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Survival of Northern Red Oak Acorns After Fall Burning

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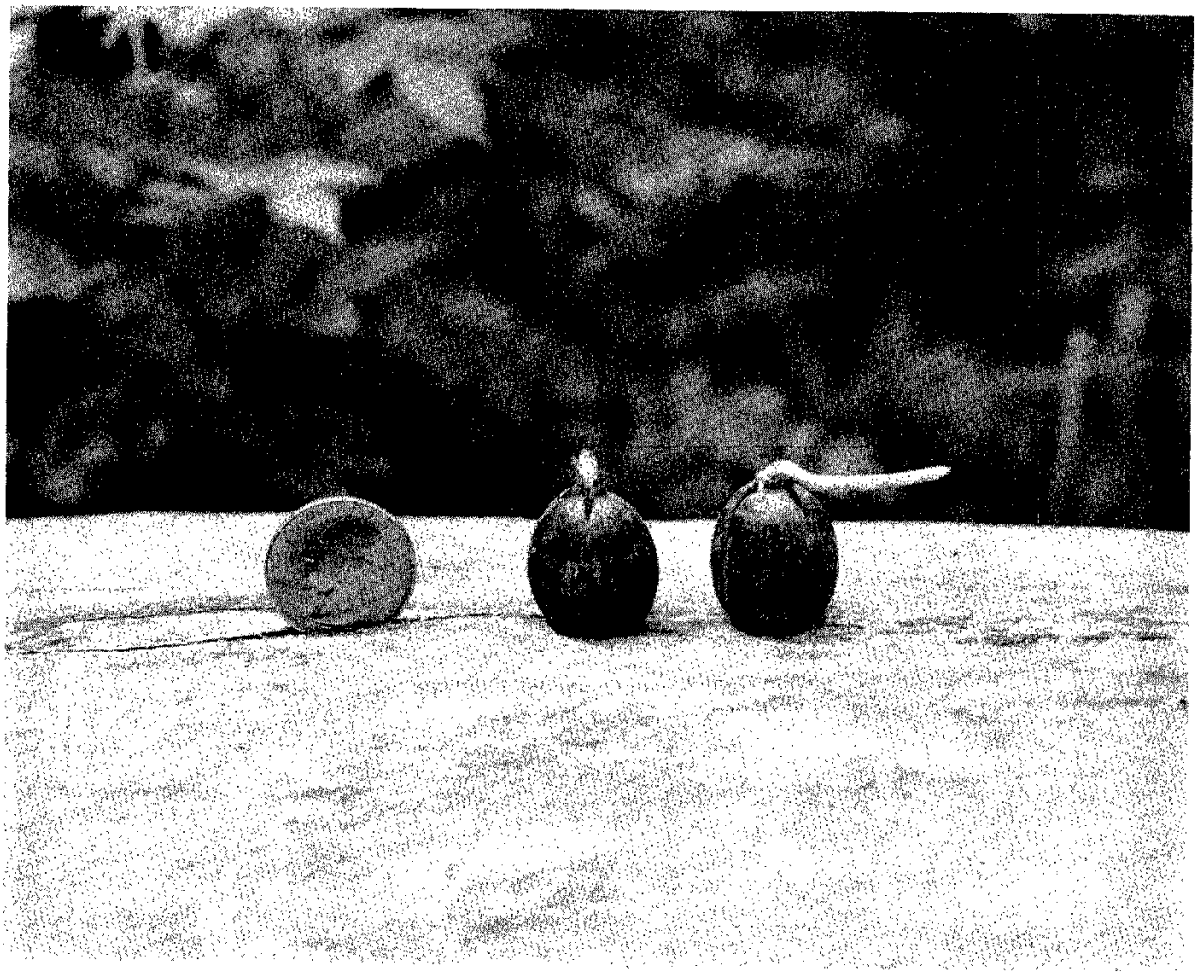

Abstract

Survival of recently fallen northern red oak acorns after exposure to a cool fall burn was determined on experimental plots in northwestern Pennsylvania. The fire consumed the leaf litter and fine woody material of the forest floor and was considered as a typical fall burn for this region. No acorns were consumed by the fire but some were charred. Between 40 and 49 percent of the acorns contained in the litter were killed. The fire was not hot enough to kill *Curculio* weevil larvae within the acorns. Burned acorns infested with *Curculio* that survived the fire had 20 percent lower germination rates than unburned acorns.

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Introduction

Perhaps more than any single factor, fire has been implicated with the establishment and perpetuation of today's oak forests. Numerous reviews point out that the exclusion of fire from mesic sites results in the replacement of oaks by other species following virtually any type of cutting (Little 1974; Lorimer 1985, 1989; Crow 1988; Van Lear 1991; Abrams 1992). The problem of regenerating oak is serious throughout Eastern North America on good growing sites, and in Europe as well (Crow and Isebrands 1986). Because of the link between fires and existing oak forests, there has been increasing interest in the use of prescribed burning to regenerate oaks (Nyland et al. 1982; Merritt and Pope 1991; Walters 1990).

Although there is considerable documentation on the effects of fire on survival of different overstory species in oak stands (Rouse 1986), there is surprisingly little information on the survival of acorns that may be present in the forest floor during a fire. Korstian (1927) found that most acorns had cooked embryos after spring fires with temperatures ranging from 500° to 1000°F in the litter layer. He concluded that acorns had little chance of survival unless they were protected by some nonflammable material. In his review of fire in temperate forests, Little (1974) mentioned that fires can have an adverse impact on oak regeneration by destroying acorns and killing small oak seedlings. Similarly, Olson and Boyce (1971) reported that acorns are destroyed by burning in wildfires, though no estimates of mortality were given.

In a study to determine the biotic factors that affect northern red oak (*Quercus rubra L.*) reproduction in northwestern Pennsylvania, burning was a treatment applied to the forest floor on a series of research plots. These fall burns were conducted shortly after the current-year's acorn crop had matured and fallen to the forest floor. Thus, these conditions provided an opportunity to determine the effects of fall burning on the survival of acorns that were present.

Methods

The burning plots were located in maturing northern red oak stands on the Moshannon State Forest and on the Allegheny National Forest in northwestern Pennsylvania. In the fall of 1989, acorn samples were collected from 23 burned and 24 unburned plots on the Moshannon State Forest, and in the fall of 1990 from 11 burned and 11 unburned plots on the Allegheny National Forest. The plot size was 14 by 14 feet. Burned and unburned plots were located close to each other and generally had a mix of acorns from some of the same trees.

The intensity of the burning treatment was relatively light and typical of cool fall fires that occasionally occur in this region, where fuel quantities are low and the humus and soil beneath the leaf litter are moist. In each of the 2 burning years, the burns were conducted between 11 a.m. and 5 p.m. when the relative humidity was between 40 and 60 percent, air temperatures near the ground were between 56° and 71°F, and winds were less than 6 miles per hour. The fires had a flame height of 1 to 3 feet, were relatively fast moving, and consumed only the surface litter, fine branches, and herbaceous vegetation. Larger branches with diameters exceeding 1 inch were not burned completely, partly because of their high moisture content. Experience suggests that the experimental burns were similar to uncontrolled fall fires that might be expected during an average season in northwestern Pennsylvania (Fred Noack, Allegheny National Forest, 1990, pers. commun.). At the time of the burning, we estimated that 95 percent of the current acorn crop had fallen and was present at different depths in the litter.

Acorns were collected from two 2-foot-wide diagonal transects on each 14- by 14-foot plot within a week after the burning had been completed. On each plot, as many as 25 acorns were collected if they were available. The actual number of acorns collected from individual plots ranged from 11 to 25, but there were 25 acorns on most plots. Only

Figure 1.—Charring of acorns from exposure to the cool fall burns varied from light to severe. No acorns were burned to the point where their high moisture content caused them to burst open.

sound red oak acorns without *Curculio* weevil exit holes and without rodent damage were collected. In all, 1,610 acorns were collected and examined over the 2-year period.

The collected acorns were placed in zip-lock bags with a few pin holes for oxygen exchange and stratified for 3 months at 40° to 45°F in moist peat. After stratification, the acorns were kept moist at 76°F for 2 weeks to allow germination to proceed. After 2 weeks, each acorn was examined for germination, as indicated by a cracked shell and protruding radicle. Germinating acorns were cut open and inspected for soundness and for damage by the *Curculio* weevil. Nongerminating acorns also were cut open to determine if they had been destroyed by *Curculio* or from burning. Each acorn was classified into four categories: Sound and germinated; *Curculio* infested and germinated; *Curculio* destroyed; Fire destroyed.

Results

Acorn Damage By Fire

One purpose of this study was to evaluate the effect of a typical fall burn on the survival of recently fallen acorns. Usually, the fire was not hot enough to cause the acorn seed coat to split, and no acorns on the sample plots were completely consumed by fire; however, many were charred (Fig. 1). Data indicated that a number of acorns were killed by fire, that is, the acorn embryos were "cooked" or dried out and the acorns did not germinate. For the study areas on the Moshannon State Forest, an average of 40 percent of the sample acorns was destroyed by fire. Similarly, 49 percent of the acorns from the Allegheny National Forest plots were destroyed by fire (Table 1).

Table 1.—Number and percentage of northern red oak acorns destroyed by fire in northwestern Pennsylvania

Location	No. acorns sampled	Fire-destroyed acorns	
		Number	Percent
Moshannon	522	211	40.4
Allegheny	270	132	48.9

Acorn Damage By Insects

Another purpose of the study was to evaluate the effect of the fire on viability and germination of *Curculio*-infested acorns. In general, the burns were not hot enough to kill the insects present in the acorns. For the study plots on the Moshannon State Forest, about 25 percent of the sample acorns were destroyed by insects on both the burned and unburned plots. For the Allegheny National Forest plots, an average of 8.5 percent of the acorns was damaged by insects for both treatments (Table 2). However, not all the insect-damaged acorns were destroyed. On the Moshannon plots, 43 percent of the acorns damaged by insects on the

Table 2.—Insect-damaged northern red oak acorns that germinated and produced a seedling on burned and unburned plots

	Acorns on burned plots					Acorns on unburned plots				
		Damaged		Germinating damaged			Damaged		Germinating damaged	
Location	Number sampled	Number	Percent	Number	Percent	Number sampled	Number	Percent	Number	Percent
Moshannon	522	122	23.4	53	43.4	537	138	25.7	87	63.0
Allegheny	270	23	8.5	2	8.7	281	24	8.5	5	20.8

burned plots germinated and produced seedlings. For the unburned plots, 63 percent germinated and produced seedlings. On the Allegheny National Forest, 9 percent of the insect-damaged acorns on the burned plot germinated while 21 percent germinated on the unburned plots. For both areas, the unburned plots consistently had better germination of insect-damaged acorns and more acorns that produced seedlings, indicating that the influence of fire plus the insect damage to the seed cotyledon resulted in loss of germination. This means that the fire was not hot enough or of sufficient duration to kill the *Curculio* larvae inside the acorns without also directly killing the acorns. Fire had no effect on the number of acorns destroyed by insects as infestation occurred before and was independent of the burn.

Effects on Acorn Production

The percentages shown in Tables 1 and 2 were applied to actual estimates of acorn production in the stands where the plots were located (Table 3). Seed-crop estimates were made using the cap count method (Shaw 1974), and were available for each study area. Using actual 1989 and 1990 per-acre estimates of acorn-crop production emphasizes the impact of fire and insects on the availability of seed for establishing new oak seedlings. Table 3 shows the number of acorns per acre that would be directly killed by fire and the additional number of burned acorns that would be lost from insect infestation for a wide range of acorn crop sites. About 40 percent of the average acorn crop would be destroyed by a typical fall fire on the Moshannon State Forest, and an additional 13 percent would be destroyed by insects for a total of 53 percent. Based on data from the Allegheny National Forest, the percentage of acorns destroyed by fire was similar to that for the Moshannon plots, but the percentage of the acorns detroyed by insects was slightly less (8 percent). Thus, the Allegheny had 48 percent of the acorn crop destroyed by fire and insects combined.

Discussion and Summary

The primary purpose of this study was to evaluate the effects of fire during the fall season on the survival and germination of red oak acorns. Included with this fire evaluation is the influence of insect-damaged acorns on acorn survival and germination. During the analyses, the

Table 3.—Estimated numbers per acre of northern red oak acorns destroyed by fire and insects

Location	Acorns per acre	Acorns destroyed by fire	Acorns destroyed by insects	Total acorns destroyed
[a]Moshannon State Forest				
Smith Road	133,584	53,968	17,658	71,626
Gordon Road	143,458	57,957	18,963	76,920
Snotrail	38,188	15,428	5,048	20,476
Average	105,077	42,451	13,889	56,340
[b]Allegheny National Forest				
Route 337	136,972	55,337	10,653	65,990
Keller Road	16,456	6,648	1,220	7,928
Buehler Corners	22,264	8,995	1,732	10,727
Whistletown	6,776	2,738	527	3,265
Average	45,617	18,429	3,548	21,977

[a]1989 acorn seed-crop estimates.
[b]1990 acorn seed-crop estimates.

effects of fire and insects were evaluated individually. The burns were monitored and classed as light-cool. This is typical of the wildfires occasionally occurring in the oak stands on the Allegheny Plateau of northwestern Pennsylvania during the fall season.

On the basis of the results of this study, forest managers generally can expect about 40 percent of a given northern red oak acorn crop on the ground to be destroyed following a typical fall burn. Similarly, we would expect about 11 percent of the burned acorn crop to be destroyed by insects—*Curculio* weevils and *Valentinia* moths. Thus, typical insect damage and a fire combined could destroy about 50 percent of the acorn crop. And this does not include acorn losses due to deer, other mammals and birds, or losses due to ground insects when the acorns germinate the following spring. Also, a fall burn will decrease the germination of insect-infested acorns. In our study, burning reduced the germination of acorns damaged by insects by 20 percent at Moshannon State Forest and by 12 percent on the Allegheny National Forest.

Unburned plots consistently had more insect-damaged acorns that germinated and produced seedlings. This suggests that the fire was hot enough to kill or cause desiccation of the embryo, and/or kill a portion of the seed cotyledon. Also, *Curculio* weevil exit holes in the acorns would increase the likelihood of drying out or desiccating and being destroyed when burned. Although the burns were of light intensity, the fall burns resulted in about 50 percent mortality. Hotter fires would likely increase mortality, and cooler fires would decrease it. Thus, seed mortality in this study was related to desiccation of the acorn cotyledon and direct killing of the seed embryos by fire, and killing by insects.

Buried acorns would have a much higher chance of survival when a typical fall burn occurs on the Allegheny Plateau. Also, for test purposes, the sample acorns in the study were stratified in moist peat, and the germination rate may be higher than obtainable in nature. In the normal environment, acorns would have a tendency to dry out as a result of the *Curculio* weevil exit holes, but this did not occur in the moist peat.

Seed crops are variable even within the same location. Also, more seed was collected in the Moshannon State Forest than in the Allegheny National Forest. In 1989, there was a good acorn seed crop at the Moshannon, so more plots were available to sample. In 1990, only one study site had a good acorn crop on the Allegheny, so fewer acorns were available to collect. Additional information on the variation in acorn seed crop produced on the study areas is discussed in Auchmoody et al.[1]

There are additional effects of fire as related to vegetation establishment. For example, fall burns as used in this study, might stimulate dormant fire cherry (*Prunus pennsylvania* L.) seeds to germinate as well as other dormant seeds of herbaceous species stored in the soil and humus layers. Other light-seeded tree species such as birch, maple, and ash would be destroyed unless some of the seed was buried in the soil.

The significance of fire in combination with insects present in forest stands cannot be overlooked when acorn seed crops are evaluated. Although fire occurs in oak stands of the Allegheny Plateau only occasionally, 40 percent of the estimated acorn crop could be destroyed by a fall burn of light intensity. Thus, to some forest managers who may be trying to regenerate northern red oak, it may become even more important to keep fire out of the forest stands.

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[1]Auchmoody, L.R.; Smith, H. Clay; Walters, Russell S. 1993. Acorn production in northern red oak stands in Pennsylvania. Manuscript in preparation.

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Keywords: Fire, northern red oak, acorn damage, *Curculio*

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