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FOREST RESEARCH NOTES

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SPRUCE-HEMLOCK FOREST SHOWS PRODIGIOUS GROWTH

The pulp and paper industry in the Pacific Northwest is able to compete successfully in national and world markets primarily because it is favored with dense stands of high-grade pulpwood in its back yard. This natural advantage need not be temporary. Here industry can obtain such stands continuously because it can grow them.

For the region's most important source of pulpwood, the spruce-hemlock type, very rapid growth is indicated by the tables published in Meyer's "Yield of Even-aged Stands of Sitka Spruce and Western Hemlock", (U.S.D.A. Tech. Bull. No. 544). In order to check these rates by periodic remeasurement, permanent plots have been established in typical stands. In the spring of 1935 eleven such plots were put in on the newly-established Cascade Head Experimental Forest, near Otis, Oregon. They were distributed along the ridge east of the headland from 800 to 1,200 feet above and from 1 to 6 miles back from the ocean front. All were located in a thrifty, well-stocked, essentially even-aged spruce-hemlock stand which followed a severe forest fire, probably in 1846. The average age of the stand when the plots were established was 83 years.

In the fall of 1940, six growing seasons later, these plots were remeasured; the results are summarized in the following table:

Statistics for eleven one-acre permanent sample plots in even-aged spruce-hemlock at Cascade Head Experimental Forest

Average of -	Spring 1935 At age 83	Fall 1940 At age 89	Change
Total number of trees	212	203	-9
D.B.H., all trees, inches	19.1	19.9	+0.8
Total height, all trees, feet	127	133	+6
Volume of -			
All trees, cubic feet	21,090	22,530	+1,440
All trees, cords	245.2	262.0	+16.8
Trees 6.6"+ d.b.h., bd.ft., Inter. rule	152,000	163,500	+11,500
Trees 11.6"+ d.b.h., bd.ft., Scrib. rule	119,200	129,700	+10,500
Mean annual increment in -			
Cubic feet	254	253	-1
Cords	2.95	2.94	-0.01
Board feet, International rule	1,831	1,837	+6
Board feet, Scribner rule	1,436	1,457	+21

At an average age of 89 years the gross volume of the entire living stand on these plots has reached the tremendous total of 22,530 cubic feet or 262 cords per acre. Measured in terms of saw timber the volume per acre is equally impressive: 129,700 board feet by Scribner rule for the trees 11.6 inches in diameter and larger and 163,500 by International rule for the trees 6.6 inches in diameter and larger. Volume on individual plots ranges from 18,370 to 27,000 cubic feet, from 110,150 to 164,400 board feet, Scribner rule, and from 134,600 to 198,450 board feet, International rule. The composition varies from pure spruce near the ocean to almost pure hemlock inland. The average cubic volume of all the plots is 54 percent hemlock, slightly more than 45 percent spruce, and less than 1 percent Douglas-fir.

The average volumes of the trees now living indicate a mean annual growth rate of 2.94 cords per acre for the whole stand or 1,457 board feet per acre, Scribner rule, for the trees 11.6 inches in diameter and larger; the saw-timber growth rate is still increasing. Between measurements this stand added 16.8 cords, or 10,500 board feet, Scribner rule, to its per-acre volumes, an increment in six seasons equivalent to the total volume found in mature pulpwood stands in some regions.

In making this striking periodic net growth this stand has not escaped loss from suppression and windfall. During the period between measurements the mortality per acre averaged 5.8 cords and 2,220 board feet, Scribner rule, of sound material. If this loss could have been salvaged the periodic growth rates would have been correspondingly increased.

This stand is remarkably sound and free from rot, but under present pulpwood cutting practices in this region probably one-quarter of the cubic or cord volumes shown in the above table would be left in the woods in stumps, tops, broken or defective pieces of felled trees, and in rough or small trees left standing. Nevertheless, the effective mean annual increment of marketable pulpwood made on this land under existing crude utilization standards is spectacular:- 2-1/5 cords per acre. The annual growth from 49,000 acres of such land, a block less than 9 miles square, could supply the wood required to operate a 150 ton sulphite pulp mill continuously at full capacity.

Forest Research Notes No. 31 P. A. Briegleb

NEW DATA ON DOUGLAS-FIR SAW-TIMBER GROWTH

Overshadowed in importance for the time being in the Douglas-fir region by a magnificent but retreating virgin forest, is a 10-million-acre crop of immature trees growing timber for future harvest. This area of young forests is equal in extent to the area of old growth in a region famous for its vast virgin timberlands. These thrifty stands are a common sight, and an encouraging sight too, for without them the region's number one pay roll producer--the sawmills--would have to shut down as the old growth is cut out. In the meanwhile, however, these junior stands are growing in extent, in value, and in volume.

The most convincing method of determining their volume growth and mortality is by an actual record or life history, based on the periodic remeasurement of typical stands. Such records for Douglas-fir stands--some of them now covering 30 years--are being accumulated on 50 permanent sample plots in western Oregon and Washington. Ten of these plots in young saw-timber stands were remeasured and another established in 1939. Their vital statistics are summarized in the following table:

Summary of saw-timber growth on the Willamette, Wind River, and Mount Hood permanent sample plots in even-aged Douglas-fir

Plot No. and age, 1939		Date established	Site quality class	Volume* fall 1939	Periodic* annual increment since established	Mean* annual increment	Periodic* annual mortality since established
				Bd. Ft.	Bd. Ft.	Bd. Ft.	Bd. Ft.
Willamette	1	1910	II	70,100	1,370	835	27
(84 years)	2	"	II	67,700	1,100	806	380
	3	"	II	76,900	1,350	915	110
Wind River	2	1914	III+	59,200	650	604	370
(98 years)	4	"	III+	65,800	1,210	671	178
	5	"	III+	64,400	627	657	543
	9	1924	IV+	40,900	202	417	343
	90	1939	III+	77,900	--	795	--
Mt. Hood	1	1930	III-	23,400	1,010	425	81
(55 years)	2	"	III-	22,700	1,290	413	0
	3	"	III-	23,400	1,210	425	26

* Gross volume per acre of trees 11.6 inches or more in d.b.h. scaled in 16-foot logs to 8-inch top by Scribner rule.

The three plots on the Willamette National Forest are the oldest in the region. In the 30 years since they were first measured their average gross sawlog volume per acre has more than doubled. It jumped from 33,400 to 71,600 board feet, Scribner rule, which is an average annual growth rate for the period of 1,273 board feet per acre per year. This is for all living trees over 11.6 inches in diameter scaled to an 8-inch top. This stand, which started to grow 28 years after the first sawmill in the region was built, now has more sound saw timber per acre than the nearby 300- to 400-year-old mature and defective virgin stands. It is growing on site quality II which is representative of large areas of the better timber-growing lands of the region. At 84 years of age the average tree is about 20 inches in diameter and 150 feet tall. These are generous proportions even for virgin timber in other regions.

Five permanent plots on the Wind River watershed of the Columbia National Forest sample an extensive 98-year-old Douglas-fir forest. On a quality of site about average for the region these plots now have a stand per acre of 62,000 board feet, Scribner rule, gross scale, which indicates a mean annual increment of 633 board feet. The record on three of these plots covers 26 growing seasons. During that period the merchantable volume increased from 42,500 board feet (Scribner rule) to 63,200 board feet per acre, an average annual increment of 796 board feet per acre.

In the spring of 1930 three plots were established on the Mount Hood National Forest in a stand then 45 years old on poor site III. The succeeding decade was one of rapid change. In 10 years the saw-timber stand more than doubled in volume. It grew from 11,400 to 23,200 board feet, Scribner rule, an average annual increment of 1,180 board feet per acre. Its high rate of growth indicates that this forest is not mature for harvest; nevertheless, the volume it has accumulated in little over half a century is greater than that of the stands now being logged in most regions.

These substantial net increments have been put on in spite of heavy mortality in the older stands, as shown by the last column of the table. Since establishment annual loss per acre has averaged 172 board feet on the Willamette plots and 358 board feet in the somewhat older stand on the Wind River plots. If this loss could have been salvaged through timely thinnings, net growth would have been increased 13 percent in the Willamette and 53 percent in the Wind River stands. Mortality appears to accelerate rapidly after the 80-year age. That thinnings are practical in such stands if they are accessible was strikingly demonstrated last year at Wind River, when an improvement cutting was made in the 98-year-old timber through commercial sale of piling.

Forest Research Notes No. 31 P. A. Briegleb

NATURAL PRUNING IN SECOND-GROWTH DOUGLAS-FIR

A study of quality wood production, started in 1939 by dissecting the knots in a few 100-year-old Douglas-firs*, has been supplemented by a study of natural pruning on 15 permanent growth plots of different age, site, and stocking classes.

On each of these plots a certain proportion of the Douglas-firs were examined for clear length, length to the bottom of live crown, height to unbroken limbs, length of stubs, and presence of epicormic branches.

It was found that in well-stocked sapling stands the lower branches on dominant and codominant trees die when they reach an age of 10 to 15 years and that by the time a tree is 30 years old the limbs are dead to the height of about 18 feet. The dead branches are then still very sound and intact except for the shedding of tips and smaller twigs. Dying of branches progresses upward to a height of 60 feet by the time a stand reaches an age of 65 years. Branch disintegration, which usually proceeds in a piecemeal fashion, is manifested here by shorter branch stubs on the lower bole and even by occasional freedom from any stubs to a height of 3 to 5 feet.

The process steadily continues and in 100-year-old stands the death of branches advances 15 to 20 feet higher or to a height of 75 or 80 feet; at this age most trees have clear lengths ranging from 5 to 12 feet. In all, it takes about 60 years from the death of a branch to its complete occlusion and this generally means an inclosed black or loose knot 6 or more inches long.

Since it takes more than 100 years for Douglas-fir to develop a completely surface-clear 16-foot log, it is safe to assume that no commercially important quantity of clear material develops before a stand is over 150 years of age, or 30 to 40 years past the age at which the mean annual increment by board-foot volume culminates in fully-stocked stands of site III. Understocked stands are even slower to prune and without artificial pruning will never produce quality material in a rotation appropriate to the site productivity.

The development of epicormic branches is common in Douglas-fir, occurring usually where the forest canopy is opened up by windfall or insect kill. All classes of trees are capable of sprouting new branches but the evidence is that the thin-barked intermediate and suppressed trees sprout more profusely once exposed to much light. Epicormic branches are seldom found on the lower 40-foot section of the bole, but this condition may not hold true for artificially-thinned stands.

Forest Research Notes No. 31 Theodore Kachin

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* Formation of knots in Douglas-fir, by Loyd Bransford and Thornton T. Munger. Forest Research Notes No. 27. 1939.

"WATER SPROUTS" ON SITKA SPRUCE

Sitka spruce is one of the species that develops water sprouts, or epicormic branches, along its stem under certain conditions. Trees whose boles were once devoid of live limbs frequently develop a new set of branches from the main crown down almost to the ground. Even trees in the dense woods have such water sprouts, but they are not as numerous or luxuriant as on trees which have been exposed to light by the cutting of their neighbors. This phenomenom is present in both thrifty and suppressed individuals.

An opportunity was afforded along the Coast Highway on the Cascade Head Experimental Forest near Otis, Oregon, to study the effect of light on the development of water sprouts on a stand of spruce and hemlock about 90 years old. This dense stand was cut through 15 years prior to the study, since when the marginal trees have been exposed to side light.

To get facts as to the effect of side light on epicormic branch formation, all Sitka spruce trees on sample strips from the edge of the right-of-way clearing into the forest for 150 feet were examined and their water sprouts described; the trees on each 30-foot segment of the strip were recorded separately.

The new limbs were classified as "developing" - thrifty new limbs on the trunk, "stationary" - limbs alive but not thrifty, "disappearing" - needles getting thin and small twigs dropping off, and "none" - trunk practically without any living water sprouts.

Character of water sprouts on Sitka spruce in relation to distance from timber's edge

Distance from timber's edge	Developing	Stationary	Disappearing	None	Total
	(No.Trees)	(No.Trees)	(No. Trees)	(No.Trees)	(No.Trees)
0 to 30 ft.	71	6	0	2	79
31 to 60 ft.	18	22	6	7	53
61 to 90 ft.	0	14	22	11	47
91 to 120 ft.	0	0	19	39	58
121 to 150 ft.	0	0	8	51	59
Total	89	42	55	110	296

The table clearly shows the difference of trend in limb development from the edge of timber into the forest. Out of a total of 296 trees tallied, 89 were listed as "developing" a new set of limbs and all of these were within the first 60 feet from the cutting edge. Forty-two were listed as "limbs stationary" or just holding their own, and all of these were within the first 90 feet. Fifty-five were listed as "limbs disappearing" from the trunks and none of these were in the first 30 feet, 6 were in the second 30 feet, and the remaining 49 were beyond the 60-foot point from the timber's edge. A total of 110 trees had no living water sprouts; 2 of these were in the first 30 feet, 7 in the second, 11 in the third, 39 in the fourth, and 51 in the fifth 30 feet from the timber's edge.

No water sprouts were noted on the western hemlocks mixed with the spruce. Observations at other points indicate that old Sitka spruce stands do not produce water sprouts as readily as do stands of this 90-year age class or younger.

This study, supplemented by general observations elsewhere, indicates that caution must be exercised in thinning or selectively cutting Sitka spruce stands of this age if quality material is to be grown. Apparently water sprouts, if given enough light, will clothe the bole with a new set of limbs which preclude the formation of clear, high-quality lumber.

Forest Research Notes No. 31 L. A. Isaac

ROADSIDE WINDFALL IN SPRUCE-HEMLOCK

There is over four times as much windfall within 100 feet of roads on the Cascade Head Experimental Forest as there is in the zone 100 to 200 feet from the roads. This fact was one of the results of a survey of about 4 miles of roadsides in a 90-year-old dense spruce-hemlock stand made to determine the effect of road building on windfall. The roads have been built in the last 5 years. They are characteristic of forest development roads, with a clearing width of about 30 feet, and, being mostly on side hills, have bank cuttings and fills.

Both sides of four segments of road were examined and the windfalls that have occurred since the right-of-way was cut through were tallied by species separately for the 100-foot strip next to the road and for the strip 100 to 200 feet from the road. In every case there was much more windfall on the strip next to the road, as shown by the following table:

Number of windfalls per acre along roads

Location		First 100 feet	Second 100 feet
Summit Road, west end,	north side	4.4	1.5
" " " "	south side	1.6	.5
Summit Road, east end,	north side	1.2	.2
" " " "	south side	.7	.2
Rose Lodge Road	northeast side	4.0	.5
" " "	southwest side	1.7	.4
Telephone Road	west side	1.6	.3
" "	east side	1.1	.1

Most of these roads were on side hills, and roughly segregating the stretches above the road from those below the road, the data indicate that the windfall on the upper side of the road is about twice as bad as on the lower side of the road - 1.7 trees per acre on the upper as against .8 on the lower side of the road. There was obviously more cutting of roots of trees on the upper side of the road, but this factor would not account for the great difference, which must be attributed chiefly to the greater exposure to the wind of the trees standing above the road.

Spruce, hemlock, and Douglas-fir all suffered but since no record was made of the total number of standing trees of each species no conclusion as to their relative susceptibility can be drawn.

The area in question is near the coast, exposed to the sweep of the ocean storms. The trees are tall and slender so that they would naturally be affected by any opening of the crown canopy more than would short and stockier trees. It is very obvious that even this 30-foot right-of-way cutting is accelerating windfall in this thrifty young stand. It is, however, too soon to know whether this windfall will be progressive or cease after the least secure trees have succumbed to the unwonted exposure.

Forest Research Notes No. 31 — Fremont McComb and T. T. Munger

EFFECT OF INCREMENT BORING ON DOUGLAS-FIR

The question is sometimes asked: Do increment borer holes in Douglas-fir induce rot or stain in the wood and what, if anything, should be done to close up the holes to forestall undesirable consequences?

So to answer these and other related questions, thirty 90-year-old trees were bored, in 1929, to a depth of 5 to 6 inches with the conventional 3/8-inch increment borer and designated for observation. The following treatments were given the boles, each tree having one hole of each treatment:

(1) Holes plugged with a maple dowel.
(2) Holes plugged with the increment core.
(3) Holes plugged with a twig.
(4) No treatment.

In 1934 fifteen of the trees, each carrying all treatments, were cut down and the borer holes dissected. No rot or stain was found then. In 1939 four more of the trees were felled and dissected. The office of Forest Pathology made cultures of some of the wood surrounding the holes as a means of detecting fungous organisms.

The following summarizes the results of detailed study of the wood surrounding the holes:

(1) A roughly elliptical zone of heavy pitch accumulation surrounds the bored hole. This pitchiness may extend to a distance of 3 inches below and above the hole but is rarely over .6 inches in width.

(2) All sapwood immediately above and below the hole is transformed into heartwood. This effect diminishes away from the hole, but some transformed sapwood is still discernible 15 inches below and above the hole.

(3) The maple dowels used in plugging part of the holes were completely impregnated with pitch. The twig dowels were partially impregnated. Holes left unplugged were completely filled with solidified resin.

(4) No evidence of wood-destroying fungi was found in the affected wood.

(5) The healing progressed most satisfactorily where the holes were left unplugged. Formation of

callus tissue around the wound and its gradual extension into the hole formed a dimple on the surface of the stem resulting in a wavy wood grain. As newly laid wood becomes more straight grained with each succeeding year, the waviness will soon disappear.

The conclusion is that while the wood near the hole is appreciably degraded, the affected area is so small that the lumber values will hardly suffer from one boring. However, inasmuch as some damage is done every time a tree is bored, the cumulative effect of repeated borings might seriously degrade a limited portion of the lower log. Therefore, repeat borings, even if spaced years apart, should be avoided.

Another set of the bored trees will be felled and dissected 5 or 10 years hence.

Forest Research Notes No. 31 — Theodore Kachin

MORTALITY OF DOUGLAS-FIR SEED TREES ON CUT-OVER LANDS

The leaving of seed trees, singly or in groups, on Douglas-fir logging operations gives rise to perplexing problems in the silvicultural management of this type. Will they withstand the slash fire, wind, and exposure, and if so for how long? What type of tree survives the best? Do they bear seed abundantly? To shed light on the subject 10 areas upon which seed trees had been left after logging were marked for study on the national forests of Washington and Oregon; they vary in size from 25 to 100 acres each and have been under observation from 11 to 15 years.

Two of the areas were destroyed by accidental fires before any data of significance were obtained; the history of the remaining 8 is given in the following table. All areas were slash burned except the first two in the table. Scattered seed trees about 1 to 3 to the acre were left on all areas except the last where they were left in groups.

Fifteen-year summary of Douglas-fir seed tree survival studies - 1939

National forest area	No. trees	Years run	Mortality: Logging and slash fire		Mortality: Windfall		Mortality: ***Other		Trees alive	
			No.	%	No.	%	No.	%	No.	%
*Willamette #1	49	15	4	8.2	22	44.9	10	20.4	13	26.5
*Willamette #2	71	15	2	2.8	2	2.8	2	2.8	65	91.6
Santiam	49	15	21	42.9	24	49.0	0	0.0	4	8.1
Mount Baker #1	30	14	0	0.0	15	50.0	8	26.6	7	23.4
Mount Baker #2	50	14	10	20.0	19	38.0	20	40.0	1	2.0
Mount Baker #3	100	13	48	48.0	16	16.0	33	33.0	3	3.0
Mount Hood #1	98	13	15	15.3	46	46.9	28	28.6	9	9.2
*Mount Hood #2	92	11	8	8.7	19	20.7	50	54.3	15	16.3
**Av. of unburned	60.0	15.0	3.0	5.0	12.0	20.0	6.0	10.0	39.0	65.0
**Av. of burned	69.8	13.3	17.0	24.3	23.2	33.2	23.2	33.2	6.5	9.3
**Av. of total	67.4	13.8	13.7	20.0	20.4	30.3	18.9	28.0	14.6	21.7

* Slash was not burned on Willamette areas #1 and #2; on Mount Hood area #2 seed trees were left in a group.

** Averages of mortality are weighted.

*** Mortality listed under "other" includes trees that died from insect injury, decay, exposure, after-effects of fire, or a combination of these causes.

Willamette area number 1 presented approximately normal conditions for the region and had it been slash burned it is probable its seed trees would have shown not 26 percent survival but more nearly the average for burned areas, which is 10 percent. Willamette area number 2 was in a somewhat open stand where the trees were naturally rather wind-firm, and more than the usual number of them were left standing, mostly on ridges. With a survival of 92 percent it represents about the most favorable conditions that are likely to be found. Mount Baker area number 2, with a 2 percent survival after 14 years, represents about the most unfavorable conditions that are likely to be encountered; it was an overmature, very dense stand on a rather moist site. The eighth area, Mount Hood number 2, had seed trees left in groups. It shows that if surrounding trees are cut and the slash burned there is likely to be a heavy loss even where seed trees are left in groups unless extreme care is used to select spots that are likely to be free from windfall and logging damage.

Windfall accounts for about a third of the losses. Most of it occurs during the first 10 years after logging and naturally the weakest trees go first, but tall, high-crowned trees just over the lee of ridges and on moist bottoms do continue to topple over just as long as there are any left to fall. Trees on ridge tops and on dry slopes appear to be least subject to loss not only from windfall but also from logging and fire as well. On the burned areas logging damage and slash burning account for nearly a quarter of the losses - not including the after-effects of slash burning, which are hard to distinguish from insect killing and overexposure. Usually a mature Douglas-fir survives a moderate slash fire, but hot fires kill by sweeping up through the foliage or by overheating the cambium.

So far as could be determined from the annual records, the periodicity of seed crops on single seed trees in the open appears to be timed about the same as for trees in nearby virgin timber. However, the abundance of seed on single trees seems to be somewhat greater than on similar trees in the virgin forest. An exception was noted in 1927 when there was a good crop on single seed trees and none in virgin timber. Some trees, even in the open, never produce cones and some never have more than light crops.

The high mortality on most of the areas (averaging 90 percent on the six burned areas) in a span of 11 to 15 years makes the single seed tree method of providing regeneration appear somewhat questionable unless enough trees are left to offset the inevitable losses. However, the range in survival from 2 percent to 92 percent illustrates clearly the variation that exists in stand conditions and operating methods, and indicates that a greater survival could be obtained if more care were exercised in leaving seed trees on more wind-firm spots, and where they might also be more free from logging and slash fire damage.

A study of seedling establishment demonstrates clearly that the past practice of leaving 2 scattered seed trees per acre is inadequate for reseeding even if they survived a few years. A considerably larger number is necessary, even on ground favorable for their survival, in order to furnish promptly after slash burning enough seed to assure a satisfactory stocking of seedlings.

Forest Research Notes No. 31 L. A. Isaac

PONDEROSA PINE SAPLING STAND RESPONDS TO THINNING

Overstocked sapling ponderosa pine stands on poor sites remain overstocked for a length of time and to a degree most undesirable from the standpoint of production. Ample evidence of this condition is furnished by a remeasurement this year of a pair of plots on the Malheur National Forest in eastern Oregon. They were established in 1930 in an overstocked 44-year-old ponderosa pine forest; one plot was thinned to a 6' x 6' spacing by removal of 89 percent of the original number of trees, while the other was left untouched for comparison.

In spite of heavy mortality through snowbreak on the thinned plot, which thus lost 15 percent of the total number of trees as contrasted to 2 percent loss on the check plot, the thinning induced a significant net acceleration of growth. Some of the important statistics taken from the 1930 and 1940 measurements are as follows:

	Thinned plot	Unthinned plot
Diameter increment for the decade, per average tree, inches	1.3	0.2
Net increment for the decade, per acre, basal area, square feet	37.3	11.2
Net increment for the decade, per acre, cubic volume, cubic feet	377.7	145.2
Loss in number of trees for the decade, per acre	180	28
Loss in cubic feet for the decade, per acre	34.9	8.0

These results indicate the unquestioned efficacy of thinning. The high mortality on the thinned plot, however, suggests that less emphasis should be given to strict spacing in thinning and more attention given to the characteristics of each individual tree that will enable it to withstand the new hazards created by treatment. It may be that a thinning which liberates only the best developed trees, from 80 to 150 per acre, would not only be just as effective in breaking stagnation and stimulating growth but would also be much more economical to perform.

Forest Research Notes No. 31 Theodore Kachin

LIFE OF SEED IN THE FOREST FLOOR

The length of time that seed retains its viability after falling to the forest floor is of vital importance in the process of natural regeneration. Definite information on the life of Douglas-fir seed was obtained from a series of tests started in 1926 at the Wind River Experimental Forest, Carson, Washington. Fresh seed was placed in wire baskets filled with duff and laid in the floor of a virgin forest so that the seed was buried to depths of 1/8 inch, 1 inch, and 2 inches. Each spring for four successive years a quarter of it was taken up and tested for germination. Tests were made three times in succession between 1926 and 1935; in each test this Douglas-fir seed showed normal germinative power the first spring but practically no germination thereafter.

The question then arose as to how long a time the seeds of the associates of Douglas-fir would retain their viability after falling to the forest floor. Accordingly, a new test was started in 1936 using the eight more important Northwest species. Each spring for four successive seasons a portion amounting to 2,000 sound seeds of each species was taken up and tested for germination. The first spring after seed fall the following germination percents were obtained: Douglas-fir, 32.5; western hemlock, 3.8; western redcedar, 3.5; ponderosa pine, 63.0; western white pine, 9.8; Sitka spruce, 96.8; Port Orford white-cedar, 1.0; noble fir, 7.4. Cutting tests made before storage indicated that the seed was above average in soundness, therefore this first year's germination was far below normal for all species except Douglas-fir, ponderosa pine, and Sitka spruce. The second year no germination was obtained except 1.2 percent from western white pine. No germination was obtained during the third and fourth years except 0.5 percent each year for Port Orford white-cedar.

Because of its heavy seed coat some delayed germination of white pine was expected but the germination of 0.5 percent for Port Orford white-cedar in the third and fourth years came as a complete surprise, particularly since it showed only 1.0 percent germination the first season and none the second.

The results of these tests of storage in the duff of the seed of eight important conifers substantiate previous findings for Douglas-fir, namely, that there is practically no germination after the first year. One-season viability seems to be the rule for Douglas-fir and its important associates, the only exceptions being western white pine and Port Orford white-cedar.

The study indicates that new forests of Douglas-fir or its associates that follow promptly on the heels of clear-cut logging or slash burning spring almost entirely from seed cast within a year previous to logging or come from seed produced following logging and carried in by the wind.

Forest Research Notes No. 31 L. A. Isaac