FIELD SURVIVAL OF CONTAINER-GROWN

JEFFREY PINE SEEDLINGS OUTPLANTED ON ADVERSE SITES 1/2/

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Abstract.--To investigate the potential of container grown seedlings outplanted on adverse sites, field survival trials were conducted using a variety of container types during the years 1971, 1972, and 1973. Field survival of Jeffrey pine seedlings was highest in a 9-inch plastic mesh container.

INTRODUCTION

As forest producing lands decrease and demands for forest products and amenities increase, there is a corresponding need to develop effective methods of reforestation on adverse as well as favorable sites. The eastside Sierra Nevada mountains exemplify this need and present particularly difficult regeneration problems. A long history of recurring fires, early and continued logging, and, more recently, large residential developments have all contributed to reduced forest cover over much of the area. While many of these areas have naturally regenerated, others have reverted to shrub communities. Natural successional cycles will eventually replace these seral communities with tree species. However, this process may require over 100 years (Skau, Meeuwig, and Townsend 1970).

Attempts to restock these sites using conventional artificial regeneration techniques have been largely unsatisfactory. Failures in direct seeding attempts have been caused by infrequent and unpredictable seed crops, unfavorable environmental conditions, and high losses to seed-eating rodents (Skau, et al. 1970; Schubert and Adams 1971). In addition, extended summer drought, excessive competition from established shrubs and the unavailability of locally produced nursery stock have all contributed to the poor performance of bare-root seedlings.

The use of container grown seedlings offers several advantages which may increase field survival especially on adverse sites. These include greater control of environmental factors during rearing and the production of an actively growing, relatively undisturbed root system. Kudrjavcev (1965), working in the pumice soils of eastern Oregon, reported 90 percent survival of ponderosa pine (Pinus ponderosa) grown in large containers. In contrast, trials with small containers on eroded watersheds in Mississippi have produced inconsistent and erratic results (McClurkin 1971). Miller and Schneider (1971), however, reported first year survival rates as high as 94 percent when jack pine (Pinus banksiana) was grown in small containers and outplanted on modified sites in Michigan. Owston (1972) concluded that although large containers have biological advantages for small scale, high priority plantings, their use could not be recommended until further field tests have been performed. Successful establishment of roadside plantings utilizing very large plastic mesh containers has been reported by Hodder and Sindelar (1972). Wollum, et al. (1973) have reported a survival rate of approximately 70 percent for ponderosa pine grown in plastic mesh containers and outplanted on open sites in New Mexico.

METHODOLOGY

The primary objective of this research is to investigate the potential of a contain-

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erized regeneration system on adverse sites where conventional regeneration methods had failed.

Materials

Seed

Locally collected Jeffrey pine (Pines jeffreyi) seed was used for all trials. Related species trials indicated a higher survival rate for Jeffrey pine than all other native and introduced species. Also, Jeffrey pine has a high commercial value in this area as a timber producing species. All seed was stratified prior to sowing to insure prompt germination and uniform seedling age.

Potting-mix

A sandy-loam soil was used as a potting-mix in the 1971 trial. However, potting-mix trials later indicated that a more extensive root system was developed in vermiculite-peat mixtures than in the sandy-loam soil. Thus, in subsequent trials, a mixture of 5 parts vermiculite and 1 part peat was used as the potting-mix. The containers were hand filled with potting-mix, sown with seed, and placed in the greenhouse.

Containers

The container types included in the 1971, 1972, and 1973 trials are shown in figures 1, 2, and 3 respectively. A description of the containers used in all trials is given in table 1.

Rearing Techniques

Uniform, favorable growing conditions were maintained throughout each container trial. Water was applied as needed throughout the greenhouse stage and a complete water soluble fertilizer was applied biweekly following germination. Root pruning was accomplished by use of a copper base wood preservative. The 1972 and 1973 trials received an extended photoperiod which consisted of a 14-hr. light period with the dark period interrupted for 1 hr. The seedlings were grown under greenhouse conditions for 7 weeks in 1971, 10 weeks in 1972, and 11 weeks in 1973, after which they were moved outside for approximately 2 weeks prior to outplanting. Hardening-off conditions consisted of reduced watering and normal fluctuations in temperature and sunlight. The containerized seedlings were outplanted in June and early July depending upon the snowpack conditions in the mountains.

Table 1.--Description of containers tested from 1971 through 1973.

Container Type	Dimensions: Dia. (in)	Depth (in)	Dia. (cm)	Depth (cm)	Material	Rooting Volume (in^3)	Rooting Volume (cm^3)	Year(s) Tested: 1971	1972	1973
Ontario	0.5	3.0	1.3	7.6	Styrene plastic	0.6	9.6	x		
Jiffy-7	1.8	1.5	4.4	3.8	Compressed peat	3.6	59.1	x		
Jiffy-Belt	1.0[1/]	3.0	2.5[1/]	7.6	Compressed peat	3.0	49.2	x		
2.5x2-Peat pot	2.5	2.0	6.4	5.1	Compressed peat	6.3	103.0	x		
2.5x3-Peat pot	2.5	3.0	6.4	7.6	Compressed peat	9.4	154.4	x		
3x3-Peat pot	3.0	3.0	7.6	7.6	Compressed peat	14.7	241.3	x		
1.2x6-Paperpot	1.2	5.9	3.0	15.0	Treated paper	6.8	106.0	x		
1.5x6-Paperpot	1.5	5.9	3.8	15.0	Treated paper	12.0	170.1	x		
2x6-Paperpot	2.0	5.9	5.0	15.0	Treated paper	18.8	294.5	x	x	
2x8-Paperpot	2.0	7.9	5.0	20.0	Treated paper	25.1	392.7		x	x
0.5x6-Conwed	0.5	6.0	1.3	15.2	Plastic mesh	1.2	19.3	x		
1x6-Conwed	1.0	6.0	2.5	15.2	Plastic mesh	4.7	77.2	x	x	
2x6-Conwed	2.0	6.0	5.0	15.2	Plastic mesh	18.8	308.9	x	x	
2x6+3-Conwed	2.0	6.0	5.0	15.2	Plastic mesh	18.8	308.9		x	
2x9-Conwed	2.0	9.0	5.0	22.9	Plastic mesh	28.3	463.3		x	x
2x9+3-Conwed	2.0	9.0	5.0	22.9	Plastic mesh	28.3	463.3			x
2x12-Conwed	2.0	12.0	5.0	30.5	Plastic mesh	37.7	617.8			x
2.5x12-Zeiset	2.5[1/]	12.0	6.4[1/]	30.5	Polyethylene covered cardboard	75.0	1229.0			x

1/Side of square.

Figure 1.-- Container types tested in 1971: (1) 2x6-Conwed; (2) 1x6-Conwed; (3) 0.5x6-Conwed; (4) Ontario; (5) 2x6-Paperpot; (6) 1.2x6-Paperpot; (7) 3x3-Peat pot; (8) 2.5x3-Peat pot; (9) 2.5x2-Peat pot; (10) Jiffy-Belt; (11) Jiffy-7.

Figure 2.-- Container types tested in 1972: (1) 2x6-Paperpot; (2) 2x8-Paperpot; (3) 1x6-Conwed; (4) 2x6-Conwed; (5) 2x6+3-Conwed, the black insert merely indicates the level to which the tube is filled with potting-mix; (6) 2x9-Conwed.

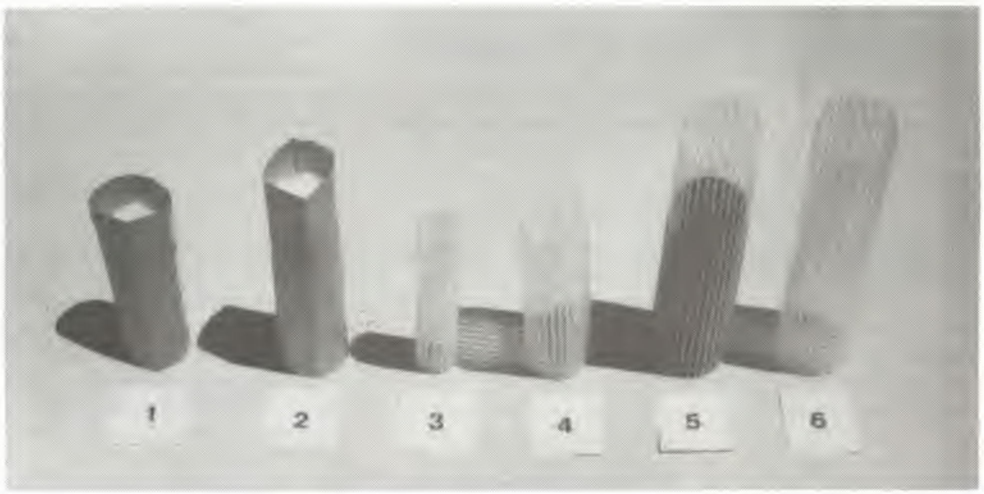
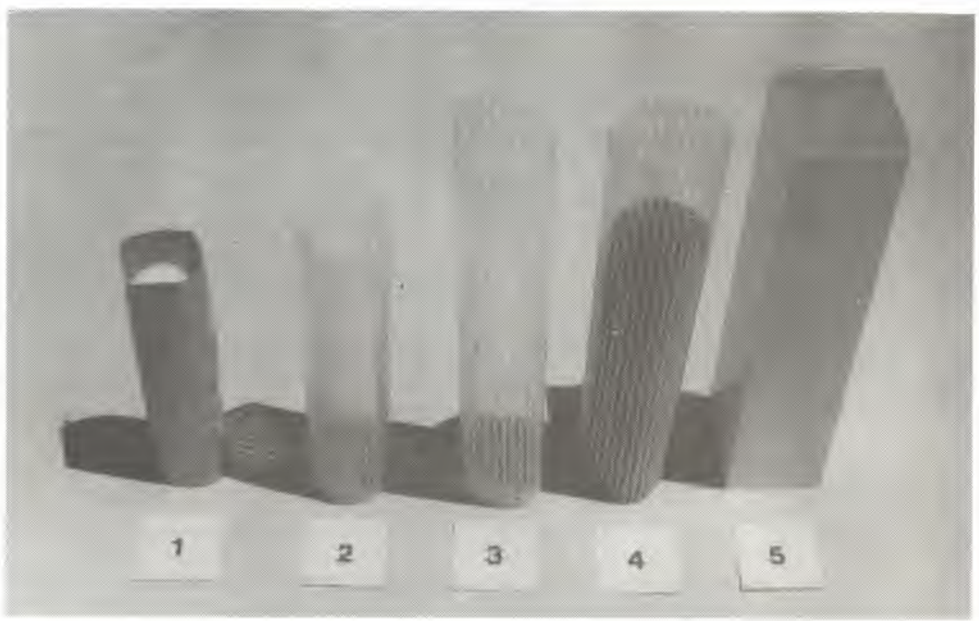


Figure 3.-- Container types tested in 1973: (1) 2x8-Paperpot; (2) 2x9-Conwed; (3) 2x12-Conwed; (4) 2x9+3-Conwed, the black insert merely indicates the level to which the tube is filled with potting-mix; (5) 2.5x12-Zeiset.



Site Selection

Presently on the eastside Sierra Nevada mountains, there are many areas which have failed to regenerate either naturally or artificially following removal of the forest cover. These adverse sites are usually 7,000- to 10,000-feet in elevation, have 30 to 50% slopes, southerly and westerly aspects, poorly developed soils, and little summer precipitation. Although annual precipitation is 24- to 35-inches, growing season precipitation is usually less than 1-inch. Soils are shallow, excessively drained, and derived from granite and/or andesite. Three areas, a logged area, a burned area, and a developed area, were selected with these typical adverse environmental conditions.

Initial trials in 1971 and 1972 were conducted on a recently logged area located 1 mile from Marlette Lake on the east rim of the Lake Tahoe Basin. Earlier attempts to restock this area by seeding and planting bare-root stock had failed. In 1973, the trial was expanded to included a burned area and a developed area. The burned area is located on a burned-over slope of the Donner Ridge fire. This site had been terraced by the U.S. Forest Service and repeated plantings of bare-root seedlings had less than 45% survival. The developed area is located in Incline Village, a recent residential development on the northeast side of Lake Tahoe. The sites selected in this area were located on roadside cut slopes.

Experimental Design

A randomized block design was used which consisted of 10 blocks (1971) and 6 blocks (1972 and 1973) at the logged area and 5 blocks (1973) at both the burned and roadside areas. Ten seedlings of each container type were randomly assigned to rows within each block. The rows followed along the contours and were spaced 2- to 3-ft apart, while the individual seedlings were planted 1- to 2-ft apart within each row.

Survival counts and the cause of mortality were recorded at monthly intervals during the first growing season. Subsequent yearly survival counts were taken in the spring and fall of each year. Data were summarized and percentages were transformed to arc sin percent for analysis of variance (Steel and Torrie 1960). The mean survival by container type for each year's trial was analyzed by Duncan's New Multiple Range Test, while individual and group container effects were isolated by orthogonal comparisons.

RESULTS

1971 Trial

Overall survival was low, with the highest first year sur val only 31% in the 2x6-Paperpot containers4/ (table 2). After 3 years, the

4/Mention of trade names does not constitute endorsement of the product by the Univer- of Nevada.

Table 2.--Mean survival of container grown Jeffrey pine seedlings outplanted at the logged site in July, 1971.

	Cause of First Year Mortality						
Container Type[1/]	Desiccation	Rodent Damage	Winter Damage	Other	First Year Survival	Second Year Survival	Third Year Survival
	%	%	%	%	%	%	%
2x6-Paperpot	20	39	6	4	31	20	14
1.2x6-Paperpot	37	31	6	7	19	13	11
2x6-Conwed	59	11	3	1	26	12	11
1x6-Conwed	52	19	2	1	26	19	19
.5x6-Conwed	69	10	9	2	10	7	6
3x3-Peat pot	50	25	8	3	14	9	5
2.5x3-Peat pot	61	21	6	3	9	5	5
2.5x2-Peat pot	62	17	3	0	18	12	10
Jiffy-7	70	12	2	8	8	5	5
Jiffy-Belt	70	27	1	1	1	0	0
Ontario	75	21	1	1	2	1	1

1/See figure 1 and table 1 for detailed description of container types.

1x6-Conwed containers had 19% survival while the 2x6-Paperpot had dropped to 14%. Mean survival, however, was favorably influenced by container length. Containers 6-inches in length showed a significantly higher survival rate than the shorter container types. 5/

The major causes of mortality were desiccation and rodent damage, with other causes amounting to less than 15%. Rodent damage was a particular problem on the Paperpot containers. These containers sustained significantly (.01) higher mortality from rodent-caused damage than did Conwed containers. The major type of rodent damage consisted of digging around the container, following which the paper was totally or partially removed, thus exposing the root system and resulting in seedling death (fig. 4). This type of damage usually occurred within a few days after outplanting, and often resulted in a complete loss of seedlings in the Paperpot containers. Clipping of seedling stems contributed to a minor portion of the total rodent damage. Paperpot containers continued to sustain rodent damage even during the second and third year in the field.

1972 Trial

The highest first year survival was 67% in the 2x9-Conwed container (table 3). Survival in this container was significantly higher than all other container types included in the trial. Increasing the tube length 3-inches resulted in a marked increase in first and second year survival. Conwed containers 9-inches in length showed a significantly (.01) higher survival rate than 6-inch Conwed containers (table 4). Similar results were also found in a comparison between Paperpot containers H- and 6-inches in length. However, comparisons between 1- and 2-inch diameter Conwed containers of the same length indicated no significant difference in seedling survival.

5/Unless otherwise stated, statistical significance is at the .05 level.

Figure 4.--Rodent digging around Paperpot container. Subsequent removal of the paper and exposure of seedling roots often occurred.

As in 1971, the major causes of mortality were desiccation and rodent damage, with winter-caused mortality comprising a minor part of the total. Again, rodent damage was severe on Paperpot containers, amounting to a loss of more than 50% of all seedlings outplanted in these containers. Seedlings in Conwed containers had significantly (.01) higher first and second year survival than those in Paperpot containers (table 4). Although rodent damage was lower in the Conwed containers, it still resulted in a considerable loss of seedlings (table 3). In a related study, there was no rodent damage on Conwed containers in which 3-inches of the plastic mesh was exposed above the soil surface (fig. 5).

Table 3.--Mean survival of container grown Jeffrey pine seedlings outplanted at the logged site in June, 1972.

Container Type 1/	Cause of First Year Mortality: Desiccation	Rodent Damage	Winter Damage	First Year Survival 2/	Second Year Survival 2/
	%	%	%	%	%
2x9-Conwed	22	7	5	67^{a}	62^{a}
2x6-Conwed	53	17	8	22^{bc}	18^{bc}
1x6-Conwed	36	20	2	42^{b}	39^{b}
2x8-Paperpot	10	58	3	29^{b}	22^{bc}
2x6-Paperpot	50	48	0	2^{c}	2^{c}

1/See figure 2 and table 1 for detailed description of container types.
2/Means with same superscript are not significantly different.

Table 4.--Individual and group comparisons of 1972 survival by container types.

Container Comparisons	Cause of First Year Mortality: Desiccation	Cause of First Year Mortality: Rodent Damage	First Year Survival	Second Year Survival
Conwed vs Paperpot	n.s.	*	**	**
2x6 vs 1x6-Conwed	n.s.	n.s.	n.s.	n.s.
2x9 vs 2x6 & 1x6-Conwed	n.s.	n.s.	**	**
2x8 vs 2x6-Paperpot	n.s.	n.s.	*	n.s.

n.s. - Comparison not significant at the .05 level.
* - Comparison significant at the .05 level.
** - Comparison signfficant at the .01 level.

Figure 5.--Twelve-week-old Jeffrey pine seedling outplanted in a 2x9+3-Conwed container.

1973 Trial

The highest first year survival rate was 86% in the 2x9+3-Conwed containers outplanted at the burned site. Overall survival in the Conwed containers was higher than other container types tested, while that in the Paperpot containers was the lowest (table 5). When all sites are considered, survival in the 2x9+3-Conwed containers was significantly higher than both the 2.5x12-Zeiset and 2x8-Paperpot containers, while the 2x8-Paperpot had significantly (.01) lower survival when compared to all container types. Increasing container length to 12 inches did not result in significantly higher survival rates. Overall survival of container types was highest at the burned site. The results showed similar differences between container types at the logged and burned areas, however, no significant difference between container types was found at the roadside area.

Causes of mortality remained consistent with the 1971 and 1972 trials, with heavy rodent damage occurring on the Paperpot container. In comparison, Conwed containers exhibited considerably less rodent damage, with no damage noted on the 2x9+3-Conwed container (table 5).

Table 5.--Mean survival of container grown Jeffrey pine seedlings outplanted at three sites in June, 1973.

Container Type[1]	Cause of First Year Mortality: Desiccation %	Rodent Damage %	Winter Damage %	First Year Survival[2] %
Logged Area				
2x9+3-Conwed	25	0	5	70[a]
2x12-Conwed	23	2	7	68[ab]
2x9-Conwed	48	2	2	48[ab]
2.5x12-Zeiset	28	18	12	42[b]
2x8-Paperpot	32	47	2	19[c]
Burned Area				
2x9+3-Conwed	2	0	12	86[a]
2x12-Conwed	40	0	2	58[b]
2.5x12-Zeiset	34	2	6	58[b]
2x8-Paperpot	40	12	4	44[b]
Roadside Area				
2x9+3-Conwed	40	0	14	46[a]
2x12-Conwed	20	0	16	64[a]
2.5x12-Zeiset	52	0	6	42[a]
2x8-Paperpot	48	2	4	46[a]
All Areas				
2x9+3-Conwed	22	0	10	68[a]
2x12-Conwed	27	1	8	64[ab]
2.5x12-Zeiset	38	7	8	47[b]
2x8-Paperpot	39	22	3	36[b]

1/See figure 3 and table 1 for detailed description of container types.
2/Means with same superscript are not significantly different.

DISCUSSION

The results from these field trials show that container grown seedlings offer considerable potential for achieving satisfactory survival rates on adverse sites. However, considerable variation in survival by container type was evident. Seedlings in small containers, 6-inches or less in length, had excessively high mortality rates. Apparently the shallow planting depth of these containers did not promote root growth to a sufficient depth to avoid the drought stresses imposed during the growing season. Although these containerized seedlings were outplanted with soils at field capacity, the lack of rainfall combined with low soil water holding capacity imposed severe water stress conditions early in the growing season. Increasing container length to 9-inches increased survival significantly. However, using containers 12-inches in length made planting considerably more difficult and did not result in higher survival rates.

In addition to mortality caused by growing season drought and subsequent dessication, damage by rodents resulted in high losses on paper containers. Rodent-caused mortality, however, was lower on plastic mesh containers and eliminated completely when 3-inches of the container was exposed above the soil surface. A beneficial microclimatic influence may result from this container extension around the seedling stem, but specific effects are unknown at this time.

Since conventional bare-root seedlings were not included in these trials, direct comparisons with containerized seedlings cannot be made. However, recorded survival rates for bare-root seedlings planted on these adverse sites has ranged from 33-43%. The higher survival rates of seedlings in certain container types not only indicate the greater potential for successful establishment using containerized seedlings, but also the necessity of adequate field testing before large commitments are made to one container type.

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