# Effects of Basal Stem Shading on Field Performance of Bareroot and Container Douglas-fir Seedlings

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## Abstract

Reforestation on hot, dry sites can be challenging. One technique to protect seedlings from heat damage is to install shade around the basal stem. This study examined field performance of bareroot and container seedlings planted on north- and south-facing aspects in southwestern Oregon with and without basal stem shading using inverted peat cups. After two seasons, seedlings planted on the north-facing plot had greater survival and lower diameter growth than those on the south-facing plot and container seedlings had more growth and higher survival than bareroot seedlings. The shade treatment did not significantly effect growth or survival. During both seasons, temperature was above normal and precipitation was below normal.

## Introduction

In southwestern Oregon, survival and growth of outplanted seedlings can be a major challenge on some sites, especially in conjunction with even-age silvicultural systems. Abiotic factors, such as excessive heat and low soil moisture, can limit reforestation success by killing, suppressing, or damaging seedlings (Cleary et al. 1978). High soil-surface temperatures can irreversibly damage stem tissue near the soil line. On south-facing slopes, lesions can develop on the south side of seedling stems. These lesions can interrupt cambium function and can be an opening for secondary damage from disease or insects. Heat damage can also occur on north-facing slopes but the mortality rate is usually half that of south-facing slopes (Helgerson et al. 1992). Adequate soil moisture is important not only for plant use but also to mitigate temperature extremes and reduce excessive heating in the root zone (Flint and Childs 1987).

Treatments and planting strategies that lower soil temperature, reduce soil-surface evaporation, and reduce vegetative competition can protect newly planted seedlings (Flint and Childs 1987). Planting in favorable microsites or artificial shading can help reduce moisture stress and increase seedling survival (Cleary et al. 1978, Helgerson et al. 1992), especially on south-facing slopes (Helgerson 1986). Shade cards can be effective but are costly and difficult to install (Helgerson 1986). Current shade card costs for material, installation, and later removal total approximately $0.90 per seedling. Another option for artificial shading is to use inverted cups with the bottoms removed. In an early study, shading the basal portion of seedlings with inverted Styrofoam™ cups around the base of Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) seedlings was as effective as shade cards (Helgerson 1990). Pots made with pressed peat moss are also commercially available and have shown to be effective (Helgerson et al. 1992).

Over the last few years, the USDI Bureau of Land Management (BLM), Medford District in Oregon has been using peat cups to increase seedling growth and survival on harsh sites. These cups cost much less than shade cards ($0.31 per seedling) because the material is relatively inexpensive, the cups are easier to install, and no removal is required since peat cups are biodegradable within a few years. Furthermore, peat cups are an environmentally friendly option compared with Styrofoam™.

Although shading seedlings with cups has been studied previously, most studies were published 30 or more years ago. Since then, stock types, seedling quality, nursery practices, and customer expectations have evolved significantly. Thus, it is worthwhile to revisit this practice and test its efficacy. The purpose of this study was to evaluate the cup-shading technique on survival and growth of modern Douglas-fir stock types over two growing seasons.

## Materials and Methods

### Study Location

The study was established at two adjacent plot locations (north and south aspects) within the 2018 Miles Fire perimeter (Butte Falls Field Office, BLM Medford District, 42°48'49.1"N 122°45'26.0"W) (figure 1). Average elevation of the study area is 3,500 ft (1,067 m), and annual precipitation ranges 35 to 55 in (90 to 140 cm) with most of the precipitation occurring in winter through early summer. The mean annual temperature is 45 to 52 °F (7 to 11 °C), and the average frost-free period is 100 to 160 days. Soils in the area are Straight-Shippa, shallow, well-drained gravelly loams with bedrock occurring between 12 and 40 in (30 and 100 cm) deep. Slopes average 25 to 35 percent at both locations. The BLM Land Use Allocation for the area is considered Harvest Land Base (USDI BLM 2016), and the Timber Production Capability Classification is designated as commercial forest land with reforestation problems due to high temperatures (USDI BLM 1986)(figure 1).

The two plot locations are approximately 130 ft (40 m) apart and are separated by a mid-sloped ridge (figure 1). The north-aspect plot (figure 2) burned at a moderately low severity in the 2018 Miles fire and was established under a canopy of mature Douglas-fir. The basal area was estimated at 100 ft$^2$ (9.3 m$^2$) live and 60 ft$^2$ (5.6 m$^2$) of standing dead. Crown cover and average diameter-at-breast-height (4.5 ft [1.4 m]; DBH) are approximately 40 percent and 24 in (61 cm), respectively. The understory was predominately Oregon grape (*Mahonia aquifolium* [Pursh] Nutt.) and canyon live oak (*Quercus chrysolepis* Liebm.). The south aspect plot (figure 3) burned at high severity in the 2018 Miles Fire and evidence indicates that it likely burned 19 years prior in the Timbered Rock Fire. The south-aspect plot is open without an overstory and approximately 50 percent of the site was covered with Pacific madrone (*Arbutus menziesii* Pursh), canyon live oak, and deerbrush (*Ceanothus integerrimus* Hook. & Am.) skeletons that have resprouted since the fire to a height of 2 to 6 ft (0.6 to 1.5 m).

### Seedlings

Two Douglas-fir stock types were used in this study. Bareroot Q-plug +1.5 (seed zone JV2) were grown at the U.S. Department of Agriculture, Forest Service, J. Herbert Stone Nursery (Central Point, OR) and 1-year-old 515A container stock (seed zone EE2) were grown at Pacific Regeneration Technologies Nursery (Hubbard, OR).

The Q-plug+1.5 was developed in the early 2000s (Landis 2007, Steinfeld 2004), and the J. Herbert Stone Nursery is the only forestry nursery in the country currently growing this stock type. The process starts at International Horticultural Technologies, LLC (Hollister CA) where Styroblock® containers (2 in$^2$ [33 cm$^3$] cavities; Beaver Plastics, Alberta, Canada) are filled with a proprietary stabilized growing medium. The pre-filled containers are then shipped to the Cal Forest nursery (Etna, CA) where they are sown in January and placed in a greenhouse. Seeds germinate and grow to about 1-in (2.5-cm) tall by April when they are transported to the J.H. Stone Nursery and transplanted into bareroot beds. During the growing season in the bareroot beds, the seedlings are root pruned 2 to 3 times and laterally root pruned once. After budset, seedlings are lifted and packed in the fall. Although the production cost for this stock type is higher than conventional 2-year-old bareroot stock types, seedlings are easier to space in the nursery beds and height is more manageable. These advantages result in a favorable root-shoot ratio.

The Styroblock® 515A (2 in [5.1 cm] diameter by 6-in [15.2-cm] depth cavities; Beaver Plastics, Alberta, Canada) were designed in 1991 to produce "Plants de Fortes Dimensions" in the cold frame system (O'Neill 2021). This container size is now the most demanded size in the Pacific Northwest and is also a popular container type throughout much of North America.

All seedlings were grown from improved seed collected from BLM's Provolt Orchard (15 mi [24 km] south of Grants Pass, OR). The JV2 and EE2 seed zones used in the study for bareroot and container seedlings, respectively, are from first-generation seed orchards that were established in 1994. The orchards were developed from phenotypic selec-

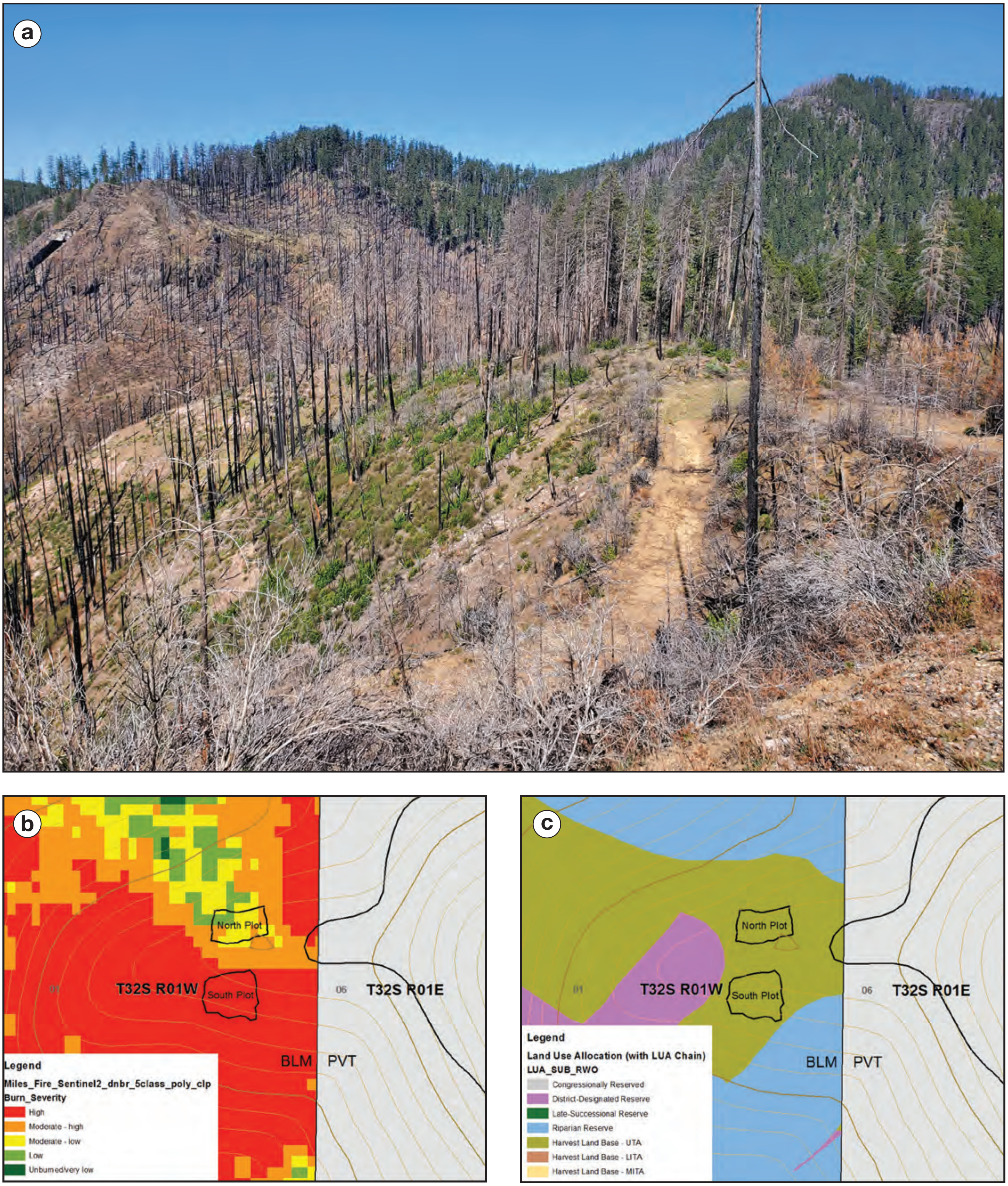


**Figure 1.** (a) The north and south plots were located (b) within the 2018 Miles Fire perimeter and (c) are considered Harvest Land Base by the USDI Bureau of Land Management. (Maps generated with ARC GIS, photo by Chad Vetter 2021)

**Figure 2.** The north-aspect plot location was installed under a canopy of mature Douglas-fir trees that were moderately burned in the 2018 Miles fire. (Photo by Chad Vetter 2021)

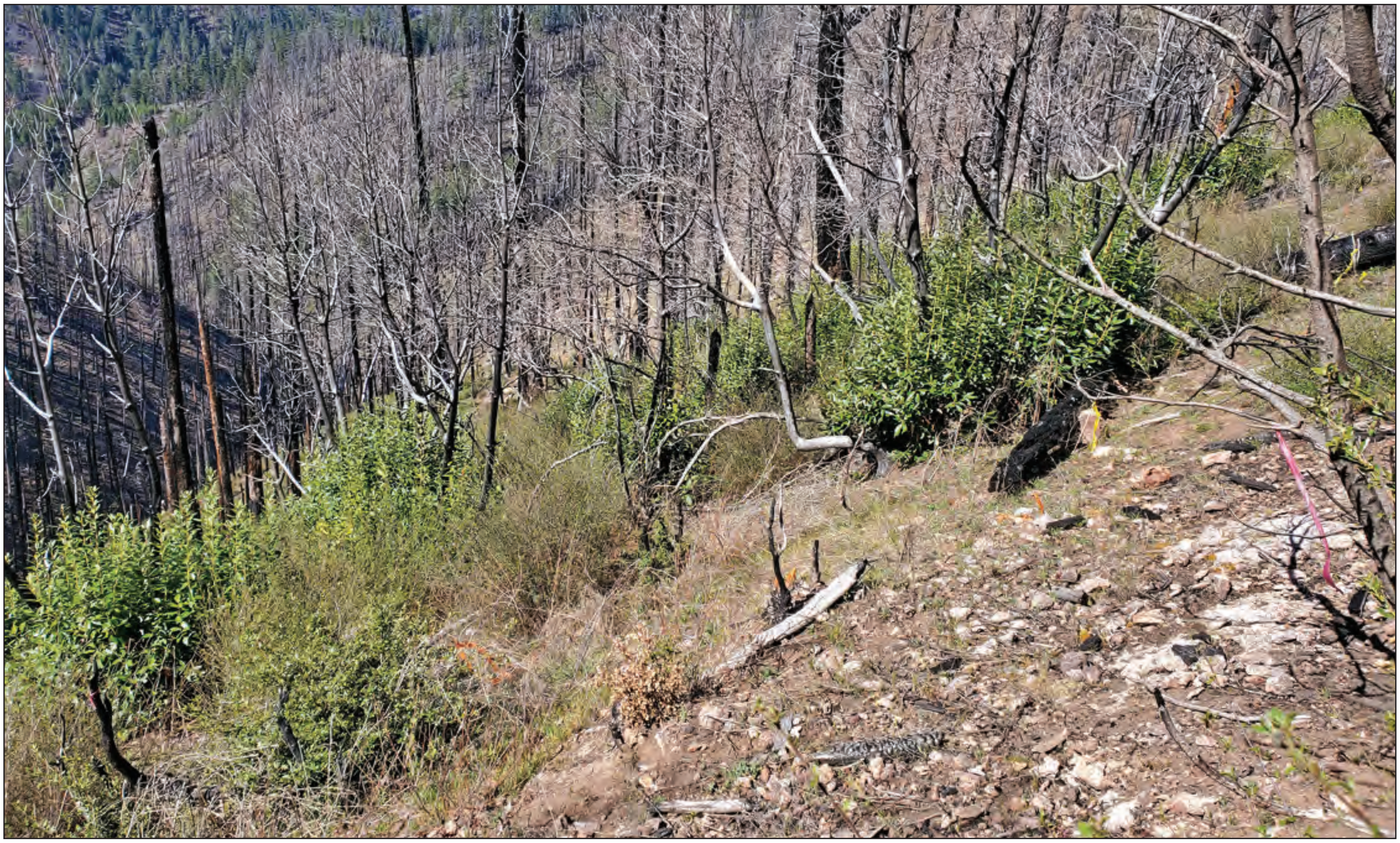

**Figure 3.** The south-aspect plot location was severely burned during the 2018 Miles fire and is an open area with no overstory. (Photo by Chad Vetter 2021)

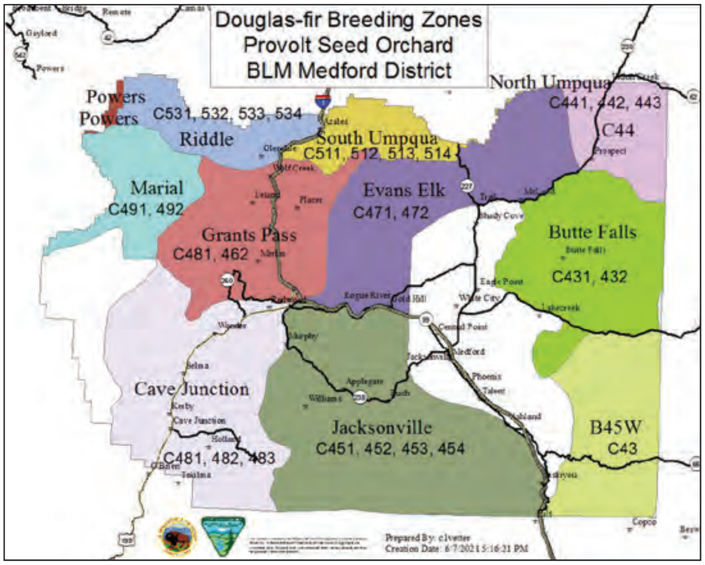


**Figure 4.** Seedlings for this study were from the Jacksonville 452 breeding zone (bareroot) and the Evans Elk 472 breeding zone (container). (Map generated by Chad Vetter using ARC GIS 2021)

tions collected from elevation bands in breeding units 472 and 452 (figure 4) and tested for growth and yield. Scion collected from the best parent trees were then field grafted to create the Evans Elk 2 (EE2) and Jacksonville 2 (JV2) orchards (table 1) (Crawford 2021).

## Treatments

Both plot locations were planted on the same day in late April 2020. All seedlings were planted at a spacing of 8 by 8 ft (2.4 by 2.4 m). Bareroot seedling roots were dipped in water prior to planting. Shade treatments were installed on half of the seedlings for each stock type. Treatments consisted of round Jiffy® peat pots (4-in [10-cm] diameter and 4-in [10-cm] depth; Jiffy Products of America Inc., Lorain, OH) inverted around the base of each seedling (figures 5 and 6). Jiffy pots are made from peat moss and wood pulp.

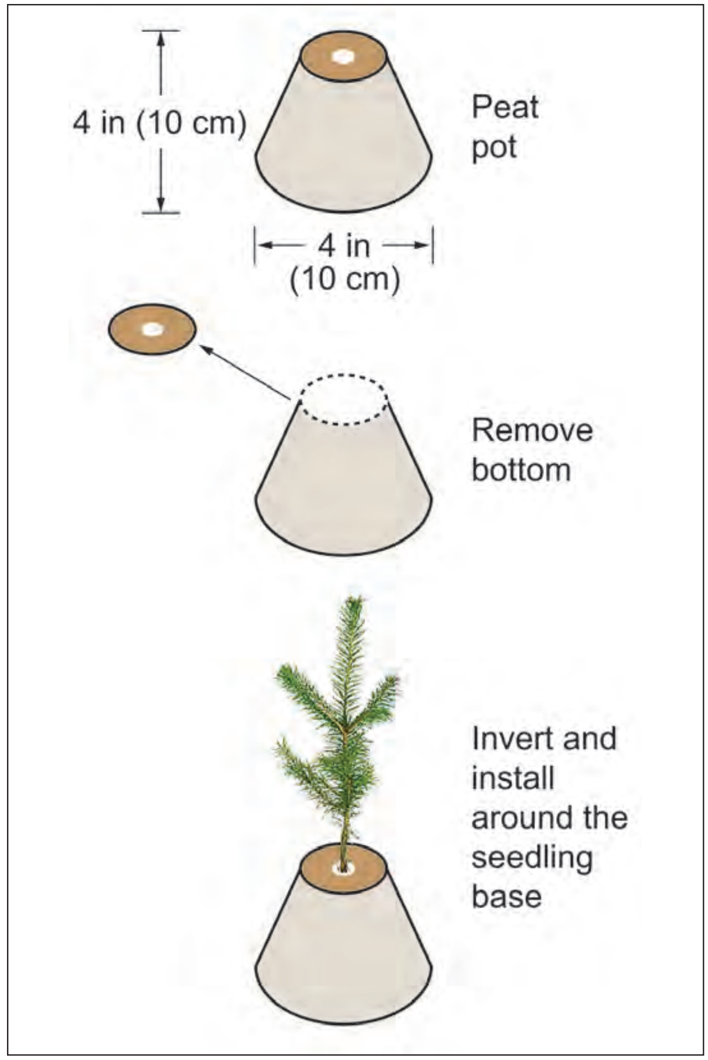


**Figure 5.** Peat pots were installed on each seedling designated for treatment by inverting the pot, removing the bottom, and placing carefully around the base of the seedling stem. (Adapted from Illustration by Chad Vetter 2019)

## Measurements

Initial heights and stem diameter were measured on all seedlings immediately after planting. Height was measured with a carpenter's tape on the uphill side from the ground to the tip of the leader. Diameter was measured at the ground line with a caliper. At the end

**Table 1.** Seed for the study was from two orchards at the USDI Bureau of Land Management Provolt Seed Orchard (near Grants Pass, OR). Bareroot seed was from the JV2 orchard and container seed was from the EE2 orchard.

| Orchard Name | Abbreviation | Breeding Unit | Elevation (ft) | 1966 Oregon seed zone | 1996 Oregon seed zone |
|---|---|---|---|---|---|
| Evans Elk 2 | EE2 | C472 | 3,000 to 4,000 | 501 / 502 | 15 / 16 |
| Jacksonville 2 | JV2 | C452 | 2,500 to 3,500 | 511 / 512 | 3 / 16 |


**Figure 6.** On each of the plot locations, half of the seedlings had (a) peat pots installed to shade their stems and (b) the other half were left unshaded. (Photos by Chad Vetter 2021)

of the first and second growing seasons (September 2020 and 2021), height and diameter were measured again along with an assessment of survival. Growth was calculated by subtracting initial values.

### Experimental Design and Data Analyses

The experimental design consisted of a 2 by 2 factorial (two stock types by two shade treatments) in a split plot. Within each whole plot (north and south aspects) there were 5 replications of each stock type and shade treatment combination. Replications were rows of 6 seedlings. Data were analyzed using SAS® software (SAS Institute 2013). Shaded seedlings that had missing cups were excluded from the analyses. Significant differences among treatments were determined using Tukey's multiple comparison test.

## Results and Discussion

Peat cups were easy to install and required no special tools. The bottoms of the cups were easy to manually tear out. The cups appear to be attractive to wildlife and insects, however. On the south plot, we suspect that wood rats removed nearly 20 percent of cups from seedlings. Also, some cups seemed to disappear slowly which may be due to wasps using the material as a resource to construct their nests (Hadley 2019).

At the end of both growing seasons, there were no interactions among aspect, stock type, or shade treatment. Seedlings growing on the north aspect plot had significantly higher survival and tended to have less diameter growth than those growing on the south aspect plot (figure 7). This result is not surprising given that south-facing aspects have hotter, drier environments compared with north-facing aspects (Redmond 1992, USDA Forest Service 2002). The increased diameter growth likely indicates greater root growth on the drier site which would be necessary for increased water uptake (Grossnickle 2005). Temperature and precipitation patterns based on a nearby weather station (Trail Creek, OR) showed that precipitation was below normal and temperature was above normal during both seasons (figure 8).

Container seedlings had significantly higher survival and greater height and stem diameter growth than bareroot seedlings. Often, container seedlings will have less transplant stress and better early growth than bareroot seedlings because their roots are protected and undamaged in the plug. This stock type difference can disappear in subsequent seasons (Haase et al. 2012, Rose and Haase 2005). The shading treatment was not statistically significant although there was an overall trend toward greater average growth for seedlings with the shading.

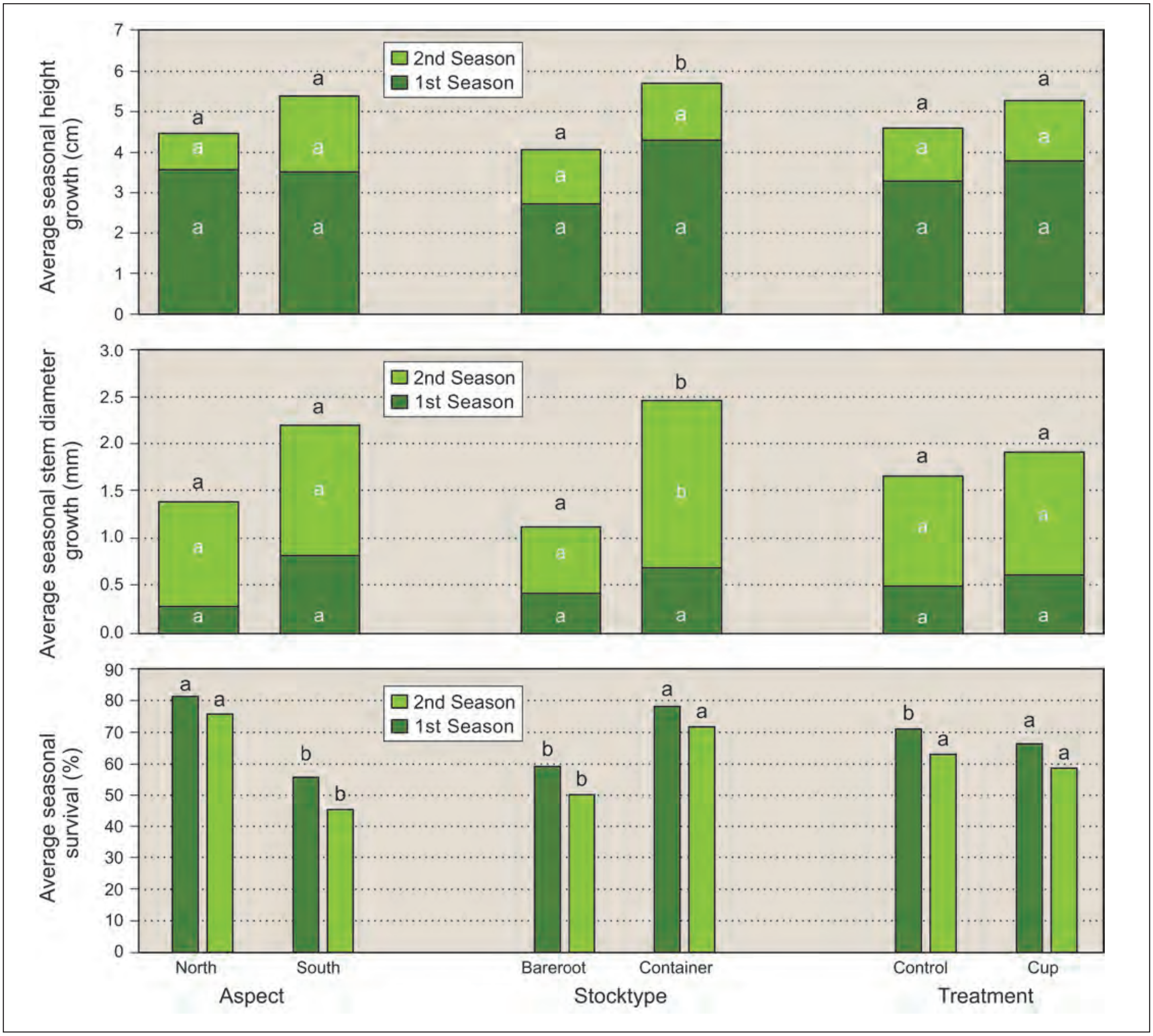


**Figure 7.** Seedling (a) height growth, (b) stem diameter growth, and (c) survival varied among treatments at the end of the two growing seasons. For each variable in each season, bars with different letters differed significantly at $\alpha \leq 0.05$ for aspect, stocktype, or treatment.

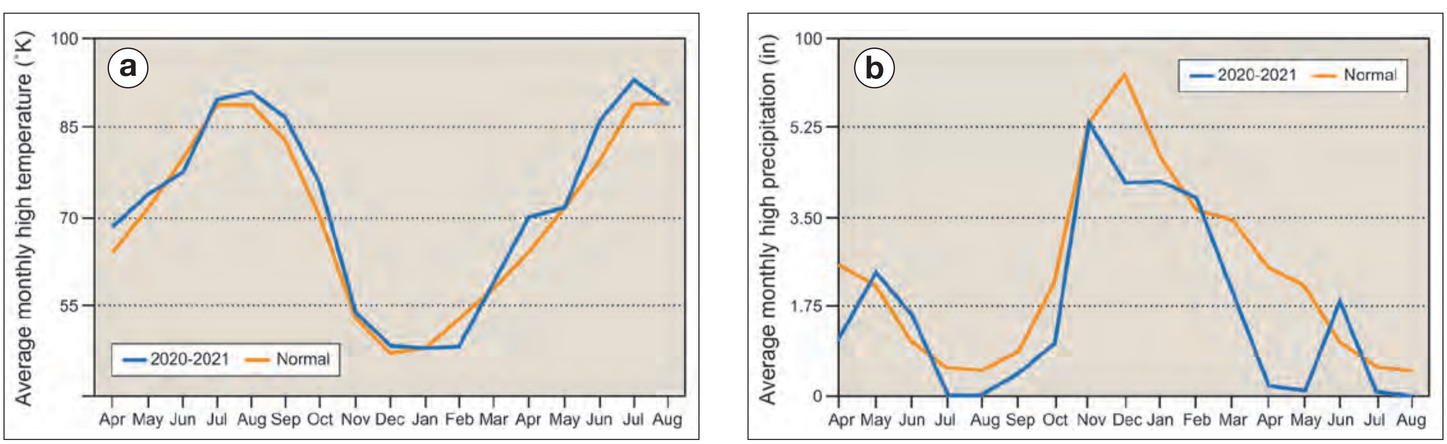


**Figure 8.** Data from a nearby weather station showed above-normal temperatures and below-normal precipitation during the two seasons after planting.

Overall, the study results were somewhat surprising given previous operational observations and earlier published studies with cups or shading that indicate increased survival or growth. In early summer, it is common to observe moisture under the cups while the adjacent soil is dry. There was quite a bit of variability in site conditions within each plot caused by microsites and browsing which may have reduced the treatment effect, though these factors did not interfere with aspect or stocktype effects. Additional research may yield a positive response depending on site conditions.

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