gust 1976

Division of Timber Research
U S D A FOREST SERVICE
RESEARCH NOTE RM-317

FOREST SERVICE
U S DEPARTMENT OF AGRICULTURE

CKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Cone Maturation in Ponderosa Pine Foliage Scorched by Wildfire

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Trees scorched to varying degrees were studied to determine the effects of a late fall wildfire on several cone and seed characteristics. While cone size, seed soundness, and seed weight were markedly less in severely scorched trees, trees with crowns scorched as much as two-thirds produced highly viable seed. Trees scorched more than two-thirds yielded small amounts of seed of dubious quality, and are poor survival risks. Seedfall from foliage-scorched trees represents a significant seed source for regeneration of burned areas.

Keywords: *Pinus ponderosa* var. *scopulorum*, fire, effect on seed production.

Foliage-scorched trees, as distinguished from trees where foliage was consumed, have reasonably good survival potential, depending on the time and intensity of the fire and the extent of scorching. Climatic conditions, the amount of photosynthetic tissue remaining and the capacity to generate new needle tissue, and resistance to insect attack will determine the ultimate survival of individual trees. But what becomes of conelets on the trees at the time of the fire? Will fertilization occur and seeds mature, or will the cones be abandoned in favor of higher priority recovery processes?

To answer these questions, several young cone-bearing ponderosa pines (*Pinus ponderosa* var. *scopulorum*) whose foliage was scorched in a fall wildfire were monitored to determine the relationship between extent of scorch and various cone and seed parameters.

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Description of Fire

During November 2-7, 1973, the fast-spreading Burnt fire covered 7,150 acres on the Coconino National Forest, Arizona. The fire was of moderate intensity due to cool ambient air conditions (50°-60°F days, subfreezing nights) and resultant higher relative humidity and fuel moisture. Stocking and ground fuels were moderate but variable because some stands had been partially cut and precommercially thinned during the 10-year period prior to the fire. Tree damage ranged from light scorch (needles killed, but not consumed, by the fire) of lower crowns in light to moderately stocked areas, to complete needle consumption (needles completely burned off the tree) in more heavily stocked areas. Scorched needles and smaller branches were typically desiccated and stiffened horizontally in the direction of fire spread. Denser stands of trees which "crowned-out" were killed outright, many seedlings and saplings were either consumed or killed by direct heat damage to the cambium, and many trees subsequently died from excessive foliage-scorch.

During the summer of 1974 it was evident that many foliage-scorched trees were putting out vigorous new growth, and conelets that had been initiated the previous year were continuing to develop. The bright green new needles contrasted with the persistent brown, scorched needles.

Study Area and Methods

The study was established on site index 50 to 54 land (Minor 1964) at 7,400 feet elevation. Orion rocky sandy loam soils on the study area were derived from igneous parent materials. In September 1974, 10 months after the fire, 38 cone-bearing trees that ranged in size from 8.0 to 21.7 inches diameter at breast height (d.b.h.), and in age from 56 to approximately 150 years old were selected for study. Trees were tagged over approximately 100 acres of the burn. The degree of damage ranged from none (control) to 74 percent of the live crown scorched (table 1).

Table 1.--Cone and seed parameters of cone-bearing ponderosa pines foliage scorched to varying degrees, Coconino National Forest, Arizona. (Burnt fire, November 2-7, 1973; cone and seed data collected November 7, 1974)

Tree data				Cone and seed data				
Tree number	Diameter at breast height	Height	Portion of crown scorched	Cone size[1]	Mean seed weight	Mean seed soundness	Mean germination[2]	Mean time for 50 percent germination
	inches	*feet*	*percent*		*g*	- - - *percent*	- - -	*days*
34	17.7	52.0	0	L	--	86.2	99.4	5.3
35	17.0	48.5	0	L	0.032	93.0	99.7	6.1
36	9.7	26.5	0	M	.027	95.8	99.8	6.4
37	17.8	42.5	0	L	.027	92.3	99.2	5.9
38	12.5	36.5	0	M	--	87.2	98.5	6.3
25	12.3	34.5	7	L	.029	90.0	99.1	6.1
26	9.5	24.0	8	M	.025	84.5	99.7	5.6
18	15.5	40.5	10	L	--	90.2	71.1	7.6
1	17.5	44.0	14	L	.026	87.0	99.4	5.4
3	13.2	31.0	16	M	.021	87.3	97.6	5.7
24	10.0	24.5	20	M	.033	83.3	98.8	5.7
20	14.9	39.5	21	M	.035	77.0	83.9	8.1
10	14.8	37.0	28	L	.045	60.0	98.0	5.8
19	13.5	33.5	30	L	.044	91.8	98.9	6.2
2	13.7	34.0	30	L	.039	94.8	99.7	5.7
28	13.3	41.0	32	M	.030	90.3	99.2	5.6
4	19.2	48.5	34	L	.051	68.0	99.7	6.0
9	16.7	42.0	35	M	.033	88.0	95.0	6.2
16	11.5	29.5	36	VS	.026	37.0	71.9	7.4
22	13.6	40.5	42	L	.038	92.4	100.0	5.7
31	11.6	38.5	46	S	.029	84.3	97.9	5.6
11	11.7	30.0	47	L	.056	77.0	98.1	6.0
7	13.2	31.5	47	M	.033	80.8	98.1	5.2
13	13.3	35.0	47	L	.044	87.5	96.0	6.1
17	8.4	26.0	48	VS	--	56.8	80.6	6.5
8	12.3	42.0	48	S	.021	44.0	90.1	5.4
21	14.4	40.0	48	L	.044	91.5	98.6	6.2
5	21.7	52.5	52	L	--	92.3	100.0	5.7
27	16.8	47.0	53	M	.041	93.0	99.5	6.7
23	11.9	30.5	54	L	.034	89.5	100.0	6.4
30	13.0	45.5	54	S	.028	33.8	87.5	6.7
29	12.2	32.0	57	S	.029	88.8	99.2	5.9
12	12.5	41.5	58	M	.034	93.8	97.9	5.5
33	11.1	33.5	60	M	.023	65.8	94.3	6.5
6	11.1	35.5	65	S	.021	85.0	99.7	5.5
32	10.4	38.0	67	S	.022	60.3	94.5	5.7
14	9.1	29.0	71	VS	.020	50.3	28.3	8.3
15	8.0	28.5	74	VS	.021	25.3	17.7	7.6

[1]L = large, M = medium, S = small, VS = very small. See figs. 1 and 2 for comparisons.
[2]Based on sound seed.

Approximately 12 cones were uniformly selected from the undamaged portion of the crown of each tree on November 7, 1974, when cones on some trees were beginning to open. Severely scorched trees yielded relatively few cones, while trees that suffered less damage provided many cones for samples. The late collection date allowed ample time for natural ripening of seed. Since cone size in some trees was clearly affected by the fire, cone volume was determined by water displacement. Seeds were extracted in a growth chamber set at 90°F and low humidity. After cleaning on a soil screen, 10 filled seeds from each of the 38 lots were weighed to the nearest 0.0001 gram to determine mean seed weight.

The seeds were stored in a freezer for 3 months before germination tests began. Each germination test consisted of four petri dishes containing 100 seeds each. The seeds were pressed into a bed of uniformly wetted Perlite, and incubated in a germinator set at 75°F and 95 percent relative humidity. Larson (1967) reported that germination of ponderosa pine seed was better at a constant 75°F than any alternating temperature. Germinated seeds (defined as when the radicle equaled the length of the seed) were removed from the petri dishes daily until no germination was recorded on two successive inspections. Ten germinants taken at random from each germination test were grown in styrofoam flats in a growth chamber for 1 month to detect any post-germination abnormalities in morphology or growth rate. At the conclusion of the germination tests (16 days' duration), ungerminated seeds were cut to determine soundness. Percentage germination was calculated on the basis of number of sound seeds. The mean number of days to reach 50 percent germination was also calculated to compare the rates of germination.

Results

Trees scorched as much as two-thirds produced cones that yielded highly viable seed (table 1, fig. 1). With the exception of five trees, all trees scorched 0 to 67 percent yielded filled seed with 90 percent germination or greater; only two trees, scorched 10 to 36 percent, yielded seed with germination less than 80 percent. The sample included only two trees with

Tree 8—scorched 48 percent

Tree 32—scorched 67 percent

Figure 1.—Both trees produced small cones that contained highly viable seeds with over 90 percent germination (filled seeds). Seed soundness and seed weight, however, were low. Photos were taken 1 year after the fire; scorched needles have fallen, but live foliage remains.

crowns scorched more than 70 percent; germination of filled seed from these trees, scorched 71 and 74 percent, was very low—only 28.3 and 17.7 percent, respectively. The plot of seed germination (fig. 2) suggests that germination of filled seed is little affected by foliage-scorch up to approximately 70 percent of the live crown, then declines abruptly. However, the sample did not include enough trees scorched more than 70 percent to clearly define this trend.

Rate of germination, measured by number of days to reach 50 percent germination (table 1), followed the same trend as percentage germination. Seed lots with over 90 percent germination varied in rate from 5.2 to 6.7 days, while the seven trees with less than 90 percent germination required 6.5 to 8.3 days. The two trees scorched 71 and 74 percent required 8.3 and 7.6 days, respectively—considerably longer than most of the other seed lots.

Seed soundness tended to decrease as the extent of foliage-scorch increased (table 1, fig. 2). However, two-thirds of the trees scorched up to 65 percent yielded over 80 percent filled seed.

Cone size varied only from large to medium in trees scorched up to 35 percent. In trees scorched more than 35 percent, cone size ranged from large to very small. Cones classed as small (S) and very small (VS) in table 1 were clearly retarded by the fire, and tended to be more prevalent as the degree of foliage-scorch increased. However, many diminutive cones yielded seeds with over 90 percent germination (fig. 3)—equal to seeds from larger cones and less severely damaged trees. The tiny cones from trees 14 and 15, which were most severely scorched, yielded seeds with low viability and soundness.

Seed weight varied directly with cone size (table 1). Large cones yielded filled seeds averaging 39 mg, compared to 30 mg for medium cones, and 24 mg for small and very small cones.

Two trees died during the period November 7, 1974, to September 9, 1975: tree number 3 from bark beetle attack, and tree number 17 from excessive heat damage to the cambium and foliage.

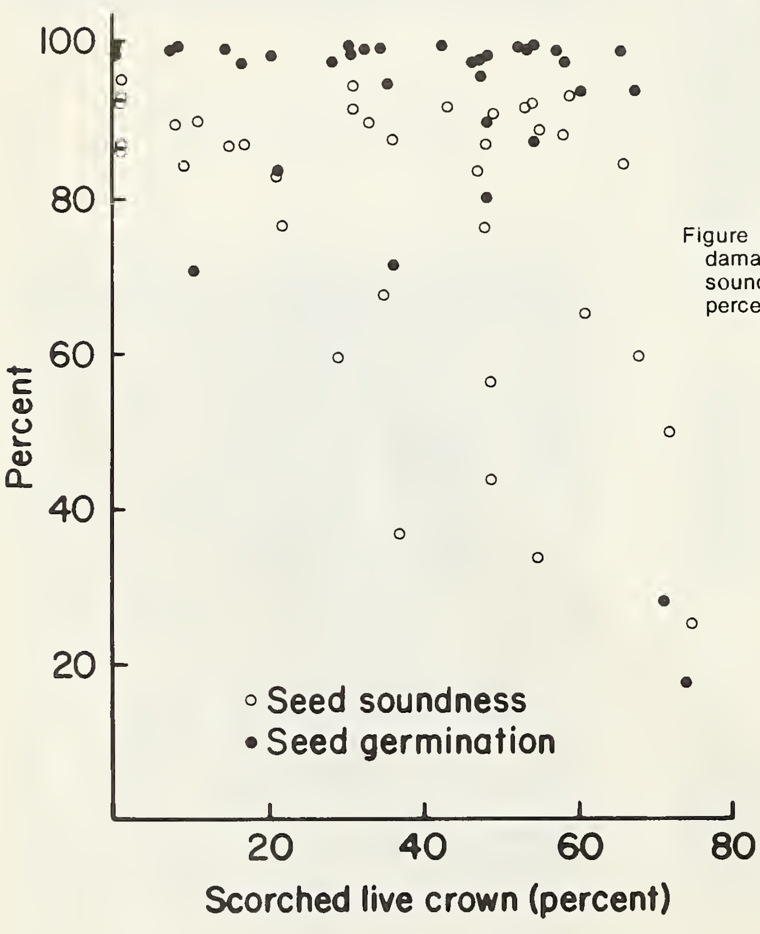
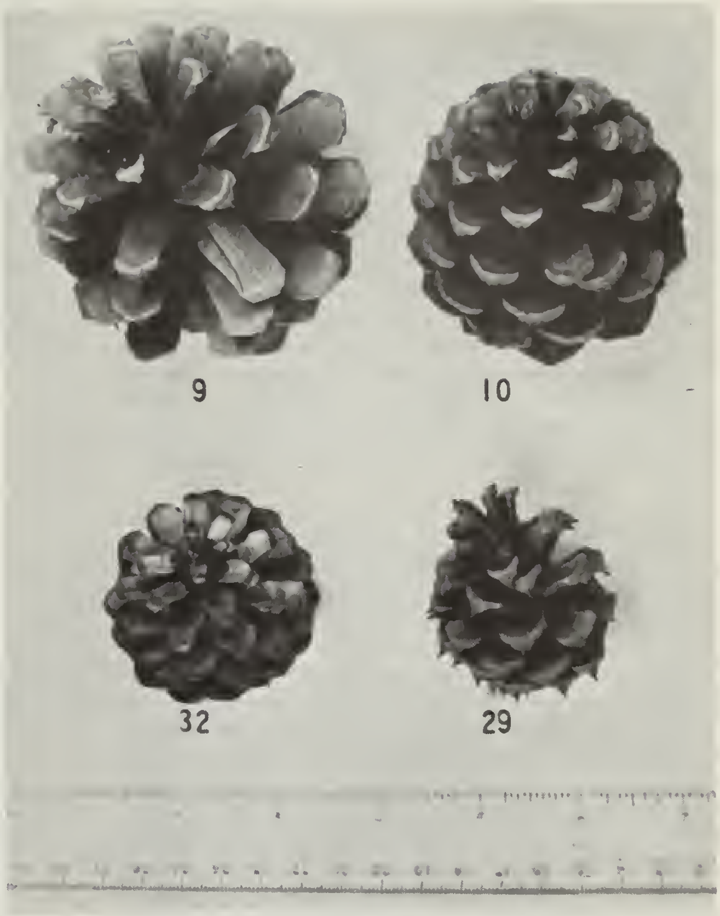


Figure 2.—Relationship between the extent of fire damage to cone-bearing trees and the germination and soundness of extracted seed at maturity. (Germination percentages are based on sound seed.)

Figure 3.—Comparison of cones from trees with varying percentages of scorch.

Cones show range in size of cones that yielded seeds with over 90 percent germination (filled seeds).



Tree 9—
35% scorch

Tree 10—
28% scorch

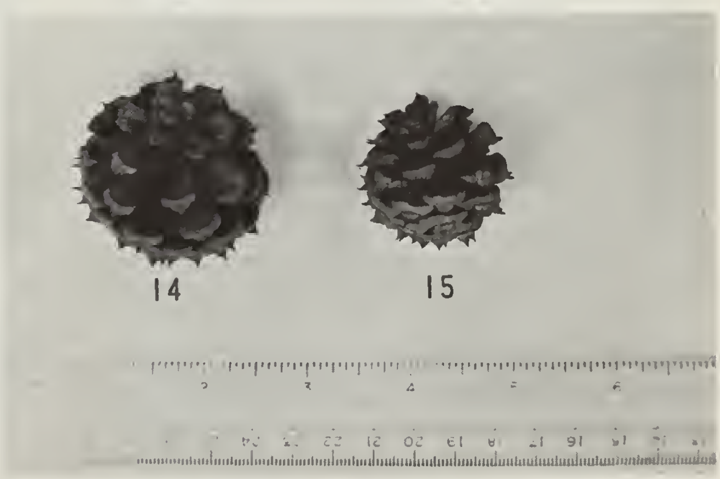
Tree 32—
67% scorch

Tree 29—
57% scorch

Tree 14—
71% scorch

Tree 15—
74% scorch

Cones from severely scorched trees were diminutive, and yielded seeds with low viability.



Discussion

Because each fire is unique, and fire intensity varies within each burn, assessing the extent of damage to individual trees is extremely difficult. The intensity of the burn, and timing of the burn in relation to the growth stage of the trees, will largely determine the amount of damage, and consequently the potential for recovery. A dormant-season fire is less damaging than one during spring and summer because of the coincidence with growth processes. In southwestern ponderosa pine, vegetative buds begin swelling as early as May 1 and shoot growth is complete by July 10. Diameter growth begins May 15 to 30, and ends sometime between September 1 and 20 (Schubert 1974). Generally, on burns during periods of minimum tree sensitivity, the potential for recovery of foliage-scorched trees and maturation of cones is good.

The results of this study show that even severely scorched trees are capable of producing viable seed. The Burnt fire occurred during the pollen-tube development stage of seed genesis; fertilization did not occur until July 1974, approximately 13 months after pollination (Krugman et al. 1974). The decrease in seed soundness and seed germination with increasing foliage-scorch could be due to heat damage to the developing pollen-tube apparatus or archegonia (multicellular sex organs within the ovule containing the egg nuclei). In trees producing diminutive cones, post-fertilization growth of the cone by cell enlargement apparently was reduced or prevented. Growth factors—including carbohydrates, nutrients, and water—were either unavailable, limited, or preferentially translocated to sites of higher priority. Thus, even in severely scorched trees, cone and seed development and maturation proceeded with only minimal amounts of needed growth factors. It appears, then, that the allocation of resources in fire-stressed ponderosa pines allows maturation of existing cones.

The average weight of filled seeds from large- and medium-sized cones was 35 mg, very close to the 37 mg reported by Larson and Schubert (1970). The small seeds extracted from diminutive cones (averaging 24 mg) are not necessarily inferior from a regeneration standpoint. Larson (1963) found that size of seed had little or no influence on rate of germination, germination percent, or seedling growth.

Seedfall from surviving foliage-scorched ponderosa pines represents an important seed source for regenerating the burn. Trees scorched less than approximately 35 percent are the best seed producers, both in quantity and quality. But more severely scorched trees, even those producing diminutive cones, are capable of contributing smaller amounts of highly viable seed. Trees with more than two-thirds of their crown scorched produce only a small number of cones and seed of dubious quality; they should not be relied upon as a seed source. Furthermore, Herman (1954) reported that trees with 60 percent or more crown kill have very low survival potential—3 percent after 6 years, compared with 86 percent survival of trees scorched less than 60 percent.

To create a favorable seedbed on burns, mechanical soil disturbance is needed in addition to the elimination of competing vegetation and baring of mineral soil by the fire (Rietveld and Heidmann 1976). Any fire-induced soil water repellency is broken up, and the reduction in soil bulk density reduces frost heaving of seedlings (Heidmann and Thorud 1975). Some soil disturbance is created by salvage logging; additional site preparation may be performed just prior to seedfall.

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