United States
Department of
Agriculture

Forest Service

**Pacific Southwest
Forest and Range
Experiment Station**

Research Paper
PSW-150

Seed Dissemination in Small Clearcuttings in North-Central California

Philip M. McDonald

McDonald, Philip M.
1980. **Seed dissemination in small clearcuttings in north-central California.** Res. Paper PSW-150, 5 p., illus. Pacific Southwest Forest and Range Exp. Stn., Forest Serv., U.S. Dep. Agric., Berkeley, Calif.

In a 1964–1967 study on the Challenge Experimental Forest, seedfall was evaluated in 2-, 5-, and 10-acre circular clearcuttings. During the 4 years, 10 seed crops, ranging from light to bumper, were produced by ponderosa pine, white fir, Douglas-fir, and incense-cedar. Seedfall ranged from 76 to 40,691 sound seed per acre (188 to 100,547/ha) for a single species in a given year. From 89 to 100 percent of each species' seed fell within an area 1½ times the height of the average dominant tree. Overall, seed distribution was highly variable.

Retrieval Terms: seed production, seed dispersal, clearcutting, *Pinus ponderosa, Libocedrus decurrens, Pseudotsuga menziesii, Abies concolor,* Challenge Experimental Forest

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Cover: Aerial view of two 10-acre (4-ha) and two 2-acre (0.8-ha) circular clearcuttings on the Challenge Experimental Forest, Yuba County, California.

Publisher:

Pacific Southwest Forest and Range Experiment Station
P.O. Box 245, Berkeley, California 94701

January 1980

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As forestry becomes more intensively applied, the need for more and better silvicultural techniques and guidelines is paramount. Clearcutting is one technique that foresters in north-central California are considering.

In young-mature, mixed-conifer stands on good sites, regeneration in natural openings has been observed to be both scanty and abundant. Further, it seems to be distributed in other than a random pattern. Reasons for these observations are unknown, although two possibilities often are heard: "It is too hot for young conifers near the clearcut center" and "brush and weeds kill conifer seedlings and this is why there are so few."

Results of this study suggest that a third reason is operative: seedfall is highly variable and could be deficient especially near the center of clearcuttings.

On the Challenge Experimental Forest in Yuba County, California, seedfall was evaluated in 2-, 5-, and 10-acre circular clearcuttings cut specifically to study natural seedfall. Corners in square or rectangular compartments receive excessive and unpredictable amounts of seed and, therefore, are difficult to study. During this 1964–1967 study, 10 seed crops ranging from light to bumper were borne by ponderosa pine, white fir, incense-cedar, and Douglas-fir. A seed crop is defined as that produced by one species in 1 year. Seedfall ranged from 76 to 40,691 sound seed per acre (188 to 100,547/ha) for a single species in a given year.

Each opening was divided into concentric zones so that seedfall of each species could be quantified relative to distance from the forest edge. In general, seedfall decreased as distance into the opening increased. Some seeds of white fir and ponderosa pine reached the center of 10-acre clearcuttings, but the smaller seeds of Douglas-fir and incense-cedar did not.

Seedfall was examined in terms of the amount of seed that fell into the different-sized clearcuttings while the soil surface in them was loose and relatively free of vegetative competition. These seeds, and resultant seedlings that survived for 4 years, formed the basis for evaluating the adequacy of natural seedfall in the clearcuttings.

Despite increasing emphasis on planting genetically superior seedlings, regeneration of thousands of acres of forest land in the West will be from natural seeding for years to come. Before natural seedfall and natural regeneration can be predicted, however, knowledge of the frequency and magnitude of seed crops, and of seed flight distance must be available.

Natural seedfall of most conifer species in most parts of California has been studied for years, but that for young-mature, mixed-conifer stands in north-central California has not. Results of this investigation, therefore, contribute both to knowledge of seedfall capability for these species at a younger age, and to seedfall information for an area where data have not existed before.

Previous work on seed dissemination of the species studied here generally shows that the amount of seed on the ground decreases rapidly with distance from the producing tree. For ponderosa pine *(Pinus ponderosa* Laws.) in Idaho, most seed fell within 66 feet (20 m) of the tree (Curtis and Foiles 1961). In central Oregon, the quantity of ponderosa pine seed dispersed into a clearcutting dropped sharply with distance from the source (Barrett 1966). Nearly three times more seed fell on the sheltered border of the clearcutting than on the more exposed border. At 265 feet (81 m) into the clearcutting, seed quantity on the sheltered side was about seven times that of the exposed. At this distance, seedfall was one-fifth and one-twelfth of that falling near the respective sheltered and exposed edges of the clearcutting. Also in central Oregon, ponderosa pine seed dissemination varied with minor differences in topography (Dahms and Barrett 1975). Taller trees located above a clearcutting cast seed farther than those slightly below it. In general, seedfall beyond 200 feet (61 m) was only 2 to 3 percent of that near the timbered edge.

Gordon (1970) noted a strong tendency for white fir *(Abies concolor* [Gord. & Glend.] Lindl.) and California red fir *(Abies magnifica* A. Murr.) seeds to be dispersed by strong southwesterly storm winds. Seed on the easterly border, therefore, was blown back under the forest canopy. Gordon concluded that "seed dispersal over openings seems to be determined largely by amounts released at the windward cutting edge."

For Douglas-fir *(Pseudotsuga menziesii* [Mirb.] Franco), Roy (1960) noted that the number of sound seed delivered to the ground decreased rapidly with increasing distance from the source. Furthermore, he stated that "seed dispersal is dependent upon the pattern of gentle and strong winds and not upon the aerodynamic characteristics of seed."

This paper describes a 4-year (1964–1967) study of seedfall on the Challenge Experimental Forest in north-central California.[1] Research on this Forest is applicable to about 1.5 million acres (600,000 ha) of highly productive timberland along the lower west slopes of the Sierra Nevada. Tree species studied were ponderosa pine, white fir, Douglas-fir, and incense-cedar *(Libocedrus decurrens* Torr.). The trees were young-mature (90 to 120 years old) and relatively tall for their age (120 to 180 feet) because of the good site.

METHODS

Dominant and codominant trees of all species on the study site numbered about 35 per acre (86/ha), 70 percent of which were ponderosa pines. Trees in these crown classes produced more than 80 percent of a seed crop (McDonald 1973, 1976). Douglas-fir, younger than ponderosa pine, was more likely found in the intermediate and codominant crown classes than in the dominant class.

[1]This study was done in cooperation with the Soper-Wheeler Company, Strawberry Valley, California.

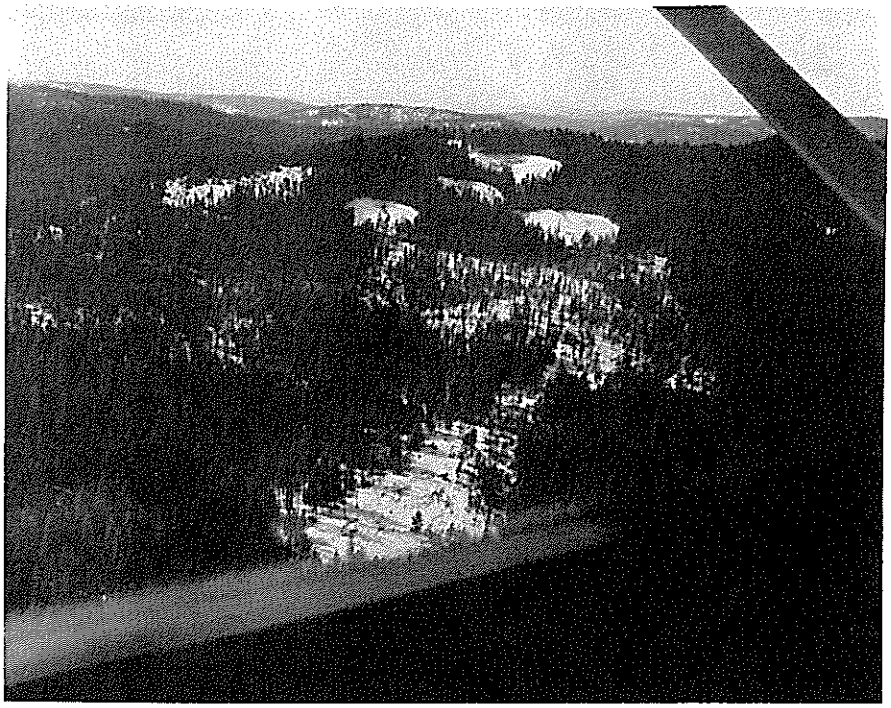

Figure 1—Aerial view of two 10-acre (4-ha) and two 2-acre (0.8-ha) circular clearcuttings on the Challenge Experimental Forest, Yuba County, California.

During the 4-year study, ponderosa pine seed crops rated as bumper in 1967, medium in 1964, and light in 1966. White fir produced medium crops in 1964 and 1967. Douglas-fir yielded light crops in 1964, 1965, and 1967, and incense-cedar bore only a few cones in 1965 and 1967.

To facilitate the study of natural seedfall, small circular areas of 2, 5, and 10 acres were clearcut *(fig. 1)*. Two clearcuttings of each size were located on a southwest aspect, and two of each size on a northeast aspect. Average slope on the southerly aspect varied from 5 to 15 percent, and on the northerly aspect from 10 to 35 percent. Relative positions of the clearcuttings on the slopes extended from near the top to near the bottom.

Each clearcutting was divided into zones. This division facilitated the quantification of seedfall at various distances into the clearcuttings. Zone 1 began at the forest edge and extended inward toward the clearcut center for 100 feet (30 m). Zone 2 extended inward 100 feet beyond that, and successive zones, if present, continued toward the plot center.

In each size of clearcutting the number of zones was:

Size *(acres)*	Radius *(feet)*	Zones
2	166	2
5	263	3
10	372	4

Sampling intensity was based on past experience with seedfall from a medium ponderosa pine seed crop, and adjusted by the proportionate area in each zone. Sampling was by foot-square (0.09 m^2) seed traps *(fig. 2)*, the reliability of which was ascertained earlier for the species being studied (McDonald 1973, Roy 1959). A polar coordinate (random bearing and distance) technique was used to place a total of 772 seed traps in the 12 clearcuttings. Each 10-acre clearcutting received 143 traps, each 5-acre opening 39, and each 2-acre clearcutting 11 seed traps. Scaled maps showed the location of each numbered seed trap in each opening.

Seed traps were cleaned before seedfall each autumn and emptied after seedfall each winter. Cutting tests assessed seed soundness. Only data for sound seed are provided in this paper.

RESULTS

Results of this study showed that seed distribution is highly variable and, in some instances, erratic. An overall finding, useful to land managers, is that 89 percent or more sound seeds of ponderosa pine, Douglas-fir, white fir, and incense-cedar fell within an area 1½ times the height of the average dominant tree.

Seedfall estimates ranged from 76 to more than 40,600 sound seed per acre for a given species in a given year *(table 1)*. Production of sound white fir and ponderosa pine seeds was particularly high in 1967 and only slightly less so in 1964. Although white fir trees made up only 3 percent of the dominant and codominant stand, they were especially fruitful.

Figure 2—A 1-foot-square seed trap in place in a clearcutting on the Challenge Experimental Forest, Yuba County, California.

When seedfall data from all species for the 4-year study were analyzed by size of clearcutting and zone, the seed distribution pattern was revealed. Regardless of the size of the clearcutting, more sound seed fell on each acre of the outermost zone nearest the forest edge *(table 2)*. And each successive zone toward the center received less seed. The lowest number of seeds per acre consistently fell in the innermost zone in each size of clearcutting. In the innermost zone, total estimated seedfall was about 4350 sound seed per acre (10,751/ha); that next to the forest edge amounted to more than 20,100 sound seed per acre (49,763/ha).

The proportion of seed of each species that fell within an area 1½ times the height of the average dominant tree (200 feet) was:

Species	*Percent*
Douglas-fir	98
White fir	91
Ponderosa pine	89
Incense-cedar	100

To ascertain seed flight distance of the various species, sound seed per acre for each species in each zone was totaled for all seed crops in 5- and 10-acre openings. Zones receiving no sound seed of a given species were especially noted *(table 3)*.

At least some seed of the species having larger seeds—ponderosa pine and white fir—were found in all zones of 10-acre clearcuttings. Of the species having smaller seeds, Douglas-fir seed was disseminated into zone 3 but not into zone 4, and seed of incense-cedar was not distributed into either zone 3 or 4. In the 5-acre openings, no seed of Douglas-fir or incense-cedar reached zone 3.

Seedfall was examined further to assess the amount of seed that fell into the different zones of each size of clearcutting the first year of the study *(table 4)*. At this time (1964) seeds were falling on recently prepared ground. The soil was loose and friable, and nearly free of competing vegetation. Subsequent seed crops fell on increasingly harder ground, covered with a rapidly increasing diversity and abundance of grasses, forbs, and woody shrubs.

DISCUSSION

The study of seed distribution is difficult because many variables must be examined. These range from weight, shape, and aerodynamics of each species' seed to such meteorological considerations as windspeed and direction, relative humidity, and temperature. Position of the tree relative to the opening where the seed will be dispersed is also a variable. Trees on the edge of the opening have better opportunities for seed dispersal than those in the second and third ranks within the forest. The inherent height of the various tree species also is important. Topographic variables such as slope, aspect, and position of opening on the slope must be considered. Seldom, if ever, does any one variable act alone. Most often, the interaction of all of them governs seedfall. It is nearly impossible to isolate the effect of each vari-

Table 1—*Sound seed per acre by species and size of clearcutting for the years 1964 to 1967 on the Challenge Experimental Forest, Yuba County, California*[1]

Species	Crop year											
	1964			1965			1966			1967		
	Size of clearcutting *(acres)*											
	2	5	10	2	5	10	2	5	10	2	5	10
	Sound seed per acre											
Douglas-fir	1,985	560	534	0	560	382	0	0	0	0	0	0
White fir	2,978	5,599	2,595	0	0	0	0	0	0	32,751	4,199	7,325
Ponderosa pine	992	1,680	687	0	0	0	0	560	153	40,691	7,559	15,344
Incense-cedar	0	0	0	0	280	228	0	0	0	992	0	76
Total	5,955	7,839	3,816	0	840	610	0	560	153	74,434	11,758	22,745

[1]Values shown are the average for the four replications of each size of clearcutting.

Table 2—*Sound seed per acre by zones within clearcuttings for the years 1964–1967 on the Challenge Experimental Forest, Yuba County, California*[1]

Zone	Size of clearcutting *(acres)*			
	2	5	10	All
	Sound seed per acre			
1	67,488	10,864	9,160	20,139
2	12,902	9,518	6,030	7,560
3	—[2]	2,520	5,878	5,406
4	—	—	4,351	4,351
All[3]	58,775	9,942	7,395	14,189

[1]Values shown are the average for the four replications of each zone for each size of clearcutting. Zone 1 for all clearcuttings is nearest surrounding timber.

[2]Dashes indicate no zone present.

[3]These data were determined through weighting by zone areas.

Table 3—*Sound seed of all seed crops, by species, in each zone of the 10-acre clearcuttings for the yeas 1964 to 1967 on the Challenge Experimental Forest, Yuba County, California*

Species	Zone			
	1	2	3	4
Douglas-fir	1,832	1,832	305	0
White Fir	11,602	11,908	9,792	6,411
Ponderosa pine	22,597	18,321	13,435	10,993
Incense-cedar	610	610	0	0

Table 4—*Seedfall from 1964 seed crop, by zones, in 2-, 5-, and 10-acre clearcuttings on the Challenge Experimental Forest, Yuba County, California*[1]

Size of clearcuttings *(acres)*	Species	Zone			
		1	2	3	4
		Sound seed per acre			
2	Douglas-fir	992	992	—[2]	—
	White fir	992	1,985	—	—
	Ponderosa pine	0	992	—	—
5	Douglas-fir	0	560	0	—
	White fir	3,639	1,680	280	—
	Ponderosa pine	1,400	280	0	—
10	Douglas-fir	458	76	0	0
	White fir	763	840	687	305
	Ponderosa pine	305	153	229	76

[1]Values shown are the average for the four replications of each zone for each clearcutting. No incense-cedar seed were found.

[2]Dashes indicate no zone present.

able or of each interaction. And the instrumentation necessary to do the job is staggering.

Sampling seedfall is also difficult and expensive. Just physically installing an adequate number of seed traps is a big job.

Sampling design and intensity for seed trap placement were based on variances derived from previous samples for apparently comparable conditions. But seed distribution in the clearcuttings was more erratic than anticipated. Many traps caught no seed. Other traps, especially near the forest edge, caught a shower of seeds, and the large number of seeds per trap boosted sample variation to high levels.

As originally envisioned, statistical analysis was to be by regression, augmented by rank tests. These techniques proved to be unsuccessful. In general, these data, given their variable nature, were not adequate to allow statistical testing. Evaluations of the results, therefore, are statistically unsubstantiated. This fact, in spite of the large seed trap sample and initial concern with sampling design, leads one to question if studies like this are practical. Inherent high variation often necessitates a huge sample, and an unrealistically high budget.

Nevertheless, results show trends which should influence silvicultural treatments. Ten seed crops were produced in 4 years, and several of these crops rated at least medium in terms of seedfall. The land manager, therefore, can count on at least some seed falling relatively soon after cutting or site preparation. Quantifying each seed crop in terms of sound seed could be

helpful to landowners contemplating natural reforestation. Because several species produced these seeds, a new stand composed of more than one species is possible. A useful overall finding is that 89 percent or more of sound seeds of ponderosa pine, Douglas-fir, white fir, and incense-cedar fell within an area 1½ times that of average dominant tree height, and, this fact agrees generally with results of other studies.

Additional findings from this study mostly concern seed distribution. The amount of sound seed distributed into clearcuttings of 2, 5, and 10 acres was highly variable *(table 1)*. However, a steady trend of decreasing seed with distance from the forest edge was evident *(table 2)*. Seeds of Douglas-fir and incense-cedar were not dispersed into the clearcuttings beyond 300 and 200 feet, respectively *(table 3)*. In support of *table 2*, a similar trend of decreasing seedfall with increasing distance toward the clearcut center for the seed crops of a given year was evident *(table 4)*. The difference in seed flight distance among species is in general agreement with Siggins (1933) who reported ponderosa pine seed to fall at a rate of 5.0 feet per second, white fir at 5.7 feet per second, and incense-cedar at 5.9 feet per second. Presumably, seeds that fall slowly have a greater potential for longer seed flight distance. With a slower rate of fall (4.4 feet per second), seed of Douglas-fir should travel farther into the clearcuttings. They did not however, because as noted earlier, trees of this species tend to be shorter with crowns in a more shielded position in the stand.

At least some seeds of ponderosa pine and white fir reach the center of 10-acre clearcuttings, however. Wind gusts, eddies, and possibly convectional lifting, aid in transporting them there. In artificially regenerated plantations they, and the seedlings which result, may or may not be desirable. If the plantation is understocked, more seedlings may be welcome; if fully stocked, eventual thinning may be necessary.

Whether or not the amount of sound seed falling into clearcuttings is adequate for successful regeneration is critical. Adequacy depends on what the landowner feels is sufficient (above the minimum standards of the California Forest Practice Act) and this, in turn, is related to management goals and productivity of the land.

An analysis of the numbers of seedlings established in this study, which are proportional to the number of seeds that fell, will be reported in another paper. In the 2-, 5-, and 10-acre clearcuttings, number of 4-year-old white fir seedlings ranged from 147 to 269 per acre (363 to 665/ha) and milacre stocking, which is a measure of seedling distribution over the landscape, varied from 12 to 18 percent. Similar values for ponderosa pine were 77 to 196 seedlings per acre (190 to 484/ha) with milacre stocking values of 7 to 17 percent. Douglas-fir and incense-cedar each had about 7 to 43 seedlings per acre and stocking of 1 to 4 percent. Seedling density of all conifer species ranged from 385 to 507 per acre (951 to 1253/ha) and milacre stocking of 24 to 35 percent.

From these kinds of data, land managers can choose seedling numbers, or seedling distributions, or both, to assess the effectiveness of natural seedfall in clearcuttings.

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