CALIFORNIA DIVISION OF FORESTRY

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

STATE FOREST NOTES

Office of the State Forester
Sacramento

NO. 28 JANUARY 1966

ARTIFICIAL SHADE IMPROVES SURVIVAL OF PLANTED DOUGLAS-FIR AND WHITE FIR SEEDLINGS

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ABSTRACT

Artificial shading of Douglas-fir and white fir planted seedlings measurably increased survival as shown by five California Division of Forestry studies conducted in northern California. Tests were made on a variety of sites; from critical valley exposures to those of mild coastal climate. It was shown that survival of shaded seedlings was two to three times greater than unshaded ones. The greatest differences in survival, of course, were on the more critical sites.

Douglas-fir (Pseudotsuga menziesii [Mirb] Franco) and white fir (Abies concolor [Gord. & Glend.] Lindl) are classed respectively in Baker's (1950) tolerance tables, as "intermediate" and "tolerant" in the amount of shade they enjoy for establishment and growth in the forest. Fowells (1965) indicates that white fir seedlings need a partially closed canopy under which to develop, and environmental conditions in large clearings inhibit regeneration. Douglas-fir develops best in its early stages when the environment is partially protected from full sunlight. Logically, then, it could be expected that shading should improve survival of planted Douglas-fir and white fir seedlings.

A number of observations and results of testing artificial shade for Douglas-fir and ponderosa pine have been published over the years, (Show, 1930; Person, 1937; Isaac, 1938; California State Board of Forestry, 1955; Maguire, 1955; Franklin, 1963), but there appears to have been little testing in replicated plots with measured shade, nor have there been tests using white fir. Duffield (1962) stated that the value of

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mechanical shade should be tested under "well controlled field conditions with adequate replication". The State Forester's Advisory Committee on Reforestation Methods and Procedures confirmed the need for shading studies, particularly for true firs (1964).

Five studies conducted by the California Division of Forestry in the last five years convincingly confirm the fact that artificial shade improves survival of Douglas-fir and white fir planted seedlings. The studies were located on two cooperative reforestation study areas: the Forest Creek Burn, Calaveras County, and the Gualala Redwoods, Sonoma County; and at two of the Division's nurseries: Ben Lomond, Santa Cruz County, and Davis Headquarters, Yolo County. Information on the sites is shown in table 1 below.

Table 1. Site information where artificial shading of Douglas-fir and white fir seedlings were tested.

Study Site	Elev. (ft.)	Approx. mean ann. rainfall (inches)	Approx. mean max. temperature May to Oct.(deg.F)	Soil	Original Vegetation Cover
Forest Creek Burn, Central Sierra Nevada Mountains	4,800	54	76.1	Cohasset loam Approx. pH 6.0	Mixed conifer, ponderosa and sugar pine, white fir and Douglas-fir
Gualala Redwoods (8 mi. from coast)	1,400	75	74.6	Hugo clay loam Approx.pH 6.0	Douglas-fir and redwood
Ben Lomond Nursery (7 mi. from coast)	2,600	60	72.7	Sheridan sandy loam pH 6.2	California live oak, madrone, and redwood
Davis Headquarters Nursery, Sacramento Valley	35	16	83.9	Yolo clay loam pH 8.0	Grass and herbs

The shading of white fir was tested on the Forest Creek Burn and at the Ben Lomond Nursery. Shading Douglas-fir was tested on the Gualala Redwoods Study, and at the Ben Lomond and Davis nurseries.

Shades for all studies were provided by shingles from five to seven inches wide, inserted in the ground on approximately the south-southwest side of each seedling, about four or five inches from its base. A portion of from eight to ten inches of each shingle was above ground, and slanted so that the top was directly over the seedling (figs. 1 and 2). Maguire (1955) pointed out the importance of placing shade in such a position, since the most severe radiation and soil surface temperatures occur about 2:00 p.m. He recommended that shingles be placed 27° west of south, which approximates the south-southwest direction used in these studies.

None of the seedlings were irrigated at any time.

Fig. 1. A shaded 2-0 Douglas-fir seedling in a study plot at the Davis Headquarters Nursery, Yolo County.

Fig. 2. Inserting a shingle to afford shade for a 1-0 Douglas-fir seedling at the Davis Nursery.

WHITE FIR

Forest Creek Burn

Both 1-0 and 2-0 age classes were used in the Forest Creek Burn study. These were hand-planted in early December 1961, using Corson planting tools. The last survival count was made October 31, 1963 (fig. 3). The 1-0 planting consisted of 10 trees each in 8 plots, and the 2-0, 10 trees each in 20 plots. In each plot, half of the trees were selected at random for shading. During the two growing seasons, practically no competing vegetation invaded the plots. Survival results are summarized in table 2. Since the 1-0 and 2-0 were planted in blocks with slightly different exposures, survival comparison of the two age classes was not possible. Also, there was an insufficient number of 1-0 seedlings planted to indicate a statistically significant survival difference between those shaded and not shaded.

Fig. 3. Checking survival of white fir shading study on the Forest Creek Burn.

Table 2. Second year survival of shaded and unshaded 1-0 and 2-0 white fir seedlings planted in the Forest Creek Burn Reforestation Study.

	1-0	2-0[a]
	-percent-	
Shaded	80	87
Unshaded	50	64

a/ Difference is significant at the .01 level.

Ben Lomond Nursery

There were two objectives in mind for the test of 1-0 white fir at Ben Lomond. One was the effects of shade, the other, two planting times. The planting times were early February and late March, 1964. A Latin-square design was used to test the four treatments (fig. 4). Twenty-five trees were planted in each plot. The plots were located near the nursery beds, but removed sufficiently so none of the cultural nursery treatments affected the test. A "Little Beaver" soil auger was used to prepare planting holes. Invading vegetation was removed periodically during the season by hand-hoeing. Survival counts were made approximately once each month through the last of December, 1964. Table 3 shows the results of the test.

Fig. 4. White fir 1-0 shading study plots at the Ben Lomond Nursery.

Table 3. First year survival of winter and spring planted, shaded and unshaded, 1-0 white fir at the Ben Lomond Nursery.

	Winter[a/]	Spring[b/]
	- - - - -percent- - - - -	
Shaded	84	89
Unshaded	64	45

a/ Difference is significant at the .05 level.
b/ Difference is significant at the .01 level.

It will be noted that there were no significant differences between winter and spring plantings, but shading improved survival considerably. Figure 5 graphically compares survival of the four test variables. The sharpest decline in survival, as might be expected, was from the last of June until the last of September.

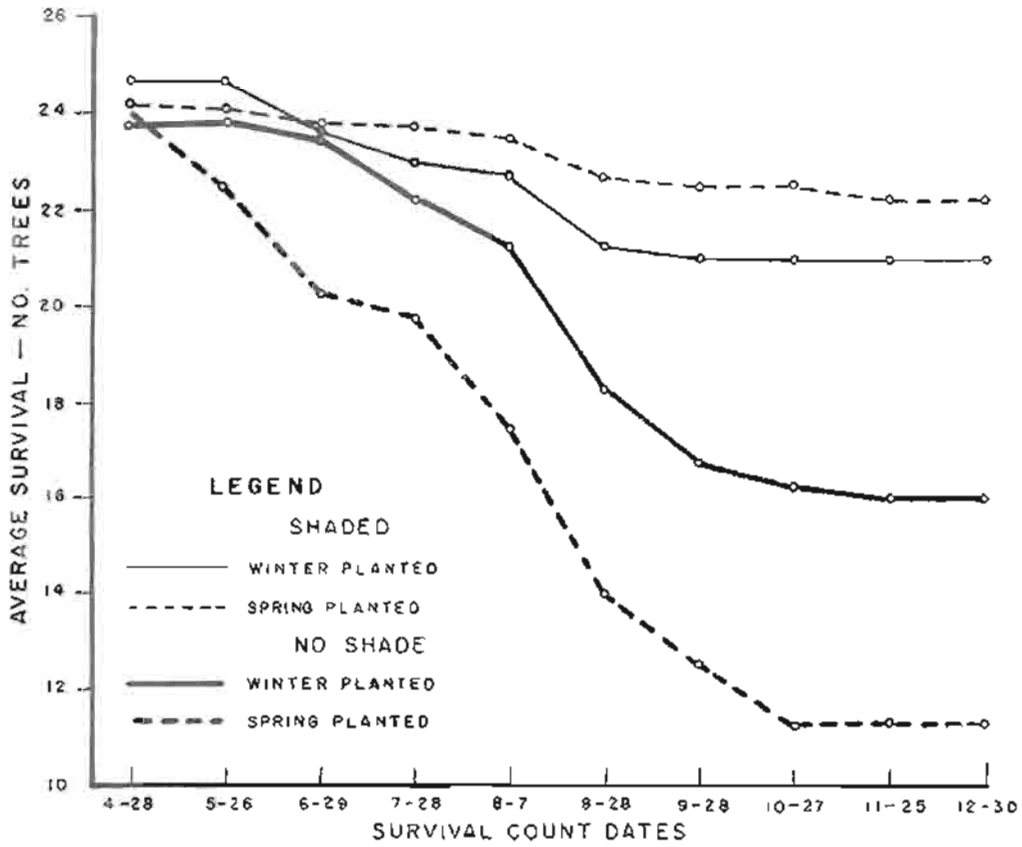

Fig. 5. Survival comparison of shaded and unshaded winter and spring planted 1-0 white fir.

DOUGLAS-FIR

Gualala Redwoods

Although the climate of the Gualala Redwoods study area is favorable for the growth of Douglas-fir, the particular site selected to test shading of Douglas-fir planting was a rather critical one (fig. 6). It was on a south exposure, there was considerable competition from grass and herbs, and sheep browsing was quite severe. As pointed out by Newton (1964), competing vegetation may offset the benefit of shingle-type shade. The area also was inaccessible during wet weather, so that close observations were not possible. Two age classes of stock were used, 1-0 and 1-1. Late fall and early spring plantings were also compared. Late fall planting was done in mid-December, and early spring planting in mid-March. Experimental design consisted of four blocks, each containing 25-tree treatment rows placed at random. Trees were planted by hand, using Corson planting tools. Survival counts were made in November 1962, and July 1963. The results of the study are shown in table 4.

Fig. 6. A row of shaded 1-1 Douglas-fir on the Gualala Redwood Reforestation Study.

Table 4. July 1963, survival of shaded and unshaded 1-0 and 1-1 Douglas-fir trees planted in Gualala Redwood Reforestation Study in December 1961, and March 1962.

	Fall		Spring[a/]	
	1-0	1-1	1-0	1-1
	- - - - - - - - percent - - - - - - - -			
Shaded[a/]	15	14	34	72
Unshaded[a/]	4	5	30	32

a/ Differences greater than 12.5 percent between any figures in columns or rows are significant at the .05 level.

Differences in survival between shaded and unshaded stock was not significant except for spring-planted 1-1. Age class seemed to make little difference in results except between spring-planted, shaded, 1-0 and 1-1. Spring planting for shaded and unshaded and 1-0 and 1-1 combined was better than fall. Severe sheep browsing undoubtedly had an effect and, in fact, may have confounded some of the results. As might be expected, 1-0 stock appeared to be more severely damaged than 1-1.

Ben Lomond and Davis Nurseries

Studies at the Ben Lomond and Davis nurseries were nearly identical, except for selection of treatments within plots. Shading of two age classes of Douglas-fir were again compared, this time, 1-0 and 2-0. Stock from the same seed source was used in both locations. Planting at Ben Lomond was done in mid-February 1963, and at Davis, two weeks later. As will be seen in table 1, the sites are quite different. Again, plots were sufficiently removed from nursery growing areas to prevent influences from nursery cultural practices affecting tests. Plot design consisted of a Latin-square with 25 trees each in 16 plots. The Little Beaver soil auger was used to prepare the planting holes. Competing vegetation was periodically removed by hand-hoeing. Survival counts were made at Davis every two weeks from mid-May through the last of October 1963, and in December 1963. The following season they were made once a month from the first of August through the first of October. At Ben Lomond, counts were made the first of each of the following months in 1963: April, August, and December. Table 5 shows the results of shading at each nursery. Figure 7 compares survival of the four treatments at the Davis Nursery, from mid-May 1963, through October 1964.

Table 5. First year survival of shaded and unshaded 1-0 and 2-0 Douglas-fir planted at the Ben Lomond and Davis Headquarters Nurseries.

	Ben Lomond				Davis	
Survival count date	11-29-63		12-23-63		10-5-64	
	1-0 1-0[a/]	2-0[a/]	1-0[a/]	2-0[a/]	1-0[a/]	2-0[a/]
	percent					
Shaded[b/]	96	92	63	86	34	75
Unshaded[c/]	34	55	2	25	0	3

a/ Differences in columns are significant at the .01 level.
b/ Differences between the Davis shaded age classes are significant at the .01 level.
c/ Differences between the Ben Lomond unshaded age classes are significant at the .05 level and between age classes in the Davis 12-23-63 count at the .01 level.

It will be noted that the more critical site at Davis emphasizes the difference between survival of 1-0 and 2-0 stock, and shading and no shading. There was no difference in the two age classes under shade at Ben Lomond.

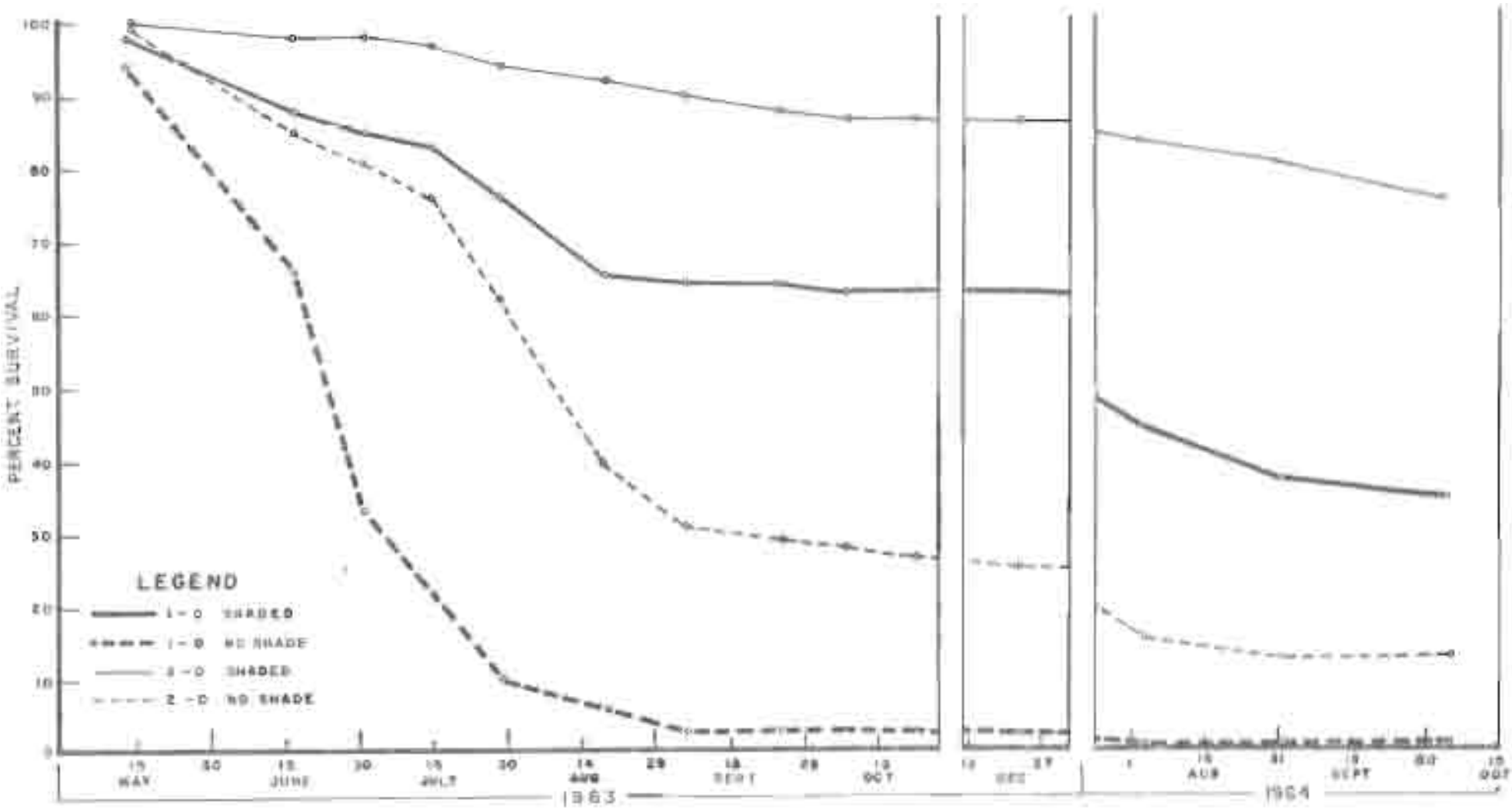

Fig. 7. Two-year survival of shaded and unshaded 1-0 and 2-0 Douglas-fir at the Davis Headquarters Nursery.

SUMMARY AND CONCLUSIONS

The five studies in which artificial shade was tested provides conclusive evidence that shading of planted Douglas-fir and white fir seedlings was beneficial. It is particularly recommended that this procedure be used for Christmas tree plantings, since more intensive practices are warranted in such operations. Costs of shading are estimated to be no more than 3 to 4 cents a tree.

The economic advantages of shading are presented in table 6. Planting costs are assumed to be 9 cents a tree, and shading a maximum of 4 cents a tree. Assumed survival of unshaded stock is 50 percent, and shaded 80 percent.

Table 6. Comparative costs of shading and no shade based on individual surviving trees.

	planting cost/tree	shading cost/tree	total cost	survival percent	cost/surviving tree
Unshaded	.09	---	.09	50	.180
Shaded	.09	.04	.13	80	.162

The assumptions in table 6, of course, do not take into account additional replanting costs and added interest charges on the capitalized investment of replanting.

Side benefits of the five studies indicate that in favorable sites of mild climate, 1-0 shaded stock survives as well as 2-0. On more critical sites, however, where there is competing vegetation, south slope aspects, high soil temperatures, and possibilities of animal damage, older age classes should be used.

Bibliography

ADVISORY COMMITTEE TO THE STATE FORESTER ON REFORESTATION METHODS AND PROCEDURES. October 8, 1964. Minutes of meeting. 7 pp.

BAKER, Frederick S. 1950. Principles of silviculture. 265 pp. McGraw-Hill Book Co., Inc.

DUFFIELD, J. W. 1962. A look at reforestation in the Pacific Northwest. Western Reforestation. Proc. Western Refor. Coord. Comm., Western For. and Cons. Assn. Conf: 2-6.

FOWELLS, H. A. 1965. Silvics of forest trees of the United States. U.S.D.A. Forest Service. Agr. Handbook No. 271. 762 pp.

FRANKLIN, Jerry F. 1963. Natural regeneration of Douglas-fir and associated species using modified clear-cutting systems in the Oregon Cascades. PNWF&RES. Research Paper PNW3. 14 pp.

ISAAC, Leo. A. 1938. Factors affecting establishment of Douglas-fir seedlings. U.S.D.A Circular 486. 46 pp.

MAGUIRE, William P. 1955. Radiation, surface temperature, and seedling survival. Forest Science 1-4:277-284.

NEWTON, Michael. 1964. Seedling survival and vegetation competition. Western Reforestation. Proc. Western Refor. Coord. Comm. Western For. and Cons. Assn. Conf: 39-42.

PERSON, Hubert L. 1937. Commercial planting on redwood cutover lands. U.S.D.A. Circular No. 434. 40 pp.

SHOW, S. B. 1930. Forest nursery and planting practice in the California pine region. U.S.D.A. Circular No. 92. 75 pp.

STATE BOARD OF FORESTRY. 1955. California's forest regeneration problems. Forest Regeneration Comm., L. S. Baker, Chairman. 45 pp.

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