The Desirability of Artificial Pruning as a Silvicultural Means of Improving the Quality of Lumber from Second-Growth Forest Stands.

by

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>The Need of Pruning</td>
<td>5</td>
</tr>
<tr>
<td>Structure of the tree as related to knots</td>
<td>5</td>
</tr>
<tr>
<td>Zones of a tree</td>
<td>5</td>
</tr>
<tr>
<td>Knots</td>
<td>6</td>
</tr>
<tr>
<td>Mode of branching in conifers</td>
<td>8</td>
</tr>
<tr>
<td>Natural Pruning</td>
<td>8</td>
</tr>
<tr>
<td>Factors affecting natural pruning</td>
<td>8</td>
</tr>
<tr>
<td>Length of time necessary for natural pruning</td>
<td>9</td>
</tr>
<tr>
<td>Formation of clear wood</td>
<td>9</td>
</tr>
<tr>
<td>Artificial Pruning</td>
<td>12</td>
</tr>
<tr>
<td>Time of year to prune</td>
<td>12</td>
</tr>
<tr>
<td>Type of trees to prune</td>
<td>13</td>
</tr>
<tr>
<td>Number of trees to prune per acre</td>
<td>13</td>
</tr>
<tr>
<td>Height to prune</td>
<td>14</td>
</tr>
<tr>
<td>Portion of green crown removed</td>
<td>14</td>
</tr>
<tr>
<td>Methods of pruning</td>
<td>16</td>
</tr>
<tr>
<td>Tools used</td>
<td>17</td>
</tr>
<tr>
<td>Crew procedure</td>
<td>19</td>
</tr>
<tr>
<td>Slash disposal</td>
<td>20</td>
</tr>
<tr>
<td>Time and cost of pruning</td>
<td>21</td>
</tr>
<tr>
<td>Resultant effects of pruning</td>
<td>24</td>
</tr>
<tr>
<td>Pruning defects</td>
<td>24</td>
</tr>
<tr>
<td>Time required for growing over of pruned branches</td>
<td>27</td>
</tr>
</tbody>
</table>
Effect on the rest of the stand----------------- 28

Value in pruning----------------------------- 29

Supplementary value in pruning---------------- 31

Summary-------------------------------------- 32

Literature Cited----------------------------- 36-37

Table I - Average amount of time necessary for pruning--21

Table II - Relation of time, size and rate of pruning---- 22
ILLUSTRATIONS

Figure 1. - Typical spike knot in northern white pine-- 7
" 2. - Intergrown and encased knots---------- 7
" 3. - Rate of natural pruning----------------- 10
" 4. - Persistence of small dead branches------- 11
" 5. - White Pine plantation showing persistence
    of small dead branches------------------ 11
" 6. - White pine tree pruned at an early age---- 15
" 7. - White pine tree pruned at a late age------ 15
" 8. - Good and bad pruning practices---------- 26
" 9. - Clear lumber produced from pruned trees--- 30

Table I - Average amount of time necessary for pruning--21
Table II- Relation of limb size and rate of pruning---- 22
INTRODUCTION

The object of this thesis is to present a picture of
the possibilities of pruning as a sound silvicultural policy
in our second-growth forests. This study is not made with
the idea of supplying complete records of costs and other
like items, but to give the reader an idea what problems
must be dealt with, and the economic returns resulting from
pruning.

In order to produce clear material on short rotations
the timber grower must resort to the practice of pruning.
At present, pruning is of little importance in the Pacific
cost region for there are large stands of virgin timber
available, but in the future when these virgin stands are
gone, the second growth stands will have to be pruned if
any clear material is to be produced, thus pruning should
become of more importance in the future.

Previous pruning studies have mostly been made within
the last decade or two. This is really too short a time
to draw satisfactory or accurate conclusions on the results
of pruning. Thus, most of the pruning studies contain in-
formation only on the methods, costs, etc., rather than on
economic returns and resulting effects of pruning.

The majority of the data presented here is taken from
library sources. The author has made one pruning study on
the Lolo National Forest in western Montana. Some of the
data from this study is presented in tabular form and also
in the recommendations.
The Need of Pruning

More than one-fourth of the entire land area of the United States is forest land or suited to forest crops. A large portion of this land is now producing only knotty second-growth timber, which is of low value compared to the clear material produced in old-growth virgin stands. In order for the timber grower to obtain the full value from his timber land he must grow high quality timber. There are two ways of producing clear timber; naturally and artificially. Nature's way of producing clear timber is very slow and expensive, as the charges for carrying timber for a long time are high. Clear lumber as now produced is cut principally from virgin-growth timber 200 to 500 years of age or more. Since it is entirely out of the question to grow clear timber on short rotations as will probably be done in the future, it will be necessary to use artificial means of producing clear timber. Pruning or the removal of branches from a tree so clear wood is formed is the method timber growers must use in order to produce clear timber on their forest land. Before pruning is undertaken we must understand a few facts about tree growth and knots.

STRUCTURE OF THE TREE AS RELATED TO KNOTS

Zones of a tree

A mature tree contains three distinct zones with respect to knots which affect the grade of lumber that may be cut from it. The inner zone or core, called the tight knot zone, consists of the portion of the tree trunk which grew before lateral branches died. The second zone consists of
the part of the tree containing encased or loose knots. The
third zone consists of the clear lumber zone which may or
may not be formed. The loose knot zone and the clear lumber
zone both depend upon the rate at which natural pruning has
been accomplished. The clear wood zone is the most valuable
part of the tree for lumber, and other similar uses. Thus
if young trees which have only a relatively thin band of
clear wood have just reached a point where their growth
is becoming most profitable, they should be left until the
clear wood zone is thick enough for advantageous use.

Knots.

Knots are a characteristic defect of lumber which is
more common than any other blemish. We may speak of a knot
as that portion of a branch, or limb that has become incor-
porated in the body of the tree. Furthermore, we may sub-
divide knots into two main kinds: **Intergrown** knot is one in
which the annual rings are completely intergrown with those
of the surrounding wood. An **Encased** knot is one whose rings
of annual growth are not intergrown with those of the sur-
rounding wood. Besides the two main kinds of knots there is
an almost endless variation in size, color, form, and quality.
They may be pin size, small, medium, or large; red in color
or black; round, oval, or V-shaped; checked, or loose; sound
or decayed; etc..

The maximum diameter of a knot depends upon the time the
branch from which the knot is formed remains alive and on the
rate of growth of the branch; the length of a knot depends
chiefly upon where the branch is broke off, close to the
trunk or some distance away from it. Knots or branches are
Figure 1.---Typical spike knot in northern white pine.

Figure 2.---A, Intergrown or "live" knot formed from portion of a living branch; B, Encased or "dead" knot formed by the inclusion of a dead branch.
small not only near the tree's center but also near its base.

Mode of branching in conifers.

The mode of branching of trees influence the number and location of knots. Lateral buds which form the branches may arise in several different locations; for example, in northern white pine the lateral branches arise at the termination of each year's growth, and in the southern pines the lateral branches may arise between the beginning and end of each year's growth, and also at the terminus of the year's growth. Each year the tree forms new lateral buds, and these in turn form new branches. Thus for each year's growth there is a new set of lateral branches formed. These branches may vary in number from three or four in Ponderosa Pine to nine or ten in White Pine. The growth and size of branches varies as to species and the growing site. Trees that are open grown have numerous and well developed branches often extending to the ground, while trees grown in dense stands have smaller limbs with a large percentage of dead limbs on the lower part of the tree trunk.

NATURAL PRUNING

Factors affecting natural pruning.

Natural pruning in forest trees results from the gradual dying of lower branches and finally the separation or disappearance of any protruding portion. Density of the stand and tolerance of the species are the two main factors that determine the rate at which the lower limbs of the tree will die, but this does not mean that intolerant trees grown in densely stocked stands will be self-pruned first. It has
been found that the dead lower branches of our important conifers will remain for years. Thus, there must be certain other factors which affect the rate of pruning. Those factors which it is logical to assume may influence the rapidity of self pruning are: Inherent resistance to decay, pitchiness, the size of the dead branch, amount of heartwood, dryness of branch, fire, and climatic conditions such as temperature, relative humidity, wind, snow and sleet.

**Length of time necessary for natural pruning.**

In comparison of northern white and red pines with southern pines, we find that the southern pines prune much faster. The average length of time that overgrown dead branches in the first 20 feet of these species persisted was 27 years for northern white and 24 years for red pine. The maximum record for these trees is 73 years in northern white pine and 67 years in red pine, both in an 86 year-old stand. Among the southern pines, dead branches persisted longest in shortleaf pine for which the average was 12 years, followed by an average of 8 years in loblolly and 6 years each in slash and longleaf pines. Figures are lacking for other species but the above named species are quite representative. In some sections of the country there will be a wide variance in the time of natural pruning. Regions of heavy snow fall, we may note that pruning of the trees has been hastened along; likewise, other factors cause a variance in pruning time.

**Formation of clear wood.**

Clear wood does not form until the diameter of the trunk
Figure 3.--Illustrating the rate of natural pruning for Northern White Pine, Red Pine, Shortleaf Pine, and Loblolly Pine.
Figure 4.--Persistence of small dead branches in (A) Northern White Pine, (B) Red Pine, and (C) Shortleaf Pine. These examples refute the opinion of many timber growers that close spacing results in the formation of clear lumber.

Figure 5.--A 37-year-old plantation of Northern White Pine. Clear wood has not yet begun to form despite the fact that the lateral branches have been dead for a long time.
has grown outward as far as the ends of the broken branches, and the growth rings have covered the broken surface. Defects of various kinds may further slow up this covering up of the branch stubs; accumulation of pitch, incorporation of bark, and swelling of the nodes will retard the formation of clear wood. Due to the slowness of natural pruning and the condition in which our second-growth stands are in, it will take anywhere from 10 to 80 years before clear wood is formed. The southern pines will probably take around 10 to 15 years and the northeast and western conifers around 80 years.

ARTIFICIAL PRUNING

Time of Year to Prune.

The best time of the year to prune is early spring and late winter. February to May are the most desirable months. During this season there is little likelihood of infection from fungi and the wounds will heal over much faster as the season's growth has not yet started. In regions where there are heavy frosts in February it will be wise to postpone pruning until later as the frost may cause enlargement of the pruning wounds and the healing will then be delayed. Another factor of importance is that there is less danger of bark stripping, resulting from pruning as branches have a tendency to snap off clean, rather than hang on and pull the bark off as they fall. Along with the pruning operation there may be some slash burning, thus it will be done at a desirable time of the year as fire danger is low with less resulting damage to ground cover.
Type of Trees to Prune.

If pruning is to be put on a dollar and cents basis we must confine our attention only to the best and most desirable trees in the stand. There is little profit in pruning trees of low grade that will probably die out in a few years, so we must select a sufficient number of the best trees which will probably make up the mature stand. Usually trees of the dominant and co-dominant crown class should be selected as "crop" trees; furthermore these trees should have the best possible form and a rapid rate of growth.

The size of tree to prune is limited by the amount of clear wood that can be laid on before logging the final crop. In other words, it would not pay to prune trees of large diameter, because there would be little clear wood formed by the end of the rotation. In pruning operations in New England where the rotation may be as low as 80 years, studies show that pruning will not pay if done on trees larger than 4 to 5 inches D. B. H. In western Montana where the Ponderosa Pine rotation may be as high as 120 to 140 years, it may possibly pay to prune as large as 8 inches D. B. H. Local studies should be made before stating a pruning limit, but it is a question whether it will pay to prune trees larger than 8 inches D. B. H.

No. of Trees to Prune Per Acre.

The number of crop trees to prune per acre will vary with the species, site and rotation age. For Ponderosa Pine stands in the southwest it is considered desirable to prune 80

1. Pruning study on Lolo National Forest in Western Mont.
to 160 trees per acre, while in western Montana, 200 to 250 trees per acre is considered best. For white pine stands in the eastern states, anywhere from 100 to 400 trees per acre is considered as desirable to prune. Availability of markets will often determine to some extent the number of trees per acre to prune. Where there is only a demand for saw logs then it would be advisable to have fewer trees per acre, but where there is a demand for smaller material as well as saw logs, then it would pay to have more trees per acre.

**Height to Prune.**

Usually it is not practical to prune trees above the height of the first log or 17 feet. As the height of pruning increases the time required to prune each tree increases, and consequently the cost is increased. Furthermore, too much crown would probably be removed if the pruning was carried much over 17 ft. Since 40 to 50% of the volume of the entire tree is in the butt log of most trees, it would not be economically justified to prune more than one log.

**Portion of Green Crown Removed.**

This is very important as a factor in that the growth and development of the tree depends on the amount of green crown left. Hawley states that all the living limbs whose foliage do not receive direct amounts of light may be removed without decreasing diameter growth. He states further that pruning of more than 50% of the live crown decreases the height growth by approximately one-third. As a general precaution, therefore, it would seem best not to remove more than four-tenths of the length of the living crown. On many
Figure 6.--Cross section of a white pine log showing small knotty core.

Figure 7.--Cross section of a white pine log showing large knotty core.
trees it will not be necessary to remove this much of the
green crown as most of the limbs on the first log are dead.

Methods of Pruning.

Pruning may be divided into two phases; low pruning and
high pruning. Low pruning runs from 0 to 12 feet, while
high pruning extends from 12 to 17 feet. Some authors
may even further subdivide the pruning operation by inclu-
ding an intermediate phase. Then the three phases would be:
Low pruning, 0 to 6 feet; Intermediate pruning, 6 to 12 feet;
High pruning, 12 to 17 feet.

There are two main methods of pruning, namely; the
Pole saw method and the Ladder method, with variations of
each. Perhaps the most efficient and widely used method is
the pole saw. The general procedure for this method is:
first, the lower branches are pruned with a hand saw or
similar tool, then the higher branches are pruned off with
a saw mounted on poles of various lengths. This method is
adapted for use in most any kind of stand. A method of
varying degrees of efficiency is the ladder method. The
type of stand determines in a large measure the efficiency
of this method; in open stands on flat terrain the ladder
method is quite efficient, but in dense stands where there
is heavy ground cover it is doubtful whether the ladder
could be used. Hand tools are used with this method, probably
the most efficient and safest tool is a hand saw. A new
method recently reported on by Mollenhauer is called the
1 Tarzan method. The essential feature of this method is to

1. The term Tarzan was first applied by Dr. Bailey Sleeth
of the Bureau of Plant Industry.
climb to the height to be pruned and then to work down. The pruner may force his way through or saw off a limb in each whorl to facilitate climbing. A modification of this method may be to prune the first 6 or 7 feet from the ground and then use a short ladder to climb into the whorl above this. This method has been found to be quite rapid and even superior to the ladder method in some types of stands.

One of the most important points in pruning trees is to be sure that all cuts are properly made. Care should be exercised in cutting off the branches so that a smooth, clean cut close to the trunk is made. Cuts made in this manner will heal with a minimum of defects and the time of healing will be decreased.

**Tools Used.**

There are a great variety of tools on the market used in pruning work, some of which are very practical to use while others are inefficient. The selection of the proper tools to use is a very important factor, affecting both the efficiency of labor and the amount of damage done to the tree. There are four broad classes of pruning tools which are as follows:

**Saws—**Handsaws as a class are the best tools; they are easier to use, do less damage to the tree, and are the safest of all. Single-edged, pull stroke saws are preferable for most pruning operations. Double-edged saws are seldom used on both sides and the unused edge is constantly snagging. Saws that cut on both strokes are very tiring when used above waist high as the push stroke loses the benefit of body weight, and relies almost entirely upon muscular exertion.
Mollenhauer, in a study of pruning tools reports that the California saw with 5½ points, long needle teeth, and pull stroke was found to be the best all 'round tool. In general, pruning saws for work above 6 feet should be 16 inches or less in blade length and with a narrow, tapering blade with as much rigidity as possible. Saws to be used on poles should be slightly curved or mounted at an angle.

**Edged tools**—The edged tools in general require a higher degree of skill than is usually available for pruning work. The use of edged tools results in heavy damage to trees; often large strips of bark are sliced off. Edged tools are not only injurious to trees, but are also quite dangerous to use, especially above the ground.

**Shears**—Shears have been found to be very unsatisfactory to use in pruning. Stubs are often left, necessitating re-trimming of the stubs. Pole models are especially unsatisfactory as the work is often 100 per cent bad. Time of pruning is higher for this tool than most other ones, and it also results in fatigue of the workers.

**Mace or Club**—In some types of stands it has been found satisfactory to knock the limbs off with a club or pole ax used as a mace. Just the small, lower, dead limbs are suited for this method of removing the limbs. Quite often stub holes are formed when limbs are knocked off. The effect of stub holes on future lumber is not known at present. Some authors believe that pitch pockets and decay might result, while other observers believe that the hole will be healed over in a short time.
Power tools—Very little pruning has been done with power driven tools, partly because of the cost and the cumbersomeness of a power operated tool. The Forest Products Laboratory has developed a light weight, power-driven pole saw that promises to be quite practical for pruning. It is claimed that this tool makes smooth cuts and is quite rapid, thus reducing pruning costs. Another advantage claimed for this saw is that it may be used for other stand improvement work. If this saw lives up to its advantages it may be used a lot more in the future.

Crew Procedure

A definite procedure must be followed in order to cover the area in the most desirable manner. Probably the best method would be to divide the crews into units, each unit working side by side but independent of each other. The units would then work across the area in strips until all the area is covered. Each unit or sub-crew would consist of a head man equipped with a hand saw, and two or three follow-up men equipped with pole saws of varying length handles. The first man would trim off the lower limbs, then the next man would trim off the next portion of the bole, while the men with the long handled saws would finish pruning to the desirable height. Also it might be desirable to have one or two clean-up men whose duty would be to cut trees to be removed, lop and pile brush.

The above method readily lends itself to close supervision by straw bosses and foreman, which is quite essential if uniform and satisfactory work is to be obtained. Care must
be taken to keep the men working far enough apart to insure safety against accidents.

Marking of trees before pruning is often desirable, especially where inexperienced men are used. A satisfactory method of marking is to paint or whitewash a band around each crop tree. The cost of this is not high, and it insures against wasting of time on undesirable trees. Where experienced men are available, and they select the tree to prune, the remainder of the crew follows up and finishes pruning the trees selected.

The type of men to select for pruning is an important item to consider as the final cost and the quality of the work depend upon it. Mollenhauer \(^3\) states that the best pruners appear to be under 160 pounds in weight, under 40 years of age, of slender build, and unafraid of working above ground. Local help when interested in the project do satisfactory work, for they seem to take a greater pride in what happens to the forest.

**Slash Disposal** (Pruning slash and thinnings)

The disposal of slash will vary as to the forest practice in the locality and the probable cost. Methods of slash disposal will vary from piling and burning to lopping and scattering. A very satisfactory method, as reported upon \(^{11}\) by Pearson has been used in the Southwest Ponderosa pine stands. This method applies only to trees that would be thinned out. A solution of sodium arsenite is introduced into holes bored in the trunk kills the tree quickly and effectively. The cost of the chemicals and their application is
much less than the labor cost when felling is employed. Advantages claimed for this method are: Beetle infestation is eliminated, elimination of damage resulting from felling trees into reproduction, and protection against snow breakage by the dead standing trees. In some regions it may be necessary to fall the taller trees as a protection against lightning.

**Time and Cost of Pruning.**

**Time**—The time required for pruning varies considerably. Such factors as, composition and type of stand, type of men used, methods used, and kind of tools used must all be taken into consideration. Thus the time required on one pruning operation may not apply to a different project.

Table I presents data on the average pruning time per acre in man days, the average pruning time per tree, per linear foot of trunk and per limb based on all trees actually pruned.

**Table I—Average pruning time per acre, per tree, per linear foot of trunk, and per limb, on basis of all trees actually pruned.**

<table>
<thead>
<tr>
<th>Localit</th>
<th>Density of stand</th>
<th>Man days per acre</th>
<th>Min. Ave. Linear Foot Pruned per Tree</th>
<th>Ave. No. of Limbs Pruned per Minute</th>
<th>Ave. Diameter of Pruned Limbs Inches</th>
<th>Basis Plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Open</td>
<td>3.41</td>
<td>8.4</td>
<td>1.59</td>
<td>4.1</td>
<td>1.00</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Dense</td>
<td>3.98</td>
<td>2.8</td>
<td>6.22</td>
<td>14.5</td>
<td>0.59</td>
</tr>
</tbody>
</table>

1. Pruning study on Lolo National Forest in western Mont.
According to this table pruning required about 3.41 man days per acre on Unit 1 and 3.98 man days on Unit 2. On Unit 1 it required one hour to prune 7 trees (one tree every 8.4 minutes) and one minute to cut off 4.1 limbs, whereas on Unit 2 it was possible in one hour to prune 21 trees (one tree every 2.8 minutes) and in one minute to cut off as many as 14.5 limbs. Furthermore, only 1.59 linear feet could be pruned per minute on Unit 1 as against 6.22 linear feet per minute on Unit 2.

The much faster rate of pruning on Unit 2 was in all cases due chiefly to the fact that the limbs averaged only about half the size of those on Unit 1. In this connection, the study by Cline and Fletcher (1) on New England white pine showed the following figures in relation of limb size to rate of pruning.

<table>
<thead>
<tr>
<th>Size of Limb</th>
<th>Time Required</th>
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<tbody>
<tr>
<td>1/2 inch</td>
<td>1 second</td>
</tr>
<tr>
<td>1 inch</td>
<td>1 1/2 seconds</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>2 1/2 seconds</td>
</tr>
<tr>
<td>1 inch</td>
<td>3 1/2 seconds</td>
</tr>
<tr>
<td>1 1/2 inches</td>
<td>5 1/2 seconds</td>
</tr>
<tr>
<td>2 inches</td>
<td>8 seconds</td>
</tr>
</tbody>
</table>

Thus where trees average large in size, and consequently have large limbs, the rate of pruning is slow and costly, even though there may be but comparatively few trees per acre.
**Cost**—The cost of pruning varies from region to region depending upon type of stand, amount of work done on the stand, and kind of labor used. Figures are conflicting, thus more work needs to be done on getting accurate cost records for each region. Moon and Brown recommend the expenditure of $2 to $3 per acre in pruning 100 of the best trees, and state that in the United States pruning may be done for 3¢ to 4¢ per tree where only the lower limbs have been taken off. The author has found that it costs from 2¢ to 5¢ per tree when pruned to a height of 17 feet. The cost per acre varied from $4 to $10 depending upon the type of stand and the number of trees pruned per acre. Pearson states that an allowance of $7 per acre is a liberal amount to prune the average run of fully stocked stands. From the above figures it may be assumed that the average cost of pruning is about 33¢ per tree or $7 per acre.

Quite often the cost of pruning may be considerably reduced by the sale of thinnings and other improvement cuttings. In white pine stands in the East, there is often a demand for all the small material removed. Similarly in the West, there may be demand for this small material for corral poles, fence posts, etc. Thus the actual cost of pruning may be considerably lowered by this increased revenue.

1. Pruning study of Lolo Forest in Western Mont.
RESULTANT EFFECTS OF PRUNING

Pruning defects

Defects that may occur from pruning are largely the result of poor workmanship. In many cases very few, if any defects will occur, while in other instances there may be many defects. Thus, this is largely a controlled factor, depending upon the quality of work done. Defects that may occur are described below:

Pitch pockets are not usually of serious nature, but they may result in lowering the quantity and quality of lumber that may ultimately be cut out from the log. Pitch accumulations result from irregular and uneven wound surfaces, especially when large green branches are cut. Trees that are pruned late in the season may exude more pitch and resin than trees pruned early in the season, thus when the annual growth rings cover up the wound this pitch accumulation is covered up forming a pocket of pitch.

Incorporation of bark is not a very serious defect of pruning, and only occurs as a result of irregular and uneven wound surfaces.

Stripped bark is sometimes a serious defect as large strips of bark may be torn off the tree trunk, thus permitting the entrance of decay organisms. Also a large wound results which may take many years to properly heal over. Stripped bark is more likely to occur when using a pole saw than from any of the other methods. Simmons (5) reports on a method of reducing stripped bark. The method consists of letting the partly sawed limb fall; invariably it will crack
at the point at which it has been sawed, leaving a stub attached to the tree from which the partly severed limb hung. With a few swift strokes of the saw the stub may be sawed off and the limb will drop free without tearing the bark.

Branch stubs are a serious defect of pruned trees, for not only is the amount of clear lumber reduced considerably, but also the grade of lumber is reduced. Branch stubs may permit rot to enter into the tree, due to the long time it takes to cover up the stubs. Pitch and bark pockets may also result from branch stubs. Under good pruning practices branch stubs are entirely eliminated, thus a serious defect of pruning is eliminated.

Decay is sometimes found in pruned trees, and may even prove to be of considerable damage in some sections of the country. This is most likely to happen under conditions where decay organisms are abundant (unsanitary forest conditions), climate is favorable, and careless pruning is done. Probably the most important factor in relation to the entrance of fungi into pruned trees, is the length of time it takes the annual growth rings to cover up the pruning wounds.  

Studies made on stands of northern white pine and red pine indicate that decay found did not enter the tree as a result of pruning. "The indications are that all knots showing decay were from branches that were dead prior to pruning. Even when pruned knots themselves contained decay, no case was found where it had spread from the knots into the

Figure 5.--Good and bad pruning practices:
A, Branches were cut close to the trunk;
B, protruding stubs left.
trunk of the tree". Cline and Fletcher state that the greatest danger of the entrance of decay into the tree from pruning wounds is in the removal of large green branches in which the heartwood is comparatively dry, but that in the case of small branches, whether living or dead, there is little danger of infection.

Sunscald may result from opening the stand up. In many pruning operations a thinning is also carried on, thus opening the stand up, sometimes too much. Sunscald is more likely to occur on smooth, thin bark trees. The actual damage results from overheating and drying out of the inner bark and cambium layer of the exposed trees. Sunscald usually does little damage to forest trees, but a similar injury termed winter sunscald is caused by a combination of high and low temperatures during the late winter or early spring, will cause considerable damage during abnormal years. The injury results from alternate freezing and thawing of the living bark tissue and cambium causing the formation of cankers. Probably, restricting the amount of thinning done will be the best method of control over sunscald.

Time required for growing over of pruned branches:

The time required for the cut surface of a pruned branch to grow over depends upon several factors outside of the branch itself. To be sure, small branches if cut close to the trunk will grow over more quickly than large ones. In branches of any size projecting stubs delay the covering over of the cut end of the branch. The trunk must increase in
size until the stub is surrounded before growth layers will begin to grow across the cut face.

Factors which influence the time required for healing of pruning wounds for a knot of a given size are: rate of diameter increase, the closeness and smoothness of the cut, and the season of the year that the pruning is done. (13)

Anderson found in Douglas Fir that wounds from living branches one-half to three-fourths inch in diameter pruned close to the trunk of the tree in February healed before autumn of the same year, but the branches pruned in later months did not heal so rapidly. Anderson further states that experiments show that in pruning dead branches, more rapid healing will result if the cut is made close enough to the trunk of the tree to wound the living cambium at the branch node in order to stimulate the immediate healing over of the wound. In applying this principle to the removal of living branches the cut must be made well into the collar at the base of the branch so that no projecting stub will be left to delay healing over of the cut surface. (2)

Hawley and Clapp report that 10 years or more, depending upon size, are required to heal over pruned branch stubs in a plantation of northern white pine spaced 6 by 6 feet. With wider spacing of the trees or by thinning the stand at the time of pruning or before, it appears that the progress of healing might have been accelerated.

Effect on the rest of the stand.

Pruning will not only effect the trees which are subjected to treatment, but will allow more light to reach
trees in the lower crown classes, thus exerting a strong influence on the rest of the stand. In giving these minor trees a chance to increase their growth, the soil and air will be utilized more closely, because their roots and crowns are active in other strata than those occupied by the root and branch systems of the dominant trees.

Value in pruning.

Improved quality of lumber is the primary value in pruning. This value results from the increase in amount of clear lumber produced from the butt log. As the butt log contains a large percentage (about one-third) of the tree's volume, a fair amount of clear material is produced, upon the length of rotation and the size of tree at time of pruning. A log 16 inches at small end containing a 6 inch knotty core, when sawed around will yield at least 75% clear boards and not more than 25% knotty.

As clear lumber commands a higher price on the market, the lumberman will increase his profits by cutting pruned trees. The spread in price between clear and common grades of lumber varies considerably from time to time, depending upon supply and demand. Roughly the lower clear grades of softwoods have a market value from 30 to 60% greater than that of the upper common grade. Undoubtedly, for a long time in the future, if not indefinitely, the demand for clear grades of lumber will continue.

A study of the benefits that may be realized from pruning crop trees in their youth was made in 1936 by
Figure 9.--Illustrating the wide clear boards that may be sawed from pruned trees. This is a butt log from a red pine pruned years ago.
Lang. Logs of different grades were followed through the mill and their product classified into lumber grades. Only butt logs were considered because pruning does not ordinarily extend above the first log length. In this instance, butt logs constituted 50 per cent of the total volume. Comparing "surface-clear" logs, or those which have no visible knots or branches, with the general run of butt logs, the contents of the former were found to have an f. o. b. - mill value of $32.90 per thousand board feet as against $24.13 for the latter. Assuming a cut of 8,000 board feet per acre, the total crop would have been worth $35.08 more per acre if all butt fogs had been "surface-clear" grade. Since the pruning of crop trees ordinarily costs about $5 per acre, this would seem to be a paying operation. Moreover, artificial pruning when the trees are small will produce a much higher per cent of clear lumber than natural pruning which in most forests is delayed until the trees are relatively large.

Supplementary value in pruning.

Reduction of fire danger may be accomplished by pruning. Many stands that have been impenetrable thickets constituting a bad fire danger have been cleaned up by a pruning operation so the fire danger has been greatly reduced. To a large degree, removal of the lower limbs of a tree, will prevent ground fires from crowning. By carrying on a thinning operation along with the pruning, dense thickets have been

cleaned up so fire will not spread so rapidly. Besides actually reducing the spread of fire through a stand, pruning puts the stand in a more open condition so fire-fighters may move around more readily.

**Improved grazing value** should be a valuable item in some regions, especially in the western states. By pruning and thinning, a stand may be opened up enough to allow sufficient sunlight to filter through the trees so as to permit a better growth of forage plants. Besides increasing the amount of forage, pruning will make it possible for stock to move more freely through the forest. Ponderosa pine stands are probably the best suited to permit this auxiliary use of the forest.

**Improvement of aesthetic beauty** will probably be of more importance in the future than at the present time. With outdoor recreation on the upswing, people will probably demand "beautification" of many forest stands. Pruning will put the forests in a condition whereby this demand is satisfied. Readily accessible stands (near highways and towns) will in all probability be improved from the aesthetic viewpoint, and as these stands are the best suited for timber growing, pruning would serve a dual purpose.

**SUMMARY**

**Conclusions and Recommendations.**

The purpose of this study is to present a complete picture of the possibilities of pruning as a sound silvi-cultural policy in our second-growth forests. Rather than present detailed data on one or several phases of pruning,
this discussion has dealt with all the phases of pruning so as to give the reader a broad view of the subject.

Before pruning should be practiced several questions must be answered.

1. How many trees to prune?
2. What type of trees to prune?
3. How high up the trunk to prune?
4. What will it cost per tree or per acre under specific conditions.
5. And above all, will it pay?

Generally speaking, the following recommendations should answer the above questions, but in some cases it may be necessary to make a special pruning study.

1. Natural pruning should not be relied upon, with the possible exception of some of the Southern Pines when grown upon fairly long rotations.
2. To limit the size of the lower tree limbs, close spacing should be resorted to, but close spacing does not materially reduce the length of time the lower branches persist.
3. To facilitate the formation of clear wood, only thrifty trees should be pruned, also pruning must be carefully done.
4. Pruning should be done during the dormant season, just before spring growth starts. February to May is the most desirable time.
5. The best trees to select for pruning should be of the dominant and co-dominant crown class. Furthermore, these trees should have the best possible form and a rapid rate of growth.
6. Trees should not be over 8 inches in diameter when pruned. The most desirable size of tree will be around 4 to 5 inches in diameter.

7. The number of trees to prune per acre will vary from 100 to not over 400, depending upon species, market conditions, etc. Stand tables and length of rotation will give a good indication of how many trees to prune per acre.

8. Usually, pruning should not extend above the height of the first log or 17 feet.

9. Ordinarily 3 to 4 tenths of the living crown will be removed. In no case should over 50% of the green crown be removed as the height growth may be seriously reduced.

10. For the average stand, hand saws and pole saws will be the most efficient tools to use. Single-edged, pull stroke saws are preferable for most pruning operations.

11. To secure uniform and satisfactory work, the crew procedure used should lend itself to close supervision by strawbosses and foremen.

12. Individual workers should be far enough apart so as to prevent accidents, which may happen when men are working too close together.

13. Slash should be disposed of in the best manner possible. Probably, piling and burning to lopping and scattering will be the best methods of slash disposal.

14. Cost of pruning should be around 3½ to 4½ per tree, or about $5 to $7 per acre. The amount of money that can be safely spent in pruning will depend upon the value of the final products.
15. Pruning should always be carefully done so there will be few resulting defects; such as, branch stubs, pitch pockets, stripped bark, etc.

16. The rapidity of healing of pruning scars depends a lot upon the care exercised in pruning. Usually it takes from 1 to 10 years to heal over pruning scars.

17. Pruned trees should yield a high percentage of clear material. A 16" log with a 6" knotty core will yield about 75% clear lumber and not more than 25% knotty.

18. To make pruning a paying proposition, the market value of clear lumber should be higher than knotty or common lumber.

19. Supplementary values of pruning; such as, reduction of fire danger, improved grazing, and improving the esthetic beauty of the forests should also be considered when pruning is done.
Literature Cited

1. Cline, A. C. and Fletcher, E. D. 1928. Pruning for Profit as Applied to Eastern White Pine. 23 pp., illus., Boston.


9. Schenstrom, S. R.
   1931. Pruning Experiments in Second-Growth Douglas
   Fir. For. Chronicle, December.

10. Paul, Benson H.
   563-566.

11. Pearson, G. A.
   1935. Timber Stand Improvement Work in the Southwest.

12. Moon, F. F., and Brown, N. C.

13. Anderson, R. T.
   1937. Pruning of Green Branches of Conifers.

14. Hicock, H. W.
   1931. Pruning in Young Plantations.

15. Bull, Henry
   1937. Tools and Labor Requirements for Pruning

Note: Illustrations were taken from U. S. D. A. F. S.,