

Study Area	Number when d.b.h. class, in inches, was--									Total
	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91& over	
SITKA SPRUCE										
Yakutat	--	2	4	9	4	6	1	1	--	27
Fick Cove	--	6	6	6	6	6	1	--	--	31
Vank Island	3	4	5	7	6	5	--	--	--	30
Maybeso Cr.	--	5	7	3	5	5	2	3	--	30
Hollis	7	9	5	6	2	1	--	--	1	31
Thorne Bay	5	9	4	3	2	--	--	--	--	23
Neets Bay	6	7	4	4	4	3	2	--	--	30
Ham Cove	3	5	5	5	5	4	1	1	1	30
Total	24	47	40	43	34	30	7	5	2	232
WESTERN HEMLOCK										
Yakutat	2	8	7	1	--	--	--	--	--	18
Fick Cove	1	5	8	9	4	3	--	--	--	30
Vank Island	6	8	8	7	1	--	--	--	--	30
Maybeso Cr.	4	7	8	7	4	--	--	--	--	30
Hollis	6	10	9	6	1	--	--	--	--	32
Thorne Bay	7	8	8	7	--	--	--	--	--	30
Neets Bay	5	5	8	8	3	1	--	--	--	30
Ham Cove	4	7	8	7	4	--	--	--	--	30
Total	35	58	64	52	17	4	--	--	--	230
WESTERN REDCEDAR										
Hollis	3	7	10	7	2	1	--	--	--	30
Thorne Bay	1	5	6	6	5	1	--	--	--	24
Neets Bay	6	6	7	6	4	--	--	--	1	30
Ham Cove	1	2	7	2	1	1	--	--	--	14
Total	11	20	30	21	12	3	--	--	1	98

Adequacy of bases

The amount of cull associated with cull indicators did not vary appreciably between the various study locations. Since a wide geographical range was sampled, there should be no appreciable variations at other locations which were not sampled. For this reason, the number of areas upon which the cull factors are based is undoubtedly adequate to give true values for the cull indicator factors wherever they may be applied in Southeast Alaska.

The number of study trees at each area is adequate for a reliable sample of cull conditions at these locations. To be reliable throughout Southeast Alaska, however, flat factors probably should be based on a larger number of study areas so that a more intensive range of cull conditions could be included.

It is suggested that, whenever possible, cruisers use the indicator factors in preference to the flat factors. This suggestion is especially applicable when a high degree of accuracy is required on small areas.

COMPUTATION PROCEDURE

Tree classification

When data for the cull factors were compiled, each study tree was first classified in one of the following three categories:

1. No cull indicators present.

2. Cull indicators on only the lower bole (first 32-foot log), or on only the upper bole (above the first 32-foot log).

3. Cull indicators on both the lower and the upper bole.

At first the trees with indicators only on the lower bole were separated from those with indicators only on the upper bole. When the cull factors were computed for these two groups, we found no significant difference whether indicators occurred on the upper bole or on the lower bole. However, when they occurred on both the upper and the lower bole, the cull was greater.

Stump heights

The stump height used in the computations was 1.5 feet (measured from the ground at the highest or uphill side) for trees up to 20.9 inches d.b.h. For all trees 21 inches d.b.h. or greater, the stump height was equal to the d.b.h. to the nearest foot; that is, trees 21 to 30 inches d.b.h. were allowed a 2-foot stump; trees 30.1 to 42 inches, a 3-foot stump; and so on.

Cull factors presented here are for the cull that occurred above these theoretical stump heights except those presented for cull in the stumps alone.

Log lengths

Log lengths were 16 feet plus trim allowance for all cubic-foot computations. For board-foot computations, 16-foot logs were used only for trees up to 20.9 inches d.b.h.; those 21 inches d.b.h. or larger were scaled in 32-foot logs. A minimum of 6 feet was used for the length of the top log.

Top diameters

Two different top diameters (diameter inside bark) were employed in all computations: a fixed top and the utilized top. The fixed top diameter was 8 inches for board-foot computations and 4 inches for cubic-foot computations. The utilized top (fig. 1) was that actually cut in the logging operations. When no part of a tree was used, the utilized top was figured as 40 percent of the d.b.h.

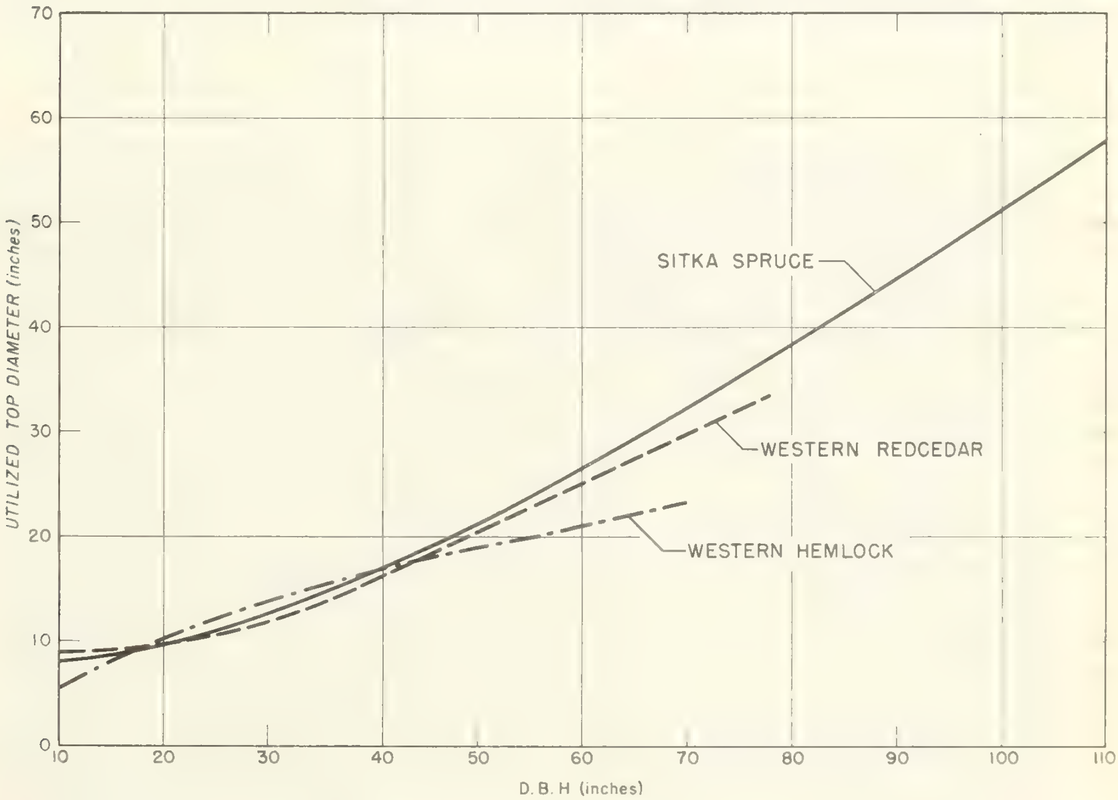

Figure 1.--Average utilized top diameter (inside bark) for trees of different d.b.h. sizes of Sitka spruce, western hemlock, and western redcedar in Southeast Alaska.

Log rules employed

The factors applying to board-foot volumes are based on Scribner Decimal-C log rule. Cubic-foot log volumes were determined from the cubic volume tables in the National Forest Scaling Handbook. Deductions for defects were made in accordance with the National Forest Scaling Handbook.

Any log that was more than 50 percent cull was considered all cull in board-foot computations, and any log that was more than 75 percent cull in cubic feet was considered all cull in cubic-foot computations. Any inconsistencies in the ratio of cubic to board-foot percentages may be accounted for in part by the fact that shake was regarded as a defect in making board-foot deductions, but not as causing loss of cubic volume of wood. Some inconsistency may be charged to making no cubic-foot deductions from saw kerf, short lengths, and trimming.

CAUSES AND TYPES OF CULL

Cull in living trees is largely due to decayed wood, but some may be due to sound defect from such causes as shake, crook, and sweep. Shake (fig. 2) is the only sound defect that contributes appreciably to cull in the stands of Southeast Alaska. Loss of volume from burning, as found in large fire scars in other regions, is inconsequential in this rain forest. Sound cull from shake caused a loss of board-foot volume but was not considered a loss in cubic volume.

Most board-foot cull and all cubic-foot cull was due to decayed wood. Decayed wood is of two types: "brown rot" and "white rot." In brown rot the causal fungi attack primarily the cellulose fibers (fig. 3); in white rot, the lignin content of the wood (fig. 5). Likewise, two general stages of decay were recognized in this study analysis. They are the early, or incipient, stage of decay (fig. 4) and the late, or typical, stage (figs. 3 and 5).

In the incipient stage the affected wood is usually discolored and firm, but often somewhat softened and weakened. Low grades of lumber may be manufactured from such wood. This wood may also be used in pulp making, though some weakening of fiber results when incipient decay of the brown rot type is used. Wood in the typical stage of decay will not make lumber, even of low grade, and the typical stage of brown rot makes wood unsuited for pulp of any kind. Part of the wood containing typical decay of the white rot type, however, may be used in pulp making but with considerable loss of yield.

Fig. 2.--Radial and circular shake in the butt of a large Sitka spruce log.

Fig. 3.--Typical brown rot caused by Polyporus schweinitzii in Sitka spruce.

Types of cull

Fig. 4.--The early, or incipient, stage of a white rot caused by Poria albipellucida in the butt of a western redcedar.

Fig. 5.--Typical white rot caused by Pholiota adiposa in the butt of a western hemlock.

In this study both brown and white rot, in both the incipient and typical stages, were considered to be cull; therefore, the cull factors discount all decayed wood. In certain uses for timber it may be desirable to know the type of rot or stage of decay likely to be found in the cull of a tree species. Table 2 shows for the various tree species the percentage of each type of rot in each stage of decay based on the cubic-foot volumes of cull found in the study trees.

If timber is to be used primarily for pulp, it will undoubtedly be desirable to know what percent of the total cull is caused by white rot and what part of the white rot is in the incipient stage of decay. Since all cubic-foot cull was caused by decay, the significance of each type of rot and each stage of decay in the total cull of a tree species can be read from table 3.

Table 2.--Percent of white rot and brown rot in each stage of decay by tree species.

Tree species	White rot		Brown rot		All rot	
	Incip.	Typ.	Incip.	Typ.	Incip.	Typ.
Sitka spruce	27	73	39	61	37	63
Western hemlock	36	64	36	64	36	64
Western redcedar	77	23	57	43	77	23

Table 3.--Percent of total cubic cull volume caused by each type of rot and stage of decay in each tree species.

Tree species	White rot			Brown rot		
	Incip.	Typ.	Total	Incip.	Typ.	Total
Sitka spruce	4	12	16	33	51	84
Western hemlock	22	40	62	14	24	38
Western redcedar	76	22	98	1	1	2

Fungi causing cull

The fungi that caused cull in the study trees are listed for each tree species in table 4. This table shows the relative importance of each fungus in producing cull.

For example, table 4 shows that in spruce trees the brown rot caused by the red belt fungus (*Fomes pinicola*) was found in more than one-fourth of the study trees and caused about 88 percent of the total brown rot, or nearly three-fourths of the total cull in that tree species. Nearly three-fifths of the decay caused by this fungus was in the typical stage. Cull of this type (fig. 3) is useless for either lumber or pulp. In contrast, table 4 shows that in western redcedar 98 percent of the total cull was caused by white rot, of which 77 percent occurred in the incipient stage. In other words, more than three-fourths of the total cull in redcedar consisted of white rot in the incipient stage of decay--a type of cull material (fig. 4) that may have limited use in both lumber or pulp manufacture.

Table 4.--Fungi found causing decay in each tree species, classified as white or brown rots and within each class, listed in order of their production of that rot; also the percentage of total cull caused by each fungus; and the percent of its decay occurring as incipient and as typical decay.

WHITE ROTS

Tree species and fungi	Study trees infected		Total white rot	Total cubic cull	Stage of decay found: Incip.	Stage of decay found: Typ.
	No.	Pct.	Pct.	Pct.	Pct.	Pct.
Sitka spruce:						
Fomes pini (Thore ex Fr.) Karst.	11	4.7	52.5	8.6	24	76
Armillaria mellea (Vahl.) Quel.	12	5.2	27.2	4.4	44	56
Fomes annosus (Fr.) Cke.	3	1.3	6.7	1.1	10	90
Merulius sp.	1	0.4	5.1	0.8	0	100
Fomes nigrolimitatus (Rom.) Egelund	1	0.4	5.0	0.8	5	95
Unknown white rots	6	2.6	3.6	0.6	44	56
Totals	31	13.4	100.	16.3	27	73
Western hemlock:						
Armillaria mellea	47	20.4	41.5	25.9	45	55
Fomes annosus	51	22.2	32.8	20.5	29	71
Pholiota adiposa (Batsch ex Fr.) Kummer.	13	5.7	14.3	9.0	28	72
Fomes robustus Karst.	7	3.0	7.7	4.8	28	72
Fomes pini	2	0.9	1.6	1.0	20	80
Fomes applanatus (Pers. ex Fr.) Gill.	3	1.3	1.5	0.9	48	52
Unknown white rots	2	0.9	0.6	0.4	35	65
Totals	117	50.9	100.	62.5	36	64
Western redcedar:						
Poria albipellucida Baxter	35	35.7	45.5	44.6	77	23
Poria weirii Murr.	35	35.7	41.4	40.6	74	26
Poria ferrugineofusca Karst.	1	1.0	3.0	2.9	69	31
Unknown white rots	17	17.3	10.1	9.9	97	3
Totals	85	86.7	100.	98.0	77	23

Table 4.--(Continued.)

BROWN ROTS

Tree species and fungi	Study trees infected		Total brown rot	Total cubic cull	Stage of decay found: Incip.	Stage of decay found: Typ.
	No.	Pct.	Pct.	Pct.	Pct.	Pct.
Sitka spruce:						
Fomes pinicola (Sw. ex Fr.) Cke.	59	25.4	87.7	73.3	41	59
Polyporus schweinitzii Fr.	4	1.7	5.2	4.3	15	85
Polyporus sulphureus (Bull.) Fr.	5	2.2	4.6	3.8	23	77
Trametes heteromorpha (Fr.) Bres.	2	0.9	1.8	1.5	52	48
Lentinus kauffmanii Smith	1	0.4	0.3	0.3	60	40
Unknown brown rots	2	0.9	0.5	0.4	19	81
Totals	69	29.7	100.	83.7	39	61
Western hemlock:						
Fomes pinicola	35	15.2	59.2	22.2	40	60
Polyporus sulphureus	6	2.6	16.6	6.2	19	81
Polyporus schweinitzii	4	1.7	13.8	5.2	25	75
Hydnum sp.	1	0.4	6.9	2.6	49	51
Unknown brown rots	8	3.5	3.5	1.3	23	77
Totals	51	22.2	100.	37.5	36	64
Western redcedar:						
Unknown brown rots	5	5.1	100.	2.0	57	43

CULL INDICATORS

The amount of cull in individual trees not only varies between tree species and diameter, but also within a given diameter class of a single species. Much of this variation can be detected in standing trees by the recognition of reliable indicators on the individual trees (figs. 6 - 18).

Reliable indicators of cull

In the analysis of the possible cull indicators the following were found to be external indicators of significant amounts of cull in the trees:

Sitka spruce

(1) Conks--of Fomes pinicola (fig. 6), F. pini (fig. 7), F. annosus, Polyporus sulphureus (fig. 8), P. schweinitzii (fig. 9), Trametes heteromorpha, or Armillaria mellea. We found no conks of F. nigrolimitatus on live trees; if they are encountered, however, they should be considered an indicator of cull.

(2) Swollen knots--caused by F. pini.

(3) Scars--caused by logging injury, falling-tree wounds, fire, or any serious injury exposing heartwood in the main bole below the merchantable top (fig. 10).

(4) Frost cracks--in the main bole (fig. 11).

(5) Rotten stubs--(old dead tops or twin boles) protruding from the lower main bole.

(6) Rotten burls or cankers--from any cause and on the main bole.

Western hemlock

(1) Conks--of Fomes pinicola (fig. 14), F. annosus, F. applanatus (fig. 15), F. robustus (fig. 16), Polyporus sulphureus (fig. 17), P. schweinitzii, Armillaria mellea, or Pholiota adiposa.

(2) Swollen knots--caused by F. pini.

(3) Scars--caused by logging, falling-tree wounds, fire, or any serious injury exposing heartwood in the main bole below the merchantable top (fig. 12).

(4) Frost cracks--in the main bole (fig. 14).

(5) Rotten stubs--(old dead tops or twin boles) protruding from the lower main bole (fig. 15).

(6) Rotten burls or cankers--caused by dwarfmistletoe on the main bole (fig. 13).

Western redcedar

(1) Sucker limbs--of bayonet type (fig. 18).

(2) Scars--any cause, when on the main bole.

(3) Dead side or dead strip--where part of the cambium is killed.

(4) Rotten burls--on the main bole.

We found no conks on living cedar trees; if any associated with decay are encountered, however, they should be considered cull indicators.

Non-indicators of cull

Certain injuries or other evidence considered as possible indicators were found not to indicate appreciable amounts of cull. They were called non-indicators. Those recorded on the study trees for each species were:

Sitka spruce--dead or spike tops, large dead branches, large or sucker-type limbs, scaly bark, knobby or rough boles, dead side, forked tops, and conks more than 1 foot from the bole on branches.

Western hemlock--dead or broken tops, dead side, sucker-type limbs, large mistletoed limbs (fig. 19), black knots (fig. 20), sound burls (fig. 21), scaly bark, forked tops, and conks (except those of *Fomes robustus*) more than 1 foot from the bole on branches.

Western redcedar--dead or spike tops (fig. 18), broken tops, forked tops, and sound burls.

How to use the indicators

In order to use the cull indicator factors properly, the cruiser must recognize the reliable indicators of cull and differentiate them from the non-indicators.

The cruiser should classify all trees on his sample strips or plots in one of the following three categories: (1) trees with no reliable indicators of cull, (2) trees with reliable indicators

Some conks that are reliable indicators of cull on Sitka spruce

Fig. 6.--Fomes pinicola on upper bole.

Fig. 7.--Fomes pini on lower bole.

Fig. 8.--Polyporus sulphureus on lower bole.

Fig. 9.--Typical Polyporus schweinitzii conk growing out of stump. On standing trees these conks usually occur on or near the ground at the tree base.

Injuries on trees that are reliable indicators of cull

Fig. 10.--Old scar and conk of _Fomes pinicola_ on lower bole of Sitka spruce, either of which is a reliable indicator.

Fig. 11.--Frost crack in lower bole of Sitka spruce showing decay from _Fomes pinicola_ which entered through the frost crack.

Fig. 13.--Rotten canker caused by dwarfmistletoe infection in the upper bole of a western hemlock tree.

Fig. 12.--Scar from deep wound in lower bole of western hemlock tree and cross section of bole from 40 feet above the ground, showing rot caused by _Fomes pinicola_ which entered through the old scar at the base.

Some conks and injuries that are reliable indicators of cull in western hemlock

Fig. 14.--Fomes pinicola conk on upper bole and frost crack on lower bole.

Fig. 15.--Fomes applanatus conks and rotten stub protruding from lower bole.

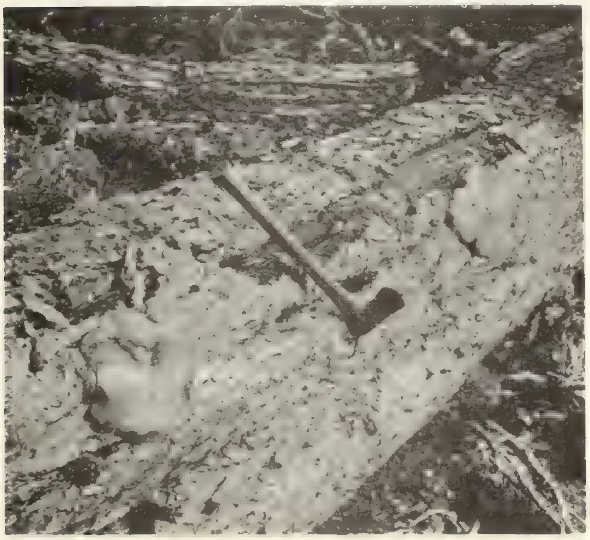

Fig. 16.--Conks of Fomes robustus on bole of felled tree showing dead side caused by this fungus.

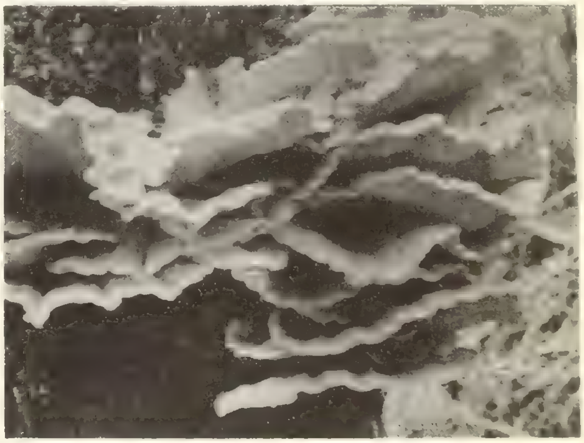

Fig. 17.--Conks of Polyporus sulphureus on lower bole. These conks are bright yellow when fresh and white and brittle when dry.

Non-indicators of cull and one indicator

Fig. 18.--Dead or spike top in western redcedar (the large sucker limb, however, is a reliable indicator of cull in redcedar).

Fig. 19.--Large mistletoed limb in western hemlock.

Fig. 20.--Black knots--common on western hemlock trees.

Fig. 21.--Sound burl, caused by dwarfmistletoe on the bole of a western hemlock tree.

confined to either the lower bole (fig. 7) or the upper bole (fig. 6), and (3) trees with reliable indicators occurring on both the lower and the upper bole (fig. 14).

The number of cull indicators on a single tree is not considered as long as their location is noted. For example, two or more indicators on the first 32-foot log or stump (figs. 10 and 15) indicate no more cull than a single one (figs. 11 and 12). Likewise, two or more indicators confined to the bole above the first 32-foot log indicate the same cull per cent as a single indicator.

Seeing more than one indicator on a tree is significant only if they occur on both the lower and the upper bole (fig. 14). Whether the indicators are confined to the lower bole or confined to the upper bole is not significant. The important thing is that they are confined to one or the other and do not occur on both.

Cull factors are also presented here for all trees with cull indicators. If these factors are to be used, the cruiser needs only to determine whether a tree has a reliable cull indicator. These factors, however, will not show local differences in the same detail that use of three separate categories will. The more general type of indicator factor is not recommended when it is desirable to determine local stand variations in cull percentages. For entire Southeast Alaska the more general factors would probably give the same over-all results as the three separate ones.

CULL FACTORS

The cull factors are given in tables 5 through 8 by 4-inch d.b.h. classes for trees from 11 inches to the maximum sizes studied in each species. The values in the tables were read from smoothed curves. If d.b.h. classes other than those given are desired, the values may be determined by interpolation or by replotting the curves and reading off the intermediate values.

Flat factors

Table 5 gives flat cull factors for Sitka spruce, western hemlock, and western redcedar. These factors are based on all trees studied, and they represent the average cull in each diameter class regardlessof cause or association with cull indicators. For each tree species, there are factors that apply to board-foot and factors that apply to cubic-foot gross volumes. The factors are for cull in the main bole from the stump to the utilized top and to a fixed top. Separate factors are included also for cull in the stump. Stump factors apply only to the gross cubic-foot volume of a cylinder the length of the stump and equal in diameter to the top of the stump. Taper in the rot column in the stump was disregarded in the same manner as the taper in the stump itself.

Table 5.--Flat factors[1] for gross board-foot and cubic-foot volumes. Percentage that is cull in trees of Sitka spruce, western hemlock, and western redcedar, by 4-inch d.b.h. classes from the stump to the utilized top and to a fixed top. For Southeast Alaska.

D.b.h. class inches	Sitka spruce Bd.-ft. To util. top	Sitka spruce Bd.-ft. To 8-in. top	Sitka spruce Cu. ft. To util. top	Sitka spruce Cu. ft. To 4-in. top	Sitka spruce Cu. ft. In stump only	Western hemlock Bd.-ft. To util. top	Western hemlock Bd.-ft. To 8-in. top	Western hemlock Cu. ft. To util. top	Western hemlock Cu. ft. To 4-in. top	Western hemlock Cu. ft. In stump only	Western redcedar Bd.-ft. To util. top	Western redcedar Bd.-ft. To 8-in. top	Western redcedar Cu. ft. To util. top	Western redcedar Cu. ft. To 4-in. top	Western redcedar Cu. ft. In stump only
11-14	3	5	2	4	0	11	10	3	3	13	52	51	28	24	30
15-18	4	6	3	4	2	11	10	4	3	13	52	52	29	25	30
19-22	6	7	4	5	5	12	12	4	4	14	54	54	30	27	30
23-26	9	9	6	6	9	14	13	5	4	16	57	56	33	31	31
27-30	11	11	7	7	12	17	16	7	6	19	60	59	39	39	34
31-34	13	13	7	8	14	21	20	9	8	23	64	63	50	47	39
35-38	14	15	8	9	15	25	24	11	11	29	69	68	58	55	45
39-42	15	16	8	10	15	28	28	15	15	36	74	73	65	62	51
43-46	15	17	8	10	16	32	32	18	18	42	78	78	71	69	58
47-50	16	18	8	11	16	35	36	22	22	48	83	83	77	76	64
51-54	16	18	8	11	16	38	40	26	26	54	88	87	83	81	70
55-58	16	19	8	11	15	41	43	30	31	60	91	90	87	86	76
59-62	16	19	8	11	15	44	46	34	35	65	95	93	91	90	83
63-66	16	19	7	12	14	47	49	38	39	70	98	96	95	94	89
67-70	16	20	7	12	14	51	52	42	43	76	100	98	98	96	95
71-74	16	20	7	12	13	--	--	--	--	--	100	99	100	98	100
75-78	16	20	6	12	12	--	--	--	--	--	100	100	100	99	100
79-82	15	20	6	12	10	--	--	--	--	--	--	--	--	--	--
83-86	15	20	6	12	9	--	--	--	--	--	--	--	--	--	--
87-90	14	20	5	12	7	--	--	--	--	--	--	--	--	--	--
91-94	13	20	5	12	6	--	--	--	--	--	--	--	--	--	--
95-98	13	20	4	12	4	--	--	--	--	--	--	--	--	--	--
99-102	12	20	4	12	2	--	--	--	--	--	--	--	--	--	--
103-106	11	20	3	12	1	--	--	--	--	--	--	--	--	--	--
107-110	10	20	3	12	0	--	--	--	--	--	--	--	--	--	--

1/ Based on the average cull in a diameter class, regardless of cause or association with cull indicators.

Indicator factors

The cull indicator factors for Sitka spruce are given in table 6, those for western hemlock in table 7, and for western red-cedar in table 8. These tables provide cull discount factors for the gross board-foot and the gross cubic-foot volumes of trees that have no cull indicators, of trees with cull indicators on only one section of the bole, of trees with indicators on both sections of the bole, and of all trees with indicators. They express the percentage of cull in the main bole from the stump to the utilized top and to a fixed top diameter of 8 inches for board-foot volumes and 4 inches for cubic-foot volumes.

The factor values were read from smoothed curves based on trees from all of the study areas and are, therefore, designed to apply throughout Southeast Alaska.

Table 6.--Indicator factors for Sitka spruce. Percentage of the gross board-foot and cubic-foot volume that is cull in trees without and in trees with cull indicators--by 4-inch d.b.h. classes from the stump to the utilized top and to a fixed top. For Southeast Alaska.

D.b.h. class inches	Trees with no indicators				Indicators on one section of bole only 1/				Indicators on both sections of bole 1/				All trees with indicators			
	Bd.-ft.--		Cu. ft.--		Bd.-ft.--		Cu. ft.--		Bd. ft.--		Cu. ft.--		Bd.-ft.--		Cu. ft.--	
	To util. top	To 8-in. top	To util. top	To 4-in. top	To util. top	To 8-in. top	To util. top	To 4-in. top	To util. top	To 8-in. top	To util. top	To 4-in. top	To util. top	To 8-in. top	To util. top	To 4-in. top
11-14	1	1	0	0	32	27	17	13	92	96	73	82	45	45	34	33
15-18	1	1	0	0	32	28	17	13	90	95	71	79	44	44	31	32
19-22	1	1	0	0	31	28	17	14	87	94	68	76	43	44	29	31
23-26	1	1	0	0	31	29	17	14	85	91	64	72	42	44	27	30
27-30	1	1	0	0	30	29	16	14	82	88	60	67	40	43	26	29
31-34	1	1	1	0	29	29	15	15	79	85	56	62	39	43	24	28
35-38	2	2	1	1	28	29	14	15	75	81	51	57	38	42	22	27
39-42	2	3	1	1	27	29	13	15	72	77	47	51	37	41	21	26
43-46	2	3	1	2	25	28	12	15	69	72	43	46	36	40	19	24
47-50	3	4	1	2	23	27	10	15	66	67	39	41	35	38	18	23
51-54	3	4	2	3	22	26	9	15	63	63	35	38	33	37	17	21
55-58	3	4	2	3	20	24	8	15	61	61	32	35	32	35	15	19
59-62	3	4	2	3	19	23	7	14	59	59	30	33	31	33	14	18
63-66	3	5	2	4	17	22	6	14	58	59	27	32	29	31	12	16
67-70	4	5	2	4	16	21	5	13	57	58	25	31	28	29	11	15
71-74	4	5	2	4	15	21	4	13	57	58	24	30	26	27	9	14
75-78	4	5	3	4	14	21	4	12	56	58	23	30	24	25	8	13
79-82	4	5	3	4	13	21	4	11	--	--	--	--	21	23	7	12
83-86	4	5	3	4	14	20	4	10	--	--	--	--	19	21	6	11
87-90	4	5	3	4	15	20	4	10	--	--	--	--	16	20	5	10
91-94	4	5	3	4	--	--	--	--	--	--	--	--	--	--	--	--
95-98	4	6	3	4	--	--	--	--	--	--	--	--	--	--	--	--
99-102	4	6	3	4	--	--	--	--	--	--	--	--	--	--	--	--
103-106	4	6	3	4	--	--	--	--	--	--	--	--	--	--	--	--
107-110	4	6	3	4	--	--	--	--	--	--	--	--	--	--	--	--

1/ The lower section of the bole is from the ground to the top of the first 32-foot log; the upper section, that portion above the first 32-foot log.

Table 7.--Indicator factors for western hemlock. Percentage of the gross board-foot and cubic-foot volume that is cull in trees without and in trees with cull indicators--by 4-inch d.b.h. classes from the stump to the utilized top and to a fixed top. For Southeast Alaska.

D.b.h. class inches	Trees with no indicators				Indicators on one section of bole only 1/				Indicators on both sections of bole 1/				All trees with indicators			
	Bd.-ft.--		Cu. ft.--		Bd.-ft.--		Cu. ft.--		Bd.-ft.--		Cu. ft.--		Bd.-ft.--		Cu. ft.--	
	To util. top	To 8-in. top	To util. top	To 4-in. top	To util. top	To 8-in. top	To util. top	To 4-in. top	To util. top	To 8-in. top	To util. top	To 4-in. top	To util. top	To 8-in. top	To util. top	To 4-in. top
11-14	4	3	1	1	25	24	9	8	35	37	14	16	26	25	10	9
15-18	5	4	1	1	25	25	9	8	37	39	14	17	27	26	10	10
19-22	6	4	1	1	26	26	10	9	40	41	16	19	30	28	11	10
23-26	7	6	2	1	28	27	11	10	44	45	18	21	34	32	13	13
27-30	9	8	3	2	31	30	12	12	49	51	22	25	38	39	16	16
31-34	11	11	4	4	33	33	14	14	54	57	28	30	41	44	19	20
35-38	14	14	6	6	36	36	16	18	60	62	34	35	45	48	23	24
39-42	17	18	9	9	39	39	19	21	66	68	41	42	48	50	27	28
43-46	20	21	12	12	42	41	23	24	71	74	49	49	50	52	31	31
47-50	23	24	15	15	45	44	27	27	76	78	56	56	51	54	34	34
51-54	27	27	18	19	47	46	31	30	80	82	61	62	52	56	36	36
55-58	30	30	22	23	49	48	34	33	84	85	66	66	53	57	38	38
59-62	33	33	26	27	51	49	36	35	86	87	70	70	54	58	40	40
63-66	35	36	29	30	52	50	38	37	87	89	73	73	55	58	42	42
67-70	37	38	31	33	53	51	40	39	88	90	74	75	55	59	44	44

1/ The lower section of the bole is from the ground to the top of the first 32-foot log; the upper section, that portion above the first 32-foot log.

Table 8.--Indicator factors for western redcedar. Percentage of the gross board-foot and cubic-foot volume that is cull in trees without and in trees with cull indicators--by 4-inch d.b.h. classes from the stump to the utilized top and to a fixed top. For Southeast Alaska.

D.b.h. class inches	Trees with no indicators: Bd.-ft.--: To util. top	Trees with no indicators: Bd.-ft.--: To 8-in. top	Trees with no indicators: Cu. ft.--: To util. top	Trees with no indicators: Cu. ft.--: To 4-in. top	Indicators on one section of bole only 1/: Bd.-ft.--: To util. top	Indicators on one section of bole only 1/: Bd.-ft.--: To 8-in. top	Indicators on one section of bole only 1/: Cu. ft.--: To util. top	Indicators on one section of bole only 1/: Cu. ft.--: To 4-in. top	Indicators on both sections of bole 1/: Bd.-ft.--: To util. top	Indicators on both sections of bole 1/: Bd.-ft.--: To 8-in. top	Indicators on both sections of bole 1/: Cu. ft.--: To util. top	Indicators on both sections of bole 1/: Cu. ft.--: To 4-in. top	All trees with indicators: Bd.-ft.--: To util. top	All trees with indicators: Bd.-ft.--: To 8-in. top	All trees with indicators: Cu. ft.--: To util. top	All trees with indicators: Cu. ft.--: To 4-in. top
11-14	44	42	20	16	49	47	28	28	75	77	67	65	68	67	43	41
15-18	45	44	21	18	50	48	29	29	76	78	68	65	69	68	44	43
19-22	46	46	22	20	51	51	32	31	76	78	68	66	69	68	46	45
23-26	48	48	25	23	54	54	35	34	77	79	69	67	70	68	49	47
27-30	50	50	31	29	59	59	41	39	78	80	69	68	70	69	53	51
31-34	52	52	38	37	65	65	47	46	80	81	71	69	72	71	58	56
35-38	55	54	45	43	72	73	55	54	84	84	74	72	74	73	64	62
39-42	58	55	49	47	80	81	63	63	88	88	80	77	80	80	71	69
43-46	59	56	51	48	88	88	71	72	93	92	88	85	89	89	79	78
47-50	60	57	52	49	94	93	77	80	97	95	95	93	97	95	93	90
51-54	61	57	53	49	99	96	83	86	100	100	100	100	100	100	100	100
55-58	61	58	53	50	100	98	88	90	100	100	100	100	100	100	100	100
59-62	--	--	--	--	100	100	92	93	100	100	100	100	100	100	100	100
63-66	--	--	--	--	100	100	96	95	100	100	100	100	100	100	100	100
67-70	--	--	--	--	100	100	98	97	100	100	100	100	100	100	100	100
71-74	--	--	--	--	100	100	100	98	100	100	100	100	100	100	100	100
75-78	--	--	--	--	100	100	100	99	100	100	100	100	100	100	100	100

1/ The lower section of the bole is from the ground to the top of the first 32-foot log; the upper section, that portion above the first 32-foot log.

ELEVATION-CULL RELATIONSHIP

Some loggers in Southeast Alaska assert that the higher their operation above sea level, the more cull they encounter in the timber stands. An effort was made to determine if this was a general condition throughout the area. The study trees were segregated by 50-foot elevation intervals and the cull percentages determined for each interval (table 9). The results of this analysis indicate no general correlation between elevation and percent of cull in any of the tree species.

Table 9.--Percent cull in three tree species, by elevation above sea level, Southeast Alaska. (Percent of gross cubic-foot volume from the ground to a 4-inch d.i.b. top in the main bole.)

Elevation intervals, feet	Sitka spruce		Western hemlock		Western redcedar	
	Basis, trees	Cubic volume cull	Basis, trees	Cubic volume cull	Basis, trees	Cubic volume cull
	Number	Percent	Number	Percent	Number	Percent
1-50	28	18	41	13	18	78
51-100	111	13	105	20	22	62
101-150	16	3	15	11	22	51
151-200	17	13	16	12	9	68
201-250	13	7	16	21	10	79
251-300	12	1	16	18	5	77
301-350	13	15	14	19	5	86
351-400	8	0	1	19	--	--
401-450	5	5	1	41	--	--
451-500	--	--	2	0	--	--
501-550	--	--	1	0	1	88
551-600	--	--	1	0	1	52
601-650	--	--	--	--	--	--
651-700	--	--	--	--	1	28
701-750	--	--	--	--	--	--
751-800	--	--	--	--	2	79
801-850	--	--	--	--	--	--
851-900	3	6	--	--	--	--
901-950	--	--	1	0	--	--
951-1000	5	0	--	--	2	83
1001-1050	1	5	--	--	--	--

AGE-CULL RELATIONSHIP

Most foresters know that the percentage of cull increases with the age of the trees in a stand. To demonstrate the relation of tree age to cull percent, the study trees were separated into 50-year age groups and the cull determined for trees of each age class. Smooth curves were drawn showing:

(1) The average percent of the gross board-foot volume that is cull in the sawlog portion of trees (fig. 22).

(2) The percent of gross cubic-foot volume of the entire tree that is cull (fig. 23).

(3) The percent of trees of each species that contained measurable amounts of rot at different ages (fig. 24).

Since the data upon which figures 22, 23, and 24 are based may be of value to Alaska forest workers, they are given in table 10 for each tree species.

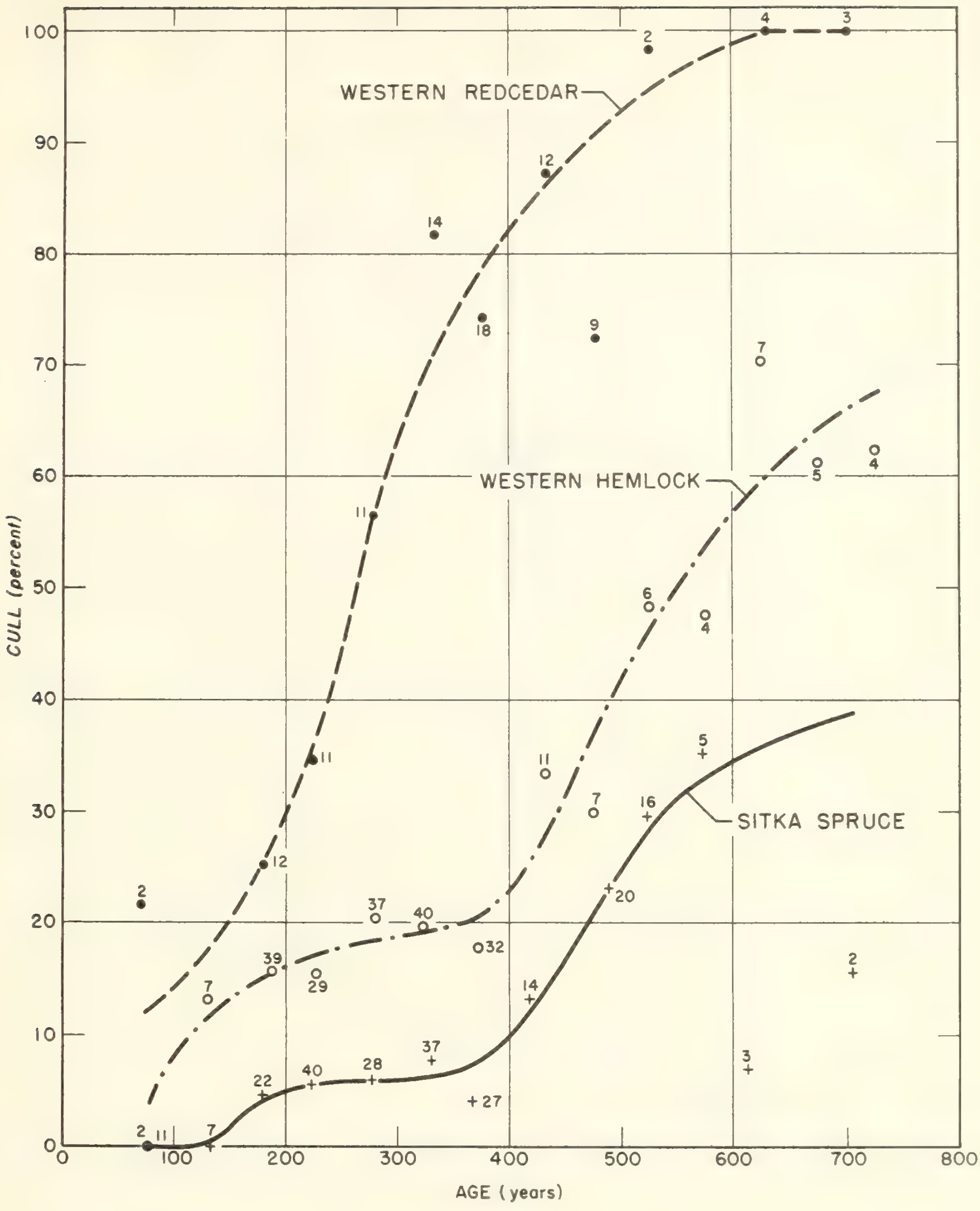

Fig. 22.--Relationship of tree age to board-foot cull in the sawlog portion of the bole; percent of gross board-foot volume that is cull, from the stump to the utilized top, Sitka spruce, western hemlock, and western redcedar in Southeast Alaska.

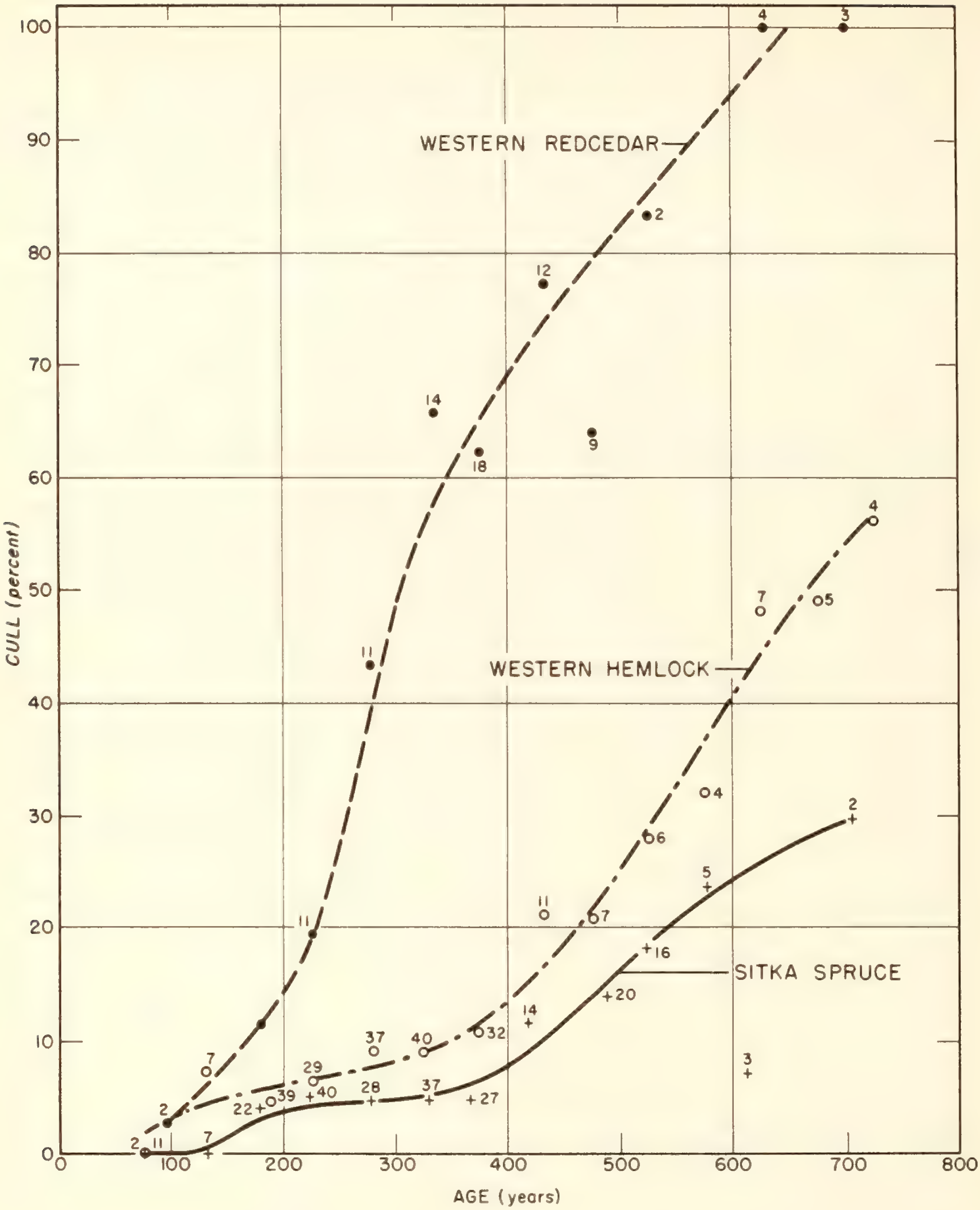

Fig. 23.--Relationship of tree age to cubic-foot cull in the entire stem; percent gross cubic-foot volume that is cull, from the ground to a 4-inch top, Sitka spruce, western hemlock, and western redcedar in Southeast Alaska.

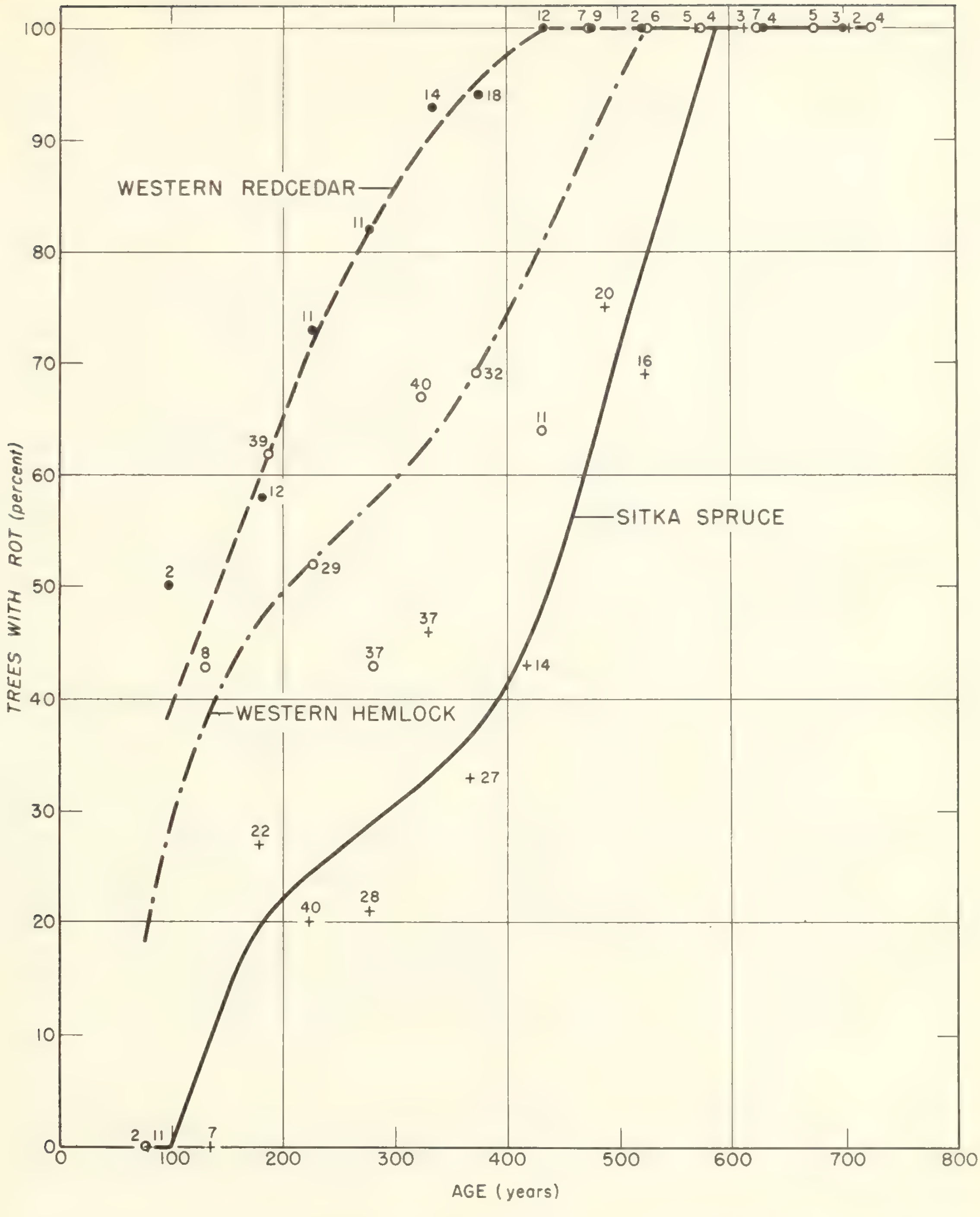

Fig. 24.--Relationship of tree age to the occurrence of rot; percent of trees containing measurable amounts of rot, Sitka spruce, western hemlock, and western redcedar in Southeast Alaska.

Table 10.--Tree diameter, volume and cull, by age class and species, Southeast Alaska.

SITKA SPRUCE

Age class, years	Average age	Average d.b.h.	Volume, stump to utilized top: Gross	Volume, stump to utilized top: Cull	Volume, stump to utilized top: Net	Volume, ground to a 4-inch top: Gross	Volume, ground to a 4-inch top: Cull	Volume, ground to a 4-inch top: Net	Study trees: Total basis	Study trees: With rot
	Years	Inches	Board-feet	Board-feet	Board-feet	Cubic feet	Cubic feet	Cubic feet	Number	Number
51-100	76	20.5	5,530	0	5,530	1,203	0	1,203	11	0
101-150	132	17.8	1,800	0	1,800	457	0	457	7	0
151-200	179	31.8	25,300	1,220	24,080	5,294	220	5,074	22	6
201-250	222	32.8	59,240	3,380	55,860	11,464	598	10,866	40	8
251-300	278	37.6	55,190	3,320	51,870	11,387	548	10,839	28	6
301-350	330	41.4	93,240	7,300	85,940	18,135	889	17,246	37	17
351-400	368	54.6	144,970	5,980	138,990	25,007	1,229	23,778	27	9
401-450	419	54.1	69,570	9,160	60,410	13,342	1,549	11,793	14	6
451-500	488	52.0	87,460	20,160	67,300	17,286	2,431	14,855	20	15
501-550	522	67.4	135,950	40,460	95,490	23,812	4,333	19,479	16	11
551-600	572	60.5	43,850	15,430	28,420	8,520	2,027	6,493	5	5
601-650	612	56.0	25,400	1,790	23,610	3,984	286	3,698	3	3
651-750	703	65.8	20,650	3,240	17,410	3,828	1,141	2,687	2	2

Table 10.--(Continued.)

WESTERN HEMLOCK

Age class, years	Aver- age	Average d.b.h.	Volume, stump to utilized top			Volume, ground to a 4-inch top			Study trees	
			Gross	Cull	Net	Gross	Cull	Net	Total basis	With rot
	Years	Inches	Board-feet			Cubic feet			Number	
51-100	77	12.0	200	0	200	52	0	52	2	0
101-150	130	19.8	2,510	330	2,180	583	43	540	7	3
151-200	188	24.2	21,960	3,480	18,480	5,276	254	5,022	39	24
201-250	228	30.1	29,340	4,590	24,750	6,239	415	5,824	29	15
251-300	280	33.2	56,350	11,470	44,880	11,090	1,027	10,063	37	16
301-350	323	34.0	58,020	11,410	46,610	11,554	1,054	10,500	40	27
351-400	372	39.2	68,290	12,240	56,050	13,385	1,453	11,932	32	22
401-450	431	36.0	19,440	6,510	12,930	3,680	781	2,899	11	7
451-500	475	43.4	16,500	4,950	11,550	3,244	679	2,565	7	7
501-550	525	41.7	13,100	6,350	6,750	2,561	718	1,843	6	6
551-600	575	46.8	10,050	4,790	5,260	1,868	600	1,268	4	4
601-650	625	48.1	14,400	10,120	4,280	3,259	1,577	1,682	7	7
651-700	675	52.5	14,740	9,020	5,720	2,982	1,463	1,519	5	5
701-750	725	64.2	16,210	10,120	6,090	3,237	1,816	1,421	4	4

WESTERN REDCEDAR

Age class, years	Aver- age	Average d.b.h.	Gross	Cull	Net	Gross	Cull	Net	Total basis	With rot
51-100	97	17.5	370	80	290	102	3	99	2	1
151-200	180	23.4	4,420	1,120	3,300	1,132	130	1,002	12	7
201-250	227	28.0	6,070	2,110	3,960	1,500	292	1,208	11	8
251-300	278	28.9	5,880	3,330	2,550	1,531	668	863	11	9
301-350	334	35.7	16,300	13,340	2,960	3,660	2,407	1,253	14	13
351-400	376	41.6	26,990	20,030	6,960	5,968	3,717	2,251	18	17
401-450	432	43.1	21,520	18,760	2,760	4,682	3,612	1,070	12	12
451-500	477	45.7	16,420	11,890	4,530	3,770	2,411	1,359	9	9
501-550	525	48.3	3,640	3,580	60	800	668	132	2	2
600-650	630	51.3	9,620	9,620	0	2,204	2,204	0	4	4
651-750	700	68.7	14,230	14,230	0	2,973	2,973	0	3	3