# FOREST RESEARCH NOTES

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# LOOKING FOR SMOKES FROM AIRPLANES

By William G. Morris

With the recent use of airplane patrol to discover fires it has become important to review what is known about the visibility of smoke and to study any new theories or applications of present knowledge that are suggested. Airplane patrol is expensive on an hourly basis. The time available for the observer to see a smoke before he has passed too far beyond it is short. For these two reasons he and the pilot should know how to fly so that any smoke in a certain place will be in the most favorable position to be seen by them.

A small number of tests and demonstrations of the difference in visibility of a small smoke viewed at different angles from the sun and against different backgrounds were made on the Chelan National Forest in 1945. Smoke candles or test smoke bombs that produce a smoke similar to that from 200 square feet of burning forest duff were used so that the smoke for different tests would be the same.

In one group of tests the smoke was kept going continuously on the airport field while an observer in a plane left the airport and climbed gradually to an elevation of 14,000 feet, at the same time flying in a gradually expanding circle around the smoke until he was 5 miles from it at an elevation of 4,000 feet. He noted the change in visibility of the smoke viewed from different locations, a few examples of which follow:

| Horizontal distance of smoke | Elevation of observer above smoke | Notes on visibility of smoke column |
|---|---|---|
| Miles | Feet | |
| 1 | 700 | Clearly visible at all angles. |
| 1 | 1,100 | Difficult to see when sun is directly behind the observer. |
| 5 | 5,000-6,000 | Not distinguishable when sun is within the quarter circle at observer's back but visible when sun is in other parts of the circle. |
| 5 | 10,000-14,000 | Barely seen when sun slightly behind observer. Satisfactorily visible when looking toward the sun at an angle of 45° from its rays. Still more visible when looking more directly toward the sun. |

These angles are horizontal angles from the sun. Owing to the altitude of the sun in the sky and the elevation of the plane, the angle between the sun and the observer's line of sight to the fire was actually greater than these when he faced the sun and less when it was at his back.

The atmosphere near the ground was moderately hazy at the time of the tests. The background for the smoke was gray gravel and sparse yellow grass.

In another group of tests single smoke candles were lit at different times here and there in a certain forested valley 16 miles long and 5 miles wide. A pilot and observer flew about 3,000 feet above watching for the smokes but not knowing where they might appear. Each smoke lasted for about 4 minutes. Out of 14 smokes set in a 2-hour period 7 were seen by the men in the plane. One was in dense, tall timber, 2 were in moderately dense timber, 1 was in a patch of saplings, and 3 were on gray rock-covered ground. All became more easily seen when the plane circled so that the observer faced the sun.

Those missed were set in similar places except that two were on the shady sides of small openings. Smoke in a shadow is difficult to see. Three of the smokes missed were set just outside of the planned test area at the beginning of the test period. They probably would have been seen if the men in the plane had been looking for smokes when they flew over that point.

The above tests demonstrate principles of smoke visibility from lookout stations that have been previously found and described in detailed reports by H. D. Bruce, C. C. Buck and W. L. Fons, G. M. Byram, R. E. McArdle, and G. D. Shallenberger and E. N. Little. Some of these principles that should be remembered in planning the use of airplanes for detecting fires are as follows:

White smoke in full sunlight is easier to see when looking toward the sun than when looking away from it. Smoke is harder to see against a light colored background than against a dark one. The visibility of a smoke against a light background decreases rapidly as the sun moves from an observer's side to a point directly behind his back. These principles of smoke visibility are contrary to those of landscape visibility.

If a smoke is in the shadow of a ridge or of tall trees it is harder to see looking toward the sun than away from it, just the opposite of the rule for smoke in sunlight. Such shadows are common in early morning and late afternoon. They make smokes harder to see than when in full sunlight.

On an overcast day the position of the sun has no effect on smoke visibility. It can be seen equally well in all directions. It can be seen better than on clear days, especially when looking away from the sun toward light backgrounds.

Large changes in smoke diameter make it visible at greater distances. If it can just be seen 11 miles against a dark background and the diameter becomes four times as large, it can then be seen 16 miles.

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# THE SPACING IN PLANTATIONS

By Thornton T. Munger

The spacing of Douglas fir trees in plantations has a marked effect on their diameters, heights, size of branches, and rate of limb shedding and on the amount of underbrush, according to a series of tests that has been under way for 26 seasons on the Wind River Experimental Forest. Here, in 1925, an area of some 15 acres was planted to Douglas fir 2 year olds employing six variations of spacing, namely, 4 x 4 foot, 5 x 5, 6 x 6, 8 x 8, 10 x 10, and 12 x 12. The plantations were maintained at these spacings.

The several plots began to reflect the results of the spacing quite early. Recently, after 26 growing seasons, they were measured and examined critically by means of sample plots within each plantation.

There has been some mortality, but not as yet from overcrowding; there is also considerable snow and ice breakage, but it could not be definitely correlated with the spacing between trees.

The statistics of number of trees, diameter, height, and volume are summarized for each spacing as follows, all values being on a horizontal acre basis:

| Spacing | Number of trees | Average diameter | Av. ht all trees | Average volume | Av. ht. dominant & codominant trees |
|---|---|---|---|---|---|
| Feet | | Inches | Feet | Cu. ft. | Feet |
| 4 x 4 | 2,280 | 2.7 | 24.5 | 1,278 | 29.9 |
| 5 x 5 | 1,694 | 2.9 | 23.1 | 965 | 27.3 |
| 6 x 6 | 1,174 | 3.3 | 25.6 | 935 | 29.4 |
| 8 x 8 | 637 (616) | 3.3 (3.8) | 22.9 (25.4) | 501 (674) | 29.2 (29.7) |
| 10 x 10 | 413 | 4.7 | 31.2 | 790 | 33.1 |
| 12 x 12 | 295 | 5.3 | 33.0 | 737 | 33.9 |

NOTE: The figures in parentheses are for a plot which is on more average soil than were the other plots in the 8 x 8 spacing.

It is interesting that there is a fairly regular progression in the average diameter and average height of all trees, as well as in the height of the dominant (and codominant) trees with increase in spacing. Exceptions are the 8 x 8 foot spacing that has now been found to fall partly on an area of inferior soil, and the 4 x 4 foot plantation that seems to have a better site (at least on the sample plots) than the 5 x 5 foot plantation. The fact that spacing seems to affect total height of the dominant and codominant trees suggests that height may not be an infallible index of site quality, at least in young and variously stocked stands.

The average crown width, limb size, and height to bottom of live crown were in 1945 as follows:

| Spacing Feet | Crown width Feet | Average limb diameter Inches | Height to bottom of live crown for 4" diameter class Feet |
|---|---|---|---|
| 4 x 4 | 4.6 | .36 | 7.1 |
| 5 x 5 | 4.8 | .40 | 3.7 |
| 6 x 6 | 5.9 | .58 | 2.2 |
| 8 x 8 | 6.9 | .54 | 1.1 |
| 10 x 10 | 8.9 | .68 | 2.1 |
| 12 x 12 | 9.4 | .76 | 0.2 |

The following tentative conclusions regarding the first 26 years of stand history may be drawn from this experiment:

(1) The average diameter increases with width of spacing and in the 12 x 12 foot plot is about twice that on the 4 x 4 plot.

(2) The wider the spacing the taller the average height of all trees.

(3) The heights of dominant trees are more nearly alike for all spacings than are the average heights of all trees.

(4) The closer the spacing the greater the basal area and cubic volume.

(5) There is a progressive increase in crown width from close to wide spacing.

(6) The diameter of the limbs at breast height is progressively greater the wider the spacing.

(7) The growth of bracken, annuals, and shrubs is much greater on the wide spacing.

This study merely furnishes the facts for this site IV land regarding the effects of close versus wide-spaced planting. It then becomes a problem for the planter to balance costs and returns. The wider the spacing the lower the initial cost and the quicker material of usable size will be available; on the other hand the greater will be the need for pruning and the longer will be the time until the flash fire hazard from rank herbage is reduced. Since regardless of the spacing of plantations pruning will be necessary to produce quality material in short rotations, perhaps it may be as well to save planting cost by spacing say 10 x 10 feet, provided high survival is assured, with the expectation of pruning early most of the trees to a height of at least 18 feet. Of course, such wide spacing would not be advisable where a quick cover is essential. The relative advantages of close versus wide spacing will also vary with site and with the prospective markets for small material that might result from thinnings.

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# SPRUCE-HEMLOCK PLOTS GROW 17,523 BOARD FEET (PER ACRE) IN 11 YEARS*

By Thornton T. Munger

A 94 year-old spruce hemlock forest on the Coast Range of Oregon actually made a net growth of 17,523 board feet in the last 11 seasons, according to measurements of the Pacific Northwest Forest Experiment Station. In the early summer of 1934 a number of permanent sample plots were established on the Cascade Head Experimental Forest (between Otis and Neskowin, Oregon) to get a continuous growth record of a typical well-stocked stand. Every tree was numbered, tagged, its diameter taken with steel tape, and the heights measured of about 40 trees per acre.

In 1940 the trees were remeasured and the results were astonishing. Again this past fall I remeasured them with the good help of five men from the Civilian Public Service camp. The results bear out the theoretical prediction. This forest, now 94 years old, has been making on the average a net annual growth per acre of 247 cubic feet or 1,454 board feet (Scribner rule in trees 12 inches and over to an 8-inch top).

A summary of the statistics of these 11 plots is shown in tabular form. Some plots were in almost pure hemlock, some were mostly of spruce, and others an even mixture of both species. The plots were placed where the forest was fully stocked but not abnormally dense. They are representative of the better portion of several thousand acres of this age class in this locality. This forest started in the ashes of the great Nestucca burn of the late 1840's or early 1850's, and has since been spared any recurring fire. Most of the old Nestucca burn has been burned and reburned.

It is noted that one plot (number 5, which is mostly spruce) has the prodigious present volume of 168 291 board feet, Scribner rule, per acre. This is gross scale, of course, with no allowance for defect or breakage. This means an average annual growth for this plot during its 94 years of 1,790 board feet.

Many trees have died from overcrowding, windfall, etc. in the last few decades which are not included in these yield figures. One plot (number 9) has had such heavy mortality that it has made very little net growth in the 11 years, and so pulls down the average. If it were possible to utilize by thinnings the trees that die, the total yields would be increased by that much over the present net stand. Moreover, this forest is still growing rapidly and apparently has not reached the culmination of its mean annual growth in saw timber volume, but has just passed the peak of its growth rate in the cubic volume of the entire stems.

While it may be idle to speculate on "what might have been" or "what might be," it is interesting to compare this area with the Tillamook burn. The climate and the soils are similar. Both areas are

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* Reprinted from "The Timberman" of March 1946, p. 48.

admirably and eminently adapted to timber growing. In the last 13 years 250,000 acres of the Tillamook burns has produced no net growth of trees. It will not produce much of anything in the next 50 or 100 years unless something drastic in hazard reduction, protection, and reforestation is done.

On the other hand this Cascade Head Experimental Forest has been producing saw timber at the rate of 1,454 board feet annually for the last century and under proper management can continue to do so ad infinitum. If the Tillamook burn area were safeguarded from fire, replanted, and given proper management, there is no reason why it should not produce almost as well as this Cascade Head area. The western portion is very similar and would grow spruce and hemlock; the eastern part would have to be mostly Douglas-fir and that does not yield as heavily as spruce and hemlock.

To assume that all the Tillamook area became fully stocked and grew like the Cascade Head area would give astronomic figures that would be too rosey for reality. But suppose that Tillamook's 250,000 acres of now thrice-burned wasteland grew timber only half as fast as these Cascade Head plots, that would give 181,750,000 board feet of saw timber. Or express this growth which Portland and northwestern Oregon industry is now losing in terms of cubic feet or cords and it amounts to 341,667 cords per year. That is enough to keep several sawmills and pulp mills busy, and give employment to thousands of people.

So these sample plots, in a forest that was well stocked by Nature and has had freedom from fires and hurricanes, tell by their periodic remeasurement the normal life history of such a stand. They prove what the volume returns from timber growing may be. They also proclaim the enormous losses when productive acres are idle.

Examples of Actual Growth of a 94-year-old Spruce-hemlock Stand
Cascade Head Experimental Forest, Oregon

(Data on horizontal acre basis)

| Plot No. | No. of trees: Hemlock | No. of trees: Spruce and Douglas-fir | Annual net growth last 11 seasons: Cu. ft. | Annual net growth last 11 seasons: Bd. ft. | Average annual growth to date: Cu. ft. | Average annual growth to date: Bd. ft. | Present saw timber volume: Bd. ft. |
|---|---|---|---|---|---|---|---|
| 1 | 244 | 5 | 286 | 1,912 | 261 | 1,514 | 142,297 |
| 3 | 78 | 71 | 214 | 1,701 | 268 | 1,646 | 154,691 |
| 4 | 65 | 121 | 212 | 1,608 | 215 | 1,474 | 138,559 |
| 5 | 35 | 111 | 276 | 1,894 | 292 | 1,790 | 168,291 |
| 6 | 155 | 33 | 275 | 1,837 | 250 | 1,464 | 137,654 |
| 7 | 193 | 47 | 322 | 2,136 | 272 | 1,528 | 143,631 |
| 8 | 316 | 4 | 318 | 2,112 | 263 | 1,387 | 130,331 |
| 9 | -- | 137 | 13 | 339 | 235 | 1,388 | 130,522 |
| 10 | 99 | 48 | 201 | 1,397 | 207 | 1,243 | 116,878 |
| 12 | 155 | 29 | 180 | 1,387 | 227 | 1,312 | 123,347 |
| 13 | 189 | 16 | 154 | 1,197 | 221 | 1,251 | 117,590 |
| Average | 139 | 57 | 223 | 1,593 | 247 | 1,454 | 136,708 |

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# A PROCEDURE FOR RATING THE POTENTIAL FIRE DANGER OF HAZARDOUS AREAS

By Harold A. Rapraeger

To help in deciding whether a forest area of dangerous fuels can be adequately protected, a procedure has been developed for rating the potential fire danger. Forest fires are usually easier and cheaper to control if the logging slash has been burned; but it may not always be necessary to go to the expense and risk of burning if the fire danger is not too great.

Each area should be rated to determine the danger. The term "fire danger," as used here, includes four main factors. These are: (1) Fuel type or hazard, (2) risk or possibility of a fire being started, (3) size of area, (4) ease of protection and control facilities. These factors can be given number values determined from studies and observations.

The fuel type can be given a value according to the rate of spread and difficulty of control. Slash is no problem if there is nothing to start a fire. Control the risk and the fire danger is small. Unfortunately the risk cannot be reduced to zero because of lightning and trespassers. The increase in risk caused by roads, railroads, ranchers, recreationists, logging operations, and lightning can be rated numerically for any combination of the preceding causative agencies.

The size of the area to be protected is also of primary importance. A small area of heavy slash can be more easily protected and with less chance of great damage than a large body of slash under the same conditions. The larger the area exposed to careless people the greater the number of firebrands that will be dropped in it. Likewise, the risk of a fire being started by lightning is four times greater on a tract of 1,000 acres than on 250 acres if other conditions are the same.

The ease of protecting the area is also to be considered. An area within one-quarter mile of the fire station can be more easily protected than a similar area 20 miles away. Travel time to the area, previously constructed fire lines and water holes, and whether or not it can be watched by a lookout affect the protection of any area.

Numerical scales for rating the different things affecting the danger have been made and a method of combining the ratings into one number has been developed. In rating the danger on a certain slash area the steps would be as follows: (1) Estimate the rate at which a fire would spread and the difficulty of controlling it. With this estimate in mind determine the class into which it falls according to the classification scheme that has been used in Oregon and Washington for a number of years. From the table provided for the purpose determine the numerical rating of the particular fuel class. (2) Estimate the time required for a small crew of fire fighters to reach the area. Using a table provided determine the numerical rating of this travel time. (3) If the area is visible to a lookout give the area the numerical rating provided for this advantage. (4) If the area has well-located firebreaks, roads, and water supply points, give it a numerical rating according to a scale provided for the purpose. (5) Combine these four ratings as directed. (6) Determine if public roads, railroads, active logging operations, land clearers, incendiarists, etc. are located near the area. With this information and a scale provided for the purpose determine the numerical rating of the chance that a fire may start on the area. In the final step a table is used which is based on the assumption that the size of tract that can be adequately protected is only half as great if the chance that a fire will start is doubled. It likewise shows that the allowable area is only half as great if the value obtained in step 5 is doubled. (7) Using the values obtained in steps 5 and 6 determine from this table the number of acres that can be adequately protected. If the tract being rated is larger than the allowable acreage, something should be done either to reduce the fuel hazard, reduce the risk, or improve the protection facilities enough to make the acreage of the tract fall within the allowable amount. It should be noted here that burning a slash may not reduce the fuel hazard sufficiently to put the acreage of the tract in the acceptable class of hazard.

The numerical values and steps described above for a typical 80 acres of Douglas-fir slash might be as follows: (1) High rate of spread and high resistance to control rating 100; 2 travel time one half hour - rating 1; (3) area visible to a lookout rating 1; (4) one dependable firebreak through the area rating 1.1; (5) combined rating 90; (6) a public road and land clearers within the area - rating risk of 10 including lightning risk; (7) final table gives 70 acres for a combined rating of 90 and a risk of 10 that a fire will start. Since the area being rated is 80 acres it has a potential danger too high for adequate protection.

Several tables have been made for use in the final step. The choice of the proper table to be used throughout a given protection district has been left to the discretion of the administrator responsible for the protection policy. The climatic factors, peak load of fires, amount of hazardous area already protected, and available manpower are all items that must be considered in determining the proper table to use.

By the use of this system a person should get more consistent results in determining the potential danger of different tracts. Likewise different men will probably get more nearly the same results when using this system. The rating tables have not yet been tested sufficiently to warrant their release for general use.

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# RECENT GROWTH RECORDS OF DOUGLAS-FIR STANDS

By Thornton T. Munger

The 64 growth plots in the Douglas-fir region which have been under observation by the Experiment Station for a considerable time are continuing to yield more and more valuable data on growth rates and the life cycle of young forests. Some of the findings on plots reexamined in the last year or two are given below as examples of how our knowledge of Douglas-fir growth may be pieced together and extended:

## 1. Sixty-year-old Stand on Mt Hood National Forest - Site III

In 15 years the average dominant and codominant tree grew in diameter from 11.6 to 14.0 inches and in height from 83 to 102 feet. The net cubic volume in this period increased 2,342 cubic feet besides which there was a mortality of 1,034 cubic feet. A comparison of the statistics of this stand in 1930 and 1945, as shown by the average of these plots on a horizontal acre basis, is as follows:

| | Cubic foot volume all conifers | Gross bd. ft. volume Scribner | Mean annual increment | |
|---|---|---|---|---|
| | | | Cu. ft. | Bd. ft. |
| In 1930 | 6,540 | 11,441 | 146 | 254 |
| In 1945 | 8,882 | 29,905 | 148 | 498 |

## 2. One-hundred-three-year-old Forest in Wind River Valley

Five plots distributed through this stand, of which three have been under observation since 1914, illustrate this forest's variability in site and growth. The following data for these "normally" stocked plots are from the 1945 remeasurement:

| Plot No. | Site | Cu. ft. vol all trees | Gross bd. ft. vol. Scribner | Net annual growth last pentad | Mean annual growth |
|---|---|---|---|---|---|
| | | | | Bd. ft. | Bd. ft. |
| 2 | III+ | 12,293 | 64,514 | 1,068 | 626 |
| 4 | III+ | 13,587 | 71,161 | 1,071 | 691 |
| 5 | III+ | 12,718 | 67,890 | 692 | 659 |
| 9 | IV+ | 9,711 | 43,473 | 523 | 422 |
| 90 | II- | 15,886 | 86 389 | 1 696 | 839 |

The mortality has been spotty both between plots and from pentad to pentad and this affects net periodic growth. In some pentads there has been a net loss in volume. The Scribner board foot losses are equivalent to about 48 percent of the net growth. This shows how much larger the realizable yields might be if the trees lost by suppression, wind, and insects could be salvaged in thinnings prior to the harvest cut.

## 3. A Plantation Made Near Hebo on the Coast Range in 1912

Four plots were established between 1928 and 1934 on low site III land, three in an 8 x 8 foot plantation and one in a direct seeded area. The planted plots show considerable contrast with natural stands on a like site. The trees are fewer in number, more regularly spaced, their average diameter is greater, and there is less mortality. The largest trees are now 15 inches in diameter and 75 feet tall. The seed spotted plot behaves more like a heavily stocked natural stand with thickets of slim trees, which, it is significant, suffered severely from snowbreakage recently. The data for these plots (as of 1944) when 34 years from seed are briefed below:

| Plot | All Douglas-firs in stand | | | | Dom. and codom. Douglas fir only | |
|---|---|---|---|---|---|---|
| | No. living per acre | Av. diameter | Av. height | Total volume | Av. d.b.h. | Av. ht. |
| | | Inches | Feet | Cu. ft. | Inches | Feet |
| 11 - planted | 410 | 8.8 | 62 | 4,462 | 9.8 | 65 |
| 12 - " | 408 | 8.8 | 62 | 4,707 | 10.3 | 66 |
| 14 - " | 431 | 8.6 | 61 | 4,677 | 9.8 | 65 |
| 13 - seeded | 876 | 5.7 | 53 | 4,401 | 7.2 | 60 |

## 4. A 90-year-old Stand Under Observation Since 1910

The first permanent growth plots to be established in the Northwest were laid out in 1910 in a 54-year-old forest on the Willamette drainage. Their eight periodic measurements trace the life history of this stand from the time it was considered wholly unmerchantable to its present attractive opportunity for a logging show. The diameter of the average tree is about 6½ inches greater than 36 seasons ago; the heights of the dominant and codominant trees increased from 120 to 163 feet. These typical site II plots have followed very closely the "normal" yields given in the standard yield tables (U.S.D.A. Tech. Bul. 201). Their data on a horizontal acre basis when first and last measured are as follows:

| Plot | Date measured | No. conifers | No. hardwoods | Volume conifers | Volume conifers |
|---|---|---|---|---|---|
| | | | | Cu. ft. | Scrib. bd. ft. |
| 1 | Apr. 1910 | 188 | 28 | 7,354 | 29,010 |
| | Oct. 1945 | 112 | 7 | 14,165 | 77,713 |
| 2 | Apr. 1910 | 214 | 8 | 8,796 | 34,710 |
| | Oct. 1945 | 117 | 3 | 13,917 | 77,153 |
| 3 | Apr. 1910 | 190 | 18 | 8,833 | 36,380 |
| | Oct. 1945 | 116 | 2 | 14,751 | 81,362 |

By the Scribner rule the peak of the mean annual growth does not appear to have been reached unless it be on plot 3. It now rates 863, 857, and 904 board feet per acre per year on the three plots; such yields should be an encouragement to any forest owner or manager of similar typical Cascade foothill timberland.

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## WINDFALL IN RELATION TO CUTTING

By Thornton T. Munger

Wind is a potent factor in forest destruction--probably as great as fire in some forest regions. Spectacular damage is done by hurricanes, tornadoes, and great blows like the Olympic Peninsula storm of January 1921. Such infrequent winds may mow down every tree in their paths regardless of species or relationship to openings or topography. Of perhaps greater moment to the forester, though less spectacular, is the wind throw and windbreakage that occurs every year here and there whenever there is a high, but not extraordinary, wind. Much of this loss from wind is associated with man's disturbance of the forest exposing a body of timber by clear cutting around it, by partial cutting of a stand, by cutting rights of way for roads through a forest. By these means wind throw is often accelerated. An understanding of windfall in relation to cutting may lead the way to forestalling some of these losses. It will also help in providing for the salvage of material that may be windfallen.

As a start in learning something definite about the relation of cutting to windfall, some counts have been made on and in the vicinity of the Cascade Head Experimental Forest, a locality of frequent high winds off the ocean.

Wind Losses in Relation to Road Clearing. A brief study, reported in Forest Research Notes No. 31 of November 1940, indicated that along selected roads on this experimental forest the windfall was four times as heavy on the strip within 100 feet of the roadside as on the strip 100 to 200 feet from the road. Following the storms of the winter of 1945-46, of which the gale of December 4, 1945 was most notable, a count of the fresh windfalls (both uprooted and broken off) was made on both sides of four miles of the Rose Lodge and Summit roads, making a separate count of those within 100 feet of the road clearing and those from 100 to 200 feet from the road. These roads ran in a general east-west direction near the top of a ridge, mostly on its north slope, and the high winds were from the south or southwest. The right-of-way clearing was quite narrow, the minimum distance between trees being about 30 feet. The forest traversed was 90-year old spruce and hemlock 110-165 feet tall.

Along this four miles of road on the 400-foot strip (200 feet on each side) there were 86 windfalls recorded. Their relationship to the distance from the road, the side of the ridge, and whether to leeward or windward of the road is shown in the following table:

Number of Windfalls Per Acre

| Location | First 100 feet | Second 100 feet |
|---|---|---|
| South of ridge on leeward side of road | .77 | .03 |
| " " " " windward " " " | .95 | .24 |
| North " " " leeward " " " | .44 | .00 |
| " " " " windward " " " | .44 | .44 |
| Top of ridge - both sides of road | .26 | .00 |

This survey indicates that the windfall the past winter was 5.8 times as heavy within 100 feet of even this narrow road than 100 to 200 feet distant--a very significant observation. It also appears that there are very close to the same number of trees on the windward side of the road as on the lee side regardless of the slope. In fact there are 48 trees that fell toward the road as against 36 that fell away from the road opening. The trees along the portion of the road north of the ridge were still exposed to and suffered considerably from the prevailing southerly winds.

The lesson taught by these surveys is that to avoid windfall losses, right of way clearing through tall, dense timber should be of minimum width consistent with other considerations.

Wind Losses in Relation to Clear Cutting. On the Salmon River Highway between Grand Ronde, Oregon and the coast a forest corridor of 200- to 300-year-old timber has been left for a distance of about 5 miles to preserve some of the original attractiveness of this road. This forest strip is from 200 to 800 feet in width on each side of the State highway and is bordered by clear-cut, logged-off land. It suffered considerably from the high winds of December 1945. To determine how far in from the cutting edge the wind throw extended a count was made of all fresh windfalls on two miles of cutting edge, one south of the timber strip (windward side) and one mile on the north or lee side, keeping separate the windfalls on the first 100-foot zone and the second 100-foot zone from the cutting edge. There were 62 windfalls (of a size to be included in this study) on the 46 acres involved. The results in terms of windfalls per acre are as follows:

| Location | Distance from cutting edge: First 100 feet | Distance from cutting edge: Second 100 feet |
|---|---|---|
| South edge (windward side) | 2.5 | 0.8 |
| North edge (leeward " ) | 1.7 | 0.4 |

This shows $3\frac{1}{2}$ times as much windfall close to the cutting edge as 100 to 200 feet from it. Contrary to expectation, the losses on the lee side of the strip are not very much less than on the windward side, as was likewise the experience along the Cascade Head roads.

In conclusion it may be stated with conviction that dense Douglas-fir, spruce, or hemlock timber exposed to high winds next to any clear cut area, whether it be a 30-foot right of way or a large logging compartment, is rendered liable to wind throw. Both the windward and the lee edges suffer, the former somewhat more. The 100-foot zone nearest the cutting opening is several times more subject to wind throw than the next 100-foot zone, but as the outer zone is thinned out the destructive effectiveness of the wind may extend farther into the timber.

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# THINNING SAPLING STANDS OF PONDEROSA PINE

By Thornton T. Munger

Ponderosa pine is a tree that regenerates in very dense, even aged thickets, that stagnate badly. To break this stagnation of growth some form of thinning would seem necessary to get maximum production. During, and even before, the CCC days some experimental thinning was done on several national forests in dense sapling and small pole stands, and thinned plots and check plots were measured for comparison.

Tentative conclusions that may be drawn from the few years' observations are:

(1) Thinning decidedly stimulated diameter growth. In one case the average diameter of the 100 largest trees per acre increased from 6.13 inches in the year 1934 to 7.73 inches in 1945 on the thinned plots and from 6.20 to only 7.35 inches on the check plots.

(2) The effects of thinning are not felt much for several years.

(3) The tenacity of life of ponderosa pine saplings even in dense stands is extraordinary. In a set of 5 plots at Pringle Falls in a 57-year old stand only 9 tagged trees died in the last 6 years on the two check plots, and only 1 on the three thinned plots that had about 500 to nearly 800 trees per acre.

(4) In one instance there was an outbreak of Ips bark beetles, coming from the slash, and considerable mortality of saplings, but the epidemic subsided after a year.

A few figures taken from the reports on three of these experiments illustrate the effect of the thinning:

(A) Malheur National Forest. Thinned plot and check established in 1930 in 44 year-old ponderosa pine. Cubic foot growth for comparable numbers of tagged trees are:

| | First 10 years | Next 5 years |
|---|---|---|
| Thinned plot | 37.8 cu. ft. | 51.9 cu. ft. |
| Check " | 14.5 " | 11.3 " |

(B) Pringle Falls Experimental Forest. Three thinned and two check plots established in 1934 in 46-year-old stand. The average diameter of the trees increased 1.13 inches in 11 years on the thinned plots and on the check plots only 0.55 inches, and the average height increased 6.5 feet on the thinned as against 6.2 on the check plots in the same period.

(C) Fremont National Forest. Five plots in a sapling ponderosa pine stand, established in 1927, three of which were thinned and two left as checks. A comparison of their growth for the period 1937 to 1945 is as follows:

| Plot number and treatment | Average diameter and height growth - 8 years | | | | | |
|---|---|---|---|---|---|---|
| | Dominant trees | | Codominant trees | | Intermediate trees | |
| | Inches | Feet | Inches | Feet | Inches | Feet |
| 1 thinned to 8 x 8' | 1.54 | 6.4 | 1.09 | 5.9 | .99 | 2.1 |
| 2 check | .75 | 5.3 | .23 | 2.1 | .12 | 1.4 |
| 3 " | .58 | 2.1 | .42 | 2.3 | .37 | 1.1 |
| 4 thinned in lanes | .75 | 2.8 | .52 | 1.9 | .59 | 1.9 |
| 5 thinned to 6 x 6' | 1.07 | 2.6 | .82 | 1.9 | .39 | 1.0 |

On most of these experimental plots the thinning was done by hand methods over the whole plot to leave only the desired number of trees; this is too expensive a method for extensive application. There is more promise of the economic practicability of crop tree pruning by which only a certain number, perhaps 80 or 100, promising trees are released by thinning and perhaps also pruned. There is also the possibility that these stagnating thickets of saplings could be cheaply and successfully thinned by machines which cut lanes and left strips of untouched trees.

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## FOG DRIP AND RAIN INTERCEPTION IN COASTAL FORESTS

By Leo A. Isaac

Twenty-seven rain gauges on the Cascade Head Experimental Forest have shown strikingly the effect of tree canopies on intercepting rain and also on creating fog drip or "horizontal precipitation" as fog drip has sometimes been called. These gauges, which were under observation from 1938 to 1941, were installed to measure the precipitation at various points and under various conditions in this rugged piece of terrain in the Oregon coastal "fog belt." The gauges were placed in sets of two or three, with one set in the open and one under the forest canopy at five different stations in the valley and on the ridge, close to the ocean and back from the ocean front.

Notable differences in the annual precipitation were revealed by the gauges in the open where there was no influence from the forest canopy, the station on the ocean front and almost at ocean level having the least rainfall and the station on top of the 1,000-foot ridge, 5 miles inland having the maximum, as indicated in the first column of the table below.

Effect of Tree Crowns on the Amount of Water Reaching the Gauges. The effect of tree crowns was twofold on the catch in the gauges below. Light rains often did little more than wet the foliage and the moisture evaporated without falling to the ground; a little may have run down the trunks and so reached the ground but not the gauges. In foggy weather the process was reversed particularly on the cloud ridden ridge close to the ocean. Here fog was collected and condensed by the tree crowns and dripped to the ground in appreciable quantities, when there was no moisture caught by rain gauges in the open. This twofold effect is illustrated by the record of four stations for 1940 and 1941 shown in the following table:

| | Annual precipitation inches | |
|---|---|---|
| | In open | Under timber |
| Headquarters - valley, 5 miles from ocean | 77.6 | 53.0 |
| Ridge top to the north, 5 " " " | 82.3 | 73.8 |
| " " " " " - 2 " " " | 78.6 | 99.1 |
| Ocean front at mouth of Salmon River | 65.9 | 53.1 |

Note that the rainfall under tree crowns at the headquarters was one third less than in the open. On the ridge to the north at an equal distance inland the variation was not so great. But on the ridge 3 miles closer to the ocean conditions were reversed and the precipitation a quarter greater under the timber than in the open. The effect of fog drip is better illustrated by a record of 18 selected weeks during 1940 and 1941 when fog hung on the ridge tops; these weeks showed 40 percent less precipitation under the timber at the headquarters station and 44 percent more under the timber than in the open at the ridge station closer to the coast. Moisture picked up by tree crowns and deposited in the form of "fog drip" on fog-swept slopes and summits was responsible for the increase.

A series of 24 weeks during 1939, 1940, and 1941 was selected to illustrate crown interception during periods when there was very little fog. These are shown in the following table for the headquarters station, the ridge station 5 miles inland, and the ridge station 2 miles inland:

| Dates | | Headquarters 5 miles inland | | Ridge station 5 miles inland | | Ridge station 2 miles inland | |
|---|---|---|---|---|---|---|---|
| | | Open | Conifer | Open | Conifer | Open | Conifer |
| 4/10 - 4/17 | 1939 | .89 | .65 | .99 | .84 | | |
| 4/17 - 4/24 | " | .62 | .21 | .52 | .36 | | |
| 5/1 - 5/8 | " | .10 | .04 | .15 | .11 | | |
| 6/1 - 6/5 | " | .70 | .61 | .78 | .60 | | |
| 6/19 - 6/26 | " | .14 | .05 | .22 | .13 | | |
| 6/26 - 6/30 | " | .13 | .07 | .12 | .03 | | |
| 9/25 - 9/30 | " | .19 | .09 | .18 | .09 | | |
| 11/1 - 11/6 | " | .73 | .52 | .68 | .46 | | |
| 1/1 (24 hrs.) | 1940 | .79 | .32 | .75 | .49 | | |
| 1/8 - 1/15 | " | 1.37 | 1.15 | 1.49 | .94 | | |
| 1/22 - 1/29 | " | 2.04 | 1.17 | 1.79 | 1.13 | | |
| 6/1 - 6/7 | " | .21 | .05 | .51 | .36 | | |
| 9/3 - 9/9 | " | .20 | .08 | .42 | .29 | .11 | .08 |
| 11/8 - 11/15 | " | .81 | .70 | 1.01 | .70 | .87 | .69 |
| 1/31 - 2/7 | 1941 | .84 | .43 | .95 | .42 | | |
| 2/7 2/14 | " | 1.21 | .82 | 1.13 | .87 | | |
| 2/21 - 2/28 | " | 1.56 | 1.08 | 1.59 | .85 | 1.62 | 1.47 |
| 4/1 - 4/7 | " | 2.31 | 1.23 | 2.31 | 1.38 | | |
| 4/7 - 4/15 | " | 1.21 | .67 | 1.27 | .96 | | |
| 4/15 - 4/21 | " | .70 | .43 | .47 | .23 | .50 | .47 |
| 4/30 - 5/7 | " | 2.52 | 1.46 | 2.85 | 1.99 | 4.16 | 2.41 |
| 5/7 - 5/14 | " | .29 | .12 | .49 | .23 | | |
| 5/21 - 5/31 | " | .58 | .30 | .67 | .42 | | |
| 10/14 - 10/21 | " | .70 | .48 | 1.13 | .79 | | |
| Average | | .87 | .53 | .94 | .61 | | |

The above record indicates pronounced crown interception of precipitation at both inland stations during every one of the 24 periods. But at the ridge station close to the coast the precipitation measured in the open exceeded that under the timber during only five of the 24 periods.

A scrutiny of the monthly records also reveals a pronounced increase in precipitation during the summer months on timbered ridges close to the coast when compared with stations farther inland. For example, during 28 days in the summer of 1940 on the ridge station near the coast .03 inches of rain fell in the open and rainfall, including fog drip, totaled 1.26 inches under the timber. During this same period no rainfall at all was recorded at the headquarters station a few miles away.

Horizontal precipitation, or fog drip, that moistens the ground during the summer months is significant because it occurs during the fire danger season and the growing season. By helping to keep the surface damp it lessens the inflammability within the forest; its moisture also helps the lesser plants and tender tree seedlings to keep green during the otherwise dry summer months.