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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
UMATILLA NATIONAL FOREST

SS
Umatilla–Studies
Annual Silvical Report

Heppner, Oregon

February 23, 1911.

The material for this report was gathered during the summer of 1910 on the Whitman National Forest. The reproduction of Yellow Pine on this Forest is excellent over most of the area. Here reproduction occurs on almost all kinds of sites and on all kinds of seed beds, from nearly barren scab rock flats and on ridges, to the partial shade and thick pine grass found in mature Yellow Pine forests. Where reproduction is so universally good it is difficult to determine which conditions are the most suitable to Yellow Pine seedlings. This matter is further complicated by the fact that the most favorable localities in a wet year would very likely be the most unfavorable sites on a dry year, such as was experienced this summer. For example, in sample plots taken on different sites it was found that the germination percent was highest on loose rocky soils on south slopes very nearly barren of other vegetation, but the mortality of the seedlings during the first year was often 100% over considerable areas. On the other hand, seedlings which had finally succeeded in getting a foothold through the pine grass under mature forests, although few in number, revealed a much larger percent of living over dead, than the less shaded and protected seedlings in the looser and more sterile soils, and in general the actual number of living seedlings was greater. As it is the living seedlings that are of importance, it may be said that partial shade and protection from sun and wind is beneficial on the whole to very young seedlings. On the other hand, if the summer had been a wet one the percentage of mortality on the looser and warmer soils would have been less and as a result the aggregate number of living seedlings might very easily have been greater than in the sheltered sites.

As the summers are generally very dry in eastern Oregon, it is a safe assumption that a seedling which germinates in a partially sheltered site has a better chance of developing into a tree than a seedling which germinates in an exposed site, and the drier the climate is, the more surely does this apply. Sample plots which were taken in widely varying places have been included at the end of this report to illustrate the mortality of Yellow Pine seedlings on varying sites. Yellow Pine does not, strictly speaking, prefer dry, hot south slopes, but being an intolerant tree, it is forced to these localities by more tolerant trees which demand moisture in the surface layers of the soil above light. Yellow Pine demands an abundance of light above all things, but is adapted to exist in very dry localities. Especially is this tree adapted to stand drought in the seedling stage, which is the most critical stage in tree development. There is no other tree of commercial importance which is able to withstand a protracted drought as Yellow Pine, due to its deep root system, and in the later stages of development it can survive and

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make fairly good growth where Douglas fir, White Fir, Lodgepole and Larch could at best make only poor growth. In such localities it can compete with these species and drive them out. However, Yellow Pine makes the best growth on deep rich soils such as is usually occupied by the above named species, when by accident it has become established there. The trees are much taller, straighter and of faster growth. Trees growing on such sites or on transition sites often grow to be 150 feet tall; the tallest Yellow Pine measured by me this summer was 177 feet high and was growing in with trees nearly all of which were over 145 feet. These trees were measured by means of a tape after they had been felled. They were all growing in a bottom land and the stand was pure Yellow Pine.

All species of trees prefer full light with an abundance of moisture, but it is the lowest degree of moisture and light on which each of the various species can survive which determines the species of tree for each locality. It is wrong to say, for example, that Spruce prefers shade and Yellow Pine prefers drought, because these conditions generally occur in the forests composed of these respective species. Could light be given to the Spruce and water to the Yellow Pine, both would be benefited. The spruce is found in dark, cool canyons because it must have an abundance of moisture, but the Yellow Pine can not grow in such places because it must have an abundance of light. All species of trees prefer full light if there is moisture, but the degree of tolerance varies with each species. Another factor other than shade, which precludes Yellow Pine from usurping territory from slopes occupied by more tolerant species, is the fact that in order to germinate, Yellow Pine seed must come in direct contact with the mineral soil. Because of the coolness of north slopes, the decomposition of the vegetable matter is retarded and an abundance of duff is formed which would prevent the roots of the Yellow Pine seedling from penetrating to the mineral soil.

Lodgepole is the only species of tree which can successfully invade the territory of the typical Yellow Pine localities, i e, south slopes, dry flats and benches, and this only after a cutting or fire. This is due to the fact that Lodgepole has nearly the same silvical characteristic regarding drought as Yellow Pine, and also to its exceptional reproductive capacity. Young Lodgepole bear fertile cones when less than 20 years old, the seeds are very abundant on older trees and retain their vitality unimpaired for several years. On the other hand, the seeds of Yellow Pine are less abundant, and the trees do not bear seeds until about 40 years old, and their vitality rarely lasts at best for more than a year. The seeds of Yellow Pine have another disadvantage in their larger size, which works against them in two ways. Firstly, they are more sought after by birds and rodents, and secondly, they can not be carried so far by the wind. Full reproduction can not be relied upon in Yellow Pine at a greater distance than one and one-half times the height of the tree in 8 to 10 years. Lodgepole reproduces abundantly at one-fourth mile from any parent tree.

Because of the great abundance and lightness of Lodgepole seed, this species can rush in after a burn or cutting and usurp the territory formerly occupied by Yellow Pine. The density with which the young Lodgepole come up and the rapidity of its growth the first few years of its life, will often very nearly prevent any Yellow Pine reproduction at

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all. If fires could be prevented for many years, Yellow Pine would gradually work in again and reclaim the lost ground, because Lodgepole is not a permanent type, depending as it does on frequently recurring fires to clear the ground of other species and make way for another crop of its own species.

Frequently Yellow Pine occurs with species other than Lodgepole on transition sites. Here the conditions may be so adjusted that no particular species is favored far beyond any other. Here we often find the best Yellow Pines. On one side of this middle or neutral territory we pass off into conditions where Yellow Pine is no longer able to compete with the other species, and on the other side we pass over into conditions where Yellow Pine becomes the dominant species.

In order to insure the best natural Yellow Pine reproduction, the seed tree method should generally be used because of the intolerance of Yellow Pine. For this purpose 3 or 4 trees should be left to the acre; all other trees other than the pine should be removed, especially all Lodgepole. It is sometimes, for other purposes than reproduction, best to leave a third or more of the stand in a logging operation, but if reproduction is the sole consideration, 3 or 4 trees per acre will produce the best results. The cutting should be made in the winter after a good seed year, and the brush should be scattered rather than burned if the fire danger is not great, so as to afford partial shade and protection for the young seedlings when they appear. On a tract on the lands of the Oregon Lumber Company, which had been cut over about three years ago, a good reproduction was found to exist very uniformly over the whole area. The cutting had been made in winter so that no fire had passed over the area, and the brush left scattered over the ground. Many of the young seedlings were on the ground before the cutting, but many more probably germinated after the cutting, from the cones of the felled trees.

There have been many different ways proposed for seeding Yellow Pine. Broadcast seeding has been tried with considerable success in the Black Hills. If climatic conditions are exactly favorable, there is no doubt about its being the cheapest method, but over large parts of the Yellow Pine range, climatic conditions are so severe as to make broadcast seeding a failure. A notable case of this occurred in southern California. Broadcast seeding would be almost certain of meeting with poor success in Eastern Oregon, New Mexico, or Arizona and all parts where the minimum annual rainfall is not at least 20 inches. The surest method of artificial reproduction is to plant 2 or 3-year old nursery stock; the cost in the beginning is heavier, but the satisfactory results obtained will more than outweigh the disadvantage of the high cost in places where the summer drought is severe or on steep south or west slopes. In other places sowing seed spots may probably be relied upon to give good results. After the first year it is almost impossible to kill a Yellow Pine seedling by drought. This year was an unusually dry one, but I was able to find only half a dozen 2-year olds and no 3-year olds that had been killed by drought. This is due in a large measure to the root system of Yellow Pine. The first year of its growth, the seedling sends down a single tap root from 6 to 7 inches long, with only short secondary roots one-half inch or less in length; the second year the tap root goes down almost a foot and the secondary roots have

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increased proportionately. This root system of Yellow Pine makes it a very difficult tree to handle in the nursery, so that where the rainfall is not too scant, it will probably be best to use the method of sowing in seed spots. The advantage of sowing in seed spots over merely broadcasting the seed, is illustrated by the great number of seedlings which survive the first winter, when planted in caches by squirrels, over those which result from seeds scattered over the ground by the wind. The mortality of the former is much less than that of the latter, due probably to the depth that the seeds were planted. It was found that in squirrel caches generally out of 12 seeds which had germinated, 9 or 10 had grown and lived through the first summer. Individual seedlings not planted by squirrels, but merely broadcasted by the wind, showed a much higher degree of mortality. Frequently the little clumps of seedlings resulting from the old squirrel caches, occur in great abundance and many hundred seedlings could be gathered from them in a short while and with little labor. This offers a suggestion for gathering seedlings for the purpose of transplanting to other localities. Where so many seedlings occur together as in a squirrel cache, they can be more easily removed from the ground, with less danger of injury to the roots which are woven closely together, and so prevent all of the earth from falling from them.

Sheep grazing is beneficial to Yellow Pine reproduction by keeping down the grass and trampling up the soil. On an area of about two acres, cleared about ten years ago and surrounded on three sides by large seed trees, only one seedling was discovered. This area had never been grazed over and the soil was very hard and was occupied by an abundance of grass and weeds. If sheep had been allowed to run over it, it is almost certain that good reproduction would have resulted, as the reproduction for this region was universally good wherever sheep had run. Sheep also keep down fires to a very great degree, and therefore work indirectly to the advantage of reproduction. In fact it would seem wise on some Forests to allow over-grazing, because of the two evils, fire and overgrazing, the former is the worst. Excessive grazing is of course detrimental to reproduction. Sheep and cattle nibble the young trees, often trample them into the ground or rub off the bark, but seedlings will survive the crossing of a band of sheep better than they can survive the passage of a fire. Perhaps in a few years public opinion will have been awakened against fires to such a degree that they will be no longer the serious problem that they now are, and it will then be possible to restrict the grazing to a proper degree. Until then reproduction may have to suffer. Wherever there has been grazing, grass does not seem to compete with Yellow Pine seedlings to a serious extent in the forest of eastern Oregon. Good reproduction occurs under mature stands in clumps often containing thousands of trees, and as scattered individuals. Especially thick clumps of reproduction are almost invariably found coming up beneath bug killed timber. It seems that the cause of this is the partial protection from the sun which the dead trees form. The shade of living trees is too heavy, but the light shade which the dead trees cast is especially favorable to seedling growth in a dry climate. Also the decaying roots provide a certain amount of fertilizer and moisture which the seedlings use.

The following data was obtained for the purpose of deriving approximate information on the mortality of Yellow Pine seedlings during the first few years of their lives.

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Incidentally the tables show the kind of localities where the conditions are most favorable to Yellow Pine reproduction. The plots were taken in localities where the conditions varied as widely from each other as possible, except that all were taken in pure Yellow Pine stands. The area had not been grazed this year, so that none of this year's seedlings had been killed by this means. The summer drought was nearly at an end so that very few, if any, of the seedlings counted as living are likely to have died before the beginning of the fall rains. The data was gathered by taking plots 2 yards square at regular intervals over sample areas of ¼ or ½ acre:

SAMPLE AREA No. 1 – SIZE ½ ACRE.

	This year's seedlings		**More than one year old**	
Plot No.	Living	Dead	Living	Dead
1	1	14		
2		7		
3		3		
4		9		
5		5	1	
6		3		
7		12		
8	2	12		
9	8	16		
10	5	24		
11	2	13		
12	6	6		
13		3		
14		23		
15	3	5		
Totals	27	155		

RESULTS FROM TABLE.

Total number of seedlings germinating on plots this Spring 182.

Total number of seedlings on one-half acre, calculated from number in Sample Plots, living 1080, dead 6200, total 6280.

Percent of living over dead 17.4% or 1267 per acre.

Description of Sample area: Absolute altitude about 3200 feet. Relative altitude 400 feet above Grande Ronde river. Slope 20%. Soil – stony and shallow, dry and warm. Ground cover – very sparse bunch grass. Brush and woody plants – none. Density – two-tenths, Yellow Pine (no other species).

Conclusions: Percent germination of seeds high, death rate too high.

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SAMPLE AREA No. 2 – SIZE ¼ ACRE.

Plot No.	This year's seedlings		More than one year old	
	Living	Dead	Living	Dead
1			1	
2				
3		14		
4		3		
5		2		
6				
7		12		
8		25		
9		3		
10		10		
11		31	1	
12		1		
Totals		101	2	

RESULTS FROM TABLE.

Total number seedlings germinating on plots this Spring 101.

Total number seedlings on one-fourth acre, calculated from number on Sample Plots, living 0, dead 2545, total 2545.

Percent of living 0%.

Description of sample area: Absolute altitude 3200 feet. Relative altitude 400 feet. Slope about 5%. Soil – at least 8 inches deep, somewhat stony. Ground cover – a little grass; very thin; no brush. Density – entirely open, but seed trees occur on all four sides of sample area. Compare this sample area with No. 1 where there was partial shade.

Conclusions: Germination percent good, but unprotected seedlings unable to withstand summer drought.

SAMPLE AREA No. 3 – SIZE ½ ACRE.

Plot No.	This year's seedlings		More than one year old	
	Living	Dead	Living	Dead
1	5		1	
2	9			
3	3	2		
4	1			
5	9	1	3	
6	7	24		

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7	7	1	
8	1		
9	7	9	
10		3	
11	3		1
12		2	2
13			1
14	1		
15	2		
16	2		
Totals	57	42	8

RESULTS FROM TABLE.

Total number seedlings germinating on plot this Spring 99.

Total number seedlings on one-half acre calculated from Sample Plot, living 2154, dead 1588, total 3742.

Percent of living 58%.

Description of Sample area: Absolute altitude 3200 feet. Relative altitude 400 feet above Grande Ronde. Slope 15 to 25 degrees. Soil – at least one foot deep. Density – open. Reproduction – excellent. This sample area taken on area cut over during last winter and the brush left on the ground. Especially good reproduction occurred in the runways whence the logs had been dragged out and the soil thoroughly churned up for a considerable depth.

Conclusion: A cut-over area offers a favorable opportunity for Yellow Pine to come in when competition with Lodgepole is not too severe.

SAMPLE AREA No. 4 – SIZE ¼ ACRE.

	This year's seedlings		**More than one year old**	
Plot No.	Living	Dead	Living	Dead
1		53		
2		15		
3		47		
4	1	32		
5	5	15	1	
6	2	18	2	
7	1	20		
8	2	26	1	
9	1	24		
10		22		
11	2	18		

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	This year's seedlings		More than one year old	
Plot No.	Living	Dead	Living	Dead
12	2	48		
Totals	16	338	4	

RESULTS FROM TABLE.

Total number of seedlings germinating on plot this Spring 354.

Total number seedlings on one-fourth acre, calculated from Sample plots, living 403, dead 8515, total 8921.

Percent of living 4-3/4%.

Description of Sample area: Absolute altitude 3200 feet. Relative altitude 400 feet above Grande Ronde. Slope 15 to 20 degrees, south. Soil – 8 to 10 inches deep, very loose and stony. Density – no seed trees occurred on the Sample area, but were on all sides and several were on the border.

Conclusion: Loose, rocky soil gives a high germination percent, but few seedlings live through the summer drought under such conditions.

SAMPLE AREA No. 5 – SIZE ¼ ACRE.

	This year's seedlings		More than one year old	
Plot No.	Living	Dead	Living	Dead
1		14	1	
2	1	29		
3	5	67		
4	17	20	3	
5	14	34		
6	15	8	39	
7	11	19	4	
8	1	7	1	
9	4	14	1	
10	3	18	2	
11	12	5	7	
12	1	18	6	
Totals	84	253	64	

RESULTS FROM TABLE.

Total number seedlings germinating on plots this Spring 337.

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Total number seedlings on one-fourth acre, calculated from Sample plots, living 2117, dead 6376, total 8493.

Percent of living over dead one-year olds 34%.

Description of Sample area: This sample area was taken close to No. 4, and all conditions, except those of shade, were identical. On this plot occurred 9 seed trees. Of these, two were 12 to 20 inches D.B.H. and the other 7 over 20 inches D.B.H. Compare number of living seedlings on this plot with those growing under full light or very nearly full light on Plot No. 4.

Conclusion: Partial shade is beneficial to one-year seedlings.

The following table is a summary of the other tables:

Number of Sample area	Size of Sample area in acres	**One year old**		**More than one year old**	
		Living	Dead	Living	Dead
1	½	27	155	1	
2	¼		101		
3	½	57	42	8	
4	¼	16	338	4	
5	¼	84	253	64	1
Totals	1¾	184	889	77	1

Results from this table show that only 21% of the seedlings which germinate live till Fall and 79% are killed by drought. It will also be noticed from the table that there is a big falling off in numbers between the one-year old seedlings and those seedlings more than one year old. It will be seen that there are only 42% as many living more than one-year olds as there are living one-year olds. The cause of the mortality in this case is, however, not due primarily to drought, but to the throwing of the seedlings by frost during their first winter. As has been before been said, Yellow Pine seedlings more than one year old are almost proof against any drought, such as is likely to occur on the Whitman National Forest.

The sum of the living and dead first year seedlings is 1073. This probably does not represent more than 10% at the most of the total number of seeds which fell from the cones. No figures were obtained to determine the germination percent of the seeds, but the probability is that 10% is too high rather than too low. It will then be seen that 10,730 seeds are necessary in order that 184 trees shall result and live through the first summer; but, of these 184 seedlings only 42% survive their first and second winters, so that it will require 10,730 seeds to produce but 77 seedlings which are reasonably certain to live past the seedling stage. In other words, only seven-tenths of one percent of the number of seeds which fall will become trees and live past the critical seedling stage. Of course these comparatively few survivors will suffer continual losses in

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number during the entire life of the stand which they compose, through the suppression of the weaker, fire, wind, insects, etc., etc.

But seven-tenths percent is really too high an estimate of the number of seedlings which survive, as this number represents the product of at least two seed years. On the other hand more seedlings would result from seed scientifically sown by man, than from those scattered promiscuously by the wind. Just the right time of year could be chosen by man, for example. Probably not more than two or three seed years are represented by the seedlings counted. The few seeds produced on non-seed years are so few that most of them are eaten by birds and rodents.

Reducing to an acre basis the {*previous*} table the following figures are obtained:

This summer's seedlings,	living	420
This summer's seedlings,	Dead	2032
More than 1 year old,	living	304
More than 1 year old,	Dead	1

Total number seedlings on average acre, living 724, dead 2033.

To insure a full stand of Yellow Pine there should be at least one three-year old seedling for every 100 square feet. This would require 435 trees per acre. In order to obtain this number of seedlings, supposing that all but seven-tenths of one percent of the seeds sown will never get beyond the seedling stage, it will be necessary to sow 62,000 seeds per acre. Allowing 10,000 seeds per pound, it will thus require 6.2 pounds of seed per acre. If it is desired to have one seedling on an average for each 36 square feet, 17 pounds of seed per acre must be sown.

If rodents could be kept away, less seed would be required, but so far as I have heard, no place where this has been tried has it met with success.

Conditions vary so tremendously in every locality that the most that can be expected in a report of this sort is to give a general idea as to the great number of seeds required, in order that a few trees may result. It would seem that broadcasting must always be a precarious method of artificial reproduction on large areas when no protection from birds, rodents, drought and a multitude of other dangers which beset the life of a seedling, can be provided.

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