PACIFIC SOUTHWEST Forest and Range Experiment Station

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SHADE IMPROVES SURVIVAL RATE OF OUTPLANTED 2–0 RED FIR SEEDLINGS

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ABSTRACT: Effect of shade on 2-0 red fir seedlings outplanted on the Tahoe National Forest, central California, was studied by comparing five treatments: no shade, low shade for 1 year and for 2 years, and high shade for 1 year and for 2 years. Seedlings benefited from shading—even under apparently excellent survival conditions in the first season. The extra cost of artificial shades may be worthwhile under some conditions.

OXFORD: 174.7 *Abies magnifica*–232.4:232.324: 232.4.
RETRIEVAL TERMS: Abies magnifica; seedling survival; outplanting; protective shading; Tahoe National Forest.

Red fir *(Abies magnifica* A. Murr.*)* plantations at high elevations (roughly 6,000 to 8,000 feet) in California have not been consistently successful. In many cases, heavy and repeated deer browsing has killed planted trees. But, more commonly, reasons for mortality of apparently healthy, properly handled and planted stock have been obscure. As a result, land managers have planted more Jeffrey pine *(Pinus jeffreyi* Grev. & Balf.*)* than red fir seedlings at high elevations—simply because they knew the pine would survive. These Jeffrey pine stands will be interesting to watch, since pure closed stands of this species seldom occur in the same ecological niche as red fir.

A study was designed to investigate the influence of a single factor—shade—on red fir seedling survival. I selected this factor for study because of previous detailed research on problems in red fir regeneration. One of these studies yielded valuable information on soil surface temperature.

Baker[1] determined that under certain conditions, western conifer seedlings could be killed by 130°F. temperature. Maguire[2] found that first-year survival rate in a maximum soil surface temperature of 162°F. was 82 percent for 2-0 ponderosa pine seedlings shaded with box shook, and 20 percent for unshaded seedlings. In a rough extension of the study he got seedling survival rates of about 82 percent when stem bases were protected by cotton batting, and about 69 percent when bases were protected by 1½-inch pieces of sheet metal. He therefore attributed the effect of shade on survival to reduction of soil surface temperature rather than to decreased plant transpiration. The California Division of Forestry[3] reported that shaded white fir seedlings at low elevations consistently had a higher survival rate than unshaded seedlings.

As an extension of a study on illumination and soil surface temperature at 6,200 feet elevation,[4] I tried to keep separate any possible differences resulting from shading whole seedlings instead of only low parts of stems and adjoining soil.

Figure 1–*An experimental block shows condition of soil surface. Details of (*A*) browse guards; (*B*) high shades; and (*C*) low shades are also shown.*

From this study on the Tahoe National Forest, central California, I found that shade–at least for the first year–helped increase survival of outplanted 2-0 red fir seedlings. Artificial shades mean an additional cost. When unshaded planted stock survives as well as it did in this study, the financial benefits from shading may be doubtful. But when planting stock vigor and site conditions will predictably affect survival adversely, the use of shades may be worth the additional cost.

METHODS

The study site was a large clearcutting at 7,600 feet elevation in the Sierraville Ranger District. Slash from a red fir sale had been bulldozed into piles and burned in 1964. This left most of the area as an expanse of bare mineral soil *(fig. 1)*.

Seedlings planted were 2-0 red fir from Mt. Shasta Nursery. They had grown in about 50 percent shade provided by overhead laths. Trees were lifted March 15, 1965, and moved to a cold storage plant at Lincoln, California. A few days before planting they were trucked to Sierraville and stored in a walk-in refrigerator.

Rows of seedlings were planted up and down slopes. Slopes and aspects of blocks were:

	Slope *(percent)*	Aspect
Block:		
A	14	S
B	11	S
C	16	E
D	3	W

The experiment, of randomized block design with four blocks and five treatments, was begun on June 4, 1965, immediately after snowmelt. Seedling treatments were: (a) no shade (N); (b) low shade for 1 year (L1); (c) low shade for 2 years (L2); (d) high shade for 1 year (H1); and (e) high shade for 2 years (H2). Each treatment in each block was represented by 25 seedlings. Survival was recorded twice each year through 1967—each spring soon after snowmelt, and late in September (before snowfall). A seedling was judged live if it had any number of green needles.

Browsing of seedlings was prevented by cylindrical screens of 1-inch netting, 8 to 9 inches in diameter, and 12 inches high, capped with 2-inch poultry netting *(fig. 1A)*.

High shade was created by fastening (with hog rings) 6-mil-thick black polyethylene sheeting to the south half-circumference of appropriate browse screens. The black plastic extended from ground level to top of screen, and extended horizontally over 2 to 4 inches of the top of the screen *(fig. 1B)*.

Low shades were constructed of sheet metal *(fig. 1C)*. Tests elsewhere had indicated that they could be inserted in the soil so that they would shade only the soil surface and lower seedling stem. At the study site, however, small rocks and pieces of slash in the soil often prevented insertion to desired depth, so the low shades also shaded much needle surface of some seedlings.

Shades for 1-year and 2-year treatments were removed in spring.

WEATHER

Cloud cover at the study site from mid-June to mid-October in the first season was observed from Sardine Lookout, 13 miles distant. Percent of days cloudy there was: 24; partly cloudy, 17; clear, 45; not recorded, 14.

Summer precipitation at the study site was not recorded, but records at Sierraville Ranger Station, 5 miles away at elevation 4,975 feet, were used as an approximation. The summer of 1965—potentially most critical to survival by being the first season of outplanting for the study—was exceptional in that much rain fell over northern California. At Sierraville Ranger Station, 4.22 inches of moisture was recorded, distributed thus: June 0.59; July 0.77; August 1.83; September 0.73; and October 0.30. Fire lookout stations at elevations higher than the Ranger Station reported more precipitation in the period, so that probably more also fell at the study site. Precipitation for the snow-free period of 1966 was low, but in 1967 was quite high again. Rainfall in the first growing season and in the 2 years following, from the time of snowmelt to October 31, was:

	Rainfall *(inches)*	Days rain fell *(No.)*
Year and date of snowmelt:		
1965: June 1	4.22	20
1966: May 15	.34	10
1967: July 1	3.02	8

RESULTS

Summer rainfall and associated cloudiness in the first season probably favorably influenced seedling survival in all treatments. I also saw excellent survival of other red fir seedlings planted throughout the large cleared site in which study blocks were located. The high rate of seedling survival under all treatments in the first season probably masked some results—especially in the first year *(fig. 2)*.

The study allowed comparison of treatments for their durations, and, in the case of shade treatments, 1 year later. Certain comparisons made were confounded by length of treatment or years since treatment, or by years (with their differences in weather conditions).

At the end of the first growing season, only three treatments were available for analysis: N, L1, and H1. However, during the first year, L2 and H2 treatments were the same as L1 and H1, respectively. Therefore three treatment groups were compared: (a) no shade; (b) low shade, and (c) high shade. Since this grouping caused an unequal number of observations per treatment, Tukey's test was used to compare means after analysis of variance showed treatment means were highly significantly different. Mean treatment survival percentages at end of the first season were: N—88.0; L—95.5; and H—98.4, with high shade significantly different from low shade.

Analyses of variance indicated no significant differences between mean survival rates when five treatments were considered at the ends of the second and third growing seasons. The nature of the data, however, suggested strongly that there were important relationships concealed by the "averaging" effect of analysis of variance *(fig. 2)*.

Therefore, analyses of variance and subsequent Tukey tests evaluated the data grouped as three treatments: no shade, low shade, and high shade *(fig. 3)*. At the end of the second season, both low and high shade treatments were significantly different from no shade. At the end of the third season, (a) low shade was significantly different from no shade, and (b) high shade was significantly different from low shade.

What caused the change of relationship between N, L, and H treatments with time is not known. Possibly the low level of solar energy reaching plants with high shade caused an imbalance between photosynthesis and respiration, and shade removal failed to overcome this effect.

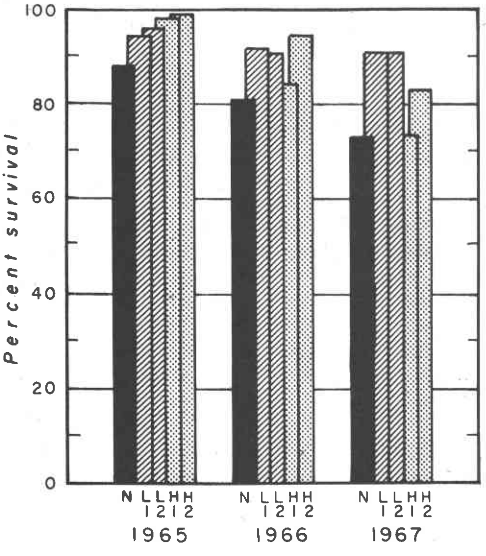

Figure 2–*Seedling survival, by treatments, at ends of first three outplanted growing seasons. Treatments: none (N); low shade for 1 (L1) and 2 years (L2); high shade for 1 (H1) and 2 years (H2).*

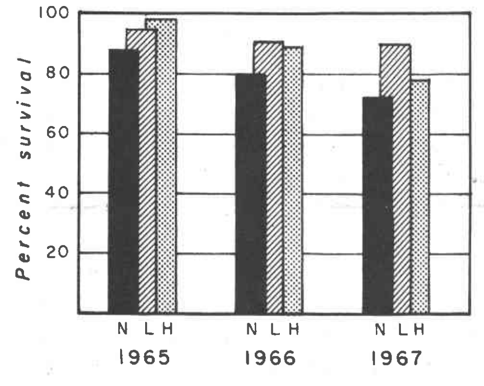

Figure 3–*Seedling survival at ends of first three outplanted growing seasons. L = treatments of low shade for 1 year and for 2 years combined; H = treatments of high shade for 1 year and for 2 years combined; N = no treatment.*

Perhaps the most important result of the study was that even with apparent excellent survival conditions in the first season, trees shaded only that year survived well that year and subsequently. The analyses, and appearance of the graphed data, indicate no appreciable benefit gained by shading beyond the first year.

Browse screens effectively protected seedlings from animal damage. The particular screens used, however, were damaged by deep snowpacks and had to be repaired each spring. Initial cost of about $1.00 each, installed, would preclude their use in most plantations.

Design of low sheet metal shades caused silt entrapment in some cases where the open part of the V faced uphill. This condition became serious only in summer 1965 when high-intensity rains fell. Silt did not kill any seedlings and was removed where necessary.

High shades made of black sheet plastic proved durable.

No low vegetation became competitive with fir seedlings during the study. At the end, though, herbs and two brush species (*Ceanothus cordulatus* Kell. and *C. velutinus* Dougl. ex Hook.) were developing in some parts of the area at rapid rates. These signs suggested that the plants might soon compete with seedlings for soil moisture.

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NOTES

[1]Baker, Frederick S. *Effect of excessively high temperatures on coniferous reproduction.* J. Forestry 27(8): 949-965, illus. 1929.

[2]Maguire, William P. *Radiation, surface temperature, and seedling survival.* Forest Sci. 1(4): 277-285, illus. 1955.

[3]California Division of Forestry. *Reforestation studies.* Dep. Conserv. 14 p., illus. 1963. *Reforestation studies.* Dep. Conserv. 19 p., illus. 1964.

[4]Gordon, Donald T. *Some preliminary findings on the effects of insolation on white and red fir regeneration.* 1965. (Unpublished paper on file at Pacific Southwest Forest and Range Exp. Sta., Redding, Calif.)

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