

## LOW TEMPERATURES OPTIMUM FOR FIELD GERMINATION OF NORTHERN RED OAK

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Northern red oak is a highly preferred species in the hardwood mixtures common to the Lake States. However, it tends to regenerate sporadically over extended periods and then occurs as an occasional species in the mixture. The low representation has most often been attributed to predation of acorns by various agents and lack of favorable stand conditions during early growth (1, 2). Initial work on optimum germination temperatures for the species, supported by preliminary data on surface soil temperatures and direct seeding trials, suggests that the low temperatures necessary for germination may not occur over a long enough period under field conditions to encourage abundant regeneration.

Acorns for the trials were obtained from central Wisconsin<sup>1</sup> during the bumper seed year of 1977. The acorns were air-dried at room temperature, sorted for presence of worm holes, float tested in water, and stored in plastic bags at about 30° to 32° F for approximately 90 days.

A series of 30-day germination tests in an unlighted, constant temperature cabinet were initiated in late January. Germination temperatures were maintained from 34° F to 81° F at

approximately 10-degree intervals. At each temperature setting, 50 acorns were placed on perlite in partially covered containers, and kept moist throughout the tests. Cabinet temperature and number of germinants were recorded daily. Acorns were considered germinated when the radicle was plainly visible.

Soil surface temperatures were recorded on both scarified and unscarified seedbeds within 10 feet of each other, under an uncut, mature, hardwood-hemlock stand on the Argonne Experimental Forest in north-central Wisconsin. The area had been scarified the previous fall after leaf drop, using an Athens disc—approximately 80 percent of the area had mineral soil exposed. Litter on the unscarified portion was predominantly hardwood, about one-half inch thick. The sensors of a dual pen recording thermograph were placed at the surface of the scarified seedbed and at the litter-mineral soil interface and kept lightly covered to restrict direct solar radiation.

### Germination Results

Germination was greatest and earliest at 34° F (table 1). Ninety percent of the acorns held at this temperature germinated, in contrast to only 14 percent at 43° F and 21 percent at 54° F. Most of the acorns that failed to germinate during the test period showed marked discoloration of

the nutmeat and no evidence of radicle development. Although 6 percent of the acorns produced a radicle at 67° F, all appeared withered and offcolor.

Germination began within 10 days at 34° F; at each higher temperature setting, the time before first germination became successively longer. The time required to reach 70 percent germination increased from 16 days at 34° F to 23 days at 67° F. Some germination did occur up to the 30th day, but in most cases was completed by the 25th.

### Surface Soil Temperatures

The average daily temperature of the soil surface on the scarified area was 32° F during the last week of April, but then increased rapidly until overstory leaf-out during the last week of May (fig. 1). In contrast, the average temperature of 32° F on the unscarified area was not reached until the second week of May. Assuming that an average daily temperature of 32° to 39° F is within the optimum range for red oak, there were 15 favorable days on the scarified area, but only 5 favorable days on the unscarified portion during the spring of 1978. Meanwhile, climatic records from the closest station reporting long term means indicated that May 1978 had been about 2° warmer than normal, but had greater than normal precipitation.

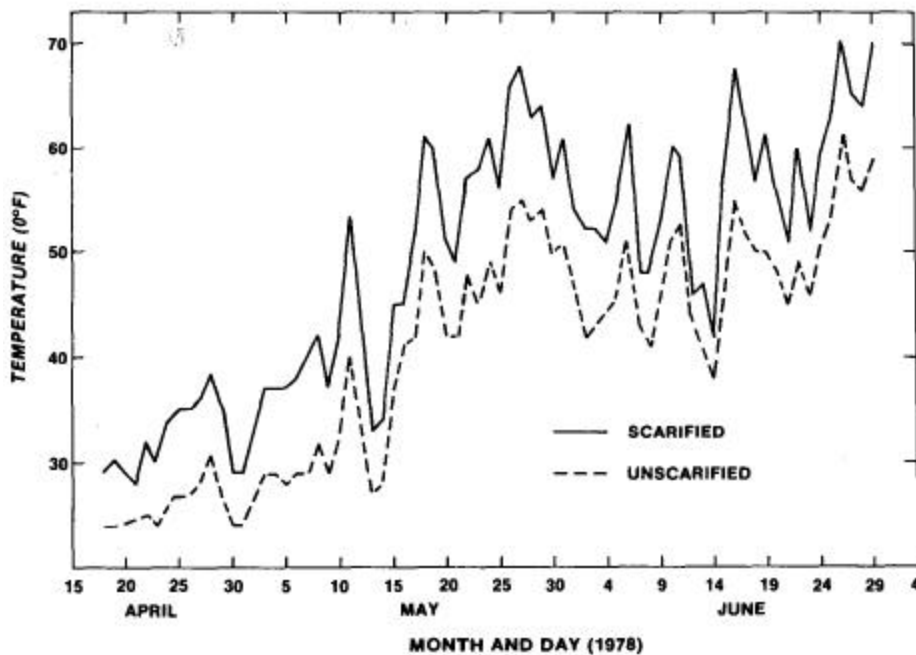
Scarification thus has two

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<sup>1</sup>Acorns supplied by Richard Beier, Wisconsin Department of Natural Resources forester, as collected on the Navarino Wildlife Area.

**Table 1.**—Number and periodicity of northern red oak acorns germinating at constant temperatures

Average cabinet temperature 0° F	Acorns germinated		Days to germination		
	No.	Percent	First	Last	70 percent
34	45	90	0	30	16
43	7	14	12	26	20
54	11	21	14	30	21
67	3	6	22	23	23
72	0	0	—	—	—
81	0	0	—	—	—



**Figure 1.**—Seasonal change in average daily surface temperature of seedbeds under an uncut hardwood-hemlock stand.

important benefits for the germination of red oak: (1) longer duration of optimum temperatures, and (2) earlier occurrence of optimum temperatures to coincide with more favorable early moisture conditions.

Throughout the observation period the scarified portion averaged about 8° F warmer than the unscarified area. The greatest difference observed was 13°, although daily variation usually was between 6° and 10°.

### Direct-Seeding Trials

A small, direct-seeding trial, using 120 acorns from the same collection, was established on an adjacent, scarified area on May 4, 1978. Single acorns were planted in mineral soil and covered with wire screens to prevent predation. The area was also under an uncut hardwood stand, although saplings and small poles had been knocked down during scarification the previous fall.

The final germination count was made on July 10th. By this date, 14 percent of the protected acorns had germinated. Therefore, their screens were removed. During this final period, the average surface temperature was between 32° and 39° F for 6 days and between 40° and 49° F for 7 days. Surface soil temperatures were higher all the remaining days. Thus, these direct-seeding results were in general agreement with the constant temperature cabinet tests.

Direct-seeding trials were made in 1978 by the Chequamegon National Forest on two salvaged areas. At both localities, the entire overstory had been removed by full tree logging, leaving a bare, fully exposed site. Acorns from a local source, but of unknown viability, were planted in mid to late May of 1978, about 2 weeks later than those on the experimental forest. Results showed between 15 and 20 percent germination on the "wetter"

site, and no germination on the "drier" site. <sup>2</sup> Germination may have been sharply reduced by higher soil temperatures and reduced moisture on the exposed site because of the later planting.

### Conclusion

These trials strongly suggest that northern red oak will germinate best at low temperatures, probably between 34° and 39° F. Observations of natural oak germination and establishment also support the concept of better germination at low temperatures. Throughout the Lake States, red oak seedlings are commonly observed in uncut stands along with sugar maple seedlings—perhaps the species requiring the lowest temperature for germination of the desirable northern hardwoods<sup>3</sup>;

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<sup>2</sup>Personal communication from Tom Smith, Staff Forester, Chequamegon National Forest on September 12, 1978.

<sup>3</sup>Sugar maple produced a bumper seed crop in the fall of 1977 but very few seeds germinated in the spring of 1978 when the snow cover disappeared rapidly. Germination of sugar maple during this spring was generally limited to residual snow banks suggesting that conditions favoring its germination had changed too rapidly.

These findings contrast sharply with the germination test results from higher temperatures reported in *Seeds of Woody Plants in the United States* (3). Further tests and field trials are warranted because of the complicating effects of temperature, time, moisture, and their interactions, as well as seed source, collection, and storage procedures.

### Recommendations

Under the low temperature concept, management methods that would provide extended periods of favorable germination temperatures are probably difficult to attain. If red oak is desired as a major stand component, pregerminated<sup>4</sup> acorns could be direct-seeded to coincide with the short period of cooler temperatures. By sowing pregerminated acorns in the spring, right after snowmelt, advantage can be taken of favorable temperatures, and a minimization of predation could result.

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<sup>4</sup>Acorns maintained at 34° to 39° F for a period of 10 to 14 days or just prior to radicle emergence.

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