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NATURAL SEED FALL IN WHITE PINE (*PINUS STROBUS* L.) STANDS OF VARYING DENSITY

Abstract.—Seed fall was observed in three stands of mature white pines at stand basal-area densities of 80, 120, and 187 square feet per acre. It was found that the intermediate-density stand produced nearly 50 percent more seed than the stands of other densities. During a good seed year this stand produced 59 pounds of dry sound seed per acre. Most of the seeds were dispersed during a 7-week period beginning about the middle of September. The seed crop was reduced by action of birds, animals, and insects.

A detailed knowledge of natural seedfall is of value to the forest manager, particularly when natural regeneration is planned. This information can also be useful in estimating seed crops and in scheduling seed-collection activities.

Little is known about the qualitative and quantitative aspects of eastern white pine seed production. Most of the meager knowledge available is in the very general source, *The Woody-Plant Seed Manual*.¹ The only detailed study of white pine seed fall was done by Messer² in Germany, and this is not readily available, even if it could be assumed to be applicable in Northeastern forests.

To gain some of the needed information about white pine seed fall, a study was made in southwestern Maine. We found that seed fall

¹United States Forest Service. WOODY-PLANT SEED MANUAL. U.S. Dep. Agr. Misc. Pub. 654, 416 pp., illus. 1948.

²Messer, H. Untersuchungen über das Fruchten der Weymouths Kiefer (*Pinus strobus* L.) und der grünen Douglasie (*Pseudotsuga taxifolia* var. *viridis*). Ztschr. Forstgenet. 5(2):33-40. 1956.

started by mid-September, peaked in late September and early October, and was 98 percent complete by the end of November. Seed production was influenced by stand density, an intermediate density producing far more seed than the uncut control stand or the heavily cut stand. The maximum seed fall per acre was 59 pounds (ovendry weight) of viable seed.

Methods and Materials

Seed fall was measured twice—during a good seed year (1965) and during a poor seed year (1968)—in a pure stand of white pine on the Massabesic Experimental Forest. This even-aged stand of pine was 80 years old in 1965. We used three 5-acre plots of different densities—80, 120, and 187 square feet of basal area per acre (table 1).

Table 1.—Average stand conditions in three white pine plots, 1965

Stand-density level	Basal area per acre	Average dominant tree measurements		
		Height	D.b.h.	Height in live crown
	<i>Sq ft.</i>	<i>Feet</i>	<i>Inches</i>	<i>Percent</i>
High	187	96	17.1	28
Intermediate	120	95	18.0	36
Low	80	101	18.4	40

Seed fall was sampled in nine rectangular (1-x-2-foot) seed traps randomly located in each of the three plots. The seed traps were emptied at weekly intervals in autumn and at longer and less regular intervals in winter. The collected seeds were cut longitudinally and examined. All well-filled seeds with fully developed embryos were classed as viable. Analysis of variance was used to evaluate the data, and orthogonal comparisons were made to locate significant differences among the three stand-density levels.

Additional observations were made in 1965 to provide an indication of total cone numbers and losses. Cone counts were made on 10 randomly selected dominant trees in the intermediate stand. The observer made binocular counts of mature normal cones and insect-infested cones in the trees. Squirrel-cut cones and insect-killed cones on the ground were also counted.

Results and Discussion

Total cone crop.—The cone counts made in 1965 provided an estimate of the number of cones per dominant tree. The mean number of mature undamaged cones per tree was 731. An average of 30 insect-killed cones remained in the crown, and an additional 14 insect-killed cones were recovered under the average tree. The primary insect infestation in all examined cones was caused by the white pine cone beetle (*Conophorus coniperda*) or the cone moth (*Dioryctria abietella*).

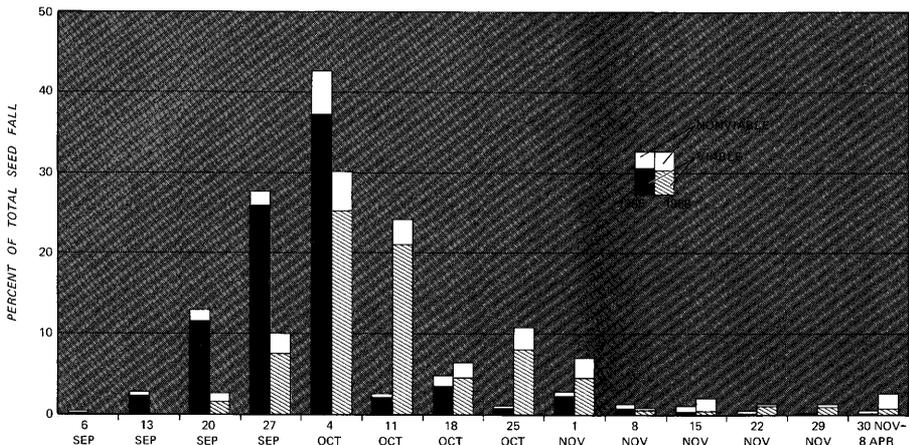
Squirrels cut and consumed or left lying on the forest floor an average of 29 cones per tree. The discarded cone cores were counted where consumption had occurred. The total cone potential per tree was 804 cones; and, of these, 91 percent (731) remained undamaged on the trees to release seed. The average number of viable seeds per cone was 32, resulting in a mean seed crop of 23,400 seeds per tree.

Time of seed fall.—Seed fall began on September 5 in 1965 and about 2 weeks later in 1968 (fig. 1). The maximum weekly seed fall occurred at the same time both years during the week ending October 4. In 1965 the seed fall diminished rapidly after October 4; in 1968 it tapered off more gradually. This difference probably reflects warm and dry weather in 1965 and cool and moist weather in 1968.

In both years seed fall after November was negligible. Only one viable seed fell in the seed traps after November 29, 1965.

From these data we conclude that cone collection for seed extraction should be completed by mid-September in this area. Also, site preparation

Figure 1.—Time of white pine seed fall in 1965 and 1968.



to increase natural regeneration should be complete by the same date to take full advantage of the natural seed supply.

Effects of stand density.—The periodic measurements of seed fall did not reveal any effect of stand density on time of seed dispersal (fig. 2); however, the total amount of seed fall was related to stand density (table 2). The total seed fall in the stand of intermediate density was significantly greater (1-percent level) than that in the other two stands in 1965. The much smaller seed crop of 1968 did not differ significantly among densities. This lack of a significant difference in 1968 was related to the light seed fall, which resulted in a high sample variability. In both seed years the ratio of seed fall in the intermediate-density stand to that in the other stand densities was similar.

The effects of stand density were logical. The uncut high-density stand with a basal area of 187 square feet was too crowded for maximum seed production; the crowns, though numerous, were small. In the intermediate-density stand, the trees were well-spaced and had larger crowns. In the low-density stand, crown development was slightly better still,

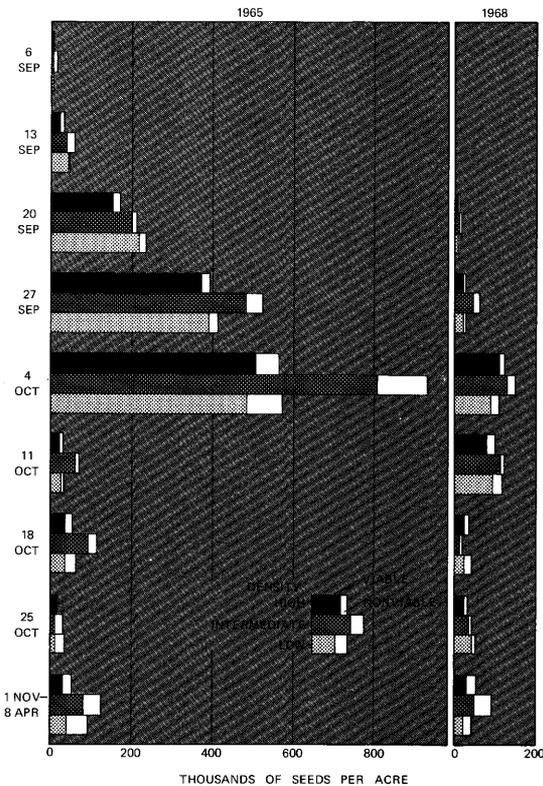


Figure 2.—Periodic seed fall as influenced by stand density.

Table 2.—Total viable seed fall per acre

Stand-density level	Viable seeds	
	1965	1968
High	1,139,820	297,660
Intermediate	1,793,220	408,980
Low	1,253,560	297,660

but too few trees remained to fully occupy the site; consequently potential seed production was limited by lack of sufficient crown area.

Cone production per tree was similar in both the intermediate- and low-density stands, but there were approximately 50 percent more trees in the intermediate stand. As a result, seed fall in the intermediate stand exceeded by about 40 percent that of the low-density stand.

Number of viable seeds per pound.—The number of oven-dry viable seeds per pound was determined once in 1965 and weekly in 1968. In early October 1965 the average number of seeds per pound was 31,700. The weekly determination made in 1968 showed the heaviest seed (28,700 per pound) fell in late September. From this time on, the mean seed weight declined about 6 percent per week, causing the average number of seeds per pound to increase. By mid-November, the average number of seeds per pound had risen to 45,000. But, because most of the seeds had fallen by mid-October, the overall average for the season was 31,000 viable seeds per pound.

Seed viability.—The percentage of viable seeds was especially high in 1965, the heavy seed year. Viability averaged 86.7 percent in 1965 and 73.4 percent in 1968. Seed viability varied widely during the time of seed fall. The period of maximum seed fall coincided with the highest viability.

In 1965 the viability was 20 percent during the first week of September, peaked at 93.6 percent in the fourth week of September, and dropped to 10 percent by the end of November. Seed viability followed a similar trend in 1968.

Seed losses caused by birds and small mammals.—In late September and October 1965, during the period of maximum seed fall, many seeds were conspicuously exposed on the ground. At this time, roving flocks of 30 to 50 rusty blackbirds (*Euphagus carolinus*) were noted in the seed-bearing stands of pine. The flocks of blackbirds were observed on many occasions scratching and feeding in the pine litter. After these birds had worked through an area, very little seed could be found.

During the same period, white-winged crossbills (*Loxia leucoptera*) were observed in the tree-tops plucking seed from open cones. Many other species of birds, including white-throated sparrows (*Zonotrichia albicollis*), fox sparrows (*Passerella iliaca iliaca*), slate-colored juncos (*Junco hyemalis hyemalis*), black-capped chickadees (*Parus atricapillus atricapillus*), and red-breasted nuthatches (*Sitta canadensis*), were frequently sighted in the seed fall area. These birds are seed eaters, and very likely they were taking some seed.

Many small mammals were seen in the area, including red-backed voles (*Clethrionomys gapperi*), white-footed mice (*Peromyscus lecopus*), chipmunks (*Tamias striatus*), and red squirrels (*Tamiasciurus hudsonicus*). Only the red squirrels were actually observed eating seed, but the other animals listed are known to be voracious consumers of white pine seed.

No measure of the amount of seed eaten by birds or small mammals was made, but it is likely that a significant portion of the seeds was consumed.

Conclusions

Stand density can have a major influence on total seed production. An intermediate density in the mature stand studied here resulted in maximum seed production.

Total seed yields of well over a million seeds per acre can be expected in good seed years from mature pine stands such as these.

White pine differs from many other species in that nearly all the seeds are released during a relatively short period in the autumn, and virtually no seed is carried over in the cones to be released during the succeeding growing season.

The loss of cones caused by insect and animals was relatively unimportant in a good seed year, averaging less than 10 percent in 1965. However, it is likely that a similar number of cones would be destroyed in a poor seed year, raising the percentage lost to a much higher level.

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