SOUTHERN FOREST EXPERIMENT STATION

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SHELTER FOR TESTING DROUGHT-HARDINESS OF PLANTED SOUTHERN PINE SEEDLINGS

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SOUTHERN FOREST EXPERIMENT STATION [1]

A plastic-covered shelter simulates drought severe enough to cause seedling mortality. Air and soil temperatures, and relative humidity, are but slightly higher under the shelter than outside it.

Drought-endurance of pine seedlings is an important research problem in east Texas, but field plantings designed to test drought effects are often jeopardized by weather vagaries. In studies on the Stephen F. Austin Experimental Forest, near Nacogdoches, planting beneath a shelter made it possible to observe seedling behavior under simulated drought. This report describes the design of the shelter and its effect on soil moisture, air and soil temperatures, and relative humidity during two growing seasons.

DESIGN AND INSTRUMENTATION

The shelter was designed and built in 1960 to keep rain from planted pines without otherwise altering their environment. This was achieved with a transparent plastic cover stretched on 10- by 10-foot sashes that were supported by a redwood frame (fig. 1). The sashes were hinged on 1¼-inch (o.d.) aluminum pipes and could be raised at the free end to provide access. Drain channels on the rafters, between individual sashes, prevented water from dripping on the plots. The long axis of the shelter was east-west oriented.

During 1960, a plastic-lined trench under the north and south drip line kept surface water from flowing onto the plots. The liner had to be renewed several times, and during the next year the trench was replaced by an aluminum barrier, set 1 foot inside the drip line of the shelter. The barrier protruded 1½ inches above the ground and was set to a depth of 24 inches, to keep both surface and subterranean water from reaching the plots. Gutters collected and diverted runoff water from the roof.

Polyethylene film (0.002-inch thick) proved unsatisfactory for the cover, as it had to be

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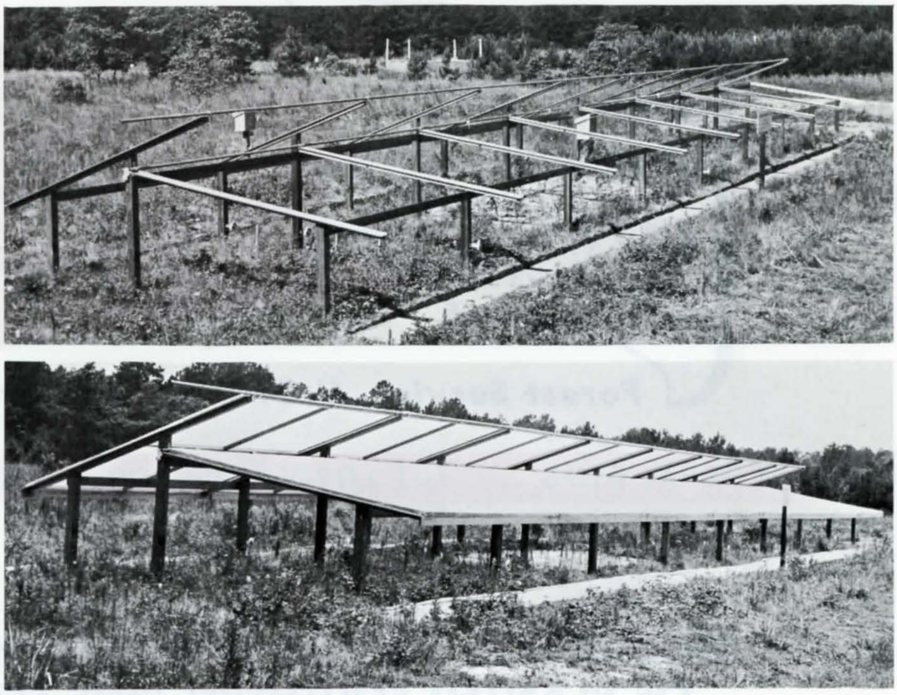

FIGURE 1.—
Above: *Frame of shelter.* Below: *Plastic-covered sashes in place. Gutters were added after the pictures were taken.*

replaced three times in the summer of 1960. The following year, Mylar W-1 (with weather-resistant treatment on one side) proved more durable. The manufacturer's advertising literature describes Mylar's light-transmitting qualities as essentially those of glass.

The total sheltered area was 80 by 16 feet. This provided six 10- by 10-foot test plots and two isolation plots of the same size on each end of the shelter's long axis (fig. 2). The shelter's cross-sectional dimensions are given in figure 3.

From three test plots the weed cover was removed along with the upper 2 to 3 inches of soil; on three other plots the weeds remained undisturbed. In 1960, loblolly pine *(Pinus taeda* L.) seedlings (1-0) were planted at 2-foot by 2-foot spacing. In 1961, the shelter was moved to a new location and the test repeated with loblolly, shortleaf *(P. echinata* Mill.) and slash pine *(P. elliottii* Engelm.) seedlings. Pines were planted in midwinter. The cover was applied in May or June and kept until fall.

In both years, gravimetric soil-moisture samples were taken to depths of 24 inches with a King tube at the time of planting and at 2-week intervals after the cover was applied. Samples were also taken along transects extending 2 feet into the unsheltered area.

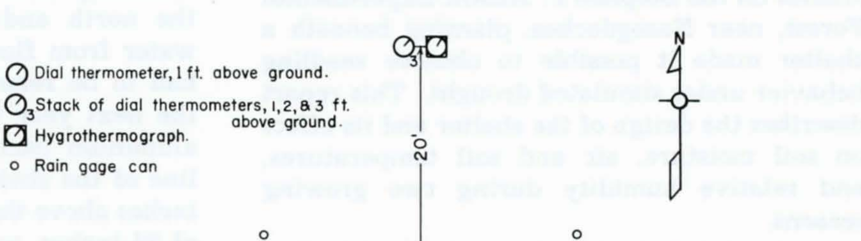

FIGURE 2.—
Sheltered area, test plots, and instrumentation.

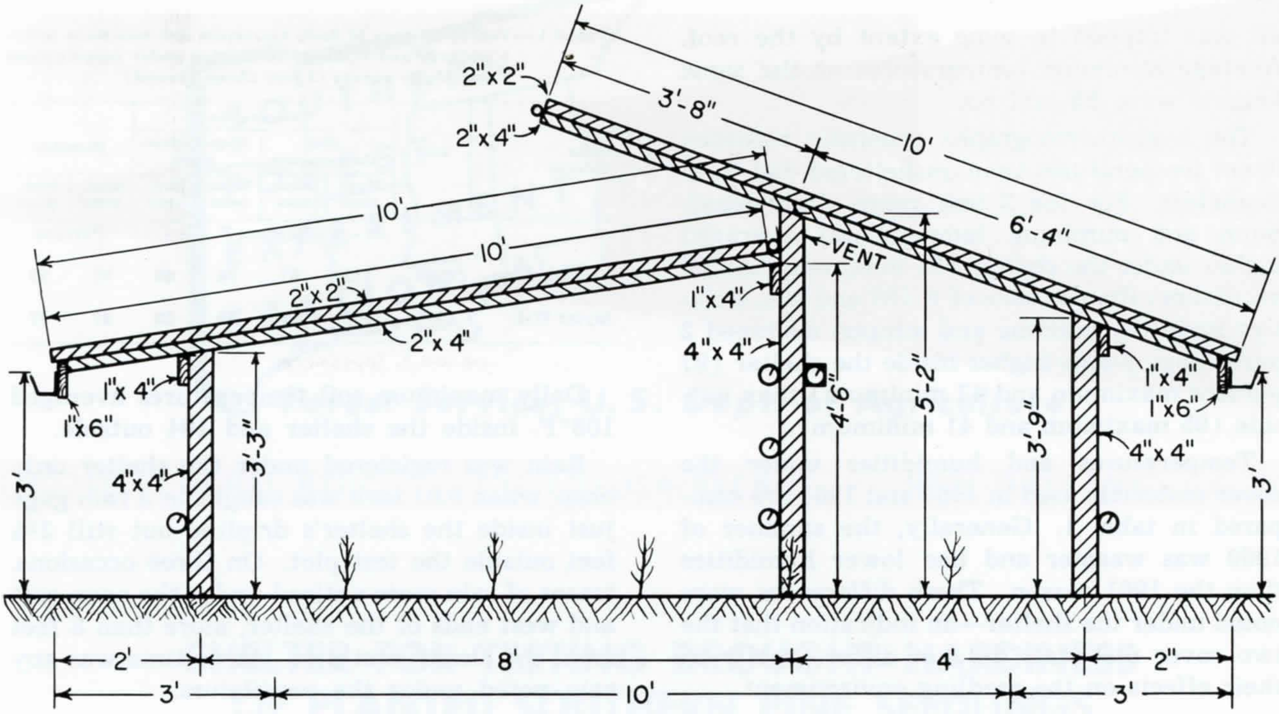

FIGURE 3.—*Cross-sectional dimensions of the shelter's frame.*

Air temperature was measured 1 foot above ground level with unshielded maximum-minimum thermometers at nine locations under the shelter and at one location 20 feet outside. Thermometers under the shelter were arranged to form transects of three units each, across the east and west ends and the middle of the shelter. Additional thermometers were used to measure temperatures at the 2- and 3-foot levels under the center of the shelter and 20 feet outside of it. Two hygrothermographs, one under and one outside the shelter, kept continuous records of temperature and relative humidity 3 feet above ground (fig. 2).

In the summer of 1960, daily maximum soil temperatures were measured at a depth of 1 inch for 2 weeks with pairs of mercury maximum thermometers installed in bare and weedy soil inside and outside the shelter.

During 1960, transects of rain gages (soil sample cans) were placed across all four edges of the shelter and also under the ventilating openings to ascertain whether winds might blow rain under the shelter (fig. 2).

SHELTER EFFECTS

During each test year, the shelter lowered soil moisture enough to cause seedling mortality, but it did not greatly change temperature and humidity in the seedlings' environment.

Soil moisture dropped below the estimated tension of 15 atmospheres (wilting percent) at all depths in weedy plots. Speed of depletion depended on the amount of herbaceous vegetation competing with the pines. Depletion rates were greatest in the upper layers, and decreased with increasing depth. On bare plots, moisture dropped below the wilting point only in the surface 6 inches.

For the two growing seasons, average daily maximum and minimum air temperatures at the 1-foot level were virtually uniform in all parts of the shelter. The maxima and minima under the long (east-west) axis of the shelter averaged slightly higher (104°F. maximum and 64°F. minimum) than under the south and north edges (102 and 63). Maxima of all nine thermometers inside averaged only a fraction higher (102.6) than on the outside (102.3). Minimum temperatures averaged 1.6° higher inside (63.3) than outside (61.7).

Average maximum temperatures under the shelter's center increased with increasing height, being 106 and 109 at the 2- and 3-foot levels. This was expected, because rising warm air was trapped to some extent by the roof. Average minimum temperatures at the same heights were 65 and 63.

The hygrothermographs generally recorded lower temperatures than unsheltered dial thermometers. For the 2 test years, daily maximum and minimum temperatures averaged higher under the shelter (91 maximum and 63 minimum) than outside of it (87 and 60). Relative humidity maxima and minima averaged 2 percentage points higher inside the shelter (97 percent maximum and 43 minimum) than outside (95 maximum and 41 minimum).

Temperatures and humidities under the cover materials used in 1960 and 1961 are compared in table 1. Generally, the summer of 1960 was warmer and had lower humidities than the 1961 season. These differences were noted under the shelter—an indication that the two cover materials did not differ greatly in their effects on the seedling environment.

TABLE 1.—*Yearly average of daily maximum and minimum temperatures and relative humidities under polyethylene and Mylar covers (3 feet above ground)*

Cover material	Year	Temperature: Dial thermometers Maximum	Temperature: Dial thermometers Minimum	Temperature: Hygrothermograph Maximum	Temperature: Hygrothermograph Minimum	Humidity Maximum	Humidity Minimum
		Degrees F.				*Percent*	
Polyethylene	1960	112	67	94	68	97	39
Mylar W-1	1961	105	59	86	59	97	47

Daily maximum soil temperatures averaged 108°F. inside the shelter and 104 outside.

Rain was registered under the shelter only once, when 0.01 inch was caught in a rain gage just inside the shelter's dripline but still 2½ feet outside the test plot. On three occasions, traces of rain were noticed under the open east and west ends of the shelter, more than 8 feet from the closest test plot. At no time was any rain noted under the ventilators.