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PRUNING IN THE MANAGEMENT OF PONDEROSA PINE.

by

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Table of Contents

List of Figures

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R. C. V.

PRUNING IN THE MANAGEMENT OF PONDEROSA PINE.

Ponderosa Pine Pinus Ponderosa Laws is a tree of slow growth under the semi-arid conditions of the southwest. With this fact in mind, the question arises as to whether it will prove economically feasible to prune the crop trees under the present system of management.

Pruning is an age-old practice that has been carried on to advantage in the intensive forestry of Europe. The demands of the market have made pruning an easy and profitable operation. Again, as in other forest management processes that have been proven through the ages, we cannot fully utilize their knowledge. The extensive management of our great variety of forests and the comparatively poor utilization by our markets, demands that we scientifically study pruning in order that we may insure ourselves against any great economic loss. We may also show where and how the operator may receive great monetary gains.

Economics and pruning were treated as a problem for white pine, (Pinus Strobus L.) in Northeastern United States by Cline and Fletcher in 1928.[4] Others followed with studies on white pine; notably those of Hawley[7] and Paul.[14] More recent studies have been conducted by Barrett and Downs[1] on pruning white pine in the Southern

Appalachians and by Bull[3] with Longleaf pine Pinus Palustris Mill in the South.

Few published studies could be found concerning any studies of pruning on ponderosa pine in the Southwest. Pruning has been done in this area and results from these operations should soon be forthcoming. In the meantime, plans are being made for much stand improvement work on the National Forests of the region and mainly in ponderosa pine. With no advance data will these operations result in a profit? This may be termed a problem of selecting the proper number of trees suitable for pruning.

As this problem lies before the administrators of the forests it was thought that a guide could be set up from the information at hand and a related bibliography collected to assist until such time as more complete results from pruning operations become available.

It was necessary to borrow pruning studies made in other regions of the United States. Some of the data of these papers may be applicable to the Southwest and were therefore incorporated in the report.

Pruning, a General Problem.

Determination of the most satisfactory time, intensity and methods of pruning may well be regarded as one of the major problems of forestry today. Our lumber trade has been built and the buying public educated on the premise of the superior value of the clear board. In the past our lumber has come from virgin stands where clear lumber was produced with self-pruning and long periods of growth. Our present clear wood is principally cut from virgin timber 200 to 500 years old.(14) It is not economic to grow timber on such a lengthy rotation; nor will the shortened rotation of our second growth stands permit production of any quantities of clear boards. The apparent problem then of the timber producer and forester is to produce the better grades of lumber economically.

Several compromise solutions to the problem have been put forth: (1) Certainly the buying public can be taught the practicability and beauty of knotty lumber, as has been done by the popularizing of knotty pine. But, as long as we have virgin stands remaining, the producer of second growth timber must prepare himself to compete with the products from such stands.(2) An attempt has been made to attack the problem at its source. The forester advocated dense stands so that trees will more quickly self-prune the lumbs of the lower bole due to the dense shade produced. For the most part, this is comparable to nature's pruning in a well-stocked stand from which we have benefited in our virgin forests. The forester has produced a more regulated self pruned stand by his planting and certainly has improved over nature's method. [1] However, it is known that for some species these measures are still not adequate. The lower branches are shaded out and are thus held to a small diameter but from that point the amount of self pruning done apparently depends on the species involved. Considering the short rotations now advocated, many species retain these small dead branches for many years.

A white pine study[14] showed dead branches to remain for an average of twenty-seven years with a maximum of seventy-three years. On a short rotation with fast growth this would produce much wood with loose knots. On a long rotation with slow growth with the same number of years for occlusion a very small portion of the lumber would have loose knots.

Example: A tree growing eight inches in diameter in thirty years will have eight inches of wood with knots. A slow growing tree putting on four inches in thirty years will have only four inches with knots before the branches drop off. This does not advocate using slow growing trees, merely that short rotations will not produce clear lumber. Cline and Fletcher[4] in their study of white pine pruning concluded that pruning is a profitable operation when confined to selected trees in the stand and done to boles not over 4 inches in d.b.h. They estimated a profit of $15.00 to $35.00 or more per M bm (in addition to 6% compound interest on the investment), depending on the future value of clear lumber.

The greatest economy in pruning will result if the operation is completed in one cutting, provided such operation has no adverse effects upon quality or growth rate. With this in mind, an experiment was initiated on the Toccoa Experimental Forest, Georgia, 1936 with white pine and a five year progress report was made by Barrett and Downs.[1] They concluded that (1) about 30 percent of the number of living whorls may be pruned without seriously reducing growth rate; (2) smooth flush cuts without splinters or breaks are important for rapid healing and quick production of clear lumber; (3) when more than one pruning to obtain a clear sixteen foot log is not feasible, pruning should not be done until the desirable trees in the stand havereached such a size that pruning to 17.3 feet from the ground will not remove more than 30 percent of the living whorls.

In the Southwest, early pruning work has been described in 1935 by G.A. Pearson.[16] He reports that starting in 1933 the Southwest was given the manpower to do improvement work on The National Forests and the Fort Valley Experimental Forests. Pearson states that it "was totally unexpected and almost equally unplanned for." Nevertheless, Region 3 now has some 54,000 acres of improved young stands of ponderosa pine as of 1935. Improvement work included the cleaning of holes and removal of defective and malformed trees. About 80 crop trees per acre were chosen, or an average spacing of about 23 feet. Cost figures are also given by Pearson but are on a per acre basis and include pruning, thinning, piling, and removing bark. He "assumes a $15.00 cost on a fairly well stocked acre to release, prune, and maintain in three or more operations the selected crop trees over a period of 120 years. If the yield is increased from $2.00 to $4.00 per thousand, the returns will be increased by $40, or $25 above the actual outlay for cultural work. In other words, the principal invested, during an average period of 80 years, will be returned with slightly more than 2 percent simple: interest." He concludes that "conservative estimated indicate that judicious stand improvement applied to suitable stands and sites in the Southwest will return its cost with a low rate of interest."

Herein have been presented what are considered to be the outstanding reports on pruning work done to date in the United States. They have been brought together and their high points presented to facilitate future pruning studies. Additional studies of importance are listed in the bibliography.

A Study of Pruning.

The lack of sufficiant information and the fact that pruning is being done in the Southwest suggested the necessity for a guide which would give an indication of the most desirable tree to prune. A method of determining the most economic d.b.h. at which to prune is presented and the most desirable diameter to prune indicated. The data presented were the best that could be secured at this time. The determination of the rate of knot occlusion was made by means that were thought to be not entirely conclusive. Further studies are indicated and until such time as new data becomes available the results of this study may be used as a guide.

I. Location of Area.

The data for this experiment were collected on the Fort Valley Experimental Forest of the Southwestern Forest and Range Experiment Station.[1] Fort Valley is located at about 7,300 ft. elevation on the Coconino Plateau in northern Arizona. It is within the Cononino National Forest, nine miles northwest of the town of Flagstaff.

A 2.5 acre plot for study was selected in a pruned area thought to be representative of all stages and types of growth. This is designated as sub-plot 12 of growth plot S-7. The area had been logged over in 1924 and the plot was established for growth studies in 1925. Growth measurements have been taken every five years. Stand improvement work was done in about 1935 and a second timber cutting was made in 1946. From this it is seen that the area represents a well released stand. A map of the plot showing the location and class of trees, the trees thinned out and the trees pruned and their position in the stand appears in Appendix A.

II. Experimental Data.

In order to determine the amount of clear wood put on the bole after pruning the rate of knot occlusion

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1. Maintained by the Forest Service, U.S. Department of Agriculture, for Arizona, New Mexico, and west Texas, with headquarters in Tucson, Arizona.

had to be determined by measurements on the standing tree. This method is used because no trees could be found that were going to the saw that had been pruned. Thus eliminating the possibility of direct measurements on old overgrown pruning wounds. Therefore an attempt was made to correlate observed rates of occlusion with known growth rates.

Measurements were therefore taken horizontally in the remaining aperture of the branch wound and estimates as to the original bfanch diameter were made. This was possible because the size and shape of the scar were usually still visible. The use of an estimate brings in a possible source of error. However this is believed to be neglible from a practical standpoint. The rate of occlusion may be closely related to diameter growth but in an actual pruning operation the production of clear wood is often delayed by: (1) improper pruning of the branch, such as leaving a branch stub protruding, cutting too close and injuring the collar, or breaking the branch, leaving a rough protrusion; (2) exuding pitch, which may form an extension of the stub; (3) folding in and over growing of the bark, extending the defect beyond the stub, or (4) variations in the thickness of the bark of the trunk at the pruned point, which may vary the length of the stub left. Because of this it was concluded that for practical usage the error involved by the estimate would prove insignificant. The measurements and tree growth data are presented in Table 1.

To relate the elapsed time it takes to occlude various sized knots the data were curved, shown in Figure 2.

The data were examined and only knots appearing on trees below 10 inch d.b.h. were thought to be significant. Therefore trees of 4 to 10 inches d.b.h. were used. The data were then put into five groups having similar rates of occlusion and the average occlusion and average amount of diameter growth for the period were determined. These were plotted in Figure 2 and a weighted curve drawn which shows the rates of occlusion for various sized knots.

With these figures together with those called for below, the value of any pruning operation can be approximated.

Figure 1.

Tree Growth and Occlusion of Pruning Wounds in Ponderosa Pine Trees. 1935-1945*

Subplot 12, Plot S-7. Fort Valley Exp. Forest.

Tree Number (1)	D B H 1935 (2)	Diameter Growth 10 yrs. (3)	Crown class (4)	Estimated Dia. O.B. of Branch when Pruned (5)	Amount Grown over Col.5 minus Present Horizontal Aperture (6)
	inches	inches		inches	inches
4135	5.1	0.6	C	0.6	0
4265	5.7	0.2	C	0.5	0
4173	7.2	0.7	C	1.5	0.25
4175	8.6	1.2	D	1.5	0.25
4026	7.6	1.0	D	1.0	0.25
4181	7.1	1.2	C	1.25	0.6
4160	5.6	.9	C	0.75	0.4
4121	5.6	1.4	C	0.5	0.5
4033	5.5	0.9	C	1.0	0.5
4066	4.5	1.0	C	0.5	0.5
4241	8.0	1.6	C	1.25	0.5
4237	7.0	1.3	X	1.0	0.4
8401	6.6	2.6	X	1.0	0.6
3014	8.7	2.5	X	1.25	0.4
4146	6.9	1.3	C	1.0	1.0
8602	5.7	1.7	C	1.0	1.0
8602	6.5	1.8	C	1.25	1.1
8598	4.6	1.4	C	0.9	0.9
8572	5.1	1.1	X	1.25	1.1
8616	4.8	1.6	C	0.9	0.9
8571	4.3	1.3	C	1.0	1.0
2-662	5.4	1.6	X	0.9	0.9
8575	5.4	1.8	X	1.5	1.4

* Growth records and tree classification from records of Fort Valley Experimental Forest.

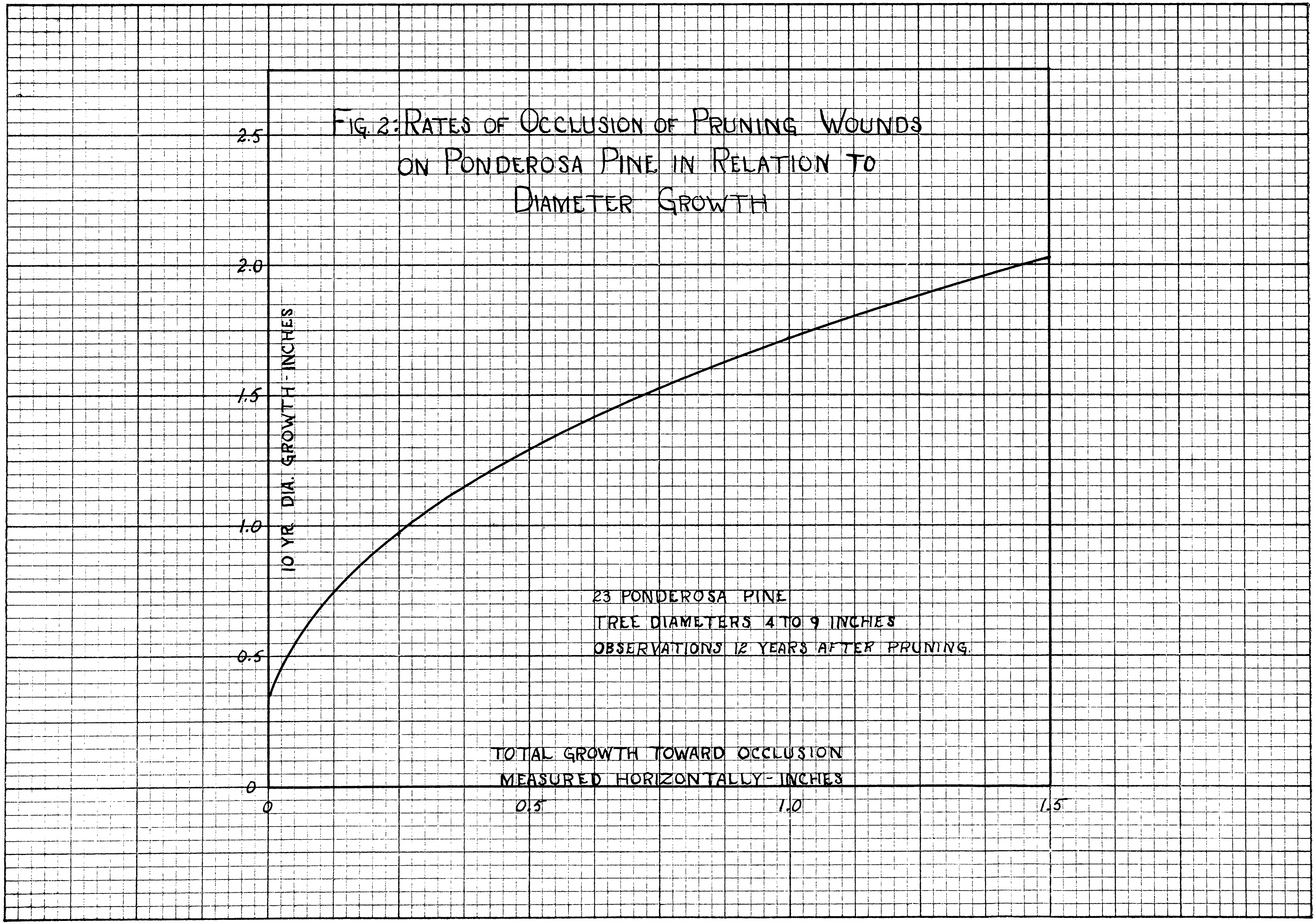
Fig. 2: Rates of Occlusion of Pruning Wounds on Ponderosa Pine in Relation to Diameter Growth
10 YR. DIA. GROWTH - INCHES
2.5
2.0
1.5
1.0
0.5
0
23 PONDEROSA PINE
TREE DIAMETERS 4 TO 9 INCHES
OBSERVATIONS 12 YEARS AFTER PRUNING.
TOTAL GROWTH TOWARD OCCLUSION
MEASURED HORIZONTALLY - INCHES
0
0.5
1.0
1.5

III. Known Values:

1. The amount of clear lumber in the pruned log.

This was calculated by diagram. A diagram was made for each scale size of log represented in the charts and the amount of clear lumber possible calculated for core sizes of four to ten inches. See example in Figure 3.

2. The cost of pruning the butt log to a height of 17 feet. The average time per tree will vary.

The labor cost will also be variable. It will vary with: (1) The prevailing labor cost of the region, (2) the effeciency of the crew, (3) the accessability of the stand, (4) the density of the stand, which will effect both the efficiency of the workers and the size of limb to prune, and (5) the site which will vary the number of whorls to be pruned. Probably the most effective of these is the size of the limb to be pruned. The larger the branch the longer it takes to prune, the longer it takes for occlusion, the more chance one takes for defect such as pitch or bark pockets or in large limbs where heartwood is present Western red rot may enter. When considering a pruning operation any one of these variables may render the operation economically unsound.

3. The rate of interest to be charged.

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4. The rotation on which the trees are managed. This will vary the length of time the labor cost is to be compounded.

Assuming that only wolf and dominant trees are considered eligible for economic pruning, their average growth rates (Figure 4) are two inches d.b.h. in ten years. If a 24 inch d.b.h. is assumed as the size at maturity the rotation is 120 years. In using these figures it must be borne in mind that they are above the average growth rate for ponderosa pine in this region. They refer to a stand that was released by cutting twice in twenty years. This may be a better than average situation today but such frequent cuttings will be commonplace before trees pruned today mature. To explore the possibilities of a smaller mature size and correspondingly shorter rotations, it is desirable to consider 20 and 22 inch mature diameters also.

Because this example uses only wolf and dominant class trees it is not to be assumed that codominant may not be pruned. Some may be pruned now as an interim crop and in the future when fully stocked stands of well managed forests eliminate the wolf tree the dominant and codominants will be pruned.

Figure 4.

Ten Year Growth Rate of Ponderosa Pine.

Subplot 12, Plot 57.

Crown Class	No Trees	10 yr. Dia. Growth inches
X	10	2.2
D	10	1.7
C	20	1.0
I	14	0.8

Diameters taken for the trees 4 to 9 inches d.b.h.

Calculated on a 20 year growth.

Data from Fort Valley Experimental Forest Records.

IV. Computation Procedure:

A sample problem will be included here to demonstrate the manner in which the values were derived. Some of the figures used are arbitrary. The values of lumber used were the O.P.A. ceiling prices of 1942 for ponderosa pine. The log values therefore do not coincide with the present values of logs. By computing the values of both the pruned and unpruned log by the per cent lumber grade out turn it is thought the difference in value between a pruned and unpruned log will remain the same for any price scale of any year. Therefore the conclusions drawn should be the same if the price differential between lumber grades remains the same.

Derivation of values for a log 24 inches d.b.h. with a 4 inch knotty core:

1. Board feet per log:

   By diagram,
   260 bd. ft. clear wood.
   15 bd. ft. knotty wood.
   (Using a 20" i.b. scale diameter)

2. Value per 16 foot log:

   Sumation of 4/4 boards by widths from the diagram. Using "B and Better" grade for clear and "No. 4 common" grade for Knotty. Computed values by width and grade from O.P.A. Regulation No. 94

3. Pruning Cost:

   Arbitrarily put at 10 min. per tree. The rate is a variable and differs with every stand and crew. The time to prune western yellow pine varies from 3 to 10 min. per tree depending on the tree.(19) A wage rate of $0.60/hr. was used and includes costs for administration.

4. Length of rotation:

A 4 inch knotty core would constitute a pruning operation when the tree had a 2" d.b.n. This would allow 2 inches on the diameter to grow over the knots and begin producing clear wood.
It is recognized that pruning a seventeen ft. height on a 2 in. tree must be done in two operations and may increase the cost.
In this example costs are regarded to be constant for all trees. It is also assumed that no branches over 1.0 inch in diameter are pruned. Two inches in diameter is allowed before clear wood is produced to allow for possible delay in sealing after occlusion. For a 1.0 inch knot the graph shows 1.7 in. of diameter growth before occlusion; therefore, 0.3 of an inch is allowed. safety factor

Time of prune 2" d.b.h.
Proposed crop tree 24" d.b.h.
Growth required 22"
Growth/10 yrs. 2"
Length of time for 2" tree to reach maturity 22" 2" 11 or 110 yrs.

5. Compound pruning cost:

$.10(1.04^{110})$ $7.48

6. Value at time of cut:

Total Value-Compound Pruning cost $14.97
$22.45 - $7.48 $14.97 log value at time of cut.

7. To get comparative values of logs not pruned the values of logs from actual mill studies were taken. The lumber grade out turn by log diameters was taken for the three log diameters and for each log grade and their values computed using O.P.A. Reulation No. 94.[12] (See Appendix C.)

A ponderosa pine mill study by Lodewick[10] was used, wherein percent grade out turn was determined for each log grade. Although this study was made in the Pacific Northwest it was used in preference to data from a mill study in the Southwest because it was much more extensive, had more sample logs and was more complete as to log diameters. A sample check was made and the studies gave similar values per log, the Northwest giving a slightly higher value.

The above method was used to compute the values for the three log diameters 20, 22, and 24 inches. In parts 1 to 6 for each size knotty core from 4 to 6 inches in diameter and in part 7 for each log grade.

Figure 5.

Value of a 24 Inch Pruned 16 Foot Log - 20 Inch Log Scale.

Size of Knotty Core	Kind of LLumber	Bd. Measure per 16' log by Diagram ft.Bm.	Value * per 16' log	Total Value	Pruning Cost	Period to End of Rotation years	Compound Pruning Cost (4%)	Net Value of Pruning
4	clear	260	$22.10	$22.45	$0.10	110	$7.48	$14.97
	knotty	15	0.35					
6	clear	253	21.29	22.21	0.10	100	5.05	17.16
	knotty	40	0.92					
8	clear	216	18.50	20.60	0.10	90	3.40	17.20
	knotty	84	2.10					
10	clear	201	17.30	19.85	0.10	80	2.30	17.55
	knotty	99	2.55					
12	clear	155	12.82	15.75	0.10	70	1.56	14.19
	knotty	117	2.93					

* Value per 16' log - calculated from diagram for board measure and prices are as quoted in O.P.A. Regulation No. 94. (Appendix C.)
Using "B and Better" grade for clear and "No. 4 Common" grade for knotty.

Figure 6.

Value of a 22 Inch Pruned 16 Foot Log - 18 Inch Scale Diameter.

Size of Knotty Core	Kind of Lumber	Bd. Measure per 16' log by Diagram (ft.Bm.)	Value * per 16' log	Total Value	Pruning Cost	Period to End of Rotation (years)	Compound Pruning Cost (4%)	Net Value of Pruning
4	clear	215	$15.47	$15.82	$0.10	100	$5.05	$10.77
	knotty	15	0.35					
6	clear	198	14.70	15.62	0.10	90	3.40	12.22
	knotty	40	.92					
8	clear	169	12.03	14.13	0.10	80	2.30	11.83
	knotty	84	2.10					
10	clear	152	10.38	12.66	0.10	70	1.56	11.10
	knotty	91	2.28					
12	clear	107	6.67	9.60	0.10	60	1.05	8.55
	knotty	117	2.93					

* Values per 16 foot log - as quoted page 21

Figure 7.

Value of a 20 Inch Pruned 16 Foot Log - 16 Inch Scale Diameter.

Size of Knotty Core	Kind of Lumber	Bd. Measure per 16' log by Diagram (ft. Bm.)	Value * per 16' log	Total Value	Pruning Cost	Period to End of Rotation (years)	Compound Pruning Cost (4%)	Net Value of Pruning
4	clear	157	$12.67	$13.02	$0.10	90	$3.40	$9.62
	knotty	15	0.35					
6	clear	147	12.32	12.78	0.10	80	2.30	10.48
	knotty	20	.46					
8	clear	119	9.31	10.51	0.10	70	1.56	8.95
	knotty	48	1.20					
10	clear	79	6.01	8.21	0.10	60	1.05	7.16
	knotty	96	2.21					
12	clear	41	3.06	6.56	0.10	50	.71	5.85
	knotty	140	3.50					

* Values per 16 foot log - as quoted page 21

23

Figure 8.

Value of Unpruned 16 Foot Logs by Log,

Grade and Diameter.*

Log Grade	Value 24" d.b.h. 16 ft. log	Value 22 d.b.h. 16 ft. log	Value 20 d.b.h. 16 ft. log
I	$12.02	$10.04	$ 7.27
II	11.08	8.64	6.70
III	9.53	8.32	5.84
IV	10.18	8.77	6.13
V	8.73	7.71	5.52
VI	7.17	6.32	4.72

* Computations for above values:

Total b.m. per log from diagram.

Price per lumber grade: Reg. 94. Office of Price Administration.

Percent lumber grade outturn per d/b.h. and log grade: From, "Lumber Recoveries at a "Representative" mill in the Ponderosa Pine Territory of Oregon and Washington." By J.E. Lodewich. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. April 29, 1941. Not published.

V. Discussion of Results.

The lack of sufficient information on pruning in the Southwest and the knowledge that extensive stand improvement work may begin led to the realization of the necessity of a guide to economic pruning. The data presented were the best that could be secured in the time allotted. The determination of the rates of occlusion were thought to be not conclusive but reasonably significant. More study is indicated with closure defect, with more log sizes, and with more branch diameters.

Comparing the value of the pruned log at the time of cutting with a 4% compound interest deduction with the values for all grades of logs we find the advantage preponderantly on the side of the pruned log. Only in the case of the smaller logs do the larger 10 and 12 inch cores show a smaller value when compared to the I and II log grade values.

From these figures it may be concluded that the optimum d.b.h. to prune is 4 inched. This point shows the highest final value for the 20 and 22 inch log. In the case of the 24 inch log pruning either the 4, 6, or 8 inch tree will give about the same results from the figures. But here again, it is felt the 4 or 6 inch tree is optimum because the higher cost of pruning larger trees (particularly true in the wolf and dominant trees here considered) is not shown in this example.

Of the three diameter values the 24 inch log shows the greatest profit per tree due to pruning. Further study should be made to definitely ascertain at what diameter log is most profitable. Larger sizes might prove preferable.

Pruning in the Southwest in leading to cheaper, high grade lumber, will open up distant markets and thus put an end to present dependence largely on local demand.

The greatest percentage of select grades are in the number one logs. In the second growth stands of the Southwest the majority of the logs are of grade V and VI. From Table 9 it can be seen that almost 83% of the logs are of grades V and VI in this stand.

Figure 9.

Ponderosa Pine Log Grades on Wing Mountain Plot, Ft. Walley Experimental Forest as Classified in standing trees.[1] (480 acres)

Log Grades*	Number of Logs	% of Total Number
1	86	0.49
2	387	2.20
3	1943	10.91
4	646	3.67
5	7849	44.54
6	6730	38.19
Total	17621	100.00

*As defined in R 3-S, Sales Policy Utilization letter of February 17, 1939. Logs classified by W.G. Thomson, 1939.

1. Pearson, G.A. and Wadsworth, F.H., "Timber Management in the Fort Valley Experimental Forest" Research Report. Southwestern Forest and Range Experiment Station. May 1940.

If we assume this to be a fairly representative stand it can be seen that a very small volume of select boards will be produced. If we can further assume that the majority of the second growth stands of the Southwest produce comparable low grade yields, a loss of markets may result. From this deduction we can place another value on pruning, that of maintaining and opening a new market for the lumber of the Southwest by producing a better quality board.

Conclusions

A guide indicating the optimum time for an economic pruning operation and the method of approach is presented. The information was thought necessary as a possible guide to stand improvement work on ponderosa pine in the Southwest. The data presented were the best that could be secured at this time. The rates of knot occlusion were made by means not entirely conclusive and further study is indicated. Until such time the results of this study may be used as a guide.

Pruning operations in western yellow pine should prove an economic benefit. Only the crop, or wolf and dominant trees, should be pruned and should be maintaining a growth of about two inches in diameter per ten years. It should be planned to maintain this growth by improvement cuts.

Trees whose branch diameters exceed 1.5 inches should not be pruned. The time to cover a larger wound is too great and the larger the prune wound the greater is the chance for other defects to enter. Preferably the maximum pruned diameter should not exceed one inch.

Pruned trees show a profit over non pruned trees. The most economical diameter to prune is a four inch tree.

From the values derived a 24 inch log gives the most profit. This is thought to be as yet inconclusive as sufficient diameters are not represented in this study.

Pruning was shown to represent a gain of 4 per cent compound interest on the cost. This is not considered a high rate and on a one-hundred-year investment may not be considered ample to cover the risks involved. But when it can be shown that 83 percent of a second growth stand produces grades V and VI logs and only 0.49 percent grade I, it can readily be seen that practically no "select" boards are being produced. With this out turn in mind it has been surmised that markets for western yellow pine will be lost through the inability to compete with the better grades of lumber from other sections of the country. Pruning will produce better quality lunber and help to maintain the markets. This is an added value and should be included with the 4 percent compound interest.

Finally the forests of the Southwest are almost totally government owned. Therefore with the long term public owner, the comparatively low monetary gains may be overshadowed by the public gains of increased business.

A method has been put forth in this study which may be applied to any stand of timber. The values used may be general, but values for individual stands are simple to procure and like calculations may be made. Therefore a method has been suggested to analyse and determine the economics of pruning ponderosa pine in the Southwest.

Further Information Needed.

The initial study of an economic pruning method indicates a need for greater exploration into the problem.

Conclusive data of knot occlusion is needed. Pruned knot studies are suggested to determine forms of defect occurring with various sized knots and with the differing methods of cutting the branch. This would be best determined by located, cutting and making a cross section of a series of completely occluded knots.

A study of labor costs is necessary to determine the rate per tree as it varies with size of tree, size of limb and site.

The amount of live crown that may be removed from ponderosa pine without seriously impairing the rate of growth, should be known. Too severe pruning may slow the growth and effectively lengthen the rotation. In conjunction the cost of pruning a 16 foot log in two operations need be determined and compared with the cost of pruning in one operation and the cost of a loss in growth due to too severe pruning.

It is hoped that this paper may be used as a guide for pruning and that it will stimulate interest and further study.

Summary.

1. Pruning is an age-old practice but has been seriously considered in the United States only in recent years.

2. Self pruning is now known to be inadequate for many species and stands of timber. On the short rotations now used, little clear lumber is produced. By controlling the density of the stand the lower branches can be shaded out and held to a small diameter, but these branches have been shown to remain on a tree for as much as 73 years and an average of 27 years.(14)

3. Statements from what are considered the outstanding papers on pruning are presented.

4. In order to determine the value of pruning the amount of diameter growth to cover a pruning wound is needed to enable one to compute the amount of clear wood a given pruned log will produce. This was done by measuring twelve year old pruning wounds and correlating them with the diameter growth of the tree for that period. From the curved data it was determined that two inches in diameter growth is necessary to occlude a one inch prune wound.

5. The length of time it takes a tree to reach maturity after pruning was found by determining the growth rate and the size at which the tree is to be cut. In a

sample problem a two-inch diameter growth in twn years was set by averaging the 20-year growth of wolf and dominant trees. Using a fixed cutting and pruning diameter the number of years to the end of the rotation was determined.

6. To determine the value of a pruned log diagrams were made and the board measurement computed. For the value of unpruned logs a mill study of ponderosa pine was used which gave the per cent lumber grade outturn by log diameter and grade. To these, ceiling prices of 1942 were applied and the values determined.

7. Four per cent compound interest on the labor cost was deducted from the value of the pruned log and then compared to the value of the unpruned log.

All cases show better than a 4 per cent return except in the 20 and 22 inch logs with 10 and 12 inch knotty cores.

It was indicated that the four inch d.b.h. was the optimum economic diameter to prune.

The procedure illustrates a method that may be used to compute the value of a pruning operation on any stand.

Bibliography

1. Barrett, L.I., A.A. Downs.

Growth response of white pine in the Southern Appalachians to green pruning. Jour. Forestry. 41:507-510. July 1943.

2. Bull, Henry.
Tools and labor requirements for pruning long leaf pine. Jour. Forestry. 35:359-364. Apr. 1937.

3. Bull, Henry.
Pruning practice in open grown long leaf pine in relation to growth. Jour. Forestry. 41:174-179. March 1943.

4. Cline, A.C., E.D. Fletcher.
Pruning for profit. Applied to eastern white pine. The Hargard Forest and Massachusetts Forestry Assoc. 1928.

5. Cummings, W. H.
Early effects of pruning in a young shortleaf pine planting. Jour. Forestry, 40:61-62. Jan. 1942.

6. Curtis, J.D.
Pruning forest trees by the finger-budding method. Jour. Forestry, 44:502-504. July 1946.

7. Hawley, R.C., R.T. Clapp.
Artificial pruning in coniferous plantations. Yale University: School of Forestry. Bul. No. 39. 1935.

8. Hawley, R.C., H.J. Lutz
Establishment, development, and management of conifer plantations in the Eli Whitney Forest, New Haven, Conn. Yale University: School of Forestry. Bul. No. 53. 1943.

9. Leather, G.F.T.
Pruning. Quart. Jour. Forestry. 30(2):152-154. April 1936.

10. Lodewick, J.E.
Lumber recoveries at a "representative" mill in the ponderosa pine territory of Oregon and Washington. Pacific NW. For. and Range Exp. Station. Portland, Oregon. Office Report. Not for publication. Apr. 1941

11. Meyer, W.H.
Pruning natural pine stands. Jour. Forestry, 38: 413-414. May, 1940.

12. Office of Price Administration.
Price schedule No. 94. Western Pine Lumber. Feb. 1942. Federal Register. 7:759-761.

13. Paul, B.H.
Pruning Naval Stores Review. 48(39):8. Dec. 24, 1938.

14. Paul, B.H.
Knots in second growth pine and the desirability of pruning. U.S.D.A. Miscellaneous Publication. #307 June, 1938.

15. Paul, B.H.
Pruning by annual removal of lateral breds. Jour. Forestry. 44:499-501. July 1946.

16. Pearson, G.A.
Timber Stand improvement in the southwest. Jour. Forestry. 33(2):128-132. Feb. 1935.

17. Pearson, G.A.
The Fort Valley Forest Experiment Station. Forest Service, U.S. Dept. of Agriculture. 1945.

18. Pearson, G.A., F.H. Wadsworth.
Timber management in the Fort Valley Experimental Forest. Research Report No. 1. Southwestern Forest and Range Experiment Station. May 1940.

19. Pearson, G.A.
Timber stand improvement in the Southwest. Federal Security Agency Civilian Conservation Corps. Forestry Publication No. 6, 1940.

20. Pearson, G.A.
Reforestation in the Southwest by C.C.C. Camps. Federal Security Agency Civilian Conservation Corps. Forestry Publication No. 7. 1940.

A P P E N D I X

MAXIMUM PRICES - PONDEROSA PINE LUMBER

F.O.B. Mill per 1000 feet board measure. Price Schedule No. 94 - Western Pine Lumber, Office of Price Administration, Feb.1942 Federal Register. Vol. 7: 759-761. Feb. 1942.

4/4 R L S 25	1 & 2 Clear (B and Better)	C Selects	D Selects
4" width	$65	$60	$46
5"	71	66	52
6"	67	62	48
8"	69	64	50
10"	71	66	52
12"	86	81	64

Add $5 for 16 ft.lengths.

Common Boards

No.	1x4"	1x6"	1x8"	1x26"	1x12"	1x14"	1x16"	1x18"	1x20"
1	$44	44	42	44	48	--	--	--	--
2	38	38	37	37	37	40	44	48	52
3	33	33	32	32	32	33	35	36	40
4	23	23	25	25	25	--	--	--	--
5	16	--	--	--	--	--	--	--	--

Shop Lumber

	4/4
4/4 Shop Common	$30
No. 3 Clears	41
No. 1 Shop	--
No. 2 "	--
No. 3 "	--

LOG GRADES
Ponderosa Pine
#s used by Fort Valley Experiment Station.

Grade 1

Shall be smooth and surface clear without indication of knots near the surface, providing, however, that two small knots are permissible if within 2 feet of the end of the log. Small fire scars not over 4 ft and ona single face or other comparable surface defects for which deductions are made in scaling are permissible.

Grade 2

Shall be smooth and surface clear on three faces, but with knots or other defects permissible on the fourth face; or shall be smooth and surface clear on the lower three-fourths of the length. In addition fire scars up to 6 ft in length or other comparable surface defects for which deductions are made in scaling are permissible on one of the three clear faces.

Grade 3.

Shall fill the requirements of either:

(1) Shall be smooth and surface clear on one or two faces, but with knots or other defects permissible on the other sides.

(2) Shall display knots on all sides which may vary from small black knots to large sound or unsound knots as long as they are at least 3 feet apart longitudinally when they are staggered or 6 feet apart when they are in solid whorls. In either at least 50 percent of the total surface of the log must be in surface clear areas at least 4 feet long by 1/4 the circumference in width.

Grade 4.

Shall display numerous knots, alive or dead, provided that all knots in the grader's judgment will cut out sound. The maximum size knots permissible for this grade shall be proportional to the size of the log. The maximum sizes are (1) for a 12-inch log 2-inch live knots or 1-inch dead knots; (2) for an 18-inch log 3-inch live knots or 2-inch dead knots; (3) for a 24-inch log 4-inch live knots and 3-inch dead knots, etc. An average spacing of at least 2 feet in required between knots of masimum size.

Grade 5

Shall meet the same requirements as a Grade 4 log in knot sizes and spacing, except unsound knots are permissible.

Grade 5, contd.

Logs with larger knots may also be admitted to this grade if at least one-fourth of the total surface of the log is in surface clear areas at least 4 feet long by 1/4 the circumference in width.

Grade 6

Shall be rough, coarse, or densely knotted logs unsuited to any of the previous grades.

General Considerations

Foregoing specifications as to spacing between knots refer to distance between knot or limb edges rather than from center to center.

Defects such as stump rot, red rot, shake, wind checks, for which scale deductions are made in ordinary scaling practice but which are not visible on the surface of the tree are not to be considered in determining these grades.

Defects such as fire scars, lightning scars, excessive crook, extreme spiral grain, and other surface indications of defect for which scale deductions are made in ordinary scaling practice and which are visible on the surface of the tree are to be considered in determining these log grades.

Standing trees shall be graded on the basis of 16-foot logs and each log shall be graded solely on the basis of its own grade characteristics, i.e., the grade characteristics of adjoining logs shall not be allowed to influence the grader's judgment.

Appendix D:

GROWTH RECORDS FOR YEARS 1925-1945 PONDEROSA PINE.

Taken from records of:
Plot 7 Sub plot 12, Fort Valley Experimental Forest.
Southwestern Forest and Range Experiment Station.

Tree No.	Crown Class	Diameter at Breast Height (inches)				
		1925	1930	1935	1940	1945
2937	C	13.3	13.7	14.0	14.4	14.5
2938	C	13.5	14.0	14.5	14.8	15.0
2945	C	13.5	13.9	14.3	14.5	14.6
2946	C	12.4	12.8	13.0	13.2	13.4
2941	S	10.3	10.5	10.7	11.0	11.0
2942	D	15.7	16.2	16.6	17.0	17.5
2943	S	9.5	9.7	9.8	10.0	10;2
2944	S	10.8	11.0	11.2	11.5	11.5
2940	D	16.1	16.8	17.7	18.5	18.6
2964	C	15.3	15.9	16.4	16.7	16.9
2963	D	15.6	16.3	16.9	17.4	17.8
2965	C	17.5	17.8	18.1	18.3	18.5
2966	C	15.8	16.2	16.7	16.8	17.0
2967	C	16.2	16.8	17.2	17.8	18.2
2968	D	17.4	18.0	18.8	19.3	19.9
2982	C	19.8	20.4	20.9	21.4	21.8
2983	C	5.8	6.4	6.7	7.1	---
2981	D	16.6	17.6	18.2	19.0	19.6
2985	C	11.3	12.5	13.1	13.6	14.3
2986	D	24.3	24.8	25.3	25.7	26.0
2988	X	17.3	18.5	19.4	20.3	20.9
2987	X	9.6	10.7	11.9	12.5	13.2
2989	D	19.7	20.4	21.1	21.7	22.2
2990	C	17.7	18.1	18.5	19.1	19.4
2992	C	14.4	15.2	15.8	16.3	16.7
2991	I	9.2	10.0	10.6	11.2	11.7
2995	D	17.7	18.0	18.4	18.7	19.6
2994	C	15.1	15.3	15.5	15.9	16.2
2993	C	13.0	13.7	14.0	14.4	14.7
2996	C	9.3	10.1	10.8	11.5	12.0
2997	C	12.1	12.7	13.3	13.7	14.1
2998	C	8.0	8.6	9.3	10.1	10.7
2999	I	5.0	6.1	6.4	6.9	7.2
3019	C	27.6	28.3	28.7	29.0	29.1
3018	X	19.2	20.0	21.0	21.7	21.9

Growth Records, continued

Tree No.	Crown Class	Diameter at Breast Height (inches) 1925	1930	1935	1940	1945
3020	X	20.3	21.0	21.8	22.5	23.0
3027	D	18.5	20.0	20.8	21.3	21.7
3021	D	24.0	25.1	26.2	27.1	28.0
3022	C	19.8	20.4	21.0	21.6	22.1
3024	X	12.7	13.7	14.9	15.8	16.7
3025	S	10.6	11.0	11.3	11.8	12.1
3026	D	20.3	21.4	22.5	23.3	23.9
3028	X	22.4	23.7	24.6	25.5	26.0
3016	X	14.9	15.6	16.4	17.0	17.7
3017	DX	22.3	22.9	24.0	24.7	25.4
3014	X	4.6	6.9	8.7	10.2	11.2
3011	D	11.6	12.6	13.6	14.4	14.8
3012	C	9.0	10.0	10.9	11.6	12.2
3000	C	8.0	8.9	9.7	10.5	11.0
3001	I	9.5	9.9	10.3	10.7	10.9
3005	S	4.5	5.0	5.4	5.6	5.8
3002	D	8.4	8.3	10.2	10.9	11.5
3010	C	9.8	10.7	11.4	12.0	12.5
3009	C	14.2	15.2	16.1	17.1	17.8
3008	I	7.9	8.3	8.8	9.2	9.7
3007	C	9.0	9.8	10.6	11.2	11.8
3006	D	14.1	14.6	15.3	15.8	16.0
4008	X	13.3	14.4	15.9	17.0	18.2
4010	X	5.6	6.6	7.8	8.6	9.2
4014	X	6.5	7.6	8.6	9.4	10.1
4015	C	5.3	6.0	7.6	7.0	7.4
4039	C	6.0	6.6	7.3	7.9	8.2
4040	C	518	6.3	6.6	7.0	7.2
4041	X	4.3	5.2	5.7	6.4	6.9
4011	X	5.0	6.2	7.3	8.2	9.0
4037	I	3.9	4.2	4.1	4.9	5.5
4035	C	7.0	7.5	8.0	8.6	9.2
4033	I	4.6	5.1	5.5	5.9	6.4
4032	D	8.0	9.0	10.1	10.9	11.4
4046	C	3.6	4.1	4.5	5.0	5.5
4049	D	6.1	6.9	7.8	8.8	9.6
4044	D	5.1	5.7	6.4	7.1	7.6
4045	D	4.6	5.4	6.0	6.6	7.2
4052	C	3.8	5.8	6.2	6.6	7.1
4053	C	5.4	5.8	6.1	6.4	6.6

Growth Records, continued

Tree No.	Crown Class	Diameter at Breast Height (Inches) 1925	1930	1935	1940	1945
4054	D	6.0	7.8	7.7	8.2	8.7
4051	C	4.3	4.8	5.2	5.7	6.3
4055	D	7.0	8.1	9.0	9.6	10.0
4056	C	4.0	4.8	5.6	6.1	6.5
4057	X	4.0	5.8	6.9	7.7	8.3
4117	D	6.4	7.2	7.6	8.0	8.4
4113	C	4.3	4.9	5.3	5.5	5.8
4114	D	7.4	8.6	9.4	10.2	11.1
4128	C	5.7	6.5	7.2	7.6	8.1
4127	D	4.5	5.2	5.8	6.2	6.6
4120	C	4.3	4.8	5.3	5.9	6.5
4025	I	4.5	4.9	5.4	5.8	6.3
4026	D	6.5	7.1	7.6	8.2	8.6
4027	I	4.8	5.2	5.3	5.5	5.8
4024	C	4.0	4.1	4.8	5.2	5.6
4029	C	5.5	6.2	6.7	7.4	8.0
4030	I	3.6	4.0	4.1	4.4	4.7
4038	C	7.5	8.8	9.4	10.0	10.3
4021	C	6.8	7.5	8.1	8.8	9.0
4023	I	4.4	4.9	5.4	5.9	6.3
4020	C	4.2	4.8	5.2	5.6	6.0
4019	I	4.0	4.4	4.9	5.3	5.6
4018	X	6.5	7.9	9.3	10.5	11.3
4017	C	3.8	4.5	5.2	5.9	6.2
4016	X	14.8	15.7	16.5	17.2	17.8
4143	D	4.6	5.9	7.2	8.2	9.0
4142	X	4.2	5.7	7.0	8.0	8.8
4139	D	7.0	8.0	8.9	9.6	10.3
4138	I	5.4	6.0	6.5	7.1	7.7
4136	C	8.1	8.9	9.7	10.1	10.3
4141	X	5.6	7.1	8.4	9.3	10.0
4135	C	4.2	4.7	5.1	5.5	5.7
4134	I	3.6	42	4.6	4.9	5.2
4133	C	5.3	5.8	6.2	6.7	7.1
4132	C	5.5	6.0	6.4	6.7	7.0
4131	D	8.0	8.6	9.3	9.9	10.5
4123	I	4.5	4.9	5.2	5.6	6.2
4124	C	5.5	5.9	6.3	6.5	7.0
4121	C	4.1	5.0	5.6	6.3	7.0
4140	X	7.4	8.3	9.0	9.6	10.2
4149	C	6.7	7.6	8.2	9.1	10.1
4146	X	5.4	6.2	6.9	7.5	8.2
4145	X	3.7	4.1	5.1	5.6	6.0
4144	X	25.7	26.6	27.3	28.1	28.7
4223	C	8.2	9.0	9.7	10.4	10.9
4222	C	9.1	9.6	9.8	10.1	10.2

Growth Records, continued

Tree No.	Crown Class	Diameter at Breast Height (inches) 1925	1930	1935	1940	1945
4221	I	5.0	5.3	5.5	5.8	5.9
4220	C	12.6	13.4	13.9	14.3	14.8
4229	I	4.4	4.7	4.9	5.0	5.3
4230	C	13.8	14.5	14.9	15.3	15.7
4219	X	8.7	9.7	10.4	11.2	12.0
4218	X	4.1	5.2	6.1	6.9	7.7
4215	C	3.7	4.4	4.9	5.3	5.7
4216	D	4.8	6.1	6.7	7.4	7.9
4217	C	4.8	5.5	6.1	6.7	7.2
4237	D	5.3	6.4	7.0	7.7	8.3
4234	C	9.8	10.5	11.0	11.6	12.0
4233	C	13.1	14.0	14.5	15.0	15.5
4232	C	12.4	13.0	13.3	13.6	14.0
4231	C	11.3	12.2	12.8	13.5	14.2
4235	I	5.3	5.7	6.0	6.2	6.5
4236	D	13.0	14.0	14.6	15.2	15.9
4228	C	17.1	17.2	17.6	17.7	17.8
4225	I	6.9	7.3	7.7	8.2	8.8
4226	C	6.1	6.9	7.5	8.1	8.9
4238	D	13.9	15.2	16.1	17.3	18.2
4240	C	8.0	8.8	9.6	10.5	11.0
4239	C	8.0	8.8	9.5	10.2	10.8
4291	C	4.1	4.9	5.3	5.6	6.6
4257	C	10.6	11.8	12.7	13.5	14.1
4258	S	4.9	5.6	6.1	worthless	
4259	C	11.2	12.1	12.9	13.5	14.1
4260	C	9.1	10.2	10.8	11.4	11.8
4262	S	4.5	4.6	4.6	4.6	4.6
4261	C	7.2	8.0	8.7	7.3	9.9
4264	C	11.5	12.1	12.4	12.7	13.0
4265	S	5.2	5.5	5.8	5.7	5.9
4266	C	6.4	7.0	7.2	7.7	7.9
4270	S	4.0	4.2	4.4	4.6	4.8
4269	S	4.7	5.0	5.1	5.3	5.4
4268	C	9.7	10.1	10.3	10.5	10.7
4267	C	11.6	12.5	13.1	13.6	14.0
4250	S	4.3	4.3	4.3	cut S.I.C.	
4251	I	5.6	6.0	6.3	6.7	7.1
4248	S	5.3	5.4	5.4	5.5	5.5
4249	D	10.1	10.9	11.2	11.6	12.2
4252	D	15.1	15.6	15.9	16.1	16.3
4112	X	4.7	5.9	6.9	7.6	8.2
4253	I	6.9	7.5	7.9	8.2	8.5
4256	C	8.8	9.9	10.6	11.3	12.0
4255	I	5.2	5.8	6.3	6.6	6.8

Growth Records, continued

Tree No.	Crown Class	Diameter at Breast Height (inches) 1925	1930	1935	1940	1945
4221	I	5.0	5.3	5.5	5.8	5.9
4220	C	12.6	13.4	13.9	14.3	14.8
4229	I	4.4	4.7	4.9	5.0	5.3
4230	C	13.8	14.5	14.9	15.3	15.7
4219	X	8.7	9.7	10.4	11.2	12.0
4218	X	4.1	5.2	6.1	6.9	7.7
4215	C	3.7	4.4	4.9	5.3	6.7
4216	D	4.8	6.1	6.7	7.4	7.9
4217	C	4.8	5.5	6.1	6.7	7.2
4237	D	5.3	6.4	7.0	7.7	8.3
4234	C	9.8	10.5	11.0	11.6	12.0
4233	C	13.1	14.0	14.5	15.0	15.5
4232	C	12.4	13.0	13.3	13.6	14.0
4231	C	11.3	12.2	12.8	13.5	14.2
4235	I	5.3	5.7	6.0	6.2	6.4
4236	D	13.0	14.0	14.6	15.2	15.9
4228	C	17.1	17.2	;7.6	17.7	17.8
4225	I	6.9	7.3	7.7	8.2	8.8
4226	C	6.1	6.9	7.5	8.1	8.9
4238	D	13.9	15.2	16.1	17.3	18.2
4240	C	8.0	8.8	9.6	10.5	11.0
4239	C	8.0	8.8	9.5	10.2	10.8
4291	C	4.1	4.9	5.3	5.6	6.6
4257	C	10.6	11.8	12.7	13.5	14.1
4258	S	4.9	5.6	6.1	worthless	
4259	C	11.2	12.1	12.9	13.5	14.1
4260	C	9.1	10.2	10.8	11.4	11.8
4262	S	4.5	4.6	4.6	4.6	4.6
4261	C	7.2	8.0	8.7	9.3	9.9
4264	C	11.5	12.1	12.4	12.7	13.0
4265	S	5.2	5.5	5.7	5.7	5.9
4266	I	6.4	7.0	7.2	7.7	7.9
4270	S	4.0	4.2	4.4	4.6	4.8
4269	S	4.7	5.0	5.1	5.3	5.4
4268	C	9.7	10.1	10.3	10;5	10.7
4267	C	11.6	12.5	13.1	13.6	14.0
4250	S	4.3	4.3	4.3	Cut S.J.C.	
4251	I	5.6	6.0	6.3	6.7	7.1
4248	S	5.3	5.4	5.4	5.5	5.5
4249	D	10.1	10.9	11.2	11.6	12.2

Growth Records, continued

Tree No.	Crown Class	Diameter at Breast Height (inches) 1925	1930	1935	1940	1945
4252	D	15.1	15.6	15.9	16.1	16.3
4112	X	4.7	5.9	6.9	7.6	8.2
4253	I	6.9	7.5	7.9	8.2	8.5
4256	C	8.8	9.9	10.6	11.3	12.0
4255	I	5.2	5.8	6.3	6.6	6.8
4254	C	7.5	84.	9.2	9.9	10.6
4256	I	5.8	6.3	6.9	Cut S.I.	
4244	C-	10.7	11.2	11.4	11.6	11.8
4245	C	9.3	9.7	10.0	10.5	10.5
4243	D	12.4	13.4	14.1	14.9	15.3
4242	D	11.00	12.00	12.7	13.2	13.6
4241	C	5.8	7.0	8.0	8.9	9.6
4214	C	4.5	5.4	6.1	6.6	7.3
4213	C	4.4	5.3	5.8	6.3	7.1
4212	C	4.7	5.3	5.9	6.5	7.3
4211	X	8.9	9.9	10.7	S.1.	diad
4210	I	4.0	4.4	4.7	5.1	5.5
4209	C	7.0	7.8	8.2	8.8	9.6
4208	I	4.0	4.3	4.6	4.7	5.2
4207	C	6.8	7.5	8.1	Dead	
4206	C	4.4	5.1	5.7	6.1	6.6
4205	D	6.5	7.2	7.4	8.1	8.7
4204	C	6.5	7.4	8.1	8.9	9.8
4202	C	6.2	6.8-	7.3	7.7	8.1
4201	C	6.6	7.3	8.0	8.4	9.1
4196		5.0	5.4	Dead Jps.		
4198	S	4.7	4.8	4.8	Dead	?
4200	D	9.0	10.0	10.8	11.7	12.6
4199	C	7.2	7.7	7.8	Dead	
4165	C	8.7	9.4	9.8	worthless	
4166	D	9.8	10.7	11.4	12.1	12.7
4167	S	3.6	3.8	4.0	4.2	4.3
4164	D	9.5	10.4	11.0	11.9	12.6
4163	C	6.2	7.0	7.5	8.0	8.6
4148	C	6.4	6.7	7.0	worthless	
4150	D	14.4	16.0	16.8	S.I. Dead	
4151	C	6.0	6.5	6.9	7.3	7.8
4152	D	8.9	9.8	10.6	11.2	11.8
4154	D	8.7	9.8	10.7	11.5	12.2
4155	D	6.5	8.0	9.2	10.3	11.3

Growth Records, continued

Tree No	Crown Class	Diameter at Breast Height (inches) 1925	1930	1935	1940	1945
4182	C	5.5	5.6	6.3	7.0	7.6
4181	C	5.5	6.5	7.1	7.8	8.3
4158	C	5.5	6.8	7.7	8.6	9.4
4161	D	7.2	8.3	9.3	10.0	10.2
4160	C	4.4	5.0	5.6	5.9	6.5
4159	D	6.9	7.1	8.6	9.2	9.9
4162	C	6.9	7.8	8.7	9.4	10.3
4172	I	3.9	4.6	5.2	5.7	6.0
4171	I	3.6	4.1	4.5	4.8	5.1
4168	I	5.6	6.1	6.4	6.5	6.8
4170	C	6.0	6.5	6.9	7.4	8.0
4173	C	6.0	6.8	7.2	7.6	7.9
4174	I	4.5	4.9	5.3	5.6	6.1
4185	C	5.1	5.7	6.1	6.6	7.0
4175	D	7.3	8.0	8.6	9.3	9.8
4178	I	5.2	5.7	6.2	6.6	7.0
4169	D	10.2	11.1	11.7	Dead	
4179	D	6.0	6.9-	7.7	8.5	9.1
4153	C	6.9	7.5	8.0	8.5	8.9
4130	C	5.3	6.0	6.6	7.1	7.6
4129	D	7.2	8.3	9.3	10.0	10.8
6228	D	16.8	17.5	18.1	18.6	18.2
6233	D	13.5	14.0	14.4	14.8	15.1
6234	D	16.4	16.9	17.5	18.2	18.5
6227	S	5.7	6.0	6.1	6.4	6.7
4067	D	3.6	5.1	6.4	7.4	8.1
6231	C	6.9	7.6	8.2	8.9	9.4
6230	C	12.4	13.0	13.8	14.5	15.1
8564	D		3.7	4.6	-	6.1
8565	D		4.8	6.2	7.5	8.3
8569	C		3.7	4.1	-	5.0
8571	C		3.8	4.3	-	5.6
8572	X		4.3	5.1	-	6.2
8568	I		4.0	4.1	-	4.7
8567	I		3.9	4.2	-	4.5
8600	C		5.0	6.2	7.1	8.0
8599	C		4.1	5.0	-	6.2
8597	c		3.6	4.3	-	5.1
8598	C		3.8	4.6	-	6.0
8596	S		3.8	4.1	-	5.0
8601	C		3.6	4.3	-	5.8
8403	D		4.0	5.2	-	6.9
8401	X		4.8	6.6	8.0	9.2

Growth Records, continued

Tree No.	Crown Class	Diameter at Breast Height (inches) 1925	1930	1935	1940	1945	
8402	I		3.8	4.4	-	5.1	
8616	C		4.0	4.8	-	6.4	
8614	I		4.0	4.4	-	5.6	
8613	I		3.9	4.0	-	4.5	
8615	I		3.9	4.2	-	4.9	
8612	I		4.0	4.1	-	4.6	
8602	C		5.2	6.5	7.8	8.3	
8604	X		3.7	5.3	-	7.7	
8603	C		4.7	6.7	-	7.4	
8609	S		3.6	3.6	-	3.9	
8575	X		4.3	5.4	-	7.2	
2-511	D			3.6	-	5.8	
2-636	C			4.0	-	5.8	
2-637	C			3.8	-	5.7	
2-662	X			5.4	-	7.0	
2-661	I			4.2	-	5.5	
2-638	I			4.0	-	4.6	
2-668	I			3.6	-	4.5	
2-670	S			4.0	-	4.9	
2-509	X			3.7	-	5.7	
2-672	C			3.9	-	5.8	
2-673	D			4.2	-	6.3	
2-676	X			4.5	-	6.7	
2-671	C			3.9	-	5.5	
2-669	C			3.6	-	4.1	
2-639	C			3.8	-	4.9	
2939	C	14.1	4.5	4.9	15.0	15.0	C
2984	D	13.2	13.9	14.5	15.0	15.5	D
4013	X	5.6	6.8	7.8	8.8	9.6	C
4034	C	7.0	7.5	7.8	cut	S.I.C.	
4118	D	9.0	10.2	11.0	11.8	12.5	C
4247	C	5.8	6.6	7.3	8.0	9.2	C
4098	D	7.4	8.3	9.5	dead	S.I.C.	

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