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GROWTH OF PONDEROSA PINE BY KEEN TREE CLASS

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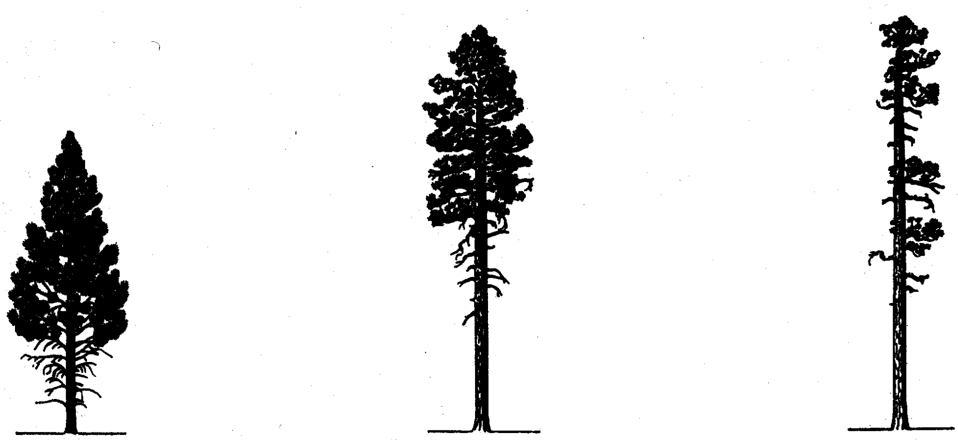


1A Young, Full Vigor — 3B Mature, Good to Fair Vigor — 4C Overmature, Fair to Poor Vigor.

SOME EXAMPLES OF THE SIXTEEN TREE CLASSES

GROWTH OF PONDEROSA PINE BY KEEN TREE CLASS

Every forester who works in the ponderosa pine woods is impressed by the tremendous range in size, quality, age, and thrift of the trees found in the virgin forest. So great is this variation from tree to tree that stand averages mean little to the timber marker trying to select trees of high value and insect risk for cutting, and at the same time reserve for future harvest the trees of low carrying charge and rapid growth rate.

In an attempt to provide a practical basis for estimating the mortality probabilities and growth potentialities of individual ponderosa pine trees, the Keen tree classification1/ was developed several years ago. Under this system, individual trees are grouped into four age classes, namely, young, immature, mature, and overmature designated respectively by numbers 1, 2, 3, and 4, and into four crown-vigor classes defined as full vigor, good to fair, fair to poor, and very poor and designated respectively by the letters A, B, C, and D. Thus, for example, under this classification of 16 groups a young tree of full vigor is termed a 1A, a mature tree of very poor vigor a 3D, etc.

The Keen tree classification system is now widely used in the ponderosa pine forests of Oregon and Washington for timber marking, for mortality, and growth studies. In modified form it is also commonly applied in the forests of the Black Hills and the Southwest.

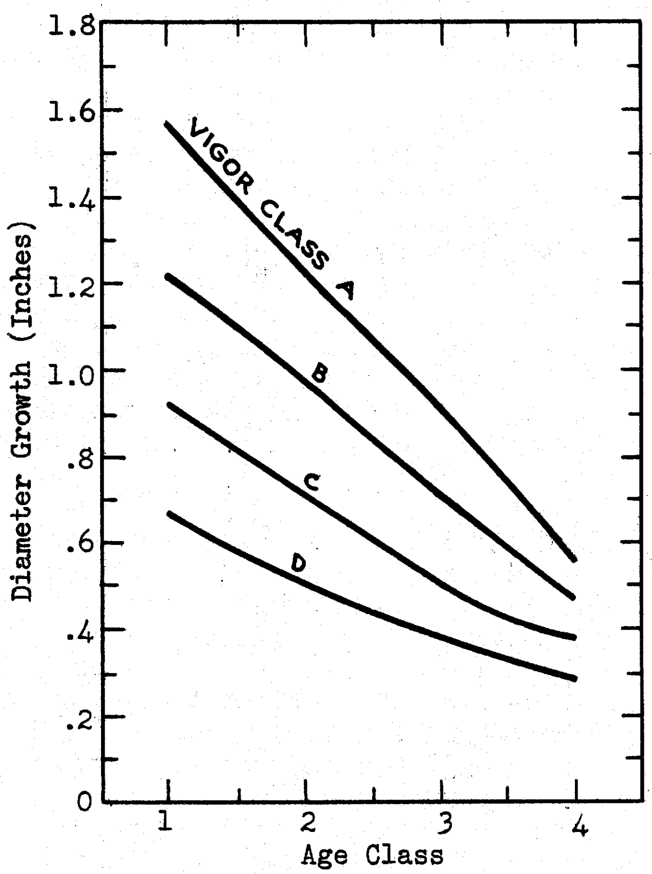
The present report presents the first comprehensive compilation of virgin stand growth rates by Keen tree class for the North Pacific region. It is based on increment core and other measurements from almost 8,000 sample trees on thirty 10-acre permanent sample plots established in virgin forests in eastern and central Oregon by the Portland Forest Insect Laboratory, Bureau of Entomology and Plant Quarantine. Although all of the plots are located in Oregon, it is believed that the findings on them are also generally applicable in central and eastern Washington. All plots were put in, the trees classified, and measurements taken and compiled by the author of the tree classification system, F. P. Keen, and his assistants.

1/ Keen, F. P. Relative susceptibility of ponderosa pines to bark beetle attack. Jour. Forestry 34:919-927, illus. 1936.
__________ Ponderosa pine tree classes redefined. U. S. Dept. Agric., Bureau of Entomology and Plant Quarantine. Mimeo., illus. 1941.

Diameter Growth

Analysis of this large amount of basic data shows that diameter growth of all tree classes as a group normally averages about three-quarters of an inch per decade. The youngest, most vigorous trees in the stand, the 1A's, make double the average growth, or about one and one-half inches in 10 years. In contrast the oldest, least vigorous trees, the 4D's, grow only about one-quarter inch per decade. Figure 1 and table 1 show the normal diameter growth rates for each of the 16 tree classes, and reveal a strikingly symmetrical relationship between the averages for the various classes.

Fig. 1
Normal 10-year Growth in D.B.H., Outside Bark, by Tree Class



Within some of the tree classes the normal diameter growth rates vary considerably, depending on tree diameter. (See table 2.) For the young and the vigorous trees as a group, i.e., tree classes 1A, 1B, 2A, and 2B, normal diameter growth diminishes as tree size increases. The larger trees, in general, are the older trees, and they grow less rapidly than do the smaller, younger individuals of the same class. At this early stage of tree development the regression of growth rate on age is sufficiently sharp to overbalance the opposite tendency for larger trees to be more vigorous than the smaller in the same age class.

For trees of corresponding good vigor in the advanced age classes, i.e., the 3A's, 3B's, 4A's, and 4B's, the relation of tree size to diameter growth rate is quite the reverse. Here the larger trees are definitely more vigorous than smaller ones of the same tree class. At this late stage in the life cycle of a tree the drop in growth rate with increasing age has flattened out so that the effect of greater vigor inherent in the larger sizes dominates in the diameter-age-vigor relationship.

Table 1.--Normal 10-year Growth in Diameter at Breast Height, Outside Bark, by Tree Class

Age class	Vigor class				Unweighted average
	A	B	C	D	
	Inches	Inches	Inches	Inches	Inches
1	1.56	1.21	.92	.66	1.09
2	1.21	.97	.71	.49	.84
3	.90	.71	.50	.37	.62
4	.55	.46	.37	.27	.41
Unweighted average	1.06	.84	.62	.45	.74

In all C-vigor classes, trees of fair to poor thrift, diameter growth rate is independent of tree size. Although the larger trees in these classes are older than their class average, there is a compensating tendency for such trees to be more vigorous than their class mean.

The D-crown trees, those of very poor vigor, in all age classes consistently show a decline in diameter growth with increase in size, a trend that might logically be associated with increasing age and increasing competition with more vigorous stand associates.

Tree diameter increment consists of the combined growth of wood and bark. For trees of normal to rapid growth, increase in bark thickness comprises about 6 percent of the total diameter increment. Trees of abnormally low vigor, however, may occasionally suffer an actual decrease in diameter outside bark, even while diameter of the wood increases slightly, owing to the loss of bark by sloughing.

Volume Growth

Individual ponderosa pine trees growing in a virgin stand on average site IV may be expected to put on a gross volume increment of from 6 to 177 board feet, Scribner rule, per decade, depending on their size, age, and vigor. From table 3, which gives normal 10-year volume growth, it is evident that trees of identical size may grow at widely varying rates; increment is much greater the younger the age and the better the vigor. In terms of board-foot volume the growth for any one tree class increases with tree size, as would be expected.

Table 2.--Normal 10-year Growth in Diameter at Breast Height Outside Bark by Tree Class and Diameter Class

Diam. at B. H.	Tree class				Tree class				Tree class				Tree class				Diam. at B. H.
	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B	3C	3D	4A	4B	4C	4D	
In.	Inches				Inches				Inches				Inches				In.
10	1.69	1.28	.92	.66	1.50	1.14	.71	.49			.50	.41				.32	10
12	1.60	1.21	.92	.64	1.42	1.07	.71	.49			.50	.39				.31	12
14	1.51	1.13	.92	.63	1.34	1.01	.71	.47		.57	.50	.38			.37	.30	14
16	1.42	1.06	.92	.61	1.28	.97	.71	.46	.73	.60	.50	.36			.37	.29	16
18	1.33	.99	.92		1.23	.93	.71	.45	.76	.64	.50	.34		.38	.37	.28	18
20	1.24	.93			1.16	.90	.71	.44	.80	.66	.50	.33		.39	.37	.27	20
22	1.15				1.13	.88	.71		.83	.68	.50	.31		.41	.37	.26	22
24					1.11	.86	.71		.86	.70	.50	.29	.48	.42	.37	.25	24
26					1.09	.84	.71		.88	.72	.50	.28	.50	.43	.37	.25	26
28					1.08	.83			.90	.74	.50	.26	.51	.45	.37	.24	28
30					1.06	.82			.92	.76	.50	.24	.52	.46	.37	.23	30
32					1.04				.94	.77	.50		.54	.46	.37	.22	32
34									.96	.78	.50		.55	.47	.37	.21	34
36									.97	.79	.50		.56	.48	.37	.20	36
38									.99	.79	.50		.57	.49	.37	.19	38
40									1.00	.80			.58	.50	.37	.19	40
42									1.01	.81			.59	.50	.37		42
44									1.02	.81			.59	.51	.37		44
46									1.02				.60	.51	.37		46
48													.60	.52	.37		48
50													.61	.52			50
54													.62				54
58													.62				58

Table 3.--Normal 10-year Gross Growth in Board Feet Per Tree by Tree Class and Diameter Class

Diam. at B. H.	Tree class				Tree class				Tree class				Tree class				Diam. at B. H.
	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B	3C	3D	4A	4B	4C	4D	
In.	Board Feet, Scribner Rule																In.
12	38	28	22	15	25	19	15	11			12	9				6	12
14	49	36	30	21	39	30	22	16		20	16	12			10	9	14
16	56	43	37	25	48	37	27	18	31	27	20	15			14	12	16
18	66	50	45		58	45	34	22	40	34	25	17		19	16	14	18
20	75	57			68	52	40	24	50	42	31	19		24	19	16	20
22	83				76	58	46		60	51	37	22		30	22	18	22
24					85	65	54		71	58	43	24	41	36	26	19	24
26					93	70	60		82	66	48	27	48	43	30	20	26
28					100	76			92	74	55	30	57	51	34	21	28
30					106	83			102	81	61	33	65	58	40	24	30
32					111				108	89	67		70	64	44	25	32
34									119	99	73		75	68	46	26	34
36									129	108	78		81	72	51	28	36
38									138	114	85		85	75	56	31	38
40									150	120			88	79	57	33	40
42									162	122			92	82	61		42
44									168	128			94	84	64		44
46									177				96	85	66		46
48													102	86	69		48
50													112	89			50
54													125				54
58													144				58

These rates of volume increment were obtained by applying the diameter growth rates shown in table 2 to a volume-over-d.b.h. table derived from the range-wide standard ponderosa pine volume tables, using tree heights from a set of coordinated height curves prepared by the Bureau of Entomology and Plant Quarantine from more than 7,000 height measurements taken on their study plots. In a similar manner volume increments based on other standards of measurement, such as cubic feet or lumber tally, may be derived from the diameter growth rates.

Gross increment of a specific virgin ponderosa pine forest can be computed by applying the growth rates per tree given in table 3 to a stand table showing number of trees by tree class and diameter class.

Volume Growth Percent

Frequently it is convenient to express growth as a percentage of the volume to which it is added. It is this measure of tree growth that is employed, along with mortality probability and net tree value, for computing priority of cutting according to the maturity selection system.2/

As shown in table 4, annual gross growth of virgin ponderosa pines ranges from .12 to 7.93 percent of their board-foot volume, depending on their size, age, and vigor. For trees of the same size, growth percent is greater the younger the age and the better the vigor, without exception. For any one tree class growth percent is smaller the greater the diameter, also without exception.

Gross growth of an individual tract of virgin pine can be computed by applying the percentages given in table 4 to a stock table for the tract showing board-foot volume by tree class and by d.b.h.

These rates of gross volume increase represent black-ink entries for the forest management ledger, but simultaneously the timber capital is constantly being depleted by insects, windfall, and other agencies that must be set down as red-ink entries.

It is evident from the preceding tables that the several tree classes differ widely in their rates of gross growth. They likewise differ greatly in their susceptibility to the natural agencies of depletion.3/ Illustrative of the correlation between loss rate and tree age and vigor are the average mortality ratios compiled by Keen from

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2/ Munger, Thornton T. They discuss the maturity selection system. Jour. Forestry 39:297-303. 1941.
Munger, Thornton T. & Briegleb, Philip A. Recent developments in pine silviculture. Northwest Science 16:40-45. 1942.

3/ See footnote 1.

Table 4.--Normal Annual Gross Growth as Percent of Board-foot Volume by Tree Class and Diameter Class

Diam. at B. H.	Tree class				Tree class				Tree class				Tree class				Diam. at B. H.
	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B	3C	3D	4A	4B	4C	4D	
In.	Percent				Percent				Percent				Percent				In.
12	7.93	5.85	4.50	3.15	5.25	4.05	3.10	2.30			1.97	1.52				1.00	12
14	4.85	3.57	2.94	2.02	3.80	2.90	2.14	1.55		1.78	1.45	1.12			.95	.81	14
16	3.38	2.62	2.25	1.49	2.88	2.24	1.66	1.12	1.75	1.50	1.14	.84			.77	.67	16
18	2.63	2.00	1.80		2.33	1.79	1.35	.86	1.51	1.29	.95	.65		.73	.61	.54	18
20	2.14	1.62			1.94	1.49	1.14	.70	1.32	1.13	.83	.52		.65	.51	.43	20
22	1.78				1.64	1.25	1.00		1.18	1.00	.73	.43		.59	.44	.35	22
24					1.40	1.06	.88		1.06	.88	.65	.37	.62	.55	.39	.28	24
26					1.21	.91	.78		.96	.78	.57	.32	.57	.51	.35	.23	26
28					1.05	.80			.86	.69	.51	.28	.53	.48	.32	.20	28
30					.92	.72			.78	.62	.46	.25	.49	.44	.30	.18	30
32					.82				.71	.57	.43		.45	.41	.28	.16	32
34									.66	.52	.40		.41	.37	.25	.14	34
36									.61	.48	.37		.38	.34	.24	.13	36
38									.58	.45	.35		.35	.31	.23	.13	38
40									.55	.43			.32	.29	.21	.12	40
42									.52	.41			.30	.27	.20		42
44									.50	.39			.28	.25	.19		44
46									.48				.26	.23	.18		46
48													.25	.21	.17		48
50													.25	.20			50
54													.24				54
58													.24				58

records on some two hundred 640- and 320-acre plots in virgin stands of Oregon and Washington during 9 years in the periods 1928-31, 1935-37, and 1939-40. These mortality ratios, given in table 5, show the relative rates of loss for the various tree classes. They also represent annual mortality percentage by tree class that would be expected if total stand mortality amounted to 1 percent annually of total stand volume. During the periods over which Keen's mortality ratios were compiled average stand mortality actually measured .93 percent per year. The normal level of total stand mortality is unknown, of course, and the best estimates of its magnitude that can be made today are crude indeed.

Table 5.--Average Mortality Ratios by Keen Tree Class[1/]

Age class	Vigor class			
	A	B	C	D
	Percent	Percent	Percent	Percent
1	.1	.3	.8	1.1
2	.2	.6	1.0	1.5
3	.3	1.0	1.9	2.6
4	.4	1.4	2.7	3.8

1/ Compiled by F. P. Keen from records of loss during the periods 1928-31, 1935-37, and 1939-40.

Perhaps the most practical present index to normal virgin stand mortality may be derived from the old assumption that, for these stands as a whole, in the long run and over large areas loss will equal gross growth. As measured by the Forest Survey completed in 1936, the normal gross annual growth of virgin ponderosa pine stands in central and eastern Oregon and Washington is about .67 percent of stand volume.

If .67 percent is used as an estimate of normal annual mortality for the total stand, then a rough estimate of average annual mortality by tree class may be obtained by multiplying Keen's mortality ratios in table 5 by .67. The resulting figures are shown in table 6. Preliminary computations by Keen indicate that mortality percentage may vary by diameter class as well as by tree class, but the existing analyses are inadequate to define accurately this suspected correlation.

Table 6.--Estimated Annual Mortality Percentage by Keen Tree Class[1]

Age class	Vigor class			
	A	B	C	D
	Percent	Percent	Percent	Percent
1	.07	.20	.54	.74
2	.13	.40	.67	1.00
3	.20	.67	1.27	1.74
4	.27	.94	1.81	2.55

1/ Derived by multiplying Keen's mortality ratios in table 5 by .67, on the assumption that over long periods mortality of all tree classes in the virgin ponderosa pine type averages .67 percent of board-foot volume, the estimated normal gross growth rate for the type at its current average stand structure.

By deducting the mortality estimates in table 6 from the gross growth rates given in table 4, net growth or loss may be computed by tree class and tree size. Such an estimated net balance between increment and mortality in the virgin forest is given in table 7. In terms of net rates the differences between the tree classes are accentuated, the extreme range being from an annual gain of 7.86 percent for the smallest, youngest, most thrifty trees to an annual loss of 2.43 percent for the largest of the oldest, least thrifty trees.

The Effect of Climatic Cycles on Growth

Rates of gross growth shown in the accompanying tables and figure are estimates of average increment during periods of so-called "normal" growth, which are believed to be associated with normal rainfall. Wide periodic variations in rainfall and in forest increment are typical of the ponderosa pine belt. The gross growth that is actually put on during any specific decade may surpass or fall short of the expected by a wide margin, perhaps as much as 40 percent, depending upon rainfall excess or deficiency, whichever occurs. Fortunately for longer periods these wide discrepancies tend to compensate.[4]

4/ Keen, F. P. Climatic cycles in eastern Oregon as indicated by tree rings. U. S. Monthly Weather Review 65:175-188, illus. 1937.

Table 7.--Estimated Annual Net Growth and Loss as Percent of Board-foot Volume by Tree Class and Diameter Class[1]

(Red figures indicate net loss)

Diam. at B. H.	Tree class				Tree class				Tree class				Tree class				Diam. at B. H.
	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B	3C	3D	4A	4B	4C	4D	
In.		Percent				Percent				Percent				Percent			In.
12	7.86	5.65	3.96	2.41	5.12	3.65	2.43	1.30			.70	.22				1.55	12
14	4.78	3.37	2.40	1.28	3.67	2.50	1.47	.55		1.11	.18	.62			.86	1.74	14
16	3.31	2.42	1.71	.75	2.75	1.84	.99	.12	1.55	.83	.13	.90			1.04	1.88	16
18	2.56	1.80	1.26		2.20	1.39	.68	.14	1.31	.62	.32	1.09		.21	1.20	2.01	18
20	2.07	1.42			1.81	1.09	.47	.30	1.12	.46	.44	1.22		.29	1.30	2.12	20
22	1.71				1.51	.85	.33		.98	.33	.54	1.31		.35	1.37	2.20	22
24					1.27	.66	.21		.86	.21	.62	1.37	.35	.39	1.42	2.27	24
26					1.08	.51	.11		.76	.11	.70	1.42	.30	.43	1.46	2.32	26
28					.92	.40			.66	.02	.76	1.46	.26	.46	1.49	2.35	28
30					.79	.32			.58	.05	.81	1.49	.22	.50	1.51	2.37	30
32					.69				.51	.10	.84		.18	.53	1.53	2.39	32
34									.46	.15	.87		.14	.57	1.56	2.41	34
36									.41	.19	.90		.11	.60	1.57	2.42	36
38									.38	.22	.92		.08	.63	1.58	2.42	38
40									.35	.24			.05	.65	1.60	2.43	40
42									.32	.26			.03	.67	1.61		42
44									.30	.28			.01	.69	1.62		44
46									.28				.01	.71	1.63		46
48													.02	.73	1.64		48
50													.02	.74			50
54													.03				54
58													.03				58

1/ Derived from tables 4 and 6.

Poor growth periods do not affect all tree classes to the same extent. This is clearly shown in table 8, which gives annual diameter growth from 1929 to 1938 (a period of exceptionally poor increment) as percent of that made during the years 1900-29 inclusive, a period selected as approximating normal growth.

Table 8.--Annual Diameter Growth, 1929-38, as Percent of That Made During the Period 1900-29, by Tree Class

Age class	Vigor class				Weighted average
	A	B	C	D	
	Percent	Percent	Percent	Percent	Percent
1	69.0	66.0	60.6	48.0	62.0
2	65.8	62.3	57.5	47.0	61.4
3	63.5	59.9	56.5	50.5	55.7
4	62.5	60.0	58.9	57.1	59.7
Weighted average	64.4	59.9	56.9	51.2	58.3

Trees of the low vigor classes suffered a greater relative reduction in growth during the unfavorable period than did the more vigorous trees. Among the vigorous trees the greatest reduction occurred in the older age classes, but among those of poorest thrift the reverse is true. Keen has found that ponderosa pine mortality increases greatly during cycles of poor growth. Loss records, however, cover too short a period to show accurately the relationship of these two variables.

Effect of Site Quality

Site quality of the plots used in this study averages class IV, which is representative of about two-thirds of the ponderosa pine lands in central and eastern Oregon and Washington. In site index units the plots averaged 77 feet.5/

On better and on poorer sites the growth rates are higher and lower respectively than those given above. For example, the normal rates of diameter growth on site III land are 10 percent greater than

5/ The site classification employed is that described in U. S. Dept. Agric. Tech. Bull. No. 630, "Yields of even-aged stands of ponderosa pine", by Walter H. Meyer. 1938.

the rates shown in tables 1 and 2 for site IV. The rates on site V are 10 percent less than those tabulated. In terms of board-foot volume, the gross growth on site III is 125 percent of the normal for site IV; that on site V is but 75 percent.

The effect of site on growth is not uniform at all times. During favorable climatic or growth cycles the difference in growth rate between good and poor sites diminishes; during periods of poor growth the difference is accentuated. Conversely, the effect of growth cycles is more pronounced on poor sites than on the good.

This logical relation of productive capacity is shown in table 9 which gives the relative diameter growth rates made on site quality classes III, IV, and V during a normal, a severely subnormal, and a somewhat supernormal growth period. During the 1929-38 period of slow growth, increment on site IV dropped to 58 percent of its normal rate. Growth on site V fell to 51 percent (46 ÷ 90) of its normal, but that on site III was less drastically reduced to 65 percent of its normal rate. During the 1900-19 period, growth on site IV was increased 10 percent above its normal level, that on site V 12 percent, but on site III tree diameters increased only 8 percent more rapidly than normally.

Table 9.--Diameter Growth as Percent of That Made On Site IV Lands During Normal Growing Cycle by Site Quality Class for 3 Growth Periods

Site quality class	Growth period		
	Normal (1900-29)	Subnormal (1929-38)	Supernormal (1900-19)
	Percent	Percent	Percent
III	110	71	119
IV	100	58	110
V	90	46	101

The effect of site index on diameter growth rate during three segments of the growth cycle is expressed mathematically in the three equations given in table 10. Joint association between site index and growth cycle is revealed by variation in the coefficients of site index. They range from .5511 for a period of good growth, when increment on all sites is more nearly the same, to 1.5020 for a severely subnormal period during which the effect of site was emphasized.

Table 10.--Equations for Correcting Diameter Growth Estimates for Differences in Site Index

Growth period	Growth cycle	Correction equation for site index
1900-29	Assumed normal	Correction (Pct.) = 46.403 + .7298 site index
1929-38	Severely subnormal	Correction (Pct.) = -15.390 + 1.5020 site index
1900-19	Slightly supernormal	Correction (Pct.) = 60.034 + .5511 site index

Effect of Stand Competition on Tree Growth

Growth of an individual tree depends not only on its own age, vigor, size, and on the productive capacity of its site, but it is also influenced by the number, the size, proximity, and competitive ability of its neighbors. In the present study, however, no satisfactory quantitative measure of this effect could be found. From these data, for example, it could not be shown that growth of individual trees is systematically related to the total volume per acre of the stand in which they grow, although this relation has been found significant and substantial in several previous growth studies in the region.

For one thing, the present data are not particularly suitable for accurately defining this effect. Although nearly 8,000 sample trees are represented, only 30 plots, 30 samples of stand competition, are included. On these 30 plots, stand volume per acre is quite closely correlated with productive capacity or site index, their correlation coefficient being .713. Within any one site index class, the range in volume per acre is small; within any volume class there is little variation in site. Hence, the net effect of either factor on growth is somewhat confused by close association with the other.

There is another reason why effect of stand competition as such is poorly defined by the present study. A large part of the variation in growth has been accounted for by tree class and tree size, two factors that are closely associated with existing as well as with past competition in an uncut forest.

The effect on growth of the change in stand competition, brought about by cutting, must be sought in stands that have been cut. Studies by the Forest Experiment Station in selectively-logged stands indicate, as a generalization for average ponderosa pine forests, that an increase in gross volume growth rate of about 30 percent may be anticipated for the trees remaining after a 50 percent cut, about 70 percent increase following a 75 percent cut.

It is most logical to believe that relief of stand competition by selective logging should also result in a decrease in mortality, perhaps proportionately greater than the corresponding increase in gross increment, if a high order of silviculture is observed in making the cut. However, if too many of the highly susceptible tree classes, or those of poor growth potentialities are left in the residual forest, or if the reserve stand is exposed to the elements by too radical release, the timber owner cannot anticipate such desirable results from cutting.

Variation in Growth Rate Within Classes

In spite of the comparatively intensive classification of trees under the Keen system, the fact remains that trees are individuals and as such exhibit an almost infinite variety of characteristics--including growth rates. Obviously it is impossible for any class average to express accurately the growth rate of every individual tree within that class--some will grow more rapidly, some more slowly, even during normal climatic cycles. The standard errors of estimate given in table 11 indicate the variation in diameter growth rate within tree classes that remains after accounting for differences in tree size and site quality. For example, as shown in table 2, the normal diameter growth rate for a 30-inch class 3B tree is .76 inches per decade. But, as indicated by table 11, one out of three such trees, on the average, may be expected to exceed or fall short of this growth rate by at least 44 percent of .76 inches. In other words, two-thirds of the 30-inch 3 B trees may be expected to make growth rates ranging between 1.09 inches and .43 inches, and one-third to make a growth of greater than 1.09 inches or less than .43 inches. The relative variation in growth rate is greater, in general, for the slower-growing tree classes, smaller for the more rapidly-growing.

Table 11.--Standard Error of Estimate of Diameter Growth Rates for Individual Trees as Percent of Class Average

Age class	Vigor class			
	A	B	C	D
	Percent	Percent	Percent	Percent
1	32	40	56	60
2	39	47	70	80
3	49	44	68	59
4	63	64	68	71

It is evident that a large part of the variation in tree growth is still unexplained. Tree classification is an invaluable aid to the timber marker, but it does not reduce his job to a mechanical routine. The growth rates within tree classes vary widely, but differences between tree-class averages nevertheless are substantial and statistically highly significant.