Artificial Pruning As A Measure Of

Controlling *Fomes pini*

In Second-Growth

Douglas-fir

by

Theodore W. Maul

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INTRODUCTION

Douglas-fir (*Pseudotsuga taxifolia*) is the most important timber tree in the Pacific Northwest. Any agent that destroys large quantities of this valuable timber is of great importance. The fungus *Fomes pini* is the greatest single agent responsible for losses in the immense stands of Douglas-fir in the Pacific Northwest.

Fomes pini is most commonly known as "conk" rot but has also been known as red ring rot, ring scale rot, honey-comb rot, and pecky wood rot. The name "conk" rot has arisen because of the "conk" or sporophore that appears on the tree indicating the presence of decay within. The conk is in reality the sporophore of the fungus and its presence indicates not only an extensive area of decay within, but is also the source of future infestation of the disease in sound trees which grow adjacent, and some times at great distances from the infected tree.

It is because of the importance of Douglas-fir and its great enemy, *Fomes pini*, that this subject was chosen.

THE NEED FOR STAND IMPROVEMENT

Old-growth forests today are becoming more and more remote from centralized manufacturing and processing plants. This fact forces attention toward management of cut-over lands and young timber stands.

It was not very many years ago that, with the low price of stumpage, the great abundance and accessibility of timber, management of our future stands of timber was sorely neglected. (By future stands reference is made to the present day cut-over lands, reproduction, and second-growth.) It is only recently with high stumpage prices and high costs of transportation that it has become possible to grow trees on a basis that could compete economically with the remaining old-growth stands.

Stand improvement is now recognized as having a definite place in forest management. Stand improvement aids in obtaining the largest total production for the rotation. It also aids in promoting the highest quality, and it provides for the harvesting of intermediate crops through thinnings. This thesis is concerned with that phase of stand improvement that will increase the ultimate quantity of the desired product through pruning.

In the past, improvement of the stand by pruning, had in mind only the improvement of quality. It is the purpose of this thesis to point out that by pruning we increase quantity as well as improve quality, and that these two factors combined should command in the future a greater attention for pruning in our growing stands of timber.

By increasing the volume of the stand is meant the increase in the amount of sound timber removed from the stand by the reduction of that portion of the volume that would be lost to <u>Fomes pini</u>.

It has been the consensus of opinion that Fomes pini is not an important factor in the management of second-growth Douglas-fir stands. This is true if we compare the losses of the second-growth stand from this decay to the losses in the old-growth stand. But we must not evaluate the losses of the second-growth stand on a comparative basis - we must evaluate them on their own worth. The present day harvester of old-growth stands has had no problems of management with respect to bringing that stand to its present age of maturity. He pays for that stand on a basis that is pretty much dependent on current market conditions and the amount of decay that the stand contains is figured in the price that he will pay for it. If this same harvester is one who has acquired his timber through one of the many land acts that were passed during the great expansion period of this nation, his problems of management have still not been great, and the price that he originally paid for his timber was so low as to compensate for its protection. The second-growth stand presents an altogether different picture. There is no gift here. All the costs of management have to be carried to the end of the rotation period. This is a stand that has to be moulded to its highest degree of efficiency in volume and quality in order that the myriad of costs and expenses that were entailed in its shaping may be met and still leave a fair return to the manager.

To date, most of our operations have been in old-growth with its sometimes high percentage of decay. Very few of our operations in the past have been in second-growth and the presence or absence of decay in these stands was not too well established. It was felt, however, that these stands were relatively free of the disease. The cruiser of the past could not tell you if the fifty-to eighty-year old stands were infected. He did not know. He did not see any external signs of the decay in these stands because he was not looking for decay in this case. These second-growth stands of eighty years or less were, on the whole, not merchantable and because of this not too much consideration was given to any defect that might have existed in them.

THE PRESENCE OF FOMES PINI IN SECOND-GROWTH

It was not until the advent of the war that attention was given to the rapidly increasing importance of second-growth forests. Some operators turned to these second-growth stands for what little saw timber they might manage to wring out of them, some for the smaller dimensional stocks such as ties, small poles, etc., but hundreds turned to these stands for large poles and piling. Accessibility and high prices were the combining factors that turned so many to the ruthless cutting of our future forests. Though this cutting of second-growth was not the best forest practice, it uncovered a few facts. One of these was the presence of *Fomes pini* in second-growth Douglas-fir.

In a piling operation in second-growth located near the Trinity River in Northern California's Trinity County during 1942, it was observed that in an area of forty acres there were approximately four trees of piling size left standing per acre because of external evidence of *Fomes pini*. (This evidence was in the form of "conk" or "swollen knots".) Of the felled trees there were on the average about 1 per acre that either broke upon being felled, thus exposing decay, or decay was exposed upon peeling the tree preparatory to loading.[1] It is of course recognized that piling is an exacting product, and that the bulk of the trees involved in the loss could have been used in the manufacture of other products, but this still does not detract from the fact that Fomes pini was in evidence in this case in a sufficiently large volume as to have an effect on the economy of the operation. It is also recognized, that of the several studies made in second-growth, this example was the most severe with respect to infection by conk rot.

In another instance, an observation was made in 1947 in Douglas County, Oregon, of a piling operation in which two stems per acre were left standing because of evidence of decay. (Approximately 10 acres noted in this case.) These trees were left in compliance with the State of Oregon Conservation Act but had there been no Act and had there been no decay, these same trees would have been taken. In other words, the presence of decay in this case made compliance with the State's Conservation Act a simple matter. By way of comment, it should be added that the practice of leaving defective trees in complying with the Conservation Act, definitely insures a source of Fomes pini spores ready to infect the young stand that these same trees are intended to originate.

"Piling men", hardly without exception, will concede that conk rot (hereafter, "conk rot" and "Fomes pini" will be construed as being one and the same thing) is one factor that must be looked for in the exacting requirements of their product, and that often a tree that otherwise

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1 This was from personal observation while in the employ of the United States Forest Service. Operation was on privately owned area. The age of this stand was between 70 and 90 years as determined by actual ring count of the trees and stumps. Particular note of this case was made by myself because of the commonly accepted theory that Fomes pini is of no importance in second-growth Douglas-fir.

looks perfect, is left standing because of visible signs of interior decay.

Decay in second-growth Douglas-fir is substantiated by Boyce (5) who noted a "Douglas-fir that was extensively decayed by Fomes pini though only 27 years old." He further noted "that in stands of second-growth, individual trees may be completely decayed before the age at which the stand as a whole becomes infected".

Control of Fomes pini (or any form of decay for that matter) as a part of any management plan is advocated by several authorities. Boyce in another work says, (6):

> "....control of decay must be concentrated on reducing financial loss to the minimum in stands of merchantable size already decayed and on preventing significant loss in future stands."

Percival adds to this with the statement that (20):

> "....any comprehensive management plan for the production of coniferous timber in the United States must include effective methods for controlling the organisms of decay."

As a result of observations in the field and studies conducted on the McDonald Forest in 1947 and 1948 on plots pruned in 1927 and 1941, this paper will attempt to point out that the ultimate yield of sound wood in a second-growth stand can be increased by the medium of artificial pruning which in turn removes the point of infection for decay by Fomes pini. In short, by removing the infection court, the volume loss is reduced which results in a "sound" volume gain.

SOME FACTS AND FIGURES ABOUT FOMES PINI

Fomes pini is commonly referred to as ring scale fungus or conk rot. In this rot the wood is riddled with small white pits or cavities apparently separated by sound wood. In its incipient stages, before the appearance of the white pits, the decay appears to be a pronounced reddish-purple discoloration, often bounded by a narrow zone of pronounced red color. Though fruiting bodies issue through knots and are perennial, the decay is not confined to any one portion of the bole but commonly extends throughout the tree. In the great majority of cases the fungus gains entrance through dead branch stubs containing heartwood. The decay progresses through the stub into the heart of the tree. When the fungus has been working in the heart of the wood for some years, the conks appear. Boyce (5) relates that "as a rule very little rot develops in a tree before a sporophore appears, or at least a 'swollen knot'". This is illustrated by Table I, also compiled by Boyce (5).

From each conk there are millions of spores produced annually. When released from the conk, the spores are carried about by the air currents. When one of these spores comes to rest upon exposed wood of a tree of a susceptible species and conditions are suitable, it germinates there, sending a fungus filament into the wood. From this filament the fungus develops, spreading up and down from the point of entrance and rotting the wood as it goes.

Of the millions of spores produced annually by each conk, it has been noted by Percival (20) that the spores of Fomes pini are cast most abundantly during two short periods in the spring and late fall. The periods of high sporulation were concurrent with rises in temperature above 50 degrees F. following a period of cool but not freezing weather. Very light sporulation continues at all times when the average temperature is above 32 degrees F.

To successfully exercise control over Fomes pini it would appear that control over the point of entry would be most effective. Table II compiled by Boyce (5) clearly shows that the point of entry to Fomes pini is through dead branch stubs. This importance of dead branch stubs as a point of entry to another form of decay (Trunk-rot, Fomes officinalis) is illustrated by Table III (5). The reason that this thesis is concerned only with Fomes pini is because of the high percentage of damage and number of infections due to this one form of decay. For data on this refer to Table IV (5).

Conk rot is responsible for by far the greatest amount of cull in Douglas-fir. In fact it has been said that if the species were free from this defect it would take its place with the pines as a relatively sound tree. Conk rot stands out as the all-important cause of decay, The volume destroyed by this decay in comparison with others is far greater than the ratio of infected trees would indicate. For example, only about one-third more trees are infected with conk rot than with Red-brown Butt Rot, yet the board foot volume of decay is slightly more than eighteen times as great. Conk rot is usually quite extensive in an infected tree, particularly in the merchantable portion of the bole.

NATURAL PRUNING IN UNDERSTOCKED STANDS

The extent to which a tree retains its dead branches varies indirectly with the degree of stocking. By this is meant that the lesser the degree of stocking, the more branches a tree within that stand will retain. Stands less than fully stocked during the early years of the rotation, and yet stocked sufficiently to close the crown towards the end of the rotation, provide the great problem of persistent branches and branch stubs that will not yield to natural pruning.

Alexander (2) in a study of stand improvement in second-growth Douglas-fir states that in a general classification of lands logged or burned prior to 1932, the forests were forty per cent well stocked, (70 to 100 per cent); 47 per cent medium stocked, (40 to 69 per cent); and 13 per cent poorly to no stocking. He also stated that since 1932, the stocking has run in pretty much the same pattern. This would indicate that 60 per cent of our second-growth forests are understocked and that the prevalence and persistence of many undesirable limbs on the trees within these forests, creates a problem not only to quality of product but as an infection court for decay. This understocking is further emphasized by Schenstrom (22) who observed that as a whole there is reason to fear that large areas in this region will not yield high quality timber in the future so long as the present systems of logging and regeneration are employed. The general way to prevent knotty wood is to secure a sufficient number of seedlings per acre.

Schenstrom's observations were made in 1931. Since then, development of the Oregon Forest Conservation Act should correct this understocking to a large degree within this state. However, there are still vast areas existing that are understocked because of practices that were employed before the existence of the Act. Then, too, the Act does not provide nor guarantee that all areas will be 100 per cent stocked after logging. The Act merely prescribes minimum standards of forest practices so that regeneration should be obtained to a fair degree. The Act should tend to lessen the per cent of poorly stocked stands that might accrue in the future. This Act, as tests by the State Board of Forestry illustrate, still permits understocking on a large percentage of recently cut-over lands. Benson (3, 4) also observed that many of our second-growth stands are understocked, and as a result natural pruning will not take place for a great many years.

Branches as a rule do not begin to die on a tree until the canopy begins to close, and the longer it takes an understocked stand to close its canopy, the longer the lower branches continue to live and the larger in diameter these branches will be. Bruce and Schumacher (8) estimate that a stand increases its degree of stocking about 4 per cent per decade until the 80th year is reached. When the canopy does close sufficiently to cause the death of the lower branches, they persist in proportion to their size and amount of heartwood. Other factors contributing to the length of time a limb persists are snow, wind, and resistance to decay. As long as a dead branch persists, the new wood which forms is pierced by a knot and the heartwood of the tree is vulnerable to the entrance of _Fomes pini_.

Although the dead branches on understocked stands may be naturally pruned within a few years, this is not often the case and when natural pruning does take place it leaves a branch stub. This branch stub, as far as infection by _Fomes pini_ is concerned, is more serious than if the branch had not naturally pruned itself. This stub is very rarely affected any further by the various influences that contribute to natural pruning, because it does not intercept enough wind or catch enough snow to cause its removal. As a result, the stub remains until the sapwood of the growing tree engulfs it. The least that can heppen will be a section within the bole of the tree that will produce extremely low grade wood because of the loose knots created by these branch stubs. A still greater danger lurks about as long as that stub remains exposed to the elements. That danger is the chance of infection by _Fomes pini_.

It has been pointed out that Fomes pini readily infects exposed heartwood. Thus for two reasons the chance of infection of a branch stub is usually greater than had the branch broken off flush with the bole. These reasons are:

1. A greater surface area of heartwood is exposed on the stub because of the angle at which the branch became severed.

2. The stub is projected sufficiently from the bole to intercept more spores.

Referring to the latter of these two points, it is quite evident that the branch that has been removed close to the bole with no projecting stub should be proportionately more free of infection danger.

NATURAL PRUNING IN FULLY STOCKED STANDS

So far the discussion has been confined to the understocked stand. The fully stocked stand also is susceptible to the infection because, though the size of the dead limb is usually much smaller, the wind velocity in a fully stocked stand is usually much less. Limbs in the fully stocked stand do not persist as long as they do in the understocked stand, although stubs of branches are in evidence. These, too, are generally much smaller in diameter and shorter in length than in the understocked stand. However, Bransford (7) relates that in well stocked Douglas-fir stands, the limbs of the lower sixteen feet were dead by the end of the thirtieth year, but it took until the eighty-fourth year for branches to drop off a tree whose cross-section was studied. Although this was an extreme case it shows the possibilities that might exist in a stand under management for a 100 year rotation. There were 54 years during which that tree was subjected to infection.

ARTIFICIAL PRUNING AS A MEASURE OF CONTROLLING FOMES PINI

It has been pointed out that *Fomes pini* is of great economic importance because of the great losses it inflicts upon the valuable Douglas-fir stands of the Pacific Northwest. Evidence of *Fomes pini* in our continually increasing stands of second-growth, shows that this form of decay will become more important as our old-growth is liquidated. Statistics and tables were listed to show that in studies made in the past, the point of infection for *Fomes pini* was the dead branch or branch stubs and scars. Attempts were made to point out that second-growth stands today are largely composed of trees that exhibit a great degree of limbiness. This is due in part to understocking and to the inefficiency of natural pruning in removing the branch cleanly. Artificial pruning may be an answer to the control of this disease. Through the following studies on McDonald Forest an attempt was made to discover the worth of this proposal.

THE STUDIES CONDUCTED ON THE McDONALD FOREST

The studies were conducted to determine whether artificial pruning reduces chances for infection at the point of branch severance. It was recognized that pruning plots that might be established at the time that this paper was conceived would prove too short for the pruned scar to heal over and too short to determine whether *Fomes pini* had infected the tree at that point. Hence it was necessary to select pruned plots that were set up a number of years ago. These plots were not laid out with the idea of studying infection of *Fomes pini* but rather to study rates of healing and other pertinent data. As a result the findings herein listed must be evaluated on that basis. In the case of the two plots studied, two additional check plots were established to set up conditions as closely related to the pruned plots as was possible.

The Wren Plot (23)

This plot was pruned in 1941 when the average age of the trees was 57 years. The average diameter at the time of pruning was 10.4 inches outside bark. Seventy trees were pruned of all dead branches to a height of 60 feet. There was no attempt to confine the plot to a given area but rather to set the plot up on a "number of trees" basis because the plot was originally studied on a per-tree basis and not an area basis. Hence the seventy trees were strung out in one general direction adjacent to a road that meandered along a ridge top. Refer to Plot I for a more detailed layout of the Wren plot and its accompanying check plot. These trees were all tagged and recorded at time of pruning and again in 1947 in order to determine diameter increase and rate of healing.

The Hebo Club was used exclusively on this plot in order that the club might be compared to other methods of pruning. The efficiency of the Hebo Club is best illustrated by Table VI which was compiled from figures gathered by Wren (23) on four different pruning plots. The Hebo Club is particularly well adapted to close and fast pruning of pole and piling size trees. The tool, as the name implies, is a club made from the handle of a hazel hoe or pick or some similarly shaped piece of hardwood. This handle is shod at the end with a piece of 1/8 inch thick steel. The length of this steel ferrule as well as the overall length of the handle is dependent on the pruning method for which the tool is to be employed. When the tool is used in two hands, as when pruning from the ground, the ferrule is 8 inches and the handle 33 inches long. When the club is to be used in one hand by a climber, the handle is 17 to 19 inches long and the ferrule 5 inches long. Other factors warranting the use of the Hebo Club over other methods of pruning are:

1. Less damage to the tree
2. Speed in its use
3. Safety for the worker

The trees in this plot were selected from the dominants and co-dominants since these trees would be the ones ultimately selected as the crop trees.

The average diameter increase of the trees in the plot over the seven year period was 1.1 inches or about .157 inch per year during that period. Thus a fairly good increment was maintained during the period in which the study was conducted. However, with over one inch of new wood during the intervening period between pruning and final gathering of data, all of the scars had not healed completely. The range of healing varied from 20 per cent to 100 per cent with the average for all scars on all trees being about 50 per cent. (To clarify further, this figure is the average of all scars on all trees in per cent of area of scar healed to area of scar at time of pruning.)

There were 147 increment borings taken over a period of several weeks to determine any evidence of decay. All borings were taken on the westerly side of the trees because of the prevailing winds coming from that direction during periods of high sporulation. Figures cited by Boyce (5) show that infection is more likely to occur on the side of the prevailing winds at the times of highest sporulation. An average of about two borings per tree were taken. The location of the borings on the tree was governed by any indication or reason to suspect the presence of decay. (Such governing factors as a slow rate of healing or a swelling at the healing area that seemed abnormal, were used.) When a core was taken from the tree it was taken in such a position adjacent to the scar as to have the apex of the boring coincide with the point of origin of the knot in question. In every case where a core was removed, the scar adjacent was closely inspected with a pocket knife and magnifying glass. In no case was any sign of decay in either advanced or incipient stages observed.

Although this plot had not been pruned long enough to determine with any degree of accuracy whether decay could have started in the trees studied, certain cultural studies by Owens (18) and other studies by Boyce (6) have shown that the spores of Fomes pini under favorable conditions will germinate in a matter of days. Under unfavorable conditions, the spore may lie dormant for a number of years. It was felt, however, that had spores found their way to the exposed heartwood of a pruned limb shortly after pruning had taken place and before a protective layer of resin had covered the scar, they (the spores) would have germinated within the 7 year period of the study and would have been in evidence in a noticeable form. After the first or second year sufficient resin has usually covered the scar to insure it against infection from that time on.

The presence of sufficient fruiting bodies adjacent to this area was noted and plotted. Refer to Plat I. The fruiting bodies were noted with respect to direction from plot and location as to prevailing winds at times of highest sporulation and were deemed adequate to provide the study plot with a sufficient source to infect all portions of it with the decay had other conditions such as moisture, temperature, and exposed heartwood been favorable. The plot was concerned with this latter condition and an attempt was made to reduce this factor to a minimum.

Check Plot For The Wren Pruning Plot

The check plot for this study was of the same age class as the study plot and was located adjacent to the pruned plot and running in the same general direction. There were only 36 trees in the check plot because factors of site, exposure, age classes, presence of fruiting bodies were not to vary any more than was possible. Of the 36 trees, one was proven to be infected with Fomes pini, having a swollen knot that upon inspecting with hand axe and increment borer was found to have a small pocket of rot in the advanced stages and with incipient decay extending about 25 inches down and 18 inches up the tree. This tree was 68 years old breast high (approximately 75 years) which was about 18 years older than the average for the two plots. Its point of infection was 21 feet above the ground. This tree was 17 inches D.B.H. It is debatable whether this tree was infected after the time of pruning in the adjacent plot and whether the tree would have been infected had it been pruned at this time, but it is felt that due to the freedom of the adjacent plot from decay, this tree would have enjoyed the same freedom had it been pruned at this time as well.

The check plot did not enjoy the same degree of stocking as the study plot. The existence of unpruned limbs was very much in evidence, extending in some cases from stubs at 6 feet above the ground to long dead branches at 50 or 60 feet. There was no record made of the extent of limbiness on the Wren Plot, but on checking the average size of the limb in the check plot with the assumed average size in the Wren Plot (determined by trees adjacent to the plot that were not tagged or pruned), it was found that the limbs in the check plot ran from 1/4 to

3/8 inches larger in diameter. (The limbs measured were at the lower levels.) From this we might conclude that the limbs might have persisted longer at the lower levels in the check plot.

The Borggreve Thinning And Pruning Plot

This plot differed from the Wren Plot as follows:

1. Age class was older (75 years at time of pruning)
2. Plot was laid out on an area basis rather than on a number of trees basis
3. Twenty years elapsed from time of pruning to the time of study
4. The site class was II (Wren was poor III or good IV)
5. The plot was thinned 26 per cent at time of pruning

After the thinning took place 55 trees were left, average age 75 years. The average D.B.H. at this time was 23.3 inches. These trees were pruned to a height of 18 feet. (No data were available as to method of pruning.) By 1937 the average diameter was 27.9 inches (1), and in 1947 the average diameter was 30.2 inches. As evidenced by cores removed in 1947, all branch scars were completely healed by 1937. (It might be pertinent at this point to add that in 1947 at the time the borings were made it was so difficult to determine the exact spot of the former limbs that only five former limbs were located. These were largely located by a slight depression or dimple in the bark.) Where it was determined that limbs had existed, borings were taken to determine the presence of decay. In this plot as in the Wren Plot, no evidence was found on that portion of the tree that was pruned, but a swollen knot about 14 feet above the highest pruned limb on one tree showed evidence of *Fomes pini*. Decay had entered through a branch stub that had since fallen off or had been sufficiently short at time of infection as to be completely grown over before the fungus attempted to push out a fruiting body. It is entirely possible that the impetus given this tree due to release through thinning was another factor contributing to the sealing over of this infected stub before a fruiting body could emerge. The extent of this infection was determined by use of the increment borer, and the tree was found to contain a small pocket of decay in the advanced stages, about 15 inches total up and down the bole. The incipient decay was not checked. It was felt that this infection resulted after the thinning and pruning because the decay was not far advanced (5). In cutting open the swollen knot, 5 growth increments were detected, indicating that the infection had not exerted any pressure outward toward forming a fruiting body before this time. The intervening years between the pruning and the closing of the opening provided by the branch stub (15 years) seems ample time for the decay to have germinated and developed to this point.

The presence of fruiting bodies with relation to this plot was noted and plotted. (See Plat II) The prevailing winds were charted and all borings were taken on the westerly side of the trees as in the Wren Plot. The swollen knot in the instance just described, was located on the northwesterly side of the tree in question.

Check Plot For The Borggreve Study

The check plot for the Borggreve Thinning and Pruning Plot was also selected adjacent to the study area in order to examine conditions as near like the study plot as possible. There were 68 trees on the acre selected for the check plot. The dominants and co-dominants only were tabulated in arriving at the figure of 68 because these were the ones that remained after the thinning in the study plot. The average diameter of the trees recorded was 26.8 inches in 1947. The average age was the same as that in the study plot. This check plot produced no signs of decay though the trees were very limby. It is possible that this may have been due to the absence of fruiting bodies in the direction of the prevailing winds. A thorough search was made to the west, southwest and south of the check plot in an effort to locate fruiting bodies in this direction. The search extended for a quarter-mile in these directions but no conks were found. (Check Plot II for layout and location of conks and direction of prevailing wind.) In laying out of this check plot, notice was made of fruiting bodies close at hand but error was made in determining the direction of the prevailing winds.

A Sample Cruise In Piling Size Second Growth

In this third study, a cruise was taken in piling-size second-growth in the vicinity of the powder house on the McDonald Forest and running in the general direction of the State Nursery. The strips were run for 1/4 mile, an off-set made of 5 chains and a return strip of 1/4 mile was run. The strips were 1 chain wide. The piling size timber tabulated ranged in age from 60 to 80 years. Trees too large or too small to make piling were not tabulated nor were species other than Douglas-fir. There were no borings taken except in infected trees and then only to determine age. On this cruise there were 42 trees tabulated as suitable for piling and of these, 3 were infected with Fomes pini. Thus, on the four acre sample, the per cent of decay was 7.1 per cent. The following table contains the pertinent data regarding the infected trees:

Tree No.	Diam.B.H.	Age	No. of Conks	Swollen Knots	Strip No.
1	18	63	1	0	1
2	20	76	1	1	1
3	20	74	0	2	2

SUMMARY OF THE STUDIES ON McDONALD FOREST

The McDonald Forest studies were not adequate to the point of substantiating definite conclusions, but they strengthen the theory that artificial pruning reduces the susceptibility of second-growth Douglas-fir to infection by Fomes pini in the pruned portion of the bole. Data collected on the study plots illustrated the following points:

1. No evidence of decay was found in the study plots on the pruned portion of the bole.
2. Evidence of decay was found in one check plot where no pruning had been done.
3. Evidence of decay was found in one study plot on a tree at a point above the highest pruned limb.
4. Evidence of decay was found in a sample cruise of second-growth averaging about 70 years of age to the extent of 7.1 per cent.
5. It was noted that the impetus given a fully stocked stand as a result of thinning, aids in the rapidity with which the trees healed pruning scars made at the same time.

CONCLUSIONS

The conclusions reached by the foregoing studies are as follows:

1. Fomes pini exists in second-growth Douglas-fir stands in sufficient quantity to affect the economics of harvesting this timber type.
2. The prevalence and persistence of branches in second-growth Douglas-fir is sufficient to provide Fomes pini with a needed point of entrance.
3. The removal of these limbs by artificial pruning reduces the susceptibility of second-growth Douglas-fir to infection by Fomes pini.

RECOMMENDATIONS

From the studies conducted, the following recommendation is made:

That crop trees be pruned to the height that is deemed economical at the time intermediate thinnings are made. Pruning should be done at this time for two reasons: (1) availability of man power because of the thinning operation; and (2) more rapid healing of pruning scars due to the increased growth rate because of release of the thinning operation. This pruning will be rewarded by improved quality and increased volume due to reduction in loss from Fomes pini.

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A P P E N D I X

Table I The Amount Of Decay With Relation To Presence Of Fruiting Bodies.

Decay	Infection		Volume of Decay					
			Percent of Total				Ave. per Infection	
	Number Basis	% Of Total	Gross		Of Conk Rot			
			bd.ft.	cu.ft.	bd.ft.	cu.ft.	bd.ft.	cu.ft.
With Sporophores	96	81.4	36.83	21.71	95.94	96.51	782	76.2
Without Sporophores	22	18.6	1.56	.78	4.06	3.49	144	12.0
With Swollen Knots	108	91.5	38.39	22.49	99.96	99.97	725	70.2
Without Swollen Knots	10	8.5	.01	.01	.04	.03	3	.2

Table II Infection Court Of Conk Rot In Douglas-fir

Infection Court	Number Basis	Percentage of Total: Number	Percentage of Total: Volume bd.ft.	Percentage of Total: Volume cu.ft.	Average Volume bd.ft.	Average Volume cu.ft.
Knots	98	83.0	99.62	99.48	796	77.0
Fire Scar	10	8.5	.04	.03	3	.2
Falling Tree Wounds	3	2.5	0	.05	0	1.4
Lightning	4	3.4	.34	.44	68	8.2
Dead Tops	1	.9	0	0	0	0
Unknown Scars	2	1.7	0	0	0	0

Table III Infection Court Of Trunk Rot In Douglas-fir

Infection Court	Number Basis	Percentage of Total: Number	Percentage of Total: Volume bd.ft.	Percentage of Total: Volume cu.ft.	Average Volume bd.ft.	Average Volume cu.ft.
Knots	7	46.7	44.6	46.1	353	28.4
Fire Scars	2	13.3	0	0	0	0
Falling Tree Wounds	4	26.7	30.0	26.9	4	29.0
Lightning	2	13.3	25.4	26.9	705	58.0

Table IV Infection Court Of Combined Decays In Douglas-fir

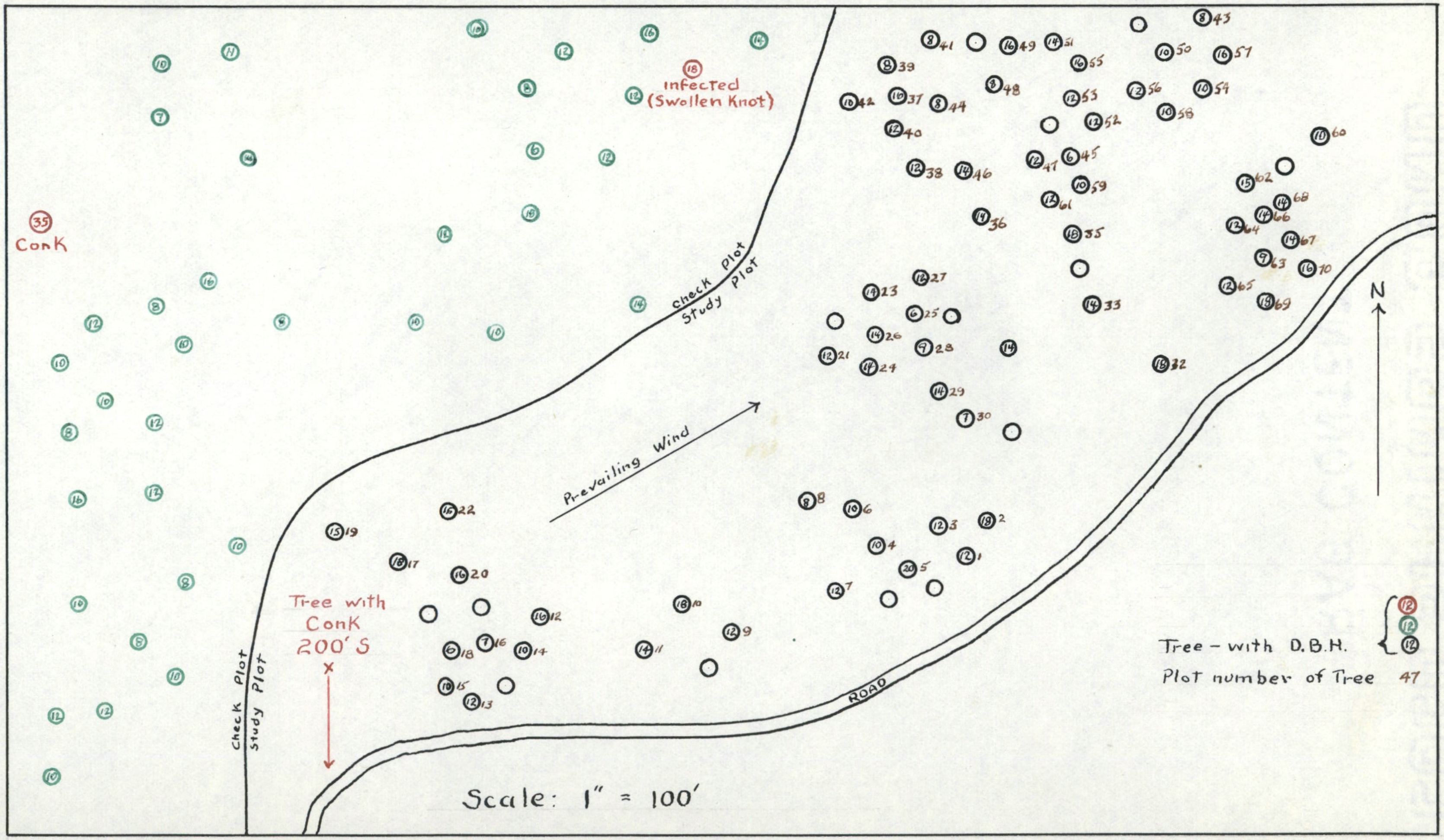
Infection Court	Number Basis	Percentage of Total			Average Volume	
		Number	Volume			
			bd.ft.	cu.ft.	bd.ft.	cu.ft.
Knots	123	43.3	89.2	89.2	664	63.9
Fire Scars	67	23.6	4.2	4.2	57	5.5
Falling Tree Scars	18	6.3	2.2	1.7	114	8.2
Lightning	19	6.7	2.5	2.4	123	11.5
Dead Tops	30	10.6	.6	1.0	19	2.8
Roots	19	6.7	.5	.6	25	2.6
Unknown	8	2.8	.8	.7	88	8.0

Table V Relative Importance Of The Various Types Of Decay Found In Douglas-fir

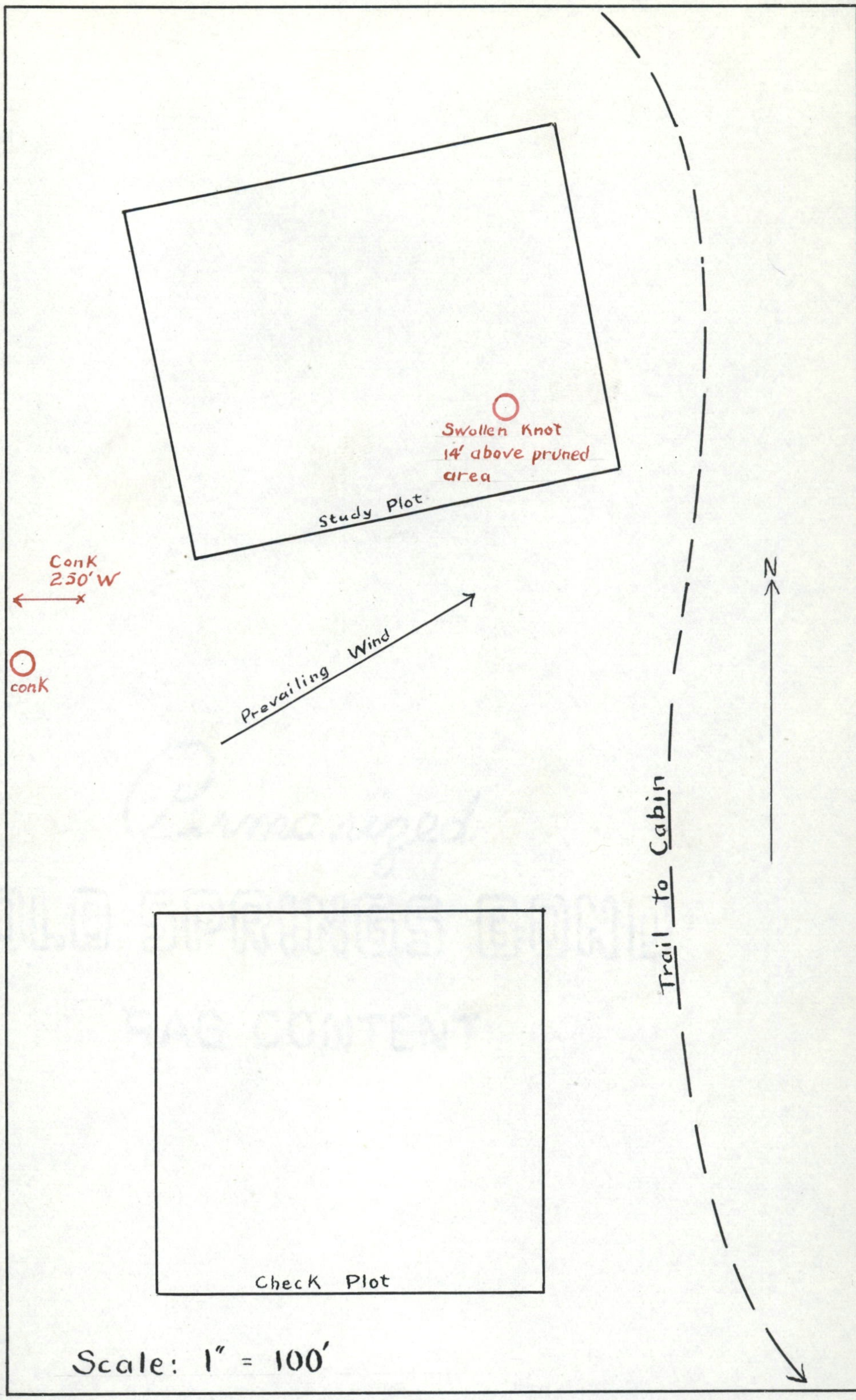
Kinds of Decay	Volume of Decay per cent of gross vol.		Inf. Trees % of Total	Infections			
				Number basis	% of Total	Average Volume	
	bd.ft.	cu.ft.				bd.ft.	cu.ft.
Conk Rot	38.4	22.5	61.0	118	41.6	663	64.2
Trunk Rot	2.7	1.3	5.9	15	5.3	369	28.7
Butt Rot	2.1	1.2	40.2	70	24.6	62	5.9
Top Rot	1.6	1.0	22.5	46	16.2	72	7.0
Unknown	.1	.1	18.9	35	12.3	4	1.0

Table VI Relative Efficiency Of Different Methods Of Pruning

Type of Instrument	% of all Scars of Area Healed	Growth Total 7 Year Period (inches)	Age Class When Pruned	Height to which Trees were Pruned
Hebo Club	.49	1.1	55	60
Hand Saw (Fanno No. 4)	.31	.92	55	60
Hardwood Club	.41	.85	55	60
Cruising Axe	.245	.87	55	60



Plat I The Wren Plot and Check Plot.



Plat II The Borggreve Plot and Check Plot.

Figure 1

Figure 2

Figures 1 and 2 Extent of limbiness on a formerly understocked stand that has now approached full stocking and a state of stagnation.

Figure 3

Figure 4

Figures 3, 4 - Persistence of limbs in the understocked stand
(Average Age - 85 years)

Figure 5 (Age 85 years Breast High) Figure 6

Figures 5, 6, Efficiency of Natural Pruning. Stand at one time had enough canopy to effect degree of pruning shown here. Compare with Figures 3 and 4 where canopy was lacking.

Figure 7
Age 63 years Breast High

Figure 8
Age 80 years Breast High

Figures 7, 8, Swollen-Knots in Second-growth Douglas-fir
(Note position of infection at branch whorls)