DIRECT SEEDING EXPERIMENTS ON THE 1951 FORKS BURN

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CONTENTS

	Page
Introduction	1
Purpose	3
Location	3
Field Procedures	5
Costs	7
Results of Species Study	7
Seed Distribution	7
Germination Tests	8
Stocking and Survival	9
Sampling Accuracy	12
Suitability of Four Species for Aerial Seeding	13
Natural Seeding on Check Area	15
Seedling Counts on Other Portions of the Burn	15
Suggestions for Improving Direct Seeding Studies	17
Conclusions	18

DIRECT SEEDING EXPERIMENTS ON THE 1951 FORKS BURN

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INTRODUCTION

Late in the summer of 1951 the Port Angeles and Western Railroad fire (commonly called the Forks fire) killed more than a half billion board feet of timber. An area approximately 20 miles long and 2-1/2 miles wide, covering 32,668 acres, was burned. It included fine virgin timber, thrifty plantations, ranch lands, reproduction areas, advanced young growth, logged-off land, and slashings.

Immediately, the burn became one of the problem areas of the State. Timber salvage, protection, and reforestation all required special consideration. Direct aerial seeding was proposed as one possibility in the reforestation program. Although most of the burn occurred in the old-growth hemlock and Douglas-fir type at higher elevations, Douglas-fir could not be sown because the seed supply in cold storage was inadequate. However, Sitka spruce seed was available in ample quantity.

A low, flat area along the North Fork of the Calawah River was selected for the spruce seeding experiment. This was one of the first large-scale aerial seedings of Sitka spruce in this country. In an attempt to aid seedling establishment, the seed was held in stratification until almost ready to germinate, then sown in the late spring.

Within the burn, a 40-acre study area was seeded by helicopter April 25, 1952 (figure 1), to compare the suitability of these species: 1/

Sitka spruce - Picea sitchensis (Bong.) Carr.
Douglas-fir - Pseudotsuga taxifolia (Poir.) Britton
Western hemlock - Tsuga heterophylla (Raf.) Sarg.
Port-Orford-cedar - Chamaecyparis lawsoniana (A. Murr.) Parl.

For simplicity, these species hereafter will be referred to as spruce, Douglas-fir, hemlock, and Port-Orford-cedar.

1/ Botanical nomenclature from Trees, Yearbook of Agriculture 1949: 768-814. U.S. Dept. of Agriculture.

Figure 1. --This helicopter was used to bait and seed 1,133 acres of the Forks burn at a total cost of $6.91 per acre.

Figure 2. --Southwest corner of the 40-acre, 4-species seeding test on the Forks burn. Hemlock trees in the background were injured by the fire, but still had enough live crown to produce viable seed.

The following agencies cooperated in the experimental project: the Olympic National Forest, the U. S. Fish and Wildlife Service, and the Pacific Northwest Forest and Range Experiment Station.

PURPOSE

The primary objectives of this study were:

(1) To determine, on a 40-acre test block, the amount and uniformity of seed distribution when sown by helicopter at the rates of one-fourth pound per acre each of spruce, hemlock, and Port-Orford-cedar, and one-half pound per acre of Douglas-fir. The four species were sown in mixture.

(2) To measure the seedling establishment and mortality on the 40-acre test area and thus compare the suitability of these four species for aerial seeding on this particular site.

(3) To measure seedling establishment on a check area where no artificial seeding was done.

(4) To evaluate in general terms the overall effectiveness of the 1,133-acre spruce seeding project.

LOCATION

The study areas are within the Olympic National Forest near the North Fork of the Calawah River and about 6 miles southwest of the Snider Ranger Station. Both seeded and check plots are located on a narrow flat about one-fourth mile wide at an elevation of 600 feet.

This flat had been logged and burned several years ago. Twice, part of the area had been planted to Sitka spruce, but both plantations had failed. At the time of the 1951 fire, it supported a cover of elk sedge, grass, briars, weeds, scattered vine maple, and brush. Old logs and debris were also abundant. In spite of the light cover, the fire burned very hard, often completely consuming green vine maple stems 2 to 4 inches in diameter at the ground level. Young hemlock, spruce, and Douglas-fir trees of seed-bearing size occur occasionally throughout the test area. Some of these trees, though damaged by the fire, are still able to produce seed (figures 2, 3, and 4).

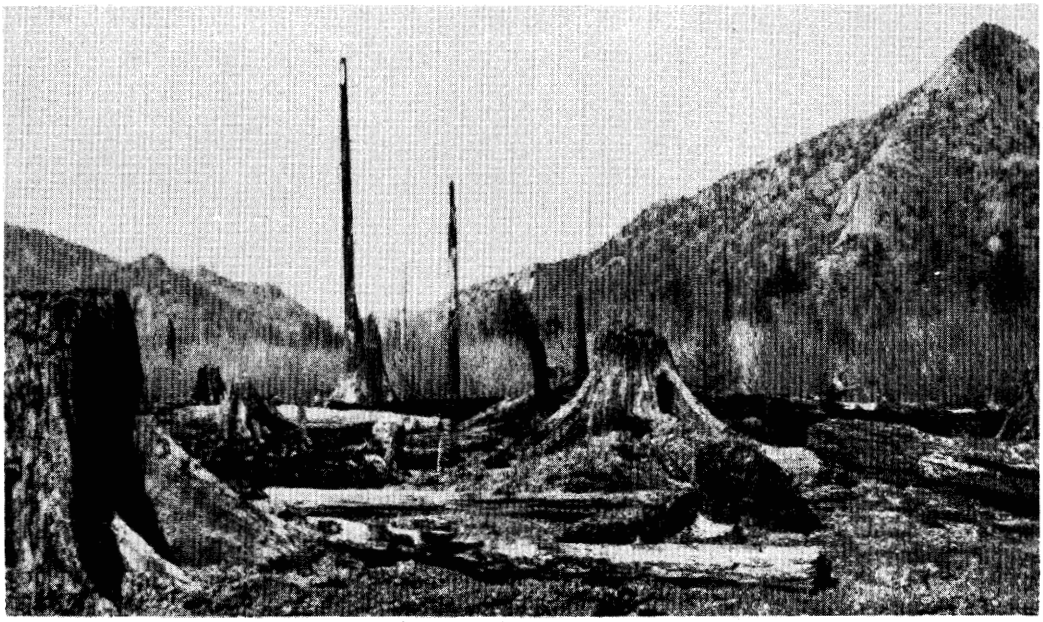


Figure 3. --Looking west across the 40-acre experimental area. The lack of vegetation as shown in the foreground was typical of much of the burn when seeded by helicopter April 25, 1952.

Figure 4. --Eastward view of the 40-acre experimental area on the Forks burn, April 1952.

FIELD PROCEDURES

After the 40-acre experimental area had been selected and surveyed, 200 mil-acre plots were established. Plots were spaced 50 feet apart in 8 rows, with 146 feet between rows (figure 5).

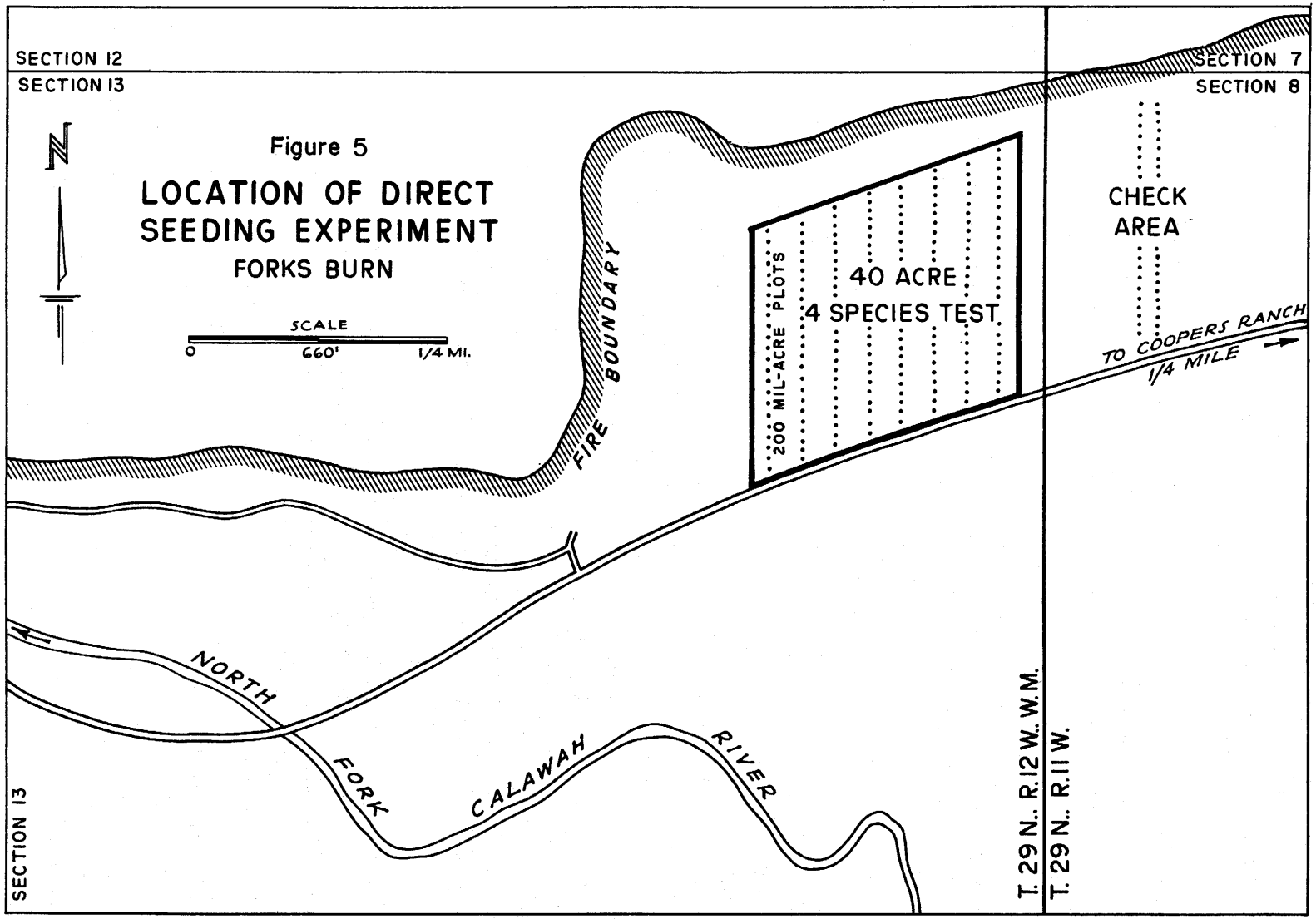
Before seeding, grain poisoned with 1080 or thallium sulphate was broadcast by helicopter to control mice. On the 40-acre test tract only thallium sulphate was used. On other portions of the seeded area both poisons were applied in combination, as well as separately.

One square foot of flypaper was placed near each of the 200 plots just before the helicopter seeded the area on April 25, 1952. Immediately after the flight, all flypaper was examined and seeds found were tallied by species.

The first examination of the test area was made June 9 to 11, 1952. Each seedling on the 200 plots was tallied by species and marked with a short piece of wire. Each plot was classified by type of ground cover and percent of mil-acre occupied by logs, stumps, and other obstructions. Vegetation was making good growth. In many places where everything had burned to the mineral soil, a dense, knee-high cover of Canada thistle was thriving. This made plot examination somewhat difficult. On an unseeded check area seedlings were counted on temporary plots (plots on which centers and seedlings were not permanently marked) to determine the extent of natural seeding. Temporary plots were also examined in other areas to compare results of 1/2-pound- and 1-pound-per-acre seeding of spruce. Unfortunately, effects of seeding rate were obscured by too many other factors to show any advantage of the heavier seeding.

Survival examinations were made December 1 to 3, 1952. Whenever a wire marker was found with no accompanying seedling, the original tally was used to determine the species of the missing seedling, then it was recorded as mortality. The check area and spruce seeded areas were also examined in December, but exact mortality could not be determined because individual seedlings had not been marked. However, spruce mortality on the 40-acre experimental area should apply to spruce on other areas.

The third seedling count on the 200 mil-acre plots was made May 11 to 13, 1953, to determine mortality during the winter and to ascertain whether any of the seed sown in April 1952 germinated the following spring.


SECTION 12
SECTION 13
SECTION 7
SECTION 8
Figure 5
LOCATION OF DIRECT SEEDING EXPERIMENT
FORKS BURN
SCALE
0
660'
1/4 MI.
FIRE BOUNDARY
200 MIL-ACRE PLOTS
40 ACRE 4 SPECIES TEST
CHECK AREA
TO COOPERS RANCH 1/4 MILE
NORTH FORK CALAWAH RIVER
SECTION 13
T. 29 N., R. 12 W. W.M.
T. 29 N., R. 11 W.

COSTS

Separate cost records were not kept on the 40-acre study area. However, the following statement prepared by the Olympic National Forest gives cost data on the entire project: 2/

Poisoning

Acres baited	1,620
Pounds of poison used (1080 and thallium sulphate)	897
Cost of poison per pound	50-60 cents
Helicopter: cost per acre baited	$0.87

Seeding

Acres seeded (national-forest land)	1,133
Pounds of spruce seed used	544
Cost of spruce seed per pound	$4.06
Helicopter: cost per acre seeded	$1.17

Total cost per acre for 1,133 acres of national forest (includes charges for salaries, equipment use, etc.) $6.91

RESULTS OF SPECIES STUDY

Seed Distribution

The use of flypaper for measuring seed distribution proved to be ineffective, mainly because of the cold weather at the time of seeding. When used below room temperatures, sheets of flypaper are extremely difficult, often impossible, to pull apart. Furthermore, when the sticky surface becomes cold, it turns into a hardened glaze and does not hold the seeds when they fall upon it. Less than one-third of the expected number of seed were caught on the flypaper (table 1). However, since calibration, measuring, and the seeding flight were all carefully controlled and observed, the actual distribution was undoubtedly fairly close to the intended rate. Distribution appeared to be fairly uniform throughout the 40 acres.

2/ Undi, Stanley I., and Poust, Ashley A. A report on the Forks burn seeding project. Olympic National Forest. 1952. (Typewritten report, 10 pp.)

Table 1. --Seed distribution on 40-acre test area.

Species	Intended rate			Seeds caught on flypaper		
	Pounds per acre	Seeds 1/ per acre	Seeds per sq. ft.	Pounds per acre	Seeds 1/ per acre	Seeds per sq. ft.
		Number	Number		Number	Number
Spruce	.25	52,500	1.2	.05	16,117	0.4
Douglas-fir	.50	22,000	0.5	.16	6,572	0.2
Hemlock	.25	74,250	1.7	.05	16,117	0.4
Port-Orford-cedar	.25	52,500	1.2	.06	17,424	0.4
	1.25	201,250	4.6	0.32	56,230	1.4

1/ Estimates of number of seeds per pound were based on "Woody-plant seed manual," U.S. Dept. Agr. Misc. Pub. 654, 416 pp. June 1948.

Germination Tests

A special germination test of the seed used exclusively on the 40-acre study area was made at the State Nursery near Littlerock, Washington. After running two 200-seed tests for a period of 60 days in open tables using vermiculite, at a fixed temperature of 70° F., the following results were obtained:

Species	Germinating capacity in percent
Spruce	77
Douglas-fir	67
Hemlock	55
Port-Orford-cedar	31

A germination test of the seed used for the whole 1,133-acre project was conducted at the Wind River Nursery, where the germination was: Spruce, 72 percent; Douglas-fir, 78 percent; hemlock, 58 percent; and Port-Orford-cedar, 45 percent.

These two tests vary slightly, but the results from the Littlerock tests are used in this analysis since they are based directly on the seed used on the experimental area.

Stocking and Survival

In this study a mil-acre plot (radius 3.725 feet) was considered stocked when it contained one or more live seedlings. Some stocking surveys require three 1-year-old seedlings to stock a mil-acre plot. Estimates of stocking are often delayed until after early mortality has leveled off at the end of the third growing season; but for this experimental study, seedlings were to be counted twice the first year, twice the second year, and once at the end of the third year. Therefore, one seedling was used as the minimum requirement to stock a mil-acre plot because it gives a more accurate record of the variations in stocking during the first three years.

On May 12, 1953, one year after seeding, 45 percent of the mil-acre plots were stocked (table 2). On a per-acre basis, 1,045 seedlings were still alive. Sixty-eight percent of the seedlings found on the 200 mil-acre plots June 10, 1952, were dead when reexamined December 1, 1952. Seedling survival by species, based on May 12, 1953 data was: Douglas-fir, 45 percent; hemlock, 32 percent; spruce, 18 percent; Port-Orford-cedar, 16 percent. Average survival for all species combined was 30 percent. During the first year the total number of seedlings per acre decreased rapidly for each species (figure 6). Douglas-fir survival, however, was considerably better than that of any of the other species tested.

Weather conditions during the summer of 1952 were favorable for seedling establishment. Precipitation records kept by the Snider Ranger Station show that 4 inches of rain fell during the 10 days after seeding. Rainfall during the summer was light but came at well-spaced intervals. Fall rains occurred somewhat later than usual; but in general, weather conditions during the first growing season were probably better than average for seedling survival.

Table 2. --Summary of seedling establishment and stocking on 40-acre test area during first year. Per-acre basis.

Item	Date or period	Spruce	Douglas-fir	Hemlock	Port-Orford-cedar	All species
Live seedlings	June '52	905	600	1,405	220	3,130
New seedlings	Dec. '52	70	130	90	20	310
Mortality	June-Dec.	710	320	940	165	2,135
Live seedlings	Dec. '52	265	410	555	75	1,305
	May '53	180	335	490	40	1,045
Percent survival 1/	Dec. '52	22	47	33	25	32
	May '53	18	45	32	16	30
Percent of mil-acre plots stocked	June '52	41	37	50	16	73
	Dec. '52	20	27	30	6	52
	May '53	14	22	28	4	45

1/ New seedlings were not included in figuring survival percentages since they appeared after the original tally.

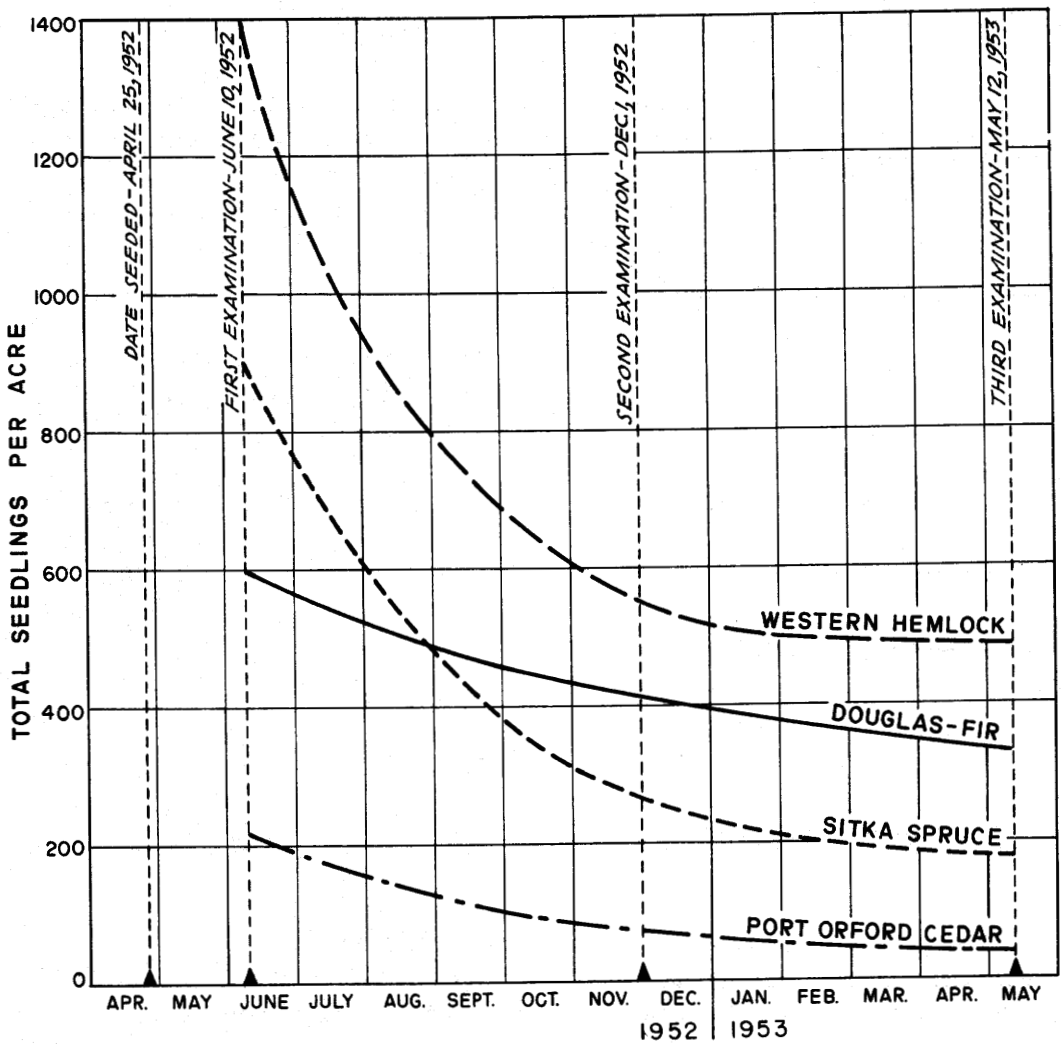


Figure 6 -- Decline in number of seedlings per acre during the first year
Basis: 200 mil-acre plots

Sampling Accuracy

The data were analyzed statistically to learn how much confidence might be placed in the computed averages, and to provide guides for the design of similar experiments.[3/]

The number of seedlings per acre estimated from the number found on the plots is subject to about a 10-percent sampling error--a little less for the June count, a little more for the December average. That is, the chances are two out of three that the true mean is within 10 percent of the sample mean. Observed values for the 200 mil-acre plots are:

	Date of Examination	
	June 10, 1952	December 1, 1952
Average number of seedlings per plot	3.130	1.305
Standard deviation	4.087	1.882
Error of the mean:		
Number	± .289	± .133
Percent	± 9.2	± 10.2
Error of stocking percent	± 3.1	± 3.5

Information on the standard deviation provides a helpful guide in planning similar experiments. Whereas 200 plots provided 10-percent accuracy, the statistics show that averages from 100 plots would be accurate within 13 or 14 percent. Accuracy required and resources available should, of course, both be considered in determining the proper number of plots.

3/ Statistical analysis by George R. Staebler, Puget Sound Research Center, Pacific Northwest Forest and Range Experiment Station.

Suitability of Four Species for Aerial Seeding

Number of seedlings alone does not provide a fair measure of the relative success of the four species; number of seeds sown and germination capacity also have to be considered. For example, it is of no significance that twice as many hemlock seedlings as Douglas-fir were found, if twice as many viable hemlock seeds fell on the area. Hence, it is necessary to make a rational estimate of the number of seedlings of each species expected if each were equally suitable, and to compare this with the actual number found. The difference is the measure of species suitability.

Unfortunately, the expected number of seedlings cannot be computed accurately because precise data on the number of seeds sown were not obtained. An estimate was calculated, however, by multiplying the average number of seeds per pound by the rate of sowing. The resulting product was multiplied by the germination percent to compute the number of viable seeds expected to fall on the plots. The percentage distribution of viable seeds by species was applied to the total number of seedlings found in order to estimate the expected number of seedlings of each species. For example, it was estimated that 24.7 percent of the viable seeds falling on the plots was spruce. Of the 626 seedlings found in June, we might expect .247 x 626, or 155, to be spruce, assuming that spruce establishes itself with average success on this site.

In June 1952, spruce and hemlock had established themselves as a result of the April seeding about as expected (table 3). Fifty-two percent more Douglas-firs than expected were established, and only half as many Port-Orford-cedars. Apparently, Douglas-fir is superior for aerial seeding on this site; Port-Orford-cedar, inferior; and spruce and hemlock, intermediate. Since some natural hemlock seed doubtless fell on the area in addition to that sown by helicopter, the expected number of hemlock seedlings should be larger than the figure given in table 3. Accordingly, the relative success of hemlock would be somewhat less than indicated. A chi-square test shows that the differences among species (table 3) could not have occurred as a result of chance sampling.

By December 1952, after one growing season, the superiority of Douglas-fir was even more pronounced (table 4). Spruce and hemlock were poorer than indicated by the spring examination. The number of Port-Orford-cedar seedlings was far below the number expected. Again the chi-square test shows these differences could not have occurred by chance.

Table 3. --Calculation of the expected number of seedlings and comparison with the actual number found, June 1952.

Species	Seeds per pound	Pounds per acre	Germination percent	Viable seeds per acre	Percent of total	Seedlings		
						Found on plots	Expected	Ratio 1/
						Number	Number	Percent
Spruce	210 M	x .25	x .55	= 28,875	24.7	181	155	117
D-fir	44 M	x .50	x .67	= 14,740	12.6	120	79	152
Hemlock	297 M	x .25	x .77	= 57,172	48.8	281	305	92
Port-Orford-cedar	210 M	x .25	x .31	= 16,275	13.9	44	87	51
Totals				117,062	100.0	626	626	

1/ Number found/ number expected.

Table 4. --Comparison of expected and actual number of seedlings, December 1952.

Species	Number of seedlings found on plots	Expected number 1/	Ratio: Found / Expected
			Percent
Spruce	53	65	82
Douglas-fir	82	33	248
Hemlock	111	127	87
Port-Orford-cedar	15	36	42

1/ Computed from percentage distribution shown in table 3.

At the beginning of the second growing season, May 12, 1953, the ratio of actual to expected number of seedlings was even greater (figure 7). In percent, these ratios were: Spruce, 69 percent; Douglas-fir, 258 percent; hemlock, 96 percent; Port-Orford-cedar, 28 percent.

Natural Seeding on Check Area

On December 2, 1952, 51 temporary mil-acre plots were examined in a strip about 500 feet east of the 40-acre test area to determine the extent of natural seeding. No seed of any species had been artificially sown on this check area, yet the examination revealed 900 hemlock seedlings to the acre: stocking was 33 percent. Twenty Douglas-fir seedlings to the acre were also found, but no spruce. Douglas-fir stocking was only 2 percent.

Undoubtedly, natural seeding of hemlock also occurred on the 40-acre, 4-species test area. This makes it impossible to compare accurately the establishment of hemlock with that of other species, as originally planned. However, the mortality figures for the four species are not affected since all seedlings were individually marked.

SEEDLING COUNTS ON OTHER PORTIONS OF THE BURN

Intensive seedling counts or stocking surveys to determine results on the main area seeded to spruce outside the experimental study plots have not yet been made. The Olympic National Forest plans to make a general stocking survey sometime after the third growing season.

A preliminary check was made by the Puget Sound Research Center on an area near the road to Grindstone Flats where spruce alone was seeded at one-half pound to the acre. Seedling counts on 56 temporary mil-acre plots examined May 13, 1953, showed very poor results. Only 54 spruce seedlings to the acre were found. Only 9 percent of the plots were stocked with spruce. Results of the examination are summarized below:

	Seedlings per acre	Percent of plots stocked
Western hemlock	1,286	36
Sitka spruce	54	9
Western redcedar	36	4

Numerous alder seedlings were also found throughout the area.

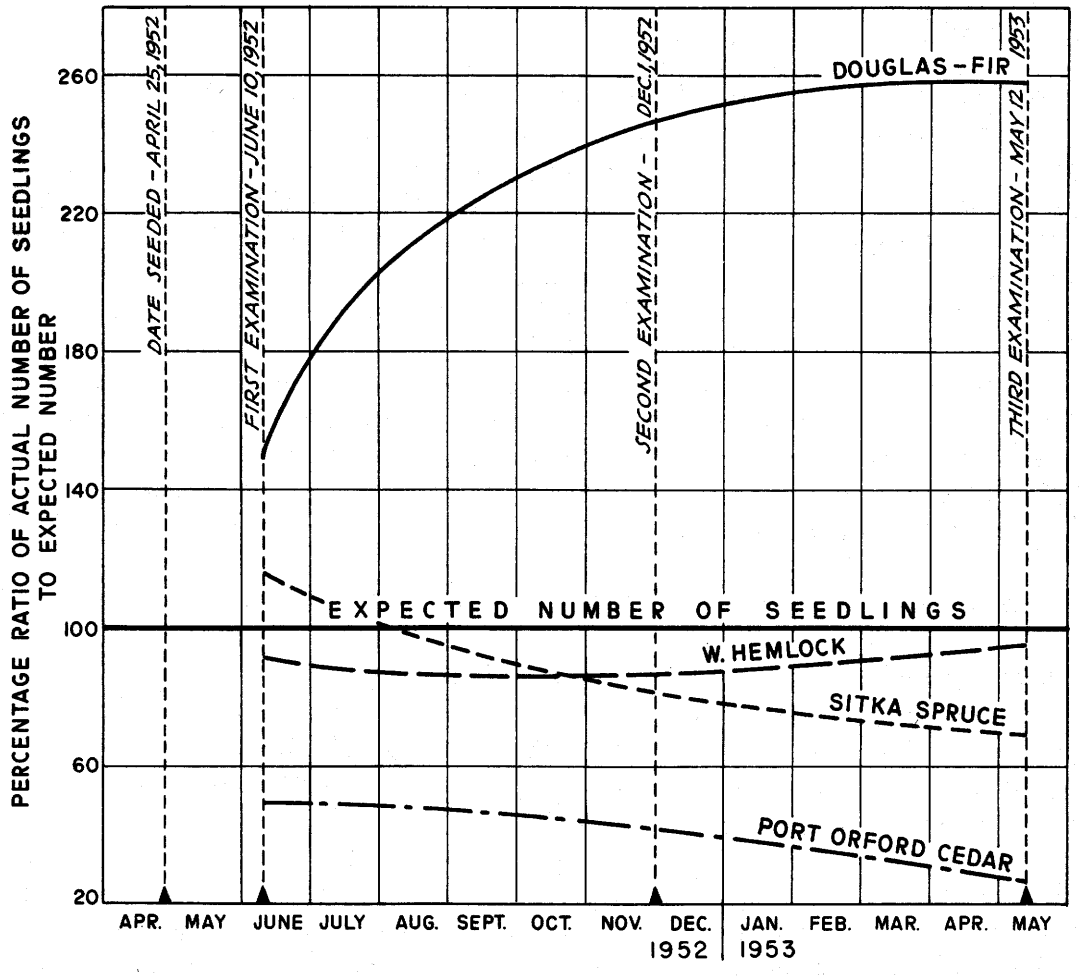


Figure 7 -- Comparative suitability of the four species tested

SUGGESTIONS FOR IMPROVING DIRECT SEEDING STUDIES

Work on this experiment in direct seeding and in other similar projects has provided a background of experience that should be helpful in planning such work in the future. Several mistakes have been made. Likewise, several new techniques have been devised, and many new ideas for improving field procedures have been developed.

Sampling seed distribution. --Flypaper is not ordinarily satisfactory for measuring seed distribution. In cool weather it is practically useless. Seed counts on stumps, roads, and bare spots are definitely uncertain and often inadequate. A special device should be developed for checking seed distribution. Bake sheets or cafeteria trays smeared with a light coating of grease might have possibilities.

Seedling markers. --On permanent sample plots field work is greatly reduced by conspicuous seedling markers. The markers should extend at least 12 or 18 inches above the ground, and the top should be brilliantly painted--different colors to be used for each species. Telephone wire with a loop in the end is good.

Isolation. --Helicopter seeding requires wide isolation between treatments. A strip at least 500 feet wide should be used to allow for a shift in wind during flights.

Grazing. --Cattle grazing should be prevented if possible. On the Forks plots many seedlings were trampled, stakes knocked out, and plots disturbed by a herd of cattle grazing on the experimental area all year.

Natural seeding. --When an experiment is designed to exclude seed from natural sources, special care should be taken in selecting the area. On the 40-acre test area at Forks, hemlock, Douglas-fir, and spruce seed trees were found within the borders of the experimental area, but only hemlock produced volunteer seedlings.

Exclosures. --Wire dome exclosures, such as those used by the U. S. Fish and Wildlife Service, are recommended for making accurate checks on germination and survival. The 4-species test on the Forks burn would have been considerably enhanced by the use of such exclosures.

Sample plots. --Statistical analysis indicates that for such studies the number of permanent sample plots could be reduced below 200 and still give sufficient accuracy. When fairly uniform conditions prevail, 100 mil-acre plots should give number of

seedlings per acre within 25-30 percent accuracy at two standard deviations or about 13 or 14 percent at one standard deviation.

Photographs. --Before and after photographs or color slides of selected areas or sample plots are always effective in showing the change in cover growth and seedling establishment.

CONCLUSIONS

At the end of the first year, May 1953, the results of the direct seeding experiments on the Forks burn may be summarized as follows:

(1) An analysis of seedling establishment of four species on a 40-acre area indicates that thus far on this particular location Douglas-fir has been distinctly superior. The percentage ratio of established seedlings to the expected number was:

	Percent
Douglas-fir	258
Western hemlock	96
Sitka spruce	69
Port-Orford-cedar	28

This does not necessarily mean that Douglas-fir is the best tree to grow here over a long rotation, but it does indicate that Douglas-fir when seeded by helicopter established itself much better than any of the other three species tested under the same conditions.

(2) Based on 200 mil-acre plots in the 40-acre area, stocking for the four species was:

	Percent
Western hemlock	28
Douglas-fir	22
Sitka spruce	14
Port-Orford-cedar	4
Any of the four species	45

(3) Survival of the four species during the first year was as follows:

	Percent
Douglas-fir	45
Western hemlock	32
Port-Orford-cedar	16
Sitka spruce	18
All species	30

(4) Seedling establishment (per acre) on the 40-acre test area, May 1953, was as follows:

Western hemlock	490
Douglas-fir	335
Sitka spruce	180
Port-Orford-cedar	40
Total	1,045

(5) An examination of the 200 mil-acre plots on May 12, 1953, showed that there was no delayed germination of seed distributed the previous spring. The only change during the winter was the normal loss from mortality.

(6) Examination of plots in an unseeded area and elsewhere indicated that hemlock seedlings from natural sources are prevalent throughout the experimental area, ranging from 900 to 1,286 per acre. Hemlock stocking in the check area was 33 percent. From 20 to 49 Douglas-fir seedlings per acre from natural seeding were also found, but no natural spruce seedlings.

(7) Records kept by the Olympic National Forest show that the total cost per acre for baiting and seeding 1,133 acres was $6.91.

(8) It is still too early to evaluate the success of the spruce seeding on the entire 1,133 acre project. The Olympic National Forest does not plan to make their stocking survey until about the third year after seeding. However, scattered preliminary examinations tend to indicate that, in most cases, spruce stocking is inadequate. For example, on a typical area near the road to Grindstone Flats, an examination of 56 temporary mil-acre plots on May 12, 1953, revealed that only 9 percent of the plots were stocked with spruce. Only 54 spruce seedlings per acre were found. On the 40-acre test area, stocking was 14 percent, or 180 spruce seedlings per acre.

It appears that natural seeding-in of Western hemlock will probably result in good restocking on many places. On all areas examined, the natural hemlock seedlings have outnumbered the spruce.