Lack of Viable Seeds in the Forest Floor After Clearcutting

Robert M. Frank & Lawrence O. Safford

Fig. 1.—A portion of an uncut strip from which forest-floor samples were taken. Hemlock on left is 20 inches d.b.h.

ABSTRACT—The viability of seeds of northern conifers apparently does not persist in the forest floor for more than one year. A set of forest-floor samples collected two years after a heavy seed crop and one year after a seed-crop failure did not produce any conifer germinants, regardless of whether or not the surfaces of the samples were disturbed. A second set of forest-floor samples collected the spring after a good conifer seed crop yielded many conifer germinants. Forest managers should not rely on seed in the forest floor for natural regeneration of northern conifers.

CURRENT TRENDS in forestry encourage clearcut harvesting in the northeastern spruce-fir forest. This raises the question: For natural regeneration, is there a supply of viable conifer seeds in the forest floor? From results of recent studies in Maine we concluded that the answer is: No.

Forest managers cannot rely on seed in the forest floor for natural regeneration of northern conifers. Although advance reproduction is usually present in the spruce-fir types (*15*), existing seedlings may not be of sufficient quantity or quality to produce a satisfactory new stand on large clearcut areas. Unless artificial regeneration is anticipated, a supply of seeds must be distributed over the clearcut area.

Because of the cool climate and the associated accumulation of thick layers of organic matter in the spruce-fir forest, many foresters believe that a large quantity of conifer seed is naturally stored in the forest floor. Although the belief is generally not supported by the results of studies (*1, 2, 7, 8, 9, 11*), there is some evidence that seed might be stored naturally under conditions similar to those in the spruce-fir region of Maine (*4, 5, 10, 14*).

The Study

To determine whether or not seeds in the forest floor retain their viability, samples of the forest floor were collected and exposed to conditions favorable to germination—conditions similar to those that exist after clearcut harvesting. The first set of samples was collected in the spring of 1966 after a heavy spruce and fir seed crop in 1964-1965 and a spruce and fir seed-crop failure in 1965-1966. Thus the samples should have contained considerable quantities of 2-year-old seed from the heavy crop of 1964-1965; and any germinants that appeared in 1966 could be assumed to be from seed at least 2-years-old because there had been a seed-crop failure in 1965-1966. A similar set of samples was collected and exposed in the spring of 1967 after the heavy seed crop of 1966-1967 to verify that spruce and fir seeds, if present, would germinate under the study conditions.

The forest floor samples were collected from a conifer stand on the Penobscot Experimental Forest in Maine. Parts of the stand had been clearcut in strips during the winter of 1964-1965. The samples came from two-chain-wide uncut strips in this stand (Fig. 1). This northern conifer stand is typical of many similar stands throughout the southern extremes of the spruce-fir forest in Maine. Dominant and codominant trees averaged 50 to 60 feet tall and were 75- to 80-years old. The stand contained 492 trees per acre, totaling 108 square feet of basal area (trees 3.5 inches d.b.h. and larger). Species composition was:

Species	Basal area (percent)
Spruce, red, white, and black [*Picea rubens* Sarg., *P. glauca* (Moench) Voss, and *P. mariana* (Mill.) B.S.P.]	15
Balsam fir [*Abies balsamea* (L.) Mill.]	30
Northern white cedar (*Thuja occidentalis* L.)	18
Eastern hemlock [*Tsuga canadensis* (L.) Carr]	10
Eastern white pine (*Pinus strobus* L.)	2
Red maple (*Acer rubrum* L.)	17
Birch, paper and gray (*Betula papyrifera* Marsh. and *B. populifolia* Marsh.)	4
Aspen, quaking and big-tooth (*Populus tremuloides* Michx., and *P. grandidentata* Michx.)	3
Other hardwoods	1

The organic horizons beneath this stand are characteristically granular mors 1 to 3 inches thick in well drained areas, and 3 to 6 inches thick in poorly drained areas. In some very poorly drained areas, sphagnum moss forms the organic horizons to a thickness of 6 to 8 inches.

Twenty randomly selected samples of the top 6 inches of forest floor plus mineral soil were taken from the center line of the uncut strips in early May 1966. The

THE AUTHORS are, respectively, assoc. silviculturist and assoc. soil scientist, Northeastern Forest Exp. Sta., U.S. Forest Serv., Orono, Maine.

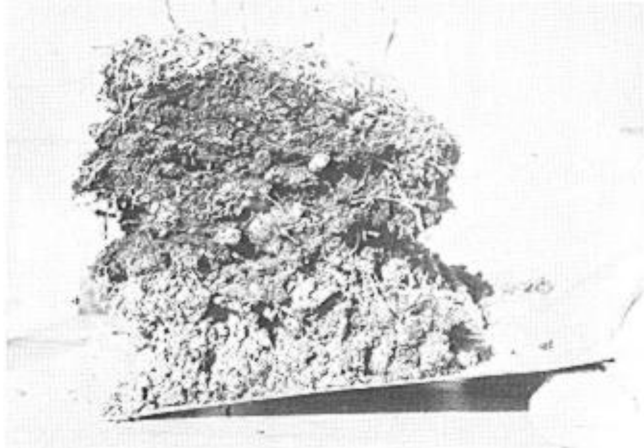

Fig. 2.—A sample soon after removal from the forest floor.

samples were approximately 6 inches square and as undisturbed as removal permitted (Fig. 2). All conifer seedlings present in the samples were removed by severing the stems at the ground line; no deciduous species were present. Each sample was placed in a container and set on a table next to the southeast side of a building located in a clearing. A single thickness of cheesecloth was placed over the entire set of samples to prevent new seed from falling in and to provide partial shade. Artificial watering was maintained as required to keep the samples moist.

Numbers and species of germinants were observed at approximately 2-week intervals from May through October. After the final count of germinants was made, the samples were stored inside an unheated building. After the sample material had frozen solid, the top of the sample—including the litter, other organic matter, and the plants that grew during the preceding season—was separated from the bulk of the sample by sawing off a slice approximately 1 inch thick with a hacksaw blade. The removed material was then discarded and the disturbed samples were retained for testing during the 1967 growing season.

In early May 1967 the disturbed samples were again set out on the table as described above. The exposed surface of forest floor approximately 1 inch below the original surface was thus observed for germination of buried seeds.

Twenty additional samples were taken in May 1967 from locations as close as possible to the 1966 sample locations. Soil disturbed by the first sampling was avoided. The new samples were placed on a second table adjoining the original set of containers. They were covered with cheesecloth, and counts of germination were made at 2-week intervals, May through October.

Information about seedfall on the Penobscot Experimental Forest for 1961-1962 through 1964-1965 was available from a previous study (*3*). These data were collected using twenty 3-by-3-foot seed traps in a mature spruce-fir stand in which about half the volume had recently been removed. The residual stand was about half spruce and one-third fir.

Additional data on seedfall were collected for the 1965-1966 and 1966-1967 seed years. A series of 81 seed traps (nine in each of nine openings) were systematically located in the clearcut strips of the stand from which forest-floor samples were collected. The traps used in this area were circular traps 10 inches in diameter. Seeds were collected bimonthly in 1965-1966 and quarterly in 1966-1967. The seed year was considered to extend from the first week in August to the last week in July. Roe (*12*), working with white spruce and balsam fir in Minnesota, found that seeds of both species were disseminated from August through May.

Results and Discussion

Seedfall. Data on seedfall for the four years preceding this study indicate that heavy spruce seed crops occurred in 1964-1965, 1963-1964, and 1961-1962 (Table 1). For balsam fir, average-to-heavy seed crops occurred in 1964-1965 and 1962-1963. Although these data were not taken in the stand from which the forest-floor samples were collected, it seems reasonable to assume that seed crops in the study area were similar (the two areas are located 2.5 miles apart).

If so, the forest-floor samples collected in May 1966 had been exposed to average or heavy seedfall of spruce or fir, or both species, during each of the four years from 1961-1962 through 1964-1965. And, since the 1964-1965 seed year was a good one for both species, the samples collected in 1966 should have contained large quantities of 2-year-old seed of both spruce and fir.

Seedfall in 1965-1966 was very poor for both spruce and fir (Table 1). Therefore, the 1966 forest-floor samples should have contained little, if any, 1-year-old seed. Any new seedlings that appeared on these samples could therefore be attributed to seed that had been in the forest floor for at least two years.

Since seedfall was heavy for both spruce and fir in 1966-1967, the samples collected in 1967 should have contained ample quantities of 1-year-old seed; new seedlings appearing on these samples would indicate that study conditions were appropriate for germination. Lack of germination on the 1966 samples could then be attributed to lack of viable seed in the forest floor.

Germination. No conifer germinants appeared in 1966 on any of the 20 forest-floor samples. Of the 78 new seedlings, 75 were birch (Table 2). Birch seedfall was heavy in 1965-66, so these seedlings presumably came from that seed crop.

One red maple and two quaking aspens—both spring-seeding species—also developed. Since the forest-floor samples were collected in early May, the seed from which the maple germinated was probably held over

Table 1.—Spruce and Fir Seedfall Before and During the Study

Date	Spruce	Fir
	Thousands per acre	*Thousands per acre*
1961–62[1]	829	128
1962–63[1]	55	1,385
1963–64[1]	1,164	214
1964–65[1]	835	421
1965–66[2]	13	1
1966–67[2]	605	782

[1] Seedfall estimated from twenty 3-by-3-foot seed traps in a mature spruce-fir stand 2.5 miles from the study area. About half the volume of this stand had been cut. About 50 percent of the residuals were spruce and about 30 percent were fir. These data were taken from a study by Hart *et al* (*3*).

[2] Seedfall estimated from 81, 10-inch diameter seed traps in the study area. The uncut strips in this stand were about 15 percent spruce and 30 percent balsam fir.

Table 2.—Seedfall and Germination[1]

Species	1966 Sample		1967 Sample	
	Seeds in traps	Germinants in samples	Seeds in traps	Germinants in samples
	Thousands per acre	*Number*	*Thousands per acre*	*Number*
Spruce	13	0	605	15
Balsam fir	1	0	782	22
Eastern hemlock	1	0	390	58
Northern white cedar	1	0	242	23
Eastern white pine	0	0	22	0
Total conifers	16	0	2,041	118
Paper birch	2,707	49	2,792	217
Gray birch	1,217	26	3,924	97
Red maple	151	1	2	5
Aspen	34	2	0	1
Pin cherry	0	0	0	2
Yellow birch	0	0	8	0
Total hardwoods	4,109	78	6,726	322
Total, all species	4,125	78	8,767	440

[1] Seedfall based on 81 seed traps. Germination represents total number of germinants in the 20 forest-floor samples for each year.

from the preceding seed year. The possibility of red maple seeds germinating the second year after dissemination has been reported by Hutnik and Yawney (*6*). This was also supported by data from the second sample. On the other hand, because aspen seeds are small, the seeds from which the two aspen seedlings grew probably fell through the cheesecloth covering.

After the top inch of organic material was removed, re-exposure in 1967 of the twenty 1966 samples failed to produce any conifer germinants. Apparently the seeds did not germinate the previous year because viable seed was lacking, not because the seed was buried too deeply.

A few birch germinants appeared on the disturbed samples, suggesting that birch seed occasionally retains its viability for two years or more. However, the quantity of birch seed germinating the second year was very small. Sedges (*Carex* sp.), raspberries (*Rubus* sp.), and violets (*Viola* sp.) also appeared on the disturbed samples in 1967.

In contrast to the 1966 samples, there were many conifer germinants on the 1967 samples (Table 2). Of the 118 conifer germinants, 15 were spruce and 22 were fir. This result is not surprising, because the seed crop of both species was heavy in 1966-67; but it does show that conifer seeds, if present, will germinate under the study conditions.

As before, most germinants on the 1967 samples were birch, and these can be attributed to another heavy birch seed crop in 1966-67. These results attest to the prolific and rather frequent seeding habits of both paper and gray birch (*13*).

A small number of red maple germinants appeared in the 1967 sample after an abundant seed fall in the spring of 1966. This indicates that some seeds of this vernal-seeding species persisted through one growing season and winter before germination. Since no samples were taken immediately after seed dispersal in June, we were not able to determine the proportion of red maple seeds that germinated in the same season as dispersed.

One quaking aspen and two pin cherry (*Prunus pensylvanica* L.f.) seedlings also appeared in the 1967 samples. The aspen, as before, is presumed to have come from a seed that fell through the cheesecloth covering. Pin cherry seeds may have been either stored in the forest floor or deposited there the preceding summer by birds or other animals.

Conclusions and Recommendations

The data reported here fail to support the hypothesis that conifer seed remains viable in the forest floor. The set of forest-floor samples collected two years after a heavy seed crop and one year after a seed-crop failure did not produce any conifer germinants either during a first year of exposure in an undisturbed condition or during a second year of exposure after being disturbed by removal of litter and other organic matter. A second set of forest-floor samples collected immediately after a good conifer seed crop and exposed in an undisturbed condition, yielded many conifer germinants.

It seems logical to conclude that seeds of northern conifers do not retain viability in the forest floor longer than one year. We therefore recommend that the forest manager should not rely on seed in the forest floor for regeneration when clearcut harvesting is contemplated.

These data also suggest that prolific species such as paper and gray birch, even though they occupy a very small part of the original stand, can produce large quantities of seedlings that could hinder the development of a subsequent stand of softwood species.

Literature Cited

1. Baldwin, H. I. 1942. Forest tree seed of the North Temperate Region with special reference to North America. Chronica Botanica Co., Waltham, Mass. 240 p.
2. Haig, I. T. 1932. Premature germination of forest seed during natural storage in duff. Ecol. 13:311-312.
3. Hart, A. C., H. G. Abbott, and E. R. Ladd. 1968. Do small mammals and ground-feeding birds affect spruce and fir reproduction? U.S. Forest Serv. Res. Pap. NE-110. NE. Forest Exp. Sta., Upper Darby, Pa., 8 p., illus.
4. Holmes, G. D. 1958. The storage of seed of temperate forest tree species. Part I. Forestry Abs. 19(3):313-322.
5. ————. 1958. The storage of seed of temperate forest tree species. Part II. Forestry Abs. 19(4):455-476.
6. Hutnik, Russell J., and Harry W. Yawney. 1961. Silvical characteristics of red maple. U.S. Forest Serv., NE. Forest Exp. Sta., Upper Darby, Pa. Pap. 142, 18 p.
7. Isaac, Leo A. 1935. Life of Douglas-fir seed in the forest floor. J. Forestry 33:61-66.
8. ————. 1940. Life of seed in the forest floor. U.S. Forest Serv., Pacific NW. Forest and Range Exp. Sta. Res. Note 31. 14 p.
9. Little, S., and H. A. Somes. 1959. Viability of loblolly pine seed stored in the forest floor. J. Forestry 57:848-849.
10. MacGillivroy, H. G. 1955. Germination of spruce and fir seed following different stratification periods. Forest Chron. 31(4):365.
11. Olmsted, N. W., and J. D. Curtis. 1947. Seeds of the forest floor. Ecol. 28:49-52.
12. Roe, E. I. 1946. Extended periods of seedfall of white spruce and balsam fir. U.S. Forest Serv., Lake States Forest Exp. Sta. Tech. Note 261. 1 p.
13. U.S. Forest Service. 1948. Woody-plant seed manual. USDA Misc. Publ. 654. 416 p.
14. Webb, L. S. 1958. The results to date of the clearcutting experiment of 1948. New Brunswick International Paper Co., Causapscal Res. Sta., Forest Res. Note 8, 6 p.
15. Westveld, Marinus. 1953. Ecology and silviculture of the spruce-fir forests of eastern North America. J. Forestry 51(6):422-430.