Research Note

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN UTAH

USDA Forest Service
Research Note INT-119 1970

SHADE INCREASES FIRST-YEAR SURVIVAL OF DOUGLAS-FIR SEEDLINGS

Russell A. Ryker and Dale R. Potter[1]

ABSTRACT

On a clearcut area of the Boise National Forest in Idaho, shading doubled first-year percent survival of Rocky Mountain Douglas-fir [Pseudotsuga menziesii *var.* glauca *(Beissn.) Franco*]. *The mortality rate among seedlings on unshaded plots was relatively constant throughout the growing season, but among seedlings on shaded plots, dropped sharply by mid-August.*

SEEDLING DISTRIBUTION SUGGESTS NEED FOR SHADE

In an effort to define regeneration problems of Rocky Mountain Douglas-fir [*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco], the senior author has examined numerous clearcut areas (1-15 years of age) throughout the National Forests of central and southern Idaho and Utah. In every case, acceptable numbers of Douglas-fir seedlings grew only within the partially shaded area at the timber's edge. No seedlings were found elsewhere on these openings, unless they were protected by shrubs and residual trees, by considerable amounts of logging debris, and/or by standing dead trees. This generality held regardless of aspect, but was less pronounced on steep north-facing slopes.

Similar findings have been reported for the Pacific Coast Douglas-fir [*Pseudotsuga menziesii* var. *menziesii* (Mirb.) Franco]. Sprague and Hansen[2] found Douglas-fir reproduction concentrated on the northeast sides of scattered oak trees growing on a southwest slope in Oregon. According to these men, clumps of reproduction are well defined; only an occasional seedling grows beyond the area shaded by a tree during the hottest part of the afternoon. Isaac[3] stated that regeneration of Pacific Coast Douglas-fir is benefited by light vegetative cover (up to 25 percent), impaired by cover greater than 25 percent, and practically prohibited by cover exceeding 80 percent. He also observed more natural restocking within shadow lines along the southerly edges of clearcut areas.

---

[1] The senior author is a Silviculturist, stationed at Boise, Idaho; the junior author is now a Forestry Research Scientist for the Pacific Northwest Forest and Range Experiment Station and is stationed in Seattle, Washington.

[2] F. LeRoy Sprague and Henry P. Hansen. Forest succession in the McDonald Forest, Willamette Valley, Oregon. Northwest Sci. 20(4): 89-98. 1946.

[3] Leo A. Isaac. Where do we stand with Douglas-fir natural regeneration research. Soc. Amer. Forest. Proc. 1955: 70-72. 1956.

Krauch[4] reported that Douglas-fir seedlings in Arizona and New Mexico require shade--especially during the first season. In a study evaluating cutting methods in Colorado, Roeser[5] found that shelterwood- and selection-cutting permitted more Douglas-fir seedlings to become established than clearcutting. Apparently, seedlings of both Douglas-fir varieties benefit from some shade during their early years, and this is probably true for transplanted trees as well.

The research upon which this note is based was initiated the summer of 1968 to determine the effect(s) of shade on the survival rate of young Douglas-fir trees through the first three growing seasons. We chose as our study plot a spot-seeded area on the Garden Valley Ranger District of the Boise National Forest in Idaho. Our objectives were to see whether shading contributed to seedling survival on that particular area and to establish the best time(s) of year to make reliable survival counts.

STUDY AREA

The 10-acre area selected for trial seeding and planting appeared to be one of the District's better sites for Douglas-fir. Before being clearcut and seeded, it supported a mixed stand of Douglas-fir, ponderosa pine, and grand fir. Willow, bitter-cherry, and maple dominated a heavy shrub understory. The soil, a sandy loam, was derived from granitic parent material. The seeded portion is on a southeast-facing, relatively uniform 40 percent slope.

PROCEDURES

Preparations for the seeding and planting trials began the summer of 1967. Slash was lopped and later burned and the study site stripped by tractor to mineral soil. Seeding was done during mid-October.

In July 1968, 80 seed spots were located and marked. These marked places--each of which supported 2 to 38 seedlings--represented 80 percent of the total population of recognizable seed spots.

Twenty randomly selected spots were covered by 2-foot-square lath screens that stood 1 foot above the ground surface and provided shade about 50 percent of the time (fig. 1). Also, all seed spots were kept weed-free during the remainder of the growing season to negate the influence of competition.

In order to evaluate the treatments' effects, we made seedling counts every 2 weeks from July 3 until September 12, 1968.

Four seed spots, to be used throughout the study, were randomly selected for soil tests. On each measurement day, samples from soils adjacent to these spots were taken from 4- to 6-inch and 8- to 10-inch depths. Soil moisture content was determined gravimetrically. In order to relate soil moisture content to the amount of moisture available to the trees, we determined the moisture-holding capacity of the soil at 15 atmospheres of tension by means of a pressure membrane apparatus.

We assumed that the major effect of shade would be to reduce soil surface temperatures. To determine the amount of reduction, we measured temperatures at four shaded spots by means of a thermistor probe and telethermometer (fig. 2). Soil surface temperatures were measured: (1) in the open, 1 foot from each screen; (2) on an unshaded strip beneath each lath screen; and (3) on a shaded strip beneath each screen. Temperature measurements were made during the early afternoon hours on clear days only. Consequently, we have data for only three of the six measurement dates.

---

[4]Hermann Krauch. Management of Douglas-fir timberland in the Southwest. Rocky Mountain Forest and Range Exp. Sta., Sta. Pap. 21, 59 p. 1956.

[5]Jacob Roeser, Jr. A study of Douglas-fir reproduction under various cutting methods. J. Agr. Res. 28: 1233-1242. 1924.

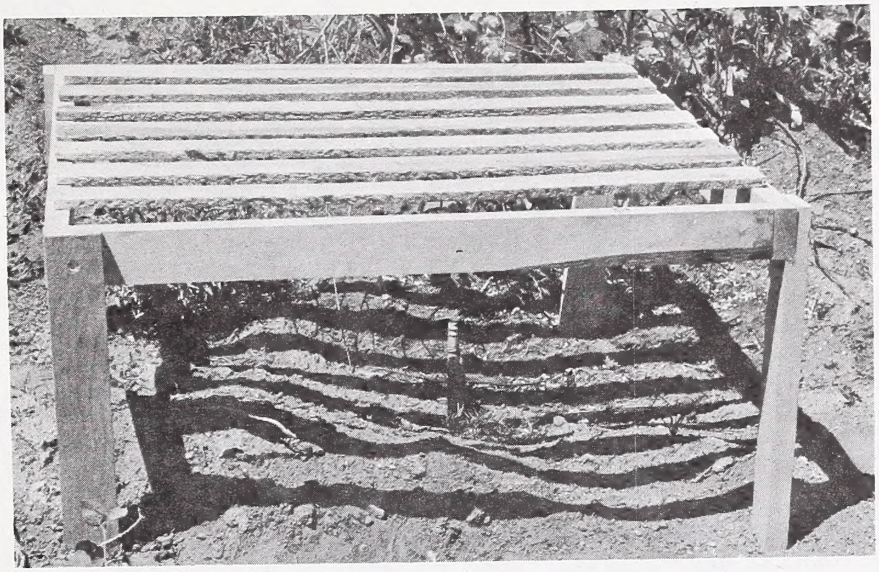

Figure 1.--Lath shade frames used for shading seed spots. Laths 1-1/2 inches wide were spaced 1-1/2 inches apart.

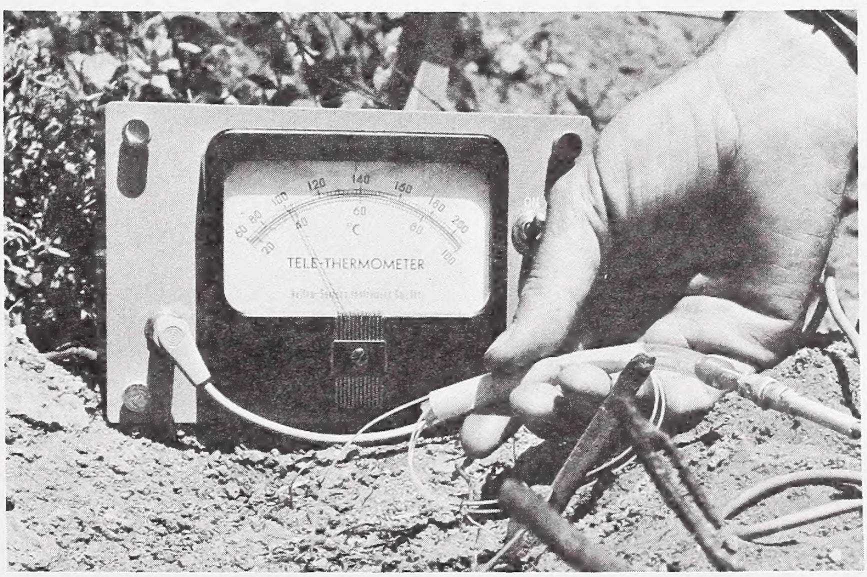

Figure 2.--Soil surface temperature is measured in the open next to a shade screen.

Krauch[4] reported that Douglas-fir seedlings in Arizona and New Mexico require shade--especially during the first season. In a study evaluating cutting methods in Colorado, Roeser[5] found that shelterwood- and selection-cutting permitted more Douglas-fir seedlings to become established than clearcutting. Apparently, seedlings of both Douglas-fir varieties benefit from some shade during their early years, and this is probably true for transplanted trees as well.

The research upon which this note is based was initiated the summer of 1968 to determine the effect(s) of shade on the survival rate of young Douglas-fir trees through the first three growing seasons. We chose as our study plot a spot-seeded area on the Garden Valley Ranger District of the Boise National Forest in Idaho. Our objectives were to see whether shading contributed to seedling survival on that particular area and to establish the best time(s) of year to make reliable survival counts.

STUDY AREA

The 10-acre area selected for trial seeding and planting appeared to be one of the District's better sites for Douglas-fir. Before being clearcut and seeded, it supported a mixed stand of Douglas-fir, ponderosa pine, and grand fir. Willow, bitter-cherry, and maple dominated a heavy shrub understory. The soil, a sandy loam, was derived from granitic parent material. The seeded portion is on a southeast-facing, relatively uniform 40 percent slope.

PROCEDURES

Preparations for the seeding and planting trials began the summer of 1967. Slash was lopped and later burned and the study site stripped by tractor to mineral soil. Seeding was done during mid-October.

In July 1968, 80 seed spots were located and marked. These marked places--each of which supported 2 to 38 seedlings--represented 80 percent of the total population of recognizable seed spots.

Twenty randomly selected spots were covered by 2-foot-square lath screens that stood 1 foot above the ground surface and provided shade about 50 percent of the time (fig. 1). Also, all seed spots were kept weed-free during the remainder of the growing season to negate the influence of competition.

In order to evaluate the treatments' effects, we made seedling counts every 2 weeks from July 3 until September 12, 1968.

Four seed spots, to be used throughout the study, were randomly selected for soil tests. On each measurement day, samples from soils adjacent to these spots were taken from 4- to 6-inch and 8- to 10-inch depths. Soil moisture content was determined gravimetrically. In order to relate soil moisture content to the amount of moisture available to the trees, we determined the moisture-holding capacity of the soil at 15 atmospheres of tension by means of a pressure membrane apparatus.

We assumed that the major effect of shade would be to reduce soil surface temperatures. To determine the amount of reduction, we measured temperatures at four shaded spots by means of a thermistor probe and telethermometer (fig. 2). Soil surface temperatures were measured: (1) in the open, 1 foot from each screen; (2) on an unshaded strip beneath each lath screen; and (3) on a shaded strip beneath each screen. Temperature measurements were made during the early afternoon hours on clear days only. Consequently, we have data for only three of the six measurement dates.

---

[4]Hermann Krauch. Management of Douglas-fir timberland in the Southwest. Rocky Mountain Forest and Range Exp. Sta., Sta. Pap. 21, 59 p. 1956.

[5]Jacob Roeser, Jr. A study of Douglas-fir reproduction under various cutting methods. J. Agr. Res. 28: 1233-1242. 1924.

RESULTS

By mid-August, the mortality rate of shaded seedlings was close to zero, but (except for a 2-week rainy period) that of unshaded seedlings was relatively constant until mid-September. On September 12, 1968, percent survival of shaded seedlings was more than twice that of unshaded seedlings (fig. 3). The *t* test shows this difference to be highly significant.

Throughout the measurement period, soil moisture content remained well above the soil's moisture-holding capacity at 15 atmospheres of tension (fig. 4).

Shade screens effectively reduced soil surface temperatures (fig. 5). The day (August 1) that we obtained the highest readings, early-afternoon temperatures averaged 142°F. in the open, 126°F. on the unshaded strips, and 100°F. on the shaded strips beneath our screens.

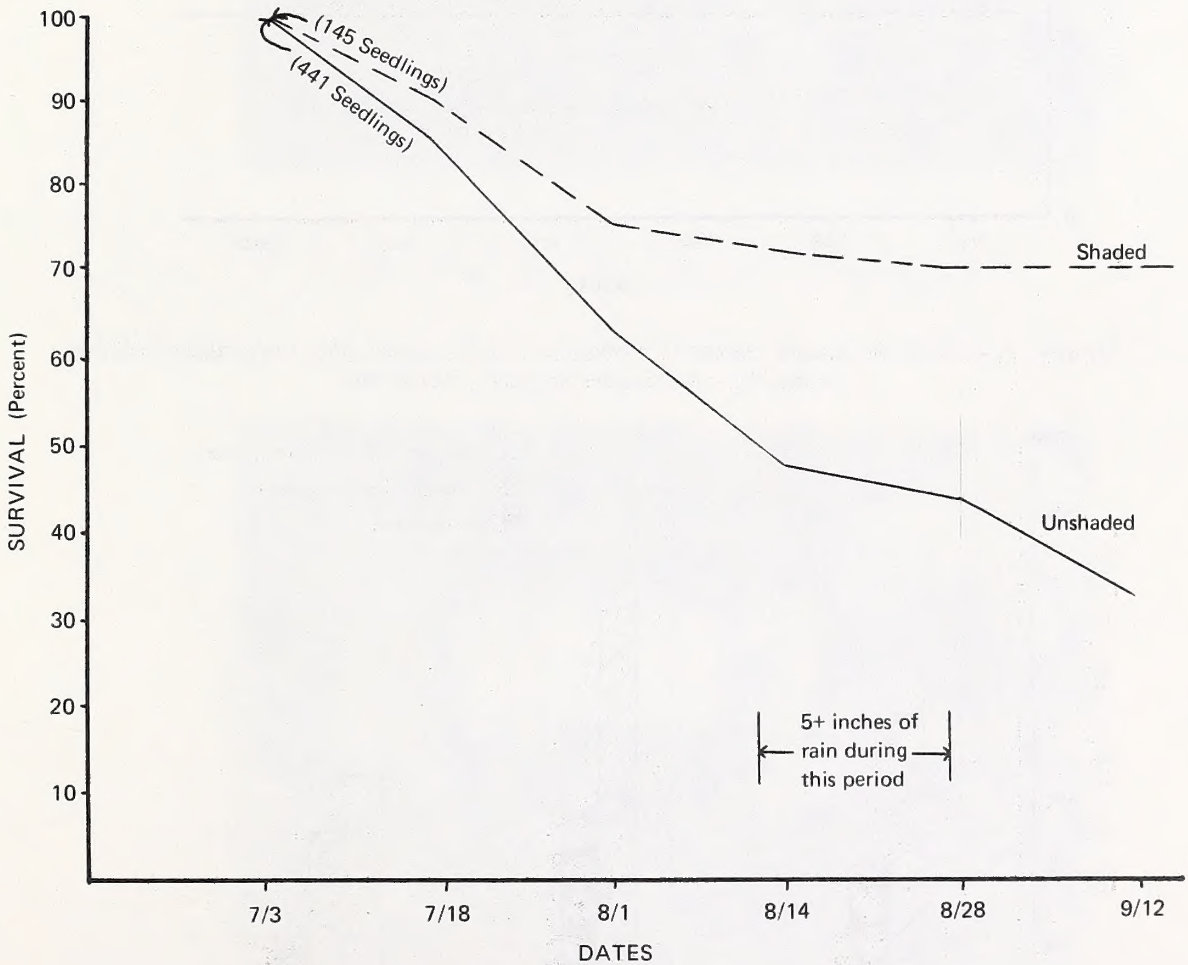

Figure 3.--Percent survival of shaded seedlings was almost twice that of unshaded seedlings late in the growing season (1968).

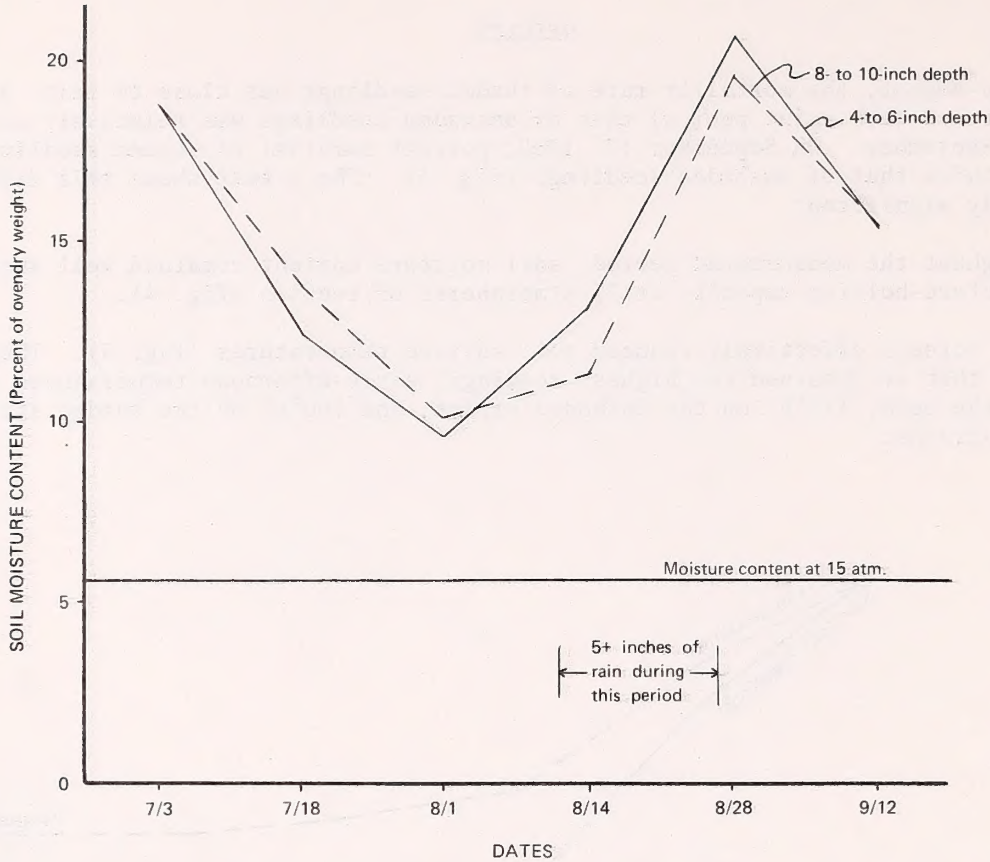

Figure 4.--Soil moisture content remained well above the moisture-holding capacity at 15-atmospheres tension.

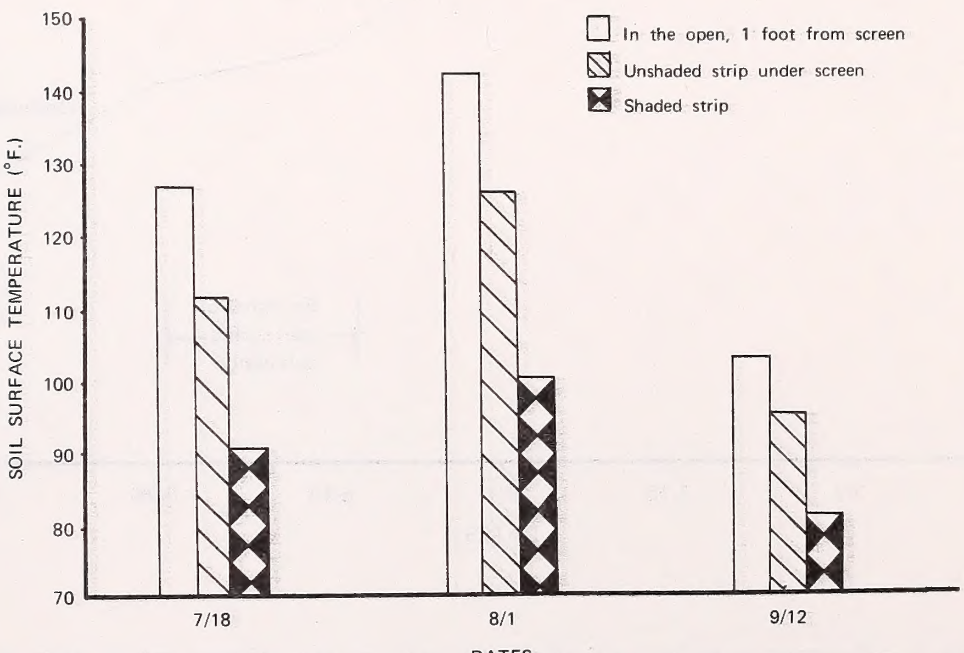

Figure 5.--Shading reduced surface temperatures.

CONCLUSIONS

Data obtained from this study support the contention that partial shade encourages establishment of Rocky Mountain Douglas-fir seedlings. Higher seedling survival rates attributed to shade probably did not result solely from reduced surface temperatures and soil moisture losses; unshaded seedling deaths continued at a relatively constant rate throughout the growing season, even though soil moisture content remained well above the 15-atmosphere level and surface temperatures decreased in early September.

Hodges and Scott[6] recently reported daily rates of net photosynthesis for seedlings of six conifer species. For four species (western hemlock, grand fir, sitka spruce, and West Coast Douglas-fir) these daily rates were highest in trees on the outer margin of the study stand. For the other two species (Scots pine and Noble fir), rates were highest in trees exposed to full sunlight.

It seems likely that a metabolic imbalance caused by internal moisture stress led to the high late-season mortality rate observed during the study reported here. Lath screens probably prevented a buildup of moisture stress in our seedlings and consequently bettered the likelihood of their survival. Shading evidently lowered leaf temperature relatively more than air temperature, thereby reducing water loss and the resultant moisture stress, and increasing net photosynthesis and probability of seedling survival.

Research is needed to determine the amount of shade required by Douglas-fir seedlings growing under various site conditions and to define the process by which shade affects seedling survival and growth.

---

[6]John D. Hodges and David R. M. Scott. Photosynthesis in seedlings of six conifer species under natural environmental conditions. Ecology 49: 973-981. 1968.