Coniferous Seedling Survival

jeffrey pine seedlings outlived white fir, ponderosa pine, and incense cedar in drought tests involving simulated dew

Edward C. Stone

Ponderosa pine has a continuous distribution at medium and lower elevations in the Sierra and inner coast ranges of California but in the middle and south coast ranges it is found only in a few scattered locations.

In the northeastern part of the state —near Susanville—where rainfall rarely exceeds 20" per year, water is so nearly limiting that it undoubtedly plays a critical role in the kind of species association that develops. Consequently, some correlation can be expected between the distribution of plants in the area and a moisture source, such as dew.

From earlier studies it appears that ponderosa pine seedlings have certain genetically fixed physiological characteristics that permit them to exist in soil after the wilting point has been reached provided there is abundant nightly dew fall. However, it can not be concluded that such a physiological characteristic is an important factor in the capacity of ponderosa pine to invade, occupy, or dominate a particular piece of ground. First it is necessary to determine to what extent associated species also have the capacity to withstand soil drought and to utilize dew.

For this reason a study was made of the three major tree species—jeffrey pine, white fir, and incense cedar—found in association with ponderosa pine in the arid northeastern part of California. On certain sites all four species are present. On other sites only ponderosa and jeffrey pine are present, and on still other sites only ponderosa pine or only jeffrey pine is present.

Two-year-old bare root stock was obtained from the United States Forest Service for these studies. In Berkeley, they were root pruned to 4" and then planted in gallon cans filled with sandy loam. After the seedlings were well established, five sunflower plants were started in each can and allowed to develop until approximately 8" tall. Watering was then discontinued.

Within two weeks the soil had reached the ultimate wilting point throughout each can and the sunflowers had wilted and died. All the coniferous seedlings, on the other hand, continued vigorous and healthy. The dead sunflowers were clipped off and each can, which now contained only the pine seedling, was sealed by placing over the top of the can a plastic envelope through which the seedling protruded. A water-tight seal around the stem was made by several turns of a fine copper wire and a heavy wrapping of electrical scotch tape. The bottom edge of the plastic envelope was sealed to the can with additional tape.

Thirty seedlings of each species or a total of 120 cans were involved. Ten cans of each species were removed when the ultimate wilting point of the sunflowers was reached and the soil moisture determined at the 4"–5" depth in each can. Then sealed cans of each species were placed upright on a table at one end of the greenhouse. On another table some distance away the other 40 remaining cans, 10 of each species, were stacked sideways—one upon another—in two racks under a fog spray nozzle. The cans were covered with a plastic sheet in which holes were cut to allow the seedlings to protrude. When the spray was turned on at night the tops of the seedlings were soon covered with moisture while the sealed cans remained almost dry, thus simplifying the leakage problem.

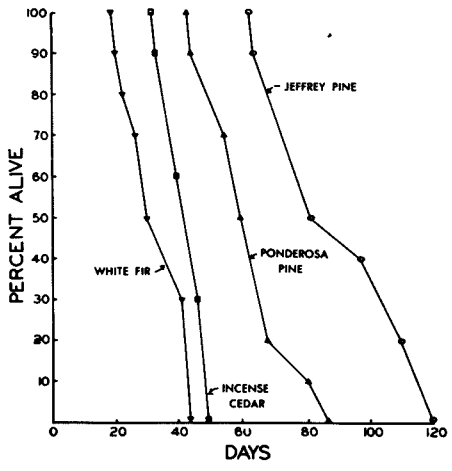
As the individual seedlings died the cans were removed to the laboratory, the date recorded and the soil moisture determined for the 4"–5" depth.

Soil Moisture at the Death Point—Ultimate Wilting Point—of Seedlings Not Receiving Spray at Night

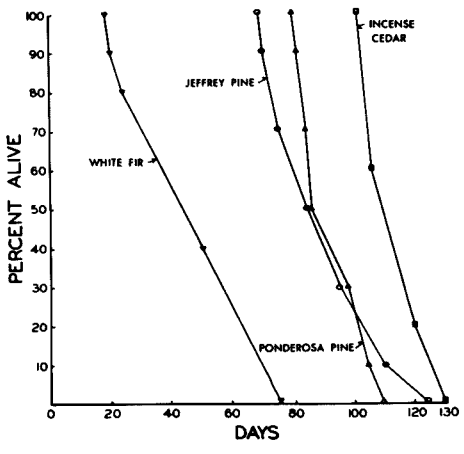
Species	Moisture content 4"–5" depth	
	Average %	Range %
Sunflower	6.5	6.3–7.0
White fir	6.8	5.7–7.8
Incense cedar	6.4	5.7–7.3
Ponderosa pine	6.1	5.2–7.3
Jeffrey pine	5.3*	5.2–5.5

* Significantly different from the other averages.

Survival in the absence of spray at night.



Survival in the presence of spray at night.



Results of Tests

Of the four species tested, only jeffrey pine removed a significant amount of water from the soil mass after the sunflowers had died.

The jeffrey pine is not necessarily the only species, of the four tested, that is capable of removing water after the ultimate wilting point of the sunflower was reached. Judged by other experi-

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Seedling Survival in the Presence and Absence of Artificial Dew

Species	Days seedlings survived after the ultimate wilting point of the sunflower had been reached			
	Spray at night			
	Without		With	
	Ave.	Range	Ave.	Range
White fir	35	20–44	55	20–76
Incense cedar	44	35–50	116	101–130
Ponderosa pine	64	46–87	94	81–110
Jeffrey pine	95	64–120	93	70–130

Individual species response within each treatment was significantly different with the exception of ponderosa pine and jeffrey pine under spray at night. Individual species response to spray was significant with the exception of jeffrey pine.

FERTI-IRRIGATION

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system each month. If two irrigations are applied each month, then 50 pounds of ammonium nitrate per acre can be added to the water during each irrigation.

The amount of fertilizer to dissolve in the tank at each sprinkler set can be decided by determining the area each sprinkler supplies with water which is equal to the distance between sprinklers along the lateral line multiplied by the distance the lateral lines are moved. The following table shows the area in acres irrigated by each sprinkler for different spacings of sprinklers and lateral lines. The sprinkled area, multiplied by the number of sprinklers operated at one time, gives the total area irrigated at that setting. The area irrigated multiplied by the desired application rate of the fertilizer in pounds per acre gives the amount of fertilizer that should be placed in the supply tank. This method of determining the correct amount of fertilizer is particularly useful where the number of sprinkler heads used varies from set to set.

Area Irrigated by One Sprinkler

Sprinkler and lateral spacings	Area in acres
20' x 40'	0.0183
30' x 40'	0.0276
40' x 40'	0.0367
20' x 50'	0.0230
30' x 50'	0.0344
40' x 50'	0.0459
20' x 60'	0.0276
30' x 60'	0.0413
40' x 60'	0.0550

Where the number of sprinklers operated at one time is fairly constant, the proper amount of fertilizer applied at each irrigation can be found by multiplying the length of the lateral line by the distance the lateral line is moved for each setting. This area in square feet divided by 43,560 gives the number of acres irrigated at one time.

The uniformity of ferti-irrigation will only be as good as the distribution of the water. Therefore, it is extremely important that the sprinkler system be properly designed and operated so that the irrigation distribution is as uniform as possible.

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SURVIVAL

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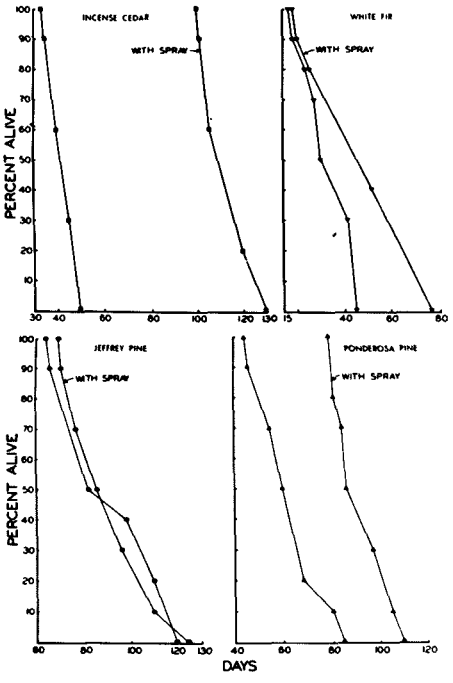
ments—with a larger sample—ponderosa pine seedlings probably would have shown a significant reduction of the soil moisture as would perhaps some of the other species. Actually the moisture content in only two of the 10 cans of ponderosa pine seedlings was out of line. Had it not been for the results with these two cans the average soil moisture reduction would have been highly significant.

When the seedlings were not exposed to spray at night, white fir died after 35 days, the incense cedar after 44 days, the ponderosa pine after 65 days, and the jeffrey pine after 95 days.

Survival in the presence and absence of spray at night.



When the seedlings were exposed to spray at night the picture changed. White fir again was the first to die although spray at night did prolong its life 20 days. Ponderosa and jeffrey pine died next at approximately the same time. This meant that the spray exposure was effective on ponderosa pine, prolonging its life 30 days, while it was not effective on jeffrey pine. Finally, the last to die was incense cedar whose life was prolonged 72 days.

Although the length of time the different species were able to survive after the sunflower had died was increased by exposure to spray at night, the exposure was not equally effective in prolonging the survival of the different species of seedlings.

The differential ability of the conifer seedling to survive after the sunflowers had died indicated a basic physiological difference in the drought resistance of white fir, incense cedar, ponderosa pine, and jeffrey pine. The experimental evidence indicates that white fir is the least resistant to drought and jeffrey pine is the most resistant with incense cedar and ponderosa pine somewhere in between. However, without additional testing it can not be assumed that the behavior of canned conifer seedlings, grown in the greenhouse, will be duplicated in the field. Only a small difference in the relative root growth rate of these species under field conditions would be required to alter the picture. For example, if white fir developed a more extensive root system in a particular soil than did jeffrey pine, then white fir might not be subjected to soil drought while jeffrey pine would.

Nevertheless most students of relationships between plants and their environment who are familiar with the distribution of these four species in California would probably rate jeffrey pine the most drought resistant, and white fir the least resistant since white fir is rarely found on dry sites and is particularly favored on northern exposures while jeffrey pine is often found on the very driest sites.

The relative response of these four species to spray at night was entirely unexpected. The lack of response of jeffrey pine and the very marked response of incense cedar can not be explained readily.

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PLUMS

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showed that some of the seedlings of myrobalan plums that are propagated by seed become infected when planted in soil containing root-knot nematodes. It is therefore important to use one of the vegetatively propagated rootstocks of known resistance in any soil that might be infested.

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