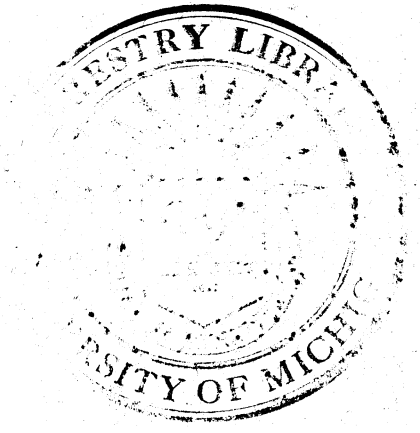
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WESTERN YELLOW PINE

Pinus Ponderosa

by

Henry C. Hulett

Respectfully submitted for Masters Degree credit in the School of Forestry and Conservation of the University of Michigan.

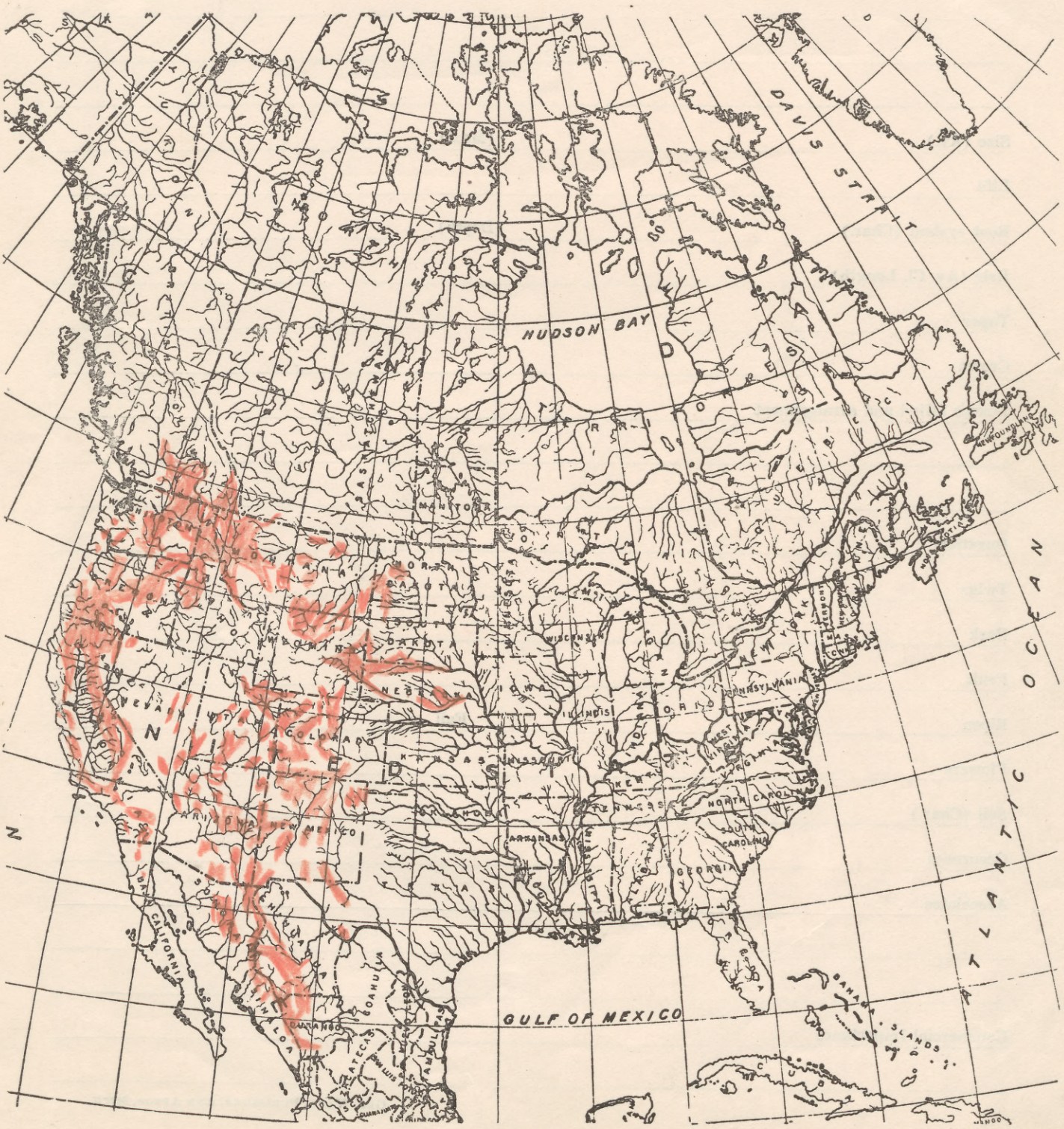
January 1929

Range (Altitudinal limits)

Optimum region

References

Geographical Distribution of *Pinus Ponderosa.*



3m-3,'25

OUTLINE FOR DENDROLOGICAL DESCRIPTION

Botanical Name Syn.

Common Name Syn.

Family

Distinguishing Characteristics

Size (Av.) (Max.)

Life

Root system (Char.) (Depth)

Bole (Av. Cl. Length)

Taper

Crown

Leaves (Kind and arrangement

Duration

Twigs

Bark

Fruit

Ripen Fall

Flowers

Soil (Char.)

Occurence

Associates

Commercial Importance

GEO. WAHR, PUBLISHER, ANN ARBOR, MICH.

Outline

REPORT ON WESTERN YELLOW PINE

Pinus Ponderosa

A. Introduction

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C. Factors influencing natural reproduction

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      a. Germination
      b. Seedbed requirements

   2. Climate
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   4. Logging practice and results
   5. Grazing
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D. Methods of marking and cutting to secure best conditions for natural reproduction

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E. Summary and conclusions

F. Literature cited.

PINUS PONDEROSA (Laws)

Western Yellow Pine is known throughout its range as pine or yellow pine, and in the lumber trade of the northwest as western pine. It has been called western soft pine and occasionally as Oregon white pine and California white pine.

It is the most widely distributed pine in the United States and one of the most valuable. It has a large variety of uses both locally and in the distant markets of the middle west and east, practically filling the lumber demand for the local needs. Its large size, good form, and easily accessible bodies, and the high technical qualities of its wood place it near the top of the list of commercially important American timber trees. (10)

Western yellow pine occurs naturally from southern British Columbia to Lower California and northern Mexico, and from the Pacific coast nearly as far east as to the one-hundredth meridian. It is found in the forests of every state west of the Great Plains, and in more than half of them it is the most important and valuable forest tree. In Arizona and New Mexico there is a western yellow pine forest which is said to be the largest continuous body of timber in the country.

Of the twelve states in which western yellow pine occurs, California has the largest area of forests composed chiefly of this species, and Oregon is second. Together these two states contain nearly 50% of the area

of commercial yellow pine forests, and probably as large a proportion of the merchantable timber.

Western yellow pine is a large, well formed timber tree. (9) In old trees the bole is usually straight and full-formed. It is well cleared of dead branches, but usually clothed with live branches for from one-half to two-thirds its height. The maximum diameter is eight feet and the maximum height 220 feet. The usual size at maturity is about 3½ feet in diameter and 110 feet in height.

The bark of the trunk in young trees is dark gray-brown, roughly furrowed, in old trees it is tan colored (or "yellow"), is broken with rather large irregular plates. The crown is at first bluntly conical, but, as the tree matures, it becomes more flat topped and bushy; and the upper branches are heavy and gnarled. The root system of mature trees consists of extensive, deep branching laterals which give the tree firm support. The foliage is not extremely heavy, and varies with the site, being extremely poor on poorer sites. Yellow pine does not cast a dense shade, and it cannot reproduce under a dense shade, therefore it is very intolerant.

(a) The forest characteristics of this tree vary decidedly in different parts of its range. The yellow pine stands of the Black Hills are quite unlike those of the Oregon Plateau or of the Sierra Mountains of California. (10)

Picture of Average Western Yellow Pine



Forest Types

Found in Western Yellow Pine Range

1. Western Yellow Pine. Consisting of stands in which the species forms 80% of the volume. Usually found in the lower portions of the timber belt, particularly in the south and west slopes in steep country and the well drained flats of the level country. As a rule it is in mixed age classes ranging all the way from seedlings to over mature trees. It is known to exist in even age classes in some of the cut-over lands in California and occasionally thru-out its range. When found in this stage it is divided into four types, as follows:

Y-4 type — Mature and over mature trees
Bark yellow & flat, tops round and flat.

Y-3 type — Thrifty, growing trees over 12 inches D. B. H. bark dark and furrowed, crowns full and pointed.

Y-2 type Thrifty young trees ranging from 4 to 12 inches D. B. H.

Y-1 type Seedling and thrifty trees under four inches D. B. H.

2. Western Yellow Pine - Sugar Pine, Mixed conifers. Consisting of mixed pines and firs with pines predominating, and sugar pine making up 60% of pine volume. Incense cedar is a secondary species. Found principally in north half of California and extending into the lower Cascade range of Oregon. This is a mature type.

3. White Fir - West Larch - Douglas Fir. Consisting of greater percent volume in above named with occasional small percentages of western yellow pine and sugar pine. This constitutes a wide range of the inferior species, especially the true firs, besides the one mentioned. The type is found both in mixed and even age stands on east and north slopes, in bottom of draws, and on poorly drained areas. It is divided into age types similar to those of the western yellow pine.

WLD was original abbreviation, it is now known as FL

FL-3 type Mature timber over twelve inches D. B. H. Bark is furrowed and rough.

FL-2 type Immature timber four inch and up. The bark is smooth and light in color. Trees are healthy and vigorous in appearance.

FL-1 type Seedlings from smallest to four inches D.B.H.

Other types either too small in area, or not of commercial importance to consider, are pure douglas fir types, lodgepole pine, subalpine, juniper, mountain mahogany, and digger pine -- oak types. These are all the

timber types, but the range includes brush, chaparrel, sage brush, grassland, and barren types, thus indicating the open nature of the western yellow pine range.

Natural Reproduction

1. Germination
2. Seed bed requirements

Seed Supply

Western yellow pine after reaching middle age produces seed fairly abundantly. The older and more mature trees bear more seed than the blackjacks, because of their greater height which gives them better exposure to sunlight. This greater seed supply is counter-balanced by the blackjack in that the younger trees produce seeds of a higher germination quality. However it takes from four to six blackjacks above eleven inches D.B.H., as they usually occur in groups, are required to produce as much seed as a single western yellow pine. Thus western yellow pine has a seed producing value about five times as great as that of blackjacks.

In an average seed year from 90% to 99% will be lost either through failure to germinate or through infant mortality. Mr. G.A. Pearson stated in his bulletin, U.S. D.A. 1105 (12) that in some reproduction plots they had under observation, showed, not more than one out of 1000 seeds germinated and lived to be more than five years old. However in a good seed year this figure will be from 1% to 5%. Mr. Perry in the Journal of Forestry, Oct. 1921 (11), states that too heavy a cutting robs the soil of shelter and it immediately bakes and dries up to such an extent that seeds never have a chance to bury themselves and germinate. He also claims that the greatest protection can be obtained when seed trees are evenly spaced. (Note -- These two articles are about conditions in Arizona.)

The minimum seed supply, therefore, should be the amount required to stock an area completely in one year under favor-

able climatic conditions. G.A. Pearsons says that about 8 lbs. per acre is a fair figure to base our conclusions on.

S.B. Show in his U.S.D.A. Bulletin 1402 (15) on California conditions says that seed of western yellow pine must come from the seed trees for it is not stored in the doff as are douglas fir and white pine seeds.

The number of seed trees required therefore to supply the necessary seed to reproduce the area would be as follows: noting first that in virgin stands where diseased and defective and over-mature trees are found, it is fair to say that they produce seed somewhat in proportion to their active crown area, and that the seed is not of appreciably inferior viability.(12)

Other things being equal, the capacity of a tree to produce seed is determined by effective leaf surface, and that anything which tends to reduce the size of the crown, or its efficiency as a food laboratory ultimately reduces the quantity but not appreciably the quality of seed.

As before mentioned the older and larger pines produce more seed than the smaller younger pines at a ratio of about five to one. Thus three to four western yellow pine trees or about sixteen blackjacks,over 11 inches in D.B.H. would be required per acre for adequate seed supply.

One exception to this might be in cut over lands, and here the immature trees may improve under the influences of increased light and moisture. However preference should be given those trees having the best past records, as recorded by cones in the tree or on the ground.

In close observation of cut over lands in Arizona G.A. Pearson found that young trees left after cutting did respond to the effects of increased light and root space, but increased seed production apparently does not take place until about five years have elapsed.

Repeated observations have shown that enormous numbers of cones die during the first season due to hot, dry winds which sweep the Arizona region during May and June. Thus causing the drying up of the pollen, stating that in the cones which reach maturity not over 1% of the ovules develop into perfect seed.

In Oregon the seed supply is not so reduced in the cone stage as it is after the seeds have fallen and have germinated. Here according to Mr. T.T. Munger, is where the great mortality takes place. In the early summer the forest floor is often thickly covered with freshly sprouted seedlings. One can return to the same area a year later and hardly find a seedling. The death rate on sixty-seven small sample plots, laid out on the Deschutes National Forest following an extremely heavy seed year with an over fully stocked seedling catch, showed after one year to be 79%. The author visited similar sample plots in 1927 laid out on the Wallowa National Forest and their mortality was 100%.

Natural Reproduction

Climate

Conditions as above cited (Page 9) do not exist, however, over the whole western yellow pine belt. In the Blue Mountains the reproduction of western yellow pine is very abundant, both in the virgin forest and after cuttings. Climate and soil conditions I believe are responsible for these conditions. The soil is a rich sandy loam, while on the other pine regions where reproduction is hard to establish the soil is shallow, rocky, sandy, or of volcanic nature.

Western yellow pine flourishes best in the heat and dryness of a continental climate such as that on the interior plateaus and mountain slopes. However it is found growing under opposite conditions such as exist on the Pacific coast.

From studies made of various elements and factors affecting western yellow pine reproduction , moisture is the most dominant physical factor. (12)

Climate is responsible for winter killing, frost heaving, drought, and temperature. Winter killing is generally associated with a deficiency of snow. There should be two to three feet of snow to protect the seedlings, by preventing soil from freezing, and also prevent transpiration during winter when plants are unable to produce. Frost heaving usually occurs during the spring and fall and is the constant thawing and freezing of the ground which raises the plants out. A drought period following germination also takes its toll, even if it occurs the second year after germination. Along with this

we generally have a high temperature and the two together will cause 100% mortality, as is found on the Wallowa National Forest.

Ideal climate for germination would be a warm temperature and plenty of rainfall during May and early June.

Mr. Perry (11) states that in Arizona the long dry seasons and severe frosts are typical of Arizona.

Natural Reproduction

Soil

Western yellow pine grows and thrives on nearly every variety of soil within its range. Each region of different soil texture will show a different growth and volume per acre. Some of the outstanding characteristics of the species is its ability to get a foothold in the disintegrating recent lava flows of central Oregon, and also its ability to grow and reproduce on almost soil-less steep slopes. It seems to prefer well-drained, loose soils; however an increase in moisture, providing the soil is well drained, makes an increase in rate of growth.

G.A. Pearsen (13) states that in Arizona and New Mexico indications are that western yellow pine reproduction is uniformly better on the coarser,sandy, gravel or stoney soils than on the finer soils, regardless of geologic origin. This seems to hold out for most of the western yellow pine regions,except possibly the Blue Mountain region where the reproduction problem is negligible and the soil is a sandy clay loam.

Mr. Pearson (13) also states that often soils on which seedlings are most numerous are too shallow or too stony to support a good stand of timber, where as the deepest and most fertile soils, which produce the heaviest stands, once they are well stocked, are often stocked below their capacity because they are unfavorable to the establishment of seedlings. Competition for water from the older trees would be one cause for this. Then, best soils produce heavy grass cover, which would be a hinderance to establishing reproduction.

Sample plots taken by J.O. Veatch of the U.S. Bureau of Soils, explain the conditions found in Arizona and New Mexico.

Soil	Seedlings per Acre
Rock outcrops	367
Very stony clay	493
Stony clay	237
Gravelly clay	137
Shallow clay	64
Deep clay	36

In the Blue Mountain region reproduction has known to run as high as 14,000 to the acre which would of course be stagnated and stunted trees. 1280 is the number of seedlings required for a fully stocked acre of seedlings for this region. This number is not hard to obtain, yet it seems relatively high as compared to the average number expected on the greatest producing soils in the southern regions of the western yellow pine.

There are certain soil relations with moisture in that sandy soils, though having a lower water holding capacity than clay soils, are able to deliver moisture to plant roots in drought periods, when none can be secured from the clay soils. It is known that pines do better in sandy than in clay soils. Reasons for this are that sandy soils permit deeper root penetration, absorb rainfall more readily, and as stated above, furnish a greater proportion of the moisture to the plant roots in droughts, than clay soils.

Rocks help in that they check run-off, and they also act as a mulch against evaporation. Thus this partly

explains why reproduction is more abundant on rocky and stoney soils than on any other.

Haasis in 1919 and 1920 made on root development examination in stock from one to five years of age, and exploded the theory as stated above that sandy soils allow deeper root penetration. He found the shallowest penetration in the gravelly and loamy soils, the deepest in fine clay soils, and intermediate penetration in the stoney clay soils. Lateral development was least in the fine clay soils, greatest in gravelly soils or cinders, such as the Deschutes and crater country in Oregon, and intermediate in stoney clay. He formulated the general rule that the more compact the soil the deeper and less branching the root, and the looser the soil the shallower and more branching the root.

Natural Reproduction

Logging Practices & Results

Western yellow pine logging is usually done with horses, various methods being used according to the density of the timber, the topography and the length of the haul. Practically every western yellow pine region has different methods of logging, but it is safe to say that horse logging is uniform throughout. One can find, these various methods used both in private and government holdings; horse logging with big wheels , bummers, wagons and spool carts. Power logging with tractors and big wheels, tractor yarders, donkeys as ground-lead, high-lead, and skidder types.

The damage to seedlings is negligible with all forms of horse logging. The greatest loss in in the large seedling and small poles which have to be swamped out around the trees to reduce friction so that horse power can handle the logs. Also the big wheels require wide roads, and where the reproduction is heavy then it is necessary to clear right of ways.

It has been proven, on the Deschutes Forest of Oregon, that it is possible to reduce the damage by use of other methods for logging. Results in California show that 80% of the reproduction survived horse and big wheel logging. Few main roads help to keep down the damage. The method has its defects in that brush, if piled before logging and during swamping so as to get it out of the way, if left on the reproduction, and when burned in this way it destroys considerable reproduction.

In the power logging the tractor logging closely represents that of horse logging. It has many advantages

over horses in that it is capable of working under rougher conditions and has more power. It is used usually with big wheels except on slopes around 45% where tractors are used alone. With one exception the tractor and big wheels have proven less damaging to reproduction than any other form of power logging (19). This one exception is in central Oregon on the Deschutes National Forest. Here the soil is of cinder, pumice and volcanic ash type and the tractors dig up every inch of space they travel over.

Figures showing the comparison of damage on two ten acre sample plots give the only disfavorable comparison of the tractor and other power logging devices, as far as damage to reproduction enters in to the subject.

The advantages of the tractor power for logging over other power methods are:

1. Reduced amount of railroad construction,
2. Lower yarding cost,
3. Flexibility of operation in open and scattered forests such as western yellow pine,
4. Very low fire danger,
5. Small amount of labor required for operation.

The percent of damage on the California pine regions show that 20% is caused by roads and 10% of the damage is off the main roads, or 70% of the reproduction survived this type of logging, as compared to 80% survival when horses were used. (15)

Within the last few years another form of tractor logging has been tried out. It is known as a yarding tractor logger. Its purpose is to reduce the number of tractor main roads, by yarding logs to one central road from a distance of 200 to 300 feet each side of the main road. Then the tractor and big wheels will not have to go over the whole area to pick up logs, but just along the

main roads. On the Deschutes National Forest in Oregon where this was tried out it showed less damage to reproduction by % to %.

In the Arizona pine regions the ground lead logging did the least damage of the high speed logging engines. Here where great care was taken the survival of reproduction could be advanced to 64% (21). In the high lead logging with the tail block 100 to 125 feet off the ground the survival was only 25%. Such conditions as this could not possibly be allowed.

Modifications of these forms were worked out by the Forest Service and tried both in the California and Oregon regions. The tractor logging was used as an alternative. In California the tractor did less damage to the reproduction than high-lead logging, when that method had been modified and tail block was lowered to 35 ft. off the ground and slow speed engines were used. In Oregon, however, the reverse was found to be true, and the high-lead did less damage than the tractors.

The reason for the reverses in results on the different sample plots in the different regions can probably be laid to the soil texture, supervision, and interests shown by operators. I can sight a case on the Wallows National Forest in Oregon where the high-lead was a total failure just because the operators were not careful and as a result, the power machine has never been allowed back onto the forest.

For recommendations I would suggest that horse logging be used as long as it is feasible and when other means are

needed that tractors be the next step and only using the power logging machines as a final resort for getting logs out of the woods. This plan should work very well for practically all the western yellow pine regions are best suited for horse logging.



Tractor Damage On Deschutes National Forest

Natural Reproduction

Grazing

Herbaceous vegetation of all kinds, especially weed-like plants, spring up quickly after trees are removed. Within five years if their growth is not interfered with, they develop a cover which is much denser than a normal grass cover. When this condition is reached the soil moisture becomes more exhausted than before the trees were cut.(8)

If the pine seedlings can secure a start before the vegetation growth becomes too dense, or if the latter is held in check by proper grazing, then the seedlings will do better on cut over land than they do on land where no trees have existed before. Without proper grazing, chances of seedlings getting started are reduced by possibilities, of poor seed year over a number of years and poor germination due to weather or seed bed conditions.

If stock is permitted to graze, such as cattle, horses and sheep, the chance for pine seedlings living is much greater provided that they too, are not devoured, as is the case on improperly grazed sheep range.

In Arizona W. J. Perry (11) says that land should be heavily grazed by cattle preceding the cuttings so as to reduce the heavy stand of bunch grass which is detrimental to the seedlings. Cattle grazing, after cuttings have been made, is not detrimental when not over-grazed. Sheep are detrimental for they eat the seedlings even when plenty of other food is handy.

G. A. Pearson (12) also refers to Arizona conditions and says that in his extensive observations and those made

by others warrant the statement, that wherever an area is well provided with seed trees and it has been adequately protected against sheep grazing and fire for ten years or more, reproduction is making substantial progress.

The persistent failure of cut-over lands to restock has been due not to the method of cutting but to the disregard of other silvicultural requirements, principally control of ground cover and protection against sheep.

On many of the pine forests of Oregon grazing ranks above timber when figured on the basis of income. This is only true however on forest where timber cutting has hardly started. The form of grazing in the past has been nearly all cattle and horses. Due to the cattle market being very unstaple, many of the former range cattle runners have substituted sheep. With sheep they have less investment per head, and two means of income, from wool and meat. From my observations it seems that sheep are taking over the country, and that such a policy does not profit from the experiences that are carried to us from the Arizona district, where sheep grazing has done much to destroy reproduction.

It is now in the experimental stage and the Forest Service believes that if careful management is given that form of grazing, so as not to over-graze any areas, that it can be carried on successfully. The present problem is, should the area be used for cattle or sheep grazing. The future question maybe, shall the area be used for wood or wool growing.

Natural Reproduction

Fire and Importance of its Control

Fire is usually thought of as a destroying element, as to maintenance of our forests. Yet it can be of a successful use in silvicultural practice. Fire when controlled can be used to release reproduction, control composition and prepare the ground for planting.

To show how light burning helps to releasing reproduction, an illustration taken from the records of a plot on the Snake Lake burning area; of Plumas National Forest, in California. (16)

Species	Number of seedlings to each 100 square feet		
	Litter Undisturbed	Litter removed by light burning	Percentage Increase
Western Yellow Pine	6	29	383
Sugar Pine	2	7	250
Douglas Fir	8	15	88
White Fir	19	34	79
Incense Cedar	25	37	48
Total	60	122	103

From the above table one would readily conceive the idea that light burning in western yellow pine forest is essential to insure the return of that species. It all depends on the degree of burning. First, we must realize that all burns will kill the present young reproduction, second that its hard to control the degree of heat in any broadcast burning. Third that to do light burning, that would be of any benefit, it would have to be done during fire season

when the litter would burn.

While in the light burns that occurred in California, and showed a good return for reproduction, as many light fires can be found in Oregon where reproduction has never come back satisfactory, where even seed trees have been left. This might be explained in that the burning was not of a light enough character.

Where reproduction is lacking altogether and the area is to be planted, then it seems that a light burning in the spring of the year would be feasible. Over an area of 2,000 acres in California brush fields where this was tried out the planting costs were reduced from $11.50 an acre to $7.08 an acre and the latter includes cost of light burning. The method used was to construct fire lines and burn from all sides toward the center of the area. This cost amounted to only 30¢ an acre. (16)

The damages caused by fires are the reason for importance of its control.

1. Site deterioration,
2. Destruction of young reproduction in seedling stage,
3. Degrade in lumber, due to fire scared butts,
4. Destroys merchantable timber by heat killing and burn down trees, especially those that have once been butt scared,
5. Paves the way for fungi and insect destruction of remaining trees,
6. Apt to change forest composition to an inferior species. Example would be that of lodgepole taking over fire burned areas in Oregon.

Natural Reproduction

Rodents, Insects and Disease

Western yellow pine rodents are grouped into two forms; one, seed-eating; two, bark gnawing. The prominent seed eating rodents are chipmunks, squirrels, mice, rats and birds. (12)

The chipmunks, mice and squirrels in a light seed season will consume the greater bulk of the crop. The activities of these pests are undoubtedly the greatest factor in accounting for the failure of broadcast sowing. This subject can also be discussed from another angle. Mr. T. T. Munger (10) in his U.S.D.A. Bul. 418 on Western Yellow Pine in Oregon, states that the chipmunk is one of our best seed sowers. On the Deschutes National Forest over various acre sample areas it was found that 85% of all one-year-old seedlings were in these chipmunk-sown groups. The reasons for better survival in the chipmunk-sown seed is that it is planted in soil, and is better able to withstand a drought period.

Birds are also known to pick up seeds, but since hard shelled seeds usually pass through the alimentary canal of birds without injury, the effect may be merely to transport the seed from one region to another. G. A. Pearson (12) sights one case in which birds have done some damage in regards to reproduction of pine, and that is the Junco bird (Junco dorsalis) has been known to pluck the seed coats and cotyledons from young seedlings and even cuts down the entire plant.

The bark gnawing rodents are the rabbits, gophers,

rats, squirrels, and procupines. The squirrels confine their activities mainly to cutting terminal twigs from the older trees. Rabbits gnaw the bark of the young seedlings and sapplings and often cut them down completely. The porcupines kill or seriously injure great numbers of seedlings from one to six feet high, and also do damage to larger trees, by partial or complete girdling. Areas have been found in the Arizona forests as large as 125 acres bearing on the average of 80 seedlings to the acre. Of this plantation 50% of the seedlings have been damaged by porcupines.

Next to fire insects are the most destructive enemies of western yellow pine. There are many insects, chiefly boring grubs, that work in dead or dying western yellow pine trees. However there are but three species important enough to interest the forester; one of them is a defoliator and the others are bark beetles. The defoliator is the pine butterfly (Neophasia menapia), a small white moth which, when in the caterpillar form (the caterpillars are black with green markings and are about 1½ inches long at maturity), feeds upon the needles of the pine. The worst known damage to date caused by this defoliator is in Yakima and Chelan Counties, Washington and here a considerable amount of the timber, both old and young, has been killed. Of the several bark beetles, the western pine destroyer (Dendroctonus brevicomis) and the mountain pine beetle (Dendroctonus monticolae) are the most dangerous in their destruction of the western yellow pine. These insects kill the trees by eating the soft inner bark and cambial layers, thereby girdling the tree. The mountain

pine beetle is by far the most dangerous enemy of the western yellow pine. It spreads infestation rapidly from acre to acre and has been known on the Wallowa National Forest to cover an area of 500,000 acres. It works more on the young trees where as the other dangerous pine beetle attacks mostly the older trees. (10)

W. H. Long has called attention to a twig disease caused by a fungus probably Cenangium abieties, which in certain localities, notably the Prescott National Forest, has injured western yellow pine saplings to a considerable extent.

Marking Methods

Cutting to Secure best Conditions for Restocking

In the data obtainable on cuttings in western yellow pine, the majority of authors described it as a selection system or a modified form of selection cutting. Mr. R. C. Hawley (7) defines the true system of selection method of cutting to be as follows; the oldest or largest trees in a stand are chosen for cutting, and remainder are left. After one or more years another cutting of the same character is made. The trees taken may occur singly or in small groups. The stand is never completely cut of its merchantable timber.

E. E. Carter (2) back, in 1908, in his article, on the silvicultural results of marking western yellow pine timber in the National forests, illustrates some of the changes that have taken place. He states that the first method of marking was by "Diameter Limit". This danger was soon discovered and corrected. Next marking plans were to leave all "blackjacks" regardless of size, as long as they were healthy. Where the "blackjacks" were lacking, then the thriftier mature trees were left. Leaving of these trees were for a seed catch and another logging cut between present seedlings and length of time required for them to grow up. The present system might be compared with the present German "shelterwood" system, except the return for the remaining trees is not as soon.

Due to the wide range of western yellow pine the writer feels that its marking policies should be discussed by regions. The belt of western yellow pine has been divided

into four separate regions. First, the southwest, Arizona and New Mexico; second, California pine regions; third, Oregon and Washington; four, the Black Hills. Each region will be treated separately.

Arizona & New Mexico. T. S. Woolsey Jr. (21) and G. A. Pearson (12) both treat the markings in this region on a parallel. Their final conclusions are nearly identical.

G. A. Pearson goes into great detail and explains the marking policies through a comparison of methods of cutting.

Group selection, scattered-seed tree and shelterwood are the feasible methods. The group selection has been the standard of the Forest Service in the southwest for the last twenty years. Even age tree groups are treated as individual trees. Here mature and over-mature trees are removed unless needed for seed protection or shelter; immature trees are left unless cut for improvement. His method removes 75% to 80% of the mature stand leaving 1,500 to 2,000 ft. to the acre in trees over eleven inches in diameter.

In the scattered seed-tree method, seed-trees are left at the rate of 3 to 4 to each acre. All trees are cut to an eleven inch diameter limit except those reserved for seed supply. Trees to be left are selected according to windfirmness, crown development and general vigor. It is a good policy to have the spacing as even as is possible.

The shelterwood method is really not a true shelterwood system, but more on the order of a group selection. It differs in that more trees and volume per acre are left per acre in the larger classes, about 6,000 to 7,000 feet per acre are left.

Table No. 1 shows the percent of survival one year, and one year three months old, in the different methods of cutting. (12)

Table No. 1

Methods of Cutting	% of Survival	
	July 1 1920 to June 15 1921	June 15 1921 to Sept. 10 1921
Group selection	26	73
Scattered seed trees	35	97
Shelterwood	43	83

From the above table we can readily see that seeds germinate and survive best when protected, but after that first year of protection they do best when they have less competition from the older trees.

Table No. 2 shows the percent of size of seedlings obtained under different methods of cutting. (12)

Table No. 2

Method of Cutting	Basis No. of Seedlings	Percent Size			
		VeryLarge	Large	Medium	Small
Group Selection	48	6	34	38	22
Scattered seed trees	139	20	23	40	17
Shelterwood	301	1	8	53	38

From the above table it shows that the shelterwood method ranks far below the other two with respect to size of seedlings, and that the scattered seed-tree method ranks highest in percentage of very large seedlings.

The evidence here obtained from tables No. 1 and No. 2 shows that the beneficial effects attributed to the shelter

of old trees were exaggerated, while associated detrimental effects were underrated. Present indications are that, on a whole, the advantages of the shelterwood method are outweighed by its disadvantages.

In the scattered seed tree method the outstanding advantages are economy in logging and the creation of favorable conditions for the growth of seedlings. A disadvantage which was anticipated is injury to seedlings through lack of sufficient shelter. The one great disadvantage of the method is that it removes the young, rapidly growing trees which should constitute the future growing stock. So vital is this fault that it bars the method from further consideration notwithstanding the fact that it appears to have the greatest possibilities in the way of reproduction.

Group-selection method comes nearest to meeting the silvicultural requirements of the western yellow pine in the southwest region at the present time. T. S. Woolsey Jr. (21) gives a good plan of procedure as a guide for this method.

Group selection or a primitive application of the shelterwood system applied to irregular stands:

(a) Removing about 2/3 of stand, leaving ½ of thrifty young and thrifty mature trees above twelve inches in diameter,

(b) Plan on returning in 20 or 30 years to cut remaining merchantable timber. Period decided according to length of time required for stand to become fully reproduced with seedlings,

(c) Cutting removes, over-mature and mature trees, defective and diseased trees,

(d) No rigid diameter limit should be set,

(e) Refrain from marking heavy on steep slopes where erosion might occur,

(f) Too heavy marking might cause windfall,

(g) More severe marking where reproduction has partially started,

(h) Marking should be an improvement cutting and where the stand runs under 2,000 ft. per acre no cutting at all should be allowed,

California. Though similar to the southwest they do have another problem to deal with and that is the danger of chaparrel taking over the land after heavy cutting, before reproduction can be established. To overcome this condition all trees left should be as evenly distributed over the area as is possible. (3)

D. Dunning (5) in his U.S.D.A. Bul. 1176 gives some results, and recommendations to consider when marking. He says that site is the most important factor in the growth of stands left after cutting. Each acre is a problem in itself and much depends on the marker's ability to recognize the character of the site, the mature stand and reproduction requirements, and to apply the right silvicultural principles as a part of the broad marking policy by which he is guided.

He also states that the best advanced reproduction in nature has occurred under conditions resembling a shelterwood system when reproduction is absent and the stand essentially even-aged, a heavy shelterwood or a seed-tree cutting leaving numerous well distributed seed-trees preferably larger than eighteen inches in diameter, will combine the most favorable conditions for improved growth and reproduction.

In irregular stands a heavy selection cutting removing 75% to 80% of the volume, and avoiding grouping of the

reserved trees as much as possible, promises to give the best silvicultural results.

Mr. T. T. Munger (10) in his Bul. 418 differs widely in his choice of silvicultural system, from that of R. H. Weidman (24) for the northwest pine regions. A brief of the two articles follows: Mr. Munger states that too sudden removal of trees injures the soil. Thus is makes it difficult, or impossible the starting of reproduction. Western yellow pine in middle life and old age demands so much light and ground space that the soil is put to the most intensive use only when the forests are uneven-aged, so that the younger trees may pass their slow-growing sapling stage in the gaps between the big trees.

He remarks that the ideal system of cutting is the selection system. With periodic cuttings taking only over-mature, defective and thoroughly ripe trees. As a rule this leaves on the ground 10% to 30% of the volume of trees above twelve inches in diameter and about 55% of trees over twelve inches in diameter by number. Cuttings should be made every sixty years with rotation at 180 years.

Group selection is often advisable where over-mature trees occur as such. Yet area marked as clear cut should not leave a cleared area of more than one acre.

The cutting should be an improvement cutting. The aim should be to reserve a well distributed stand of young thrifty and thrifty mature stand. Trees reserved are not seed trees but a nucleus of a later cutting.

Mr. Weidman (24) states that an even-aged succession

forest in western yellow pine is a proven fact. This even-aged forest is developing extensively on old private cut-over areas and on the more heavily cut of timber sale areas regardless of our intention.

Mr. Weidman commits himself in the two above statements. He gives neither figures or location of said even-age stands of pine timber in the northwest. No doubt small areas are even-aged, but the whole pine belt of the northwest cannot be called even-aged by a long ways. Furthermore as many proofs can be shown where natural reproduction is not found to be coming back in even-age stands. For instance, in central Oregon where private companies clear cut and left trees (not good seed-trees, but trees capable of eventually seeding the area), that are reseeding the area in an uneven age class^es as nature made it the first time. It seems feasible that areas might be fully stocked with same age seed if germination conditions and growing conditions remained favorable, but it is not probable.

Mr. Weidman goes on by stating that clear cutting, with provisions for safeguarding the advanced reproduction by leaving scattered seed trees, would be a sound silvicultural system for the northwest. To practice it would mean, practically, the cutting of but five or six additional trees per acre than are now cut on timber sales, and this would result in leaving the cover of advance reproduction to develop without overhead competition, into a thrifty second growth forest.

For parts of the northwest, the Blue Mountain region where Mr. Weidman no doubt took his observations, his

silvicultural plan should work very satisfactory as far as reproducing the area goes. For site qualities are better there than elsewhere in the northwest. His system would hardly work on the east slope of the Cascade range, for there the soil is of a pumice ash character and does not reproduce readily, or rapidly.

From my own observations of the timber in the northwest I would suggest that the system of cutting to be used would be called a "salvage cutting", and that it would follow closely to the plan of Mr. Munger's. Only taking out the over-mature and mature, and diseased and defective trees with the minimum volume left, not less than 20% of merchantable stands, and the maximum amount 100%, providing the timber was all immature and not in need of an improvement thinning. The first cut would be made with the plan in mind to return to the area within sixty years to make another such cutting as the first, and in this way have a sustained cut and a perpetual timber supply with a periodic income.

This plan is being followed on the northwestern forests, on government land only. Few companies see the benefit of leaving enough timber to insure another cut, or two, while the reproduction is maturing into timber size. This plan is conservative and does away with risks, in obtaining reproduction, as far as having the necessary stock on the ground to reseed the area. On sites where reproduction is obtained easily, the stand has been opened enough so that ample room is open for reproduction, for such sites the reproduction will generally come in under the present stand before cutting. On poor sites where brush and other

factors may enter in, to retard reproduction enough timber has been left to reseed and protect the area until the seedlings are capable of caring for themselves.

Mr. P. T. Smith (17) gives us a good picture of the Black Hills silvicultural system. He states that climate conditions and growing seasons are very favorable for reproduction of western yellow pine. That even-age stands are most desirable and produce the best growth per stand.

Mature stands are cut on the shelterwood system removing 60% to 70% of the crop. Then returning in twenty to forty years and cutting remainder of virgin timber. The seed years are regularly good every three years, and that germination conditions are good every year. He recommended that the mixed-age stands be converted into even-age stands and then use the shelterwood system.

Marking Methods

Rate of Growth after Cutting

In marking western yellow pine with the view of leaving timber for a second or later removal, the following study of the trees will help one to know what to expect in rate of growth. (6)

Trees with crowns of normal size or larger, grow faster than trees of the same diameter and crown class with smaller than average crown by from 30% to 100% or more.

Trees with a general appearance of vigor produced by dense, dark green foliage, pointed tops, and dark rough bark are usually growing 100% to 200% more rapidly than trees of the same size and crown class with scanty pale foliage, flat or dead tops, and smooth yellow bark.

Trees with large pointed crowns respond more promptly to release by cutting than trees with small badly formed crowns.

Trees growing at a slow rate as indicated by small crowns, flat tops, etc., may show a greater relative response to cutting than trees of vigorous appearance, but the absolute rate attained is seldom as high as that of the latter trees.

The maximum rate of current growth is usually reached six to nine years after cutting, depending on site, probably sooner on poor than on good sites, and sooner by trees with large well-formed crowns. Vigorous western yellow pine trees in some cases still show the effects of release by cuttings made over thirty years ago.

Marking Methods

Windfall and Result

An article in Proc. Soc. Amer. Foresters, Vol. 10 (1915-1916) on windfall damage in selection cutting in Oregon by Kan Smith and R. H. Weitknecht summarizes the damages that might be encountered in this source. (18)

Analysis was made on the Whitman National Forest on the Eccles Lbr. Company sale and the Baker White Pine Lbr. Company sale and the results are as follows: no diameter over 12 inches is safe from windthrow, and increased risk with increased diameter. For twelve inch diameter stock the windfall was found to run about 7% while for diameters over thirty inches the windthrow ran over 40%.

Danger of windfall increases with height. It was found that 50% of the trees over 110 feet high were windthrown. They state that any tree over 100 feet high is a poor risk. In general one might say that all trees whose crowns extend above the general crown cover are poor risks.

Trees with dense or mediumly dense crowns are particularly subject to windthrow. Open foliage crowns, regardless of size, are much less liable to be blown over. The character of the bark of the tree has very little effect upon their windfirmness.

Contrary to expectations windfall loss was found to be apparently as great on medium, and deep soils, as on shallow soils, other things being equal.

Groups showed more windfall than even spaced areas. This is due to the fact that one tree will knock others

over, and also weaken the root system of trees left standing. Groups do not give mutual support but give mutual resistance to wind.

The blow-down in virgin stands nearby was only one-fifth as great. This does not agree with R. H. Weidman's (22-23) observations on a blow-down in the Klamath Falls region of southern central Oregon. Here the storm damage was as great in virgin stands as in cut over.

Local topography apparently does not have a very marked influence on liability to windthrow. Windthrow however is slightly more on ridge tops and lee slopes.

Wind velocity during the destruction of these areas was about forty miles per hour. A modified selection system was used in both sales, and both sales were struck by the same storm, yet the author is unable to explain why the windfall was only one-sixth as great on the Baker white pine sale than on the Eccles Lbr. Co. sale.

Marking Methods

Slash Disposal

Brush disposal in western yellow pine can be accomplished in the most profitable way by not setting on any one definite policy, but in using the combination of two methods, both separately and together.

First method, piling and burning and second method scattering and lopping. (9)

The writer believes it best to pile and burn the brush on areas where it is exceptionally dense, and where reproduction has already started. At first some apprehension was felt regarding the survival of seedlings in burned brush piles, because of the usual absence of shelter or soil cover. Plots examined in Arizona by G. A. Pearson (12) completely dispelled this fear, because not only are the seedlings from two to three times as numerous as on adjoining grassy areas, but they are noticeably larger and more thrifty. From standpoint of size the seedling coming in in burned brush piles are second only to those in stump patches.

Places not to pile and burn brush, would be on steep slopes where soil is loose and soil cover is sparse and erosion is apt to take place, on rocky flats where soil is thin and of a poor site.

In scattering and lopping the brush, the soil receives the benefits of its shelter and also its fertilizer when it has decomposed. It is indeed wise to scatter and lop brush on all poor sites, where erosion might take place, where reproduction needs protection from winds,

frost, and drought periods. When the reproduction has this protection from the brush, then it is also subject to damping-off, excess shading, and in some cases to injurious competition for soil moisture, for while the reproduction is protected, so are other plants.

After the third or fourth year after cutting and the needles have dropped off the twigs and onto the ground, then the advantages of the brush is better realized. It gives evaporation protection in cinders, and clay soils. Disadvantages are also present in that the needle hinders germination.

The third and final stage of transfering brush to humus starts, from seven to ten years after cutting and lasts eight to ten years. The needles eventually become reduced to a thin layer of semidecomposed material suggesting a forest mold. The branches break up, caused by a dry rot, Lenzites sepiaria. This final stage is wholly favorable to reproduction.

W. Westveld (25) in his experiments on reproduction and brush disposal, draws the conclusion that leaving of brush in its natural state after logging is more beneficial to reproduction than if it is lopped to fine.

Since the scattering method had been substituted for burning, other methods have developed. Dr. Long developed his theory of rot, and showed that limbs when left on the bole decayed faster than when cut off and lying flat on the ground.

A new method was thus worked out and is known as "top pulling" and is substituting both for piling and lopping of the brush. Tops had to be pulled at least twenty-five

feet from the base of all live trees. It works out well where reproduction is scarce. Also it helps in keeping cattle and sheep from totally over-grazing the whole area, and provides a place for reproduction to come in under protection. (4)

Two reasons for piling and burning of brush are, where it is essential to reduce the fire risk, and second where it is necessary to prevent the breeding of destructive insect species in the slash.

Summary and Conclusions

Reproduction

Failure of reproduction is apt to be due less to poor germination than to high mortality during the first two or three years following germination. The high death rate of seedlings less than one year old can often be attributed largely to the fact that germination does not, as a rule, take place until July or August. Thus the seedlings are very tender at the end of the growing season. Droughts in September and October get the largest majority of them. Others are killed by frost and frost heaving of the ground. Also the dry summers following germination takes its toll.

The presence of brush and litter resulting from logging, if properly distributed helps to protect the reproduction, by protecting young seedlings against drought, frost, and frost heaving, and wind.

The following factors influence the density of natural reproduction found on the virgin and cut-over areas:

1. Seed Supply
2. Climate
3. Soil
4. Herbaceous vegetation
5. Cutting
6. Brush disposal
7. Grazing
8. Miscellaneous enemies
    a. Fire
    b. Insects
    c. Rodents

REPRODUCTION FILLING IN HOLES IN FOREST



Logging practices are radically different on practically all yellow pine areas. The one uniform form of logging is the horse method. Today in many regions the tractors are replacing the horses.

Following are the methods of logging used:

1. Horse and vehicle
2. Tractor and vehicle
3. Tractor yarders, with tractor and vehicle
4. Ground lead skidders
5. High lead skidders

For recommendations I would suggest that horse logging be used as long as it is feasible and when other means are more economical both for the forest and operator, then the tractors will replace horses, and only as a final resort will power logging with skidders be used.

Marking

From observations both in the field and from literature available it seems to the writer that nearly all the uncut yellow pine areas are in the same condition, that is over-mature and mature. Most of the forest stands are going backwards in volume.

It seems that the best policy for marking of our western yellow pine stands is a flexible one. Practically every acre has its own problem and therefore the marking of the pine stands should be placed in the hands of competent men.

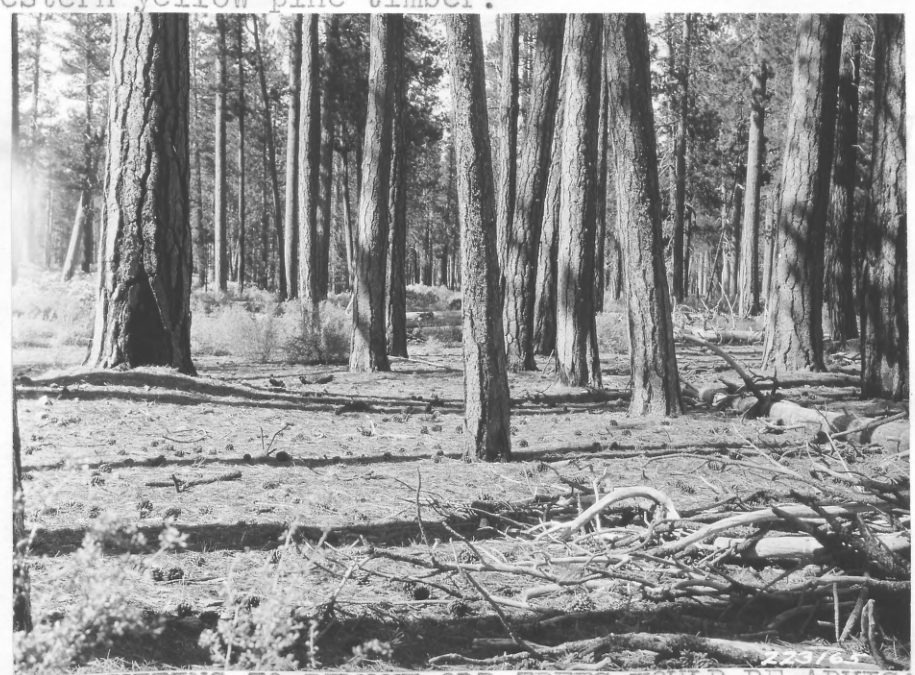
The first cut should be called a "salvage cut" and should include:

1. Over-mature and mature trees
2. Defective and diseased trees

Timber removed should not be in excess of 2/3 the volume in merchantable size.

The future marking policy should be either the selection or the group selection system, preferably the latter.

Following are pictures showing young and old stands of western yellow pine timber:



SALVAGE CUTTING TO REMOVE OLD TREES WOULD BE ADVISABLE



ONLY A LIGHT IMPROVEMENT CUTTING WOULD BE MADE.
NOTE THRIFTY TIMBER COMPARED TO Lower PICTURE
ON PAGE43.

The following picture shows results after a salvage cutting has been made. A heavy stand of timber still remains.



Brush disposal is a vital problem. It should be disposed of on some areas and on others it should be scattered. Pulling tops into cleared openings is the latest method, which has been successfully tried in the southwest. The only disadvantage with this method is to get the operator to pull the tops the required distance from the live trees which is 25 to 35 feet.

Following are some pictures of areas where brush should be piled, or tops pulled, and where brush should be burned:



WHERE BRUSH SHOULD BE BURNED



WHERE SCATTERING AND LOPPING SHOULD BE PRACTICED

Grazing on Cut-over Lands

Sheep grazing not infrequently results in serious damage to small size advance reproduction by tramping and nipping, where as cattle grazing apparently does little harm.

Prevention of reproduction on certain cut-over lands abundantly supplied with seed trees is usually chargeable to sheep grazing.

Properly controlled grazing hastens breaking up of slash left after logging, and is a great aid in chopping up litter and facilitating control of fires.

It is probable that, with proper management of stock, grazing of cut-over lands can be carried on with only minor damage to advance reproduction.

Where reproduction is entirely lacking previous to cutting, then it is advisable to graze area heavily just previous to cutting so as to cut down the herbaceous vegeta-

tion and reduce root competition.

The essential steps in producing full timber crops may be summed up as follows:

1. Put into effect good fire protective measures,
2. Regulate and control grazing,
3. Protect reserved trees and advance growth during logging,
4. Remove only over-mature, diseased, and malformed trees,
5. Leave all thrifty growing timber for future cut and supply,
6. Treat all species equally,
7. Leave on an average of ten to 15 trees per acre, or six to seven thousand board feet,
8. Where volume runs under three thousand board feet to the acre, don't mark except for defective and diseased trees,
9. Where soil is thin and lacking of humus, scatter the brush in preference to burning,
10. Burn brush where ground cover is already dense.

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