A 4-YEAR RECORD OF SITKA SPRUCE AND WESTERN HEMLOCK SEED FALL

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SUMMARY

Four years' measurement of seed fall in the spruce-hemlock type on the Cascade Head Experimental Forest indicates that an ample supply of seed is distributed over clear-cut areas under staggered-setting cutting. The largest tract sampled was 81 acres; in spite of a seed crop failure in 1950, it received an average of 243,000 viable spruce and hemlock seeds per acre yearly on a high ridge near the center of the area. In the spruce-hemlock type it is apparently practical to clear cut fairly large openings and still depend upon adjacent stands for an adequate distribution of seed.

During 1951 and 1952, clear-cut tracts received 352,000 viable seeds per acre annually. Under nearby dense stands annual seed fall was 5,448,000 viable seeds--15 times as much.

During the 4-year period, spruce and hemlock seed fall consistently started during the last 10 days in October, usually when the first dry east wind occurred. Fall slash burning in the fog belt is usually completed before this period and does not endanger seed fall of the current season. Half the seed fell by mid-November and 90 percent by February 1. Seed fall period was strongly influenced by species, years, elevation, and proximity to the ocean.

Viability of spruce and hemlock seed averaged 55.5 percent. Little difference was found between species, but the heaviest seed crop had the highest viability and the poorest seed crop the lowest. Tests on one area showed that more seeds were disseminated by occasional dry northeast winds than by prevailing southwest winds.

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A 4-YEAR RECORD OF SITKA SPRUCE AND WESTERN HEMLOCK SEED FALL ON THE CASCADE HEAD EXPERIMENTAL FOREST

By

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INTRODUCTION

Forest management practices in the Pacific Northwest fog belt are dependent in large measure on seeding habits of Sitka spruce (Picea sitchensis) and western hemlock (Tsuga heterophylla). Size of clearcut, for example, is influenced by dissemination distance. Need for planting, in turn, depends mainly upon frequency and abundance of seed crops. Slash burning, in turn, should be correlated with seed years and dates of seed dispersal.

Information available in the literature is limited. Estimated size of the annual cone crop is known from reports sent in by national forests, but these records are general in nature. As early as 1925-29, Isaac studied both hemlock and Douglas-fir seed. 1/ He found that hemlock seed, when released at 200 feet elevation in a 12.5-mile-an-hour wind, traveled as far as 3,800 feet, but heaviest seed fall was at 2,000 feet from the release point. This distance was greater than that for Douglas-fir and other species tested. Isaac also determined vertical rate of fall of hemlock seed in still air to be 2.05 feet per second. Siggins calculated the average rate of fall for spruce seed to be 3.1 feet per second and for hemlock 2.6 feet per second. 2/ Good spruce seeds weighed 0.0034 gram

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1/ Isaac, L. A. Seed flight in the Douglas fir region. Jour. Forestry 28: 492-499. 1930.

2/ Siggins, H. W. Distribution and rate of fall of conifer seeds. Jour. Agric. Res. 47(2): 119-128. 1933.

each and good hemlock seeds weighed 0.0021 gram each. Garman studied seed production in stands of Douglas-fir, hemlock, and cedar on Vancouver Island and found hemlock to be much more prolific than its associates. 3/

A recent 4-year study of seed fall in the spruce-hemlock type on the Oregon coast has provided much additional information. The study was conducted on staggered clear-cut settings and under dense stands. Seed source was 100-year-old spruce and hemlock on the Cascade Head Experimental Forest in the fog belt of western Oregon. Therefore, results should be generally applicable to similar stands in the spruce-hemlock type.

MEASURING SEED FALL

Boxlike traps with a fine screen floor to retain seed and a coarse hardware cloth top to exclude rodents were used to measure seed fall (fig. 1). Some traps were about 4 feet square and others were 2 feet by 3 feet. In determining the effective area of a trap, the inside and outside dimensions of the trap were averaged to allow for seeds that might fall on the edge boards. This allowance was based on the assumption that half the seeds falling on the edge boards would eventually fall into the trap. The larger traps had an effective area of 15.5 square feet, and the smaller ones 5.7 square feet.

Collection Procedure

Beginning in September, seed traps were examined every few days to determine when seed fall started. Thereafter, seed was collected from the traps monthly until February. A final collection was made each year during June or July.

Seeds collected from the traps were classified by species and counted. Approximate viability was determined by cutting test, that is, seeds were opened with a razor blade and the cross sections examined; those appearing firm and white were considered viable. 4/

3/ Garman, E. H. Seed production by conifers in the coastal region of British Columbia related to dissemination and regeneration. British Columbia Forest Serv., Tech. Pub. No. T. 35, 47 pp. illus. 1951.

4/ U. S. Forest Service. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus. 1948.

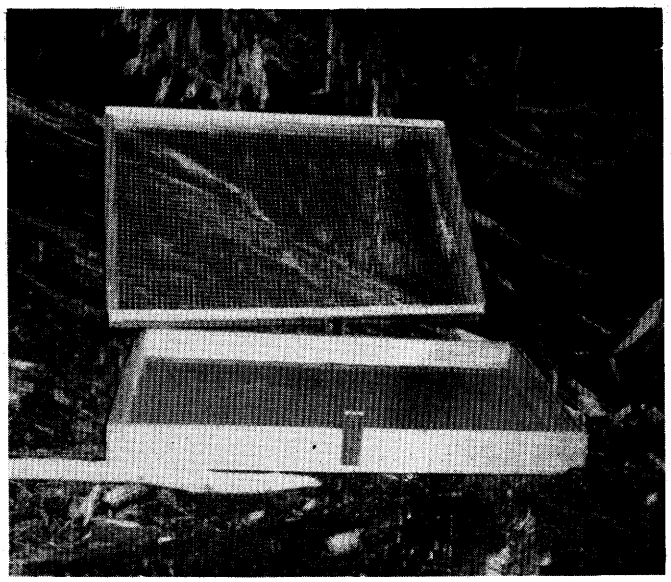

Figure 1.--A 5.7-square-foot seed trap used to measure seed fall on the Cascade Head Experimental Forest.

Seed Source

Seed obtained on all areas sampled came from a stand of fully stocked 100-year-old spruce and hemlock. Douglas-fir (Pseudotsuga menziesii) made up about 15 percent of the stand next to some areas, but because of repeated seed crop failures, it contributed less than 1 percent of the measured seed fall. Consequently, Douglas-fir seed fall was not included in the analysis.

Measurements

The seed fall study was started in 1949 when traps were placed on two clear-cut tracts in the Cascade Head Experimental Forest. Both tracts were part of a staggered-setting logging experiment in which each cutting was completely surrounded by green timber.

Tract A was a 21-acre clearcut, rectangular in shape, 1,700 feet long in a north-south direction, and 530 feet wide. A high east-west ridge through the center of the tract divided it about equally into two

slopes facing north and south. On August 22, 1949, 20 seed traps were placed on tract A (fig. 2). Each trap had an effective area of 5.7 square feet, making a total trap area of 114 square feet (table 1).

Tract B was an 81-acre clearcut, irregular in shape, with a high ridge jutting out into the center (figs. 2 and 3). Only 4 seed traps were available for this tract during the first season, and they were set out on September 7, 1949. The traps were placed on the ridge near the center of the clearcut because the ridge was most inaccessible to seed, the nearest seed source being 550 feet north. Tree crowns were about level with or slightly higher than the elevation of the traps. Remainder of the tract was generally lower in elevation and nearer to the seed source.

Measurements in 1950 were the same as in 1949 except that 5 additional seed traps were placed on the high ridge near the center of tract B, increasing total trap area on this tract to 119.9 square feet. Measurements in 1951 and 1952 on tracts A and B were the same as in 1950. Four additional clearcuts were sampled during these last 2 years (table 1). These tracts were also part of a staggered-setting logging trial and were completely surrounded by green timber. In each tract, seed traps were placed near the center of the clearcut.

In 1951, seed fall under dense spruce-hemlock stands was measured by seed traps placed under the forest canopy on 4 timbered plots.

Table 1.--Effective area of seed traps on 6 clear-cut tracts

Clear-cut tract	Area 1/	Effective trap area			
		1949	1950	1951	1952
	Acres	Square feet			
A	21	114.0	114.0	114.0	114.0
B	81	42.4	119.9	119.9	119.9
C	20	--	--	17.1	5.7
D	15	--	--	17.1	17.1
E	34	--	--	17.1	5.7
F	52	--	--	17.1	11.4

1/ Average size of clearcut was 36.7 acres.

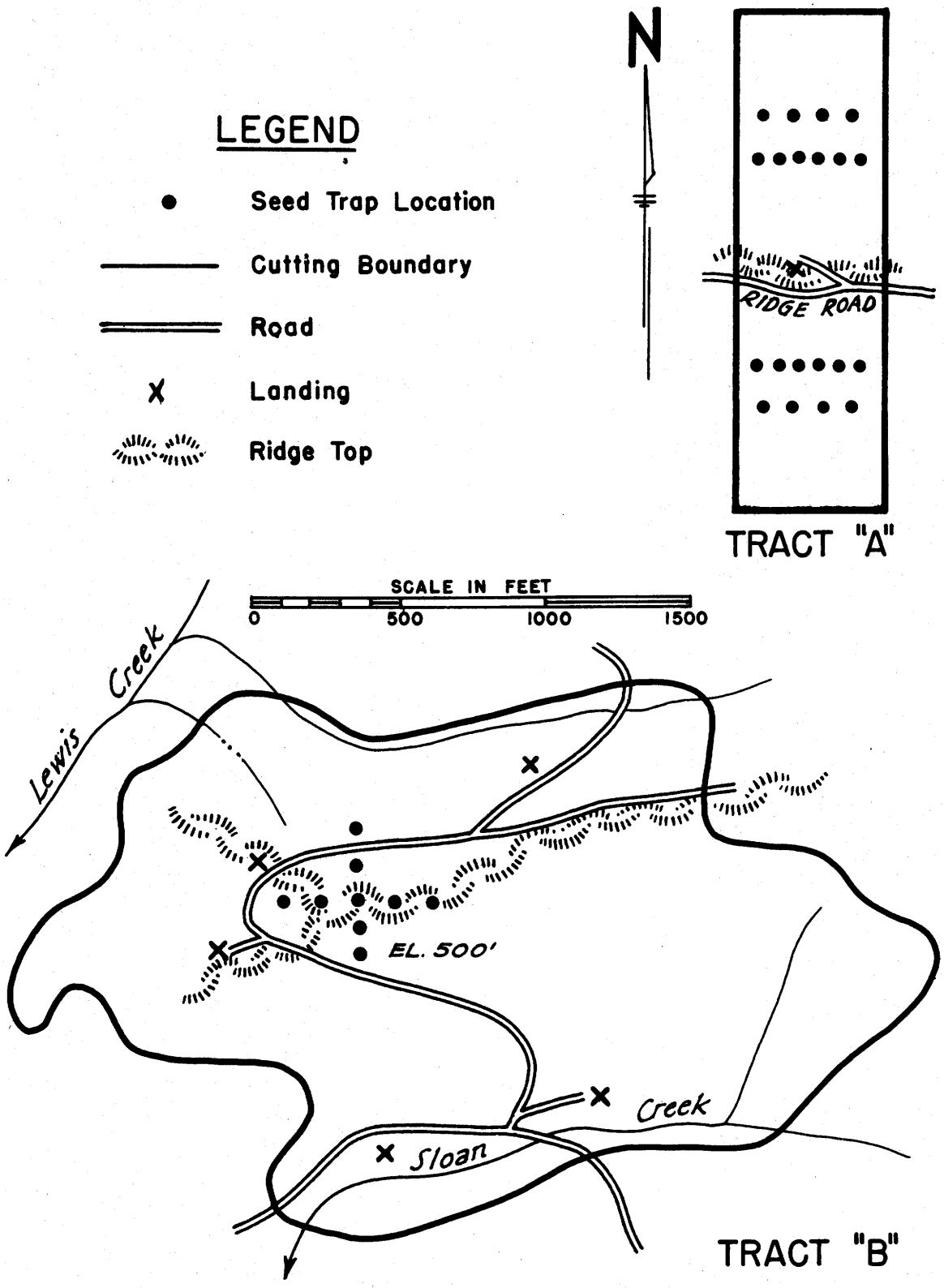

Figure No. 2----- Seed trap locations on clear cut tracts A and B, Cascade Head Experimental Forest.

Figure 3.--Tract B was an 81-acre clearcut surrounded by green timber. Seed traps were located on the high ridge near the center.

RESULTS

Seed Fall on Clear-cut Tracts

All clear-cut tracts tested received an abundant supply of viable spruce and hemlock seed within the 4-year period (table 2). The staggered-setting system of clearcutting provided a dependable and adequate supply of well-distributed seed on all clear-cut areas sampled.

The high ridge near the center of tract B received 243,000 viable spruce and hemlock seeds per acre annually over the 4-year period. Apparently, adequate amounts of viable seed can be expected on clear-cut areas as large as 81 acres.

Because traps were near the center of each clearcut, recorded seed fall probably was close to the minimum received on the tract. The remainder of each tract was nearer to the seed source and probably received more seed.

Table 2.--Viable seed fall per acre on 6 clear-cut tracts, Cascade Head Experimental Forest, 1949-52 [1/]

Species and year	Tract						Average	
	A	B	C	D	E	F		
	Thousands						Thousands	Lbs. [2/]
Spruce								
1949	346.7	362.5	--	--	--	--	354.6	1.7
1950	--	.4	--	--	--	--	.2	--
1951	101.3	91.9	147.7	15.3	76.5	114.6	91.1	0.4
1952	6.0	4.7	68.8	33.1	22.9	38.2	28.9	0.1
Hemlock								
1949	460.3	305.0	--	--	--	--	423.6	1.5
1950	--	.4	--	--	--	--	.2	--
1951	706.9	157.6	254.7	56.0	175.8	102.0	242.2	0.8
1952	66.7	50.7	588.4	374.4	382.1	584.6	341.2	1.1
Both								
1949	807.0	667.5	--	--	--	--	737.2	3.2
1950	--	.8	--	--	--	--	.4	--
1951	808.2	249.5	402.4	71.3	252.3	216.6	333.4	1.2
1952	72.7	55.4	657.2	407.5	405.0	622.8	370.1	1.2

1/ Based on measurements near center of clear-cut tracts.

2/ Based on 210,000 seeds per pound for spruce and 297,000 seeds per pound for hemlock.

Seed fall varied considerably by species, by years, and among the different tracts, even though all measurements were within a 10,000-acre experimental forest. Seed crops were classified by species and years as follows:

Year	Spruce	Hemlock
1949	Abundant	Abundant
1950	Failure	Failure
1951	Light	Medium
1952	Light	Abundant

Seed fall on 21-acre tract A was greater than on 81-acre tract B, but the difference was not due solely to size of clearcut. Seed collected near the center of tract A averaged 421,975 viable spruce and hemlock seeds per acre per year, compared to an average of 243,000 on tract B. A comparison of annual seed fall by species shows part of the difference between the tracts was the result of a much heavier hemlock seed crop at tract A in 1951. Hemlock generally produced more seed than spruce. This was an advantage to tract A because its surrounding timber had a higher percentage of hemlock trees than tract B.

Seedlings on tract A were counted in the spring of 1954 to study seedling distribution by ground surface and cover conditions. There were an estimated 15,714 trees per acre, 1 year old or older, growing on the area 6 years after clearcutting. An estimated 4,406 trees per acre were recorded as "established" trees, which probably will not be crowded out by competing vegetation.5/

Seed Fall Under Dense Stands

The 1951 and 1952 seed crops under dense spruce-hemlock stands were estimated to be 5,448,000 viable seeds per acre per year (table 3) compared to 352,000 on the clear-cut tracts. In other words, seed fall under the forest canopy was 15 times greater than on the clearcuts. Garman6/ obtained comparable results in British Columbia where viable hemlock seed that fell 1 to 5 chains outside the timber boundary was about 10 percent of the amount falling 1 to 5 chains within the timber.

The 1951 and 1952 viable seed fall under the forest canopy varied widely depending upon species composition (table 4). Hemlock was the better seed producer during this period. Stand composition averaged 52 percent hemlock and 47 percent spruce, but seed fall averaged 96 percent hemlock and 4 percent spruce.

Season of Seed Fall

Spruce and hemlock seed fall on the experimental forest started each year in the last 10 days of October. It was apparently correlated with the first dry easterly winds that occurred during that period and

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5/ Berntsen, Carl M. Seedling distribution by ground surface and cover condition on a 21-acre clearcut in the spruce-hemlock type. Pacific Northwest Forest and Range Experiment Station. 1954. Manuscript.

6/ See footnote 3 on page 2.

Table 3.--Viable seed fall per acre under dense spruce-hemlock stands, 1951 and 1952

Species and year	Timbered plot 1	2	3	4	Average
	Thousands				Thousands
Spruce					
1951	125	294	313	73	201
1952	76	516	485	54	283
Hemlock					
1951	5,600	482	1,063	2,517	2,416
1952	11,979	2,220	3,660	14,130	7,997
Total	17,780	3,512	5,521	16,774	10,897
Annual	8,890	1,756	2,760	8,387	5,448

Table 4.--Stand composition and annual fall of viable seed under dense spruce-hemlock stands, 1951-52

Plot	Stand composition		Annual seed fall	
	Spruce	Hemlock	Spruce	Hemlock
	Percent	Percent	Thousands	Thousands
1	2	97	100	8,790
2	83	15	405	1,351
3	89	10	399	2,366
4	3	97	64	8,324
Average	47	52	242	5,206

there was usually a very heavy fall the first day. Drying winds earlier in the month failed to advance the beginning date. In 1953, drying winds did not occur in late October or November, and only a few seeds fell during that period; the main crop fell later. In the fog belt, slash is usually burned before the middle of October so there is little danger that the current year's seed crop will be destroyed in the slash-burning operation. Based on 1949-52 measurements, 50 percent of the viable seed crop was on the ground by mid-November and 90 percent by about February 1 (fig. 4). Some seed fell as late as April and May. This distribution is in marked contrast to experience on Vancouver Island, where very little hemlock seed fell before March.7/

In 1951 and 1952 time of seed fall was apparently related to elevation and proximity to the ocean. The areas sampled, 6 clear-cut tracts and 4 timbered plots, divided logically into 2 groups. Tracts A, B, and C and timbered plot 1 ranged from 5 to 6 miles from the ocean and from 500 to 800 feet in elevation. Tracts D, E, and F and timbered plots 2, 3, and 4 ranged from 1 to 3 miles inland and from 800 to 1,500 feet in elevation. In 1951, inland sample areas at lower elevations had 86 percent of the viable seed on the ground by December 30, but coastal areas at higher elevations had only 69 percent. By January 29, the inland areas had received 96 percent of the total crop and the coastal areas 92 percent. The 1952 seed crop followed a similar trend of earlier seed fall at low-elevation inland points. By January 14, the inland areas had 92 percent of the crop on the ground, coastal areas only 76 percent.

Percent of Viable Seed

Viability of spruce and hemlock seed averaged 55.6 percent, but wide variation occurred between years (table 5). The heavy 1949 seed crop had the highest viability; the few seeds that fell in 1950 had very low viability. Almost no variation between species was noted except in 1950, when spruce viability was higher than that of hemlock. However, 1950 data were based on a small number of seeds and may not be reliable.

7/ See footnote 3 on page 2.

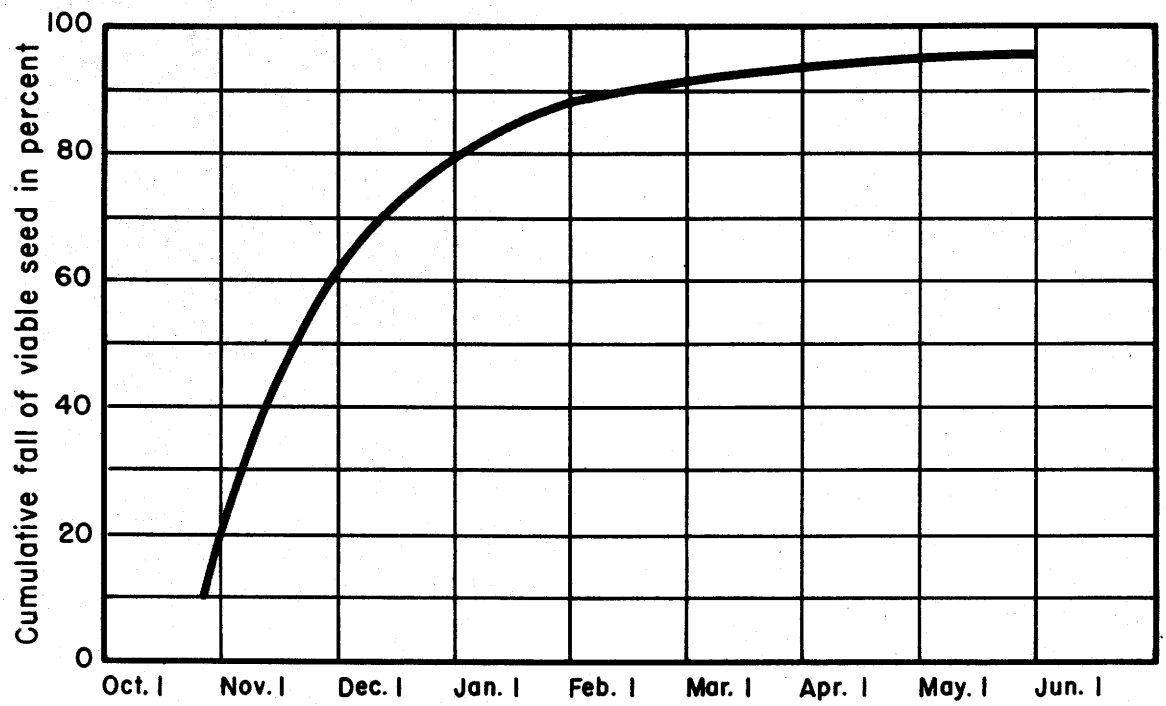

Figure No. 4 -- Season of seed fall for Sitka spruce and western hemlock on the Cascade Head Experimental Forest.

Table 5.--Viability of spruce and hemlock seed, 1949-52

Year	Spruce	Hemlock	Average
		Percent	
1949	78	72	75
1950	34	7	21
1951	54	55	55
1952	51	52	52

Viability of seed falling in the open areas did not differ greatly from that of seed found under the forest canopy. Viability percentages were as follows:

Year	Timbered plots	Clearcuts
1951	54	55
1952	53	41

Viability varied considerably with season. Viability of the first seeds collected in the fall was average or slightly above. Seed collected during November and December, when most of the seed fell, had the highest viability. Maximum recorded was 86 percent for seeds collected during November 1949. During late winter and spring, viability tapered off gradually. Lowest percentages recorded were for June and July collections.

Seed Dissemination in Relation to Prevailing Winds

Prevailing southwest winds may have only a minor effect on seed dispersal. The 20 seed traps on tract A were tabulated according to distance from both the nearest northeast and southwest seed sources. Traps nearer the northeast timber boundary received more seed, indicating that most of the seed crop was disseminated by occasional dry northeast winds. Point of least seed fall was not midway between the two timber boundaries, but only about a fourth of the distance outward from the southwest boundary.

DISCUSSION

This 4-year study has answered several important questions about seed fall from a 100-year-old spruce-hemlock stand. It has also shown wide variation in seed fall by years, species, elevation, and proximity to the ocean. Conclusions based on the 4-year study are as follows:

1. Small, clear-cut tracts in the spruce-hemlock type characteristic of the staggered-setting system received an abundant supply of seed from surrounding green timber. An 81-acre tract received ample seed well distributed over the area.

2. Seed fall started with the first drying winds during the last 10 days of October. This is after normal slash burning season. Seed fall tapered off gradually, with some seed coming down as late as April and May.

3. Hemlock was a more prolific seed producer than spruce.

4. Seed fall under dense, 100-year-old spruce-hemlock stands was about 15 times greater than on clear-cut tracts.

5. Season of seed fall was later in areas of high elevation near the ocean than in inland areas at lower elevations.

6. Viability of spruce and hemlock seed averaged about 55 percent.

There is much yet to be learned. An important question to be answered is whether a seed source on only one side of a clearcut will be adequate. This will be the situation with progressive strip cutting into the southwest storm winds to minimize blowdown. The distance seed is disseminated needs further investigation. Foresters need to know how seed production is influenced by age of tree, crown class, crown release, and climatic factors. As this information becomes available, it will be utilized to prepare increasingly effective plans for regeneration of the timber crop.