Reprinted from:
Great Plains Agric. Counc. Publ. 68.

CONTAINERIZED SEEDLINGS ON THE LINCOLN NATIONAL FOREST 1/

Bruce A. Buchanan 2/

Abstract.--Survival rates of ponderosa pine planted as nursery stock, direct seed, and various container types were compared. Book planters, Styroblocks and nursery stock performed similarly (average survival 30 percent). Conwed tubes, peat blocks, and direct seeding each had low survival (10 percent or less).

INTRODUCTION

Reforestation of the burned areas in the southwest is of great importance because of the high recreational use of New Mexico's forests. The aesthetic, environmental, and economic demands on the forest nearly always exceed the rate at which these burns naturally regenerate after fire.

Conventional methods of artificial reforestation, i.e. planting two year (2+0) nursery stock or direct seeding, are generally an unrewarding gamble on the Lincoln National Forest. For example the survival of nursery stock averages 10-15 percent and direct seed even less. In situations where soil water conditions are near optimum, survival of nursery stock often averages 30 percent.3/

It is very important that regeneration attempts are timed to periods of near optimum soil water conditions. These periods normally result when precipitation is average or above average. Because a two or three year lead-time is needed to plan for nursery stock, planting does not always coincide with optimum conditions of soil water.

A method that holds promise of reducing lead-time to less than six months and possibly improve on survival rates is containerized seedlings. The performance of containerized stock in comparison to nursery stock is relatively unknown for the southwest.

The object of this study was to compare survival rates of ponderosa pine trees grown in several kinds of containers to nursery stock and direct seeding reforestation techniques.

STUDY AREA

The Lincoln National Forest is located in the southcentral part of New Mexico and has an area of 446,473 hectares. Approximately 30 percent of the area is classified as commercial forest land. A breakdown of forest types follows:4/

	Hectares	Percent of Commercial Forest
Spruce - fir	1,135	0.8
Aspen	3,499	2.6
Ponderosa pine (includes some SW white pine)	37,351	27.9
Mixed conifer	44,831	33.4
Non-stocked	21,277	15.9
Non-accessible	25,997	19.4
Total commercial forest	134,090 ha.	

The non-stocked areas (16%) have resulted primarily from large forest fires that characteristically destroy several thousand hectares of timber in a single burn. A recent example was in April of 1974 when a small campfire resulted in a 6,100 hectare burn.

The average annual precipitation in the Lincoln Forest ranges from 48 cm (19 in) to 63 cm (25 in) at elevations of 2100m (7000 ft) and 2400m (8000 ft), respectively. Approximately 50 percent of the annual precipitation occurs during July and August. The months of April, May, and June, known as the drought season, collectively account for less than 15 percent of the annual rainfall (USWB).

1/Paper presented at North American Containerized Forest Tree Seedling Symposium, Denver, Colorado, August 26-29, 1974.

2/Assistant Professor of Forest Soils, Department of Agronomy, New Mexico State Univsity, Las Cruces, New Mexico, 88003.

3/Unpublished records, Lincoln National Forest, Mayhill Office, Mayhill, New Mexico.

4/Unpublished records, Lincoln National Forest Supervisors' Office, Alamogordo, New Mexico.

Soils of the Lincoln are dominantly Mollisols with small areas of Alfisols and Aridisols. The major kinds of soils at lower elevations are Lithic Calciustolls overlying limestone and at upper elevations are Typic Haploborolls and Pachic Haploborolls also over lying limestone (Maker, Derr and Anderson, 1972).

METHODS

Plots

In March of 1973, 18 plots (10 x 10m) were established on various burned areas in the Lincoln National Forest. Study plots were positioned on different slopes, aspects and elevations. One common factor to all plots was the site had adeqate soil depth for the plating of 2+0 nursery stock. In many instances the soils are too shallow or rocky for economic planting of deep rooted stock.

Ten treatments were replicated 10 times at each plot (total of 100 trees planted per plot). The treatments applied to the 18 plots are shown in Tables 1-6.

Ponderosa Pine Planting Stock (treatments)

Nursery stock--The Forest Service donated 260, 2+0 ponderosa pine nursery stock planted in the 18 study plots. The trees came from the supply used for the 1973 spring planting.

Direct seed--The Forest Service donated about 1 kg of ponderosa pine seed that had been collected on the Mayhill District, Lincoln National Forest.

Book planters--Three sizes of book-planters produced by Spencer-Lemaire Ind., Ltd., were used. The sizes were, 1) Ferdinand 3 cu in (50cc); 2) Hillson 10 cu in (160cc); 3) Tinus 30 cu in (500cc). The book planters were seeded with ponderosa pine on October 1, November 1, and December 1, 1972 to produce, at the time of planting containerized stock of 20, 16, and 12 weeks of age, respectively. The substrates used included forest soil, peat, vermiculite, and silva fiber. Different combinations of the substrates were used to develop 21 mixtures. The trees were watered three times a week and supplemented with 1/2 strength Hoagland's solution once a week until they were removed from the greenhouse in mid February 1973.

Canadian Styroblock--Trees grown in the 2 cu in (35cc) Canadian Styroblocks were treated identically as the book planters with respect to age of seeding, substrate mixtures, watering, and fertilizations.

Peat Block--Two types of peat blocks, commonly used for transplanting tomatoes were tested. The small peat block was approximately 5x5x5 cm in size. The large block was 15x3x3 cm in size. Both peat blocks were seeded on January 1, 1973, and watered and fertilized as described for the book planters.

Conwed Tubes--The Conwed tubes are a cylindrical plastic mesh 10.5 cm long and 1.5 cm in diameter and available from Conwed plastics. Substrate mixtures included peat, silva fiber, and forest soil. The tubes were seeded on January 1 of 1973 and watered and fertilized as described for the book planters.

Planting

Prior to planting at each location where a tree or seed was to be planted an area 50 x 50 cm was scalped. Scalping was done to reduce competition by surrounding vegetation for water. A McLeod fire rake 25 cm wide was used to remove the vegetation and expose a surface of bare soil. The tree or seed to be planted was located near the center of the scalp. Technique is similar to that described by Foiles and Curtis (1973).

Nursery stock--was planted in 10 cm dia holes 20-30 cm deep that were augered with a hand carried power auger. Approximately half of the nursery stock was planted with the roots placed against the side of hole (side-planted), and the other half with roots positioned in the center of the hole (center-planted).

Direct seed--was planted in a 1-5 cm depression made in the scalpes with a pulaski axe. An attempt was made to plant 10 seeds at variable depths.

Book planters--The Tinus and Hillson planters were planted in 10 cm dia holes made with the power auger. The Ferdinand was planted in 2.5 cm dia hand augered holes.

Canadian Styroblocks--were planted the same as the Ferdinand book planters.

Peat blocks--The small peat blocks were planted in holes made with a pulaski axe. The large peat block was planted in 10 cm dia holes made with the power auger.

Conwed tubes--were planted by using a "dibble-bar". The operation involves pushing a steel bar similar in shape to the tube into the soil and then inserting the tube in the hole. Planting technique is described by Wollum et al. (1973).

The data presented here represent survival recorded in mid-April 1974, approximately 13 months after planting. Chi-square tests have been used to statistically compare the treatments.

RESULTS AND DISCUSSION

The allocation of treatments for the 18 study plots is presented in six planting designs. A brief discussion is given for each design.

Planting design one--(Table 1) is a summary of 13 month survival of nursery stock on the 18 study plots. Center and side planted stock is compared.

The 27.5 percent survival of nursery stock compares well to the 30 percent average attained by the Forest Service under favorable soil conditions on the Lincoln.5/ These survival rates can hardly be considered economical reforestation but do reflect to the problems of regeneration in the Southwest described by Schubert (1970).

A comparison of nursery stock center planted with nursery stock side planted (chi square test 1-1) shows no significant difference. The recommended method on the Lincoln Forest has been to center plant nursery stock In this study side planting was easier and less time consuming than center planting. Therefore, side planting could be adopted without reduction in survival.

The survival of nursery stock varies greatly on the different plots (chi square test 1-2). Most of the variability of nursery stock survival is in the living and death from environment columns (chi square tests 1-3 & 1-5). The animal damage is relatively the same across plots (chi square test 1-4). Nursery stock survival should be expected to change with the variability of elevation, slope, and aspect in the 18 study plots. The true effect of these three site characteristics cannot be evaluated here but in general survival increased with decreasing elevation, decreasing slope, and north versus south aspects.

Planting design two--(Table.2) is a summary of nine kinds of ponderosa pine planting stock on study plots 2, 6, 12, and 15. All container types, direct seed, and nursery stock are compared.

5/Unpublished records, Lincoln National Forest, Mayhill Office, Mayhill, New Mexico.

The comparison of all planting stock to one another in design two shows that survival varies significantly among treatments (chi square test 2-1). Four container types (Tinus, Hillson, Ferdinand, and Styroblock) and two nursery stock plantings are compared among themselves and with each other. They all seem to have equal survival (chi square tests 2-2 and 2-3). The survival of the four containers mentioned above and two nursery stock plantings combined were compared to the combined survival of Conwed tubes, peat blocks, and direct seed (chi square test 2-4). The survival of the Conwed tubes, peat blocks and direct seed is significantly lower than the 28 percent average of the first mentioned group.

The Tinus, Hillson, Ferdinand, and Styroblock will apparently perform similar to nursery stock in north aspects. Arnott's (1971) comparison of Douglas-fir as bare-root and Styroblock shows similar trends as here only his survival rates exceeded 80 percent.

In previous studies with the Conwed tube by Wollum et al. (1973) on the Lincoln Forest, survival after one year was 2 percent for similar areas. Direct seeding often gives low survival (Foiles and Curtis, 1973) and should only be recommended during the best of environmental conditions. The peat-blocks were not successful and teach a lesson that what's good for tomatoes may not be good for pine trees.

Planting design three--(Table 3) is a summary of four kinds of ponderosa pine planting stock on study plots 4, 8, 9, 14, 16, 17, and 18. The comparison is among two container types (Ferdinand and Canadian Styroblocks), direct seed, and nursery stock.

A comparison of survival for all planting stock shows in design three that performance is quite different (chi square test 3-1). The Ferdinand and Styroblock have very similar survival rates (chi square test 3-2), but both have higher survival than nursery stock (chi square test 3-3).

The older Ferdinand seedlings seem to have a slight advantage in survival (chi square test 3-4). Styroblocks, however, performed similarly at the two ages.

Direct seed and nursery stock have similar success but their survival rates were very low.

The data seem to indicate that containers are better suited for south, and east plots than the nursery stocks.

Table 1.--Nursery stock survival after 13 months on study plots 1-18 and elevation, slope and aspect for each plot.

Plot number	Elevation m	Slope --%--	Aspect	No. trees planted	Trees living 1/	Dead environment 1/	Dead animal 1/
1	2130	9	N	20	35	25	40
2	2130	10	N	20	20	55	25
3	2130	11	S	20	30	65	5
4	2130	15	S	10	0	100	0
5	2160	7	N	20	60	30	10
6	2160	8	N	20	50	10	40
7	2160	10	S	20	30	35	35
8	2250	10	E	10	20	70	10
9	2250	10	E	10	40	50	10
10	2300	9	E	10	80	10	10
11	2300	9	E	10	30	60	10
12	2300	11	N	20	55	25	20
13	2440	10	E	10	10	70	20
14	2440	13	SW	10	10	60	30
15	2440	14	N	20	15	70	15
16	2440	16	SW	10	0	90	10
17	2440	17	E	10	0	90	10
18	2440	17	E	10	10	80	10
Average sum of plots					27.5	55.3	17.2
Nursery stock center-plant				150	32	51	17
Nursery stock side-plant				110	28	49	23

Chi square test for:	df	chi square	sig. 2/
1-1 LDA Nursery stock center vs nursery stock side	2	1.58	ns
1-2 LDA Nursery stock all plots	34	92.03	**
1-3 LD- Nursery stock all plots	17	64.91	**
1-4 L-A Nursery stock all plots	17	20.91	ns
1-5 -DA Nursery stock all plots	17	40.72	**

1/ Trees living - assessment given to trees having green needles. Dead environment - assessment given to trees that died from environmental conditions. Dead animal - assessment given to trees that died from animal damage.

2/ Significance - * 90% probability level. ** 95% probability level. ns - nonsignificant.

Table 2.--Survival of seven container types, nursery stock and direct seed on four north aspect plots.

Planting Stock and Substrate	Age (weeks)	No. trees planted	Trees living 1/	Dead Environment 1/	Dead animal 1/
TINUS Peat: Vermiculite	20	39	31	26	43
HILLSON Peat: Vermiculite	20	38	24	47	29
FERDINAND Peat: Vermiculite	20	40	20	40	40
CANADIAN STYRO-BLOCK Peat: Vermiculite	20	40	25	45	30
CONWED TUBE Peat: Silva: Soil	8	40	10	70	20
PEAT BLOCK LARGE Peat	8	40	3	80	17
PEAT BLOCK SMALL Peat	8	40	3	80	17
DIRECT SEED (Record is % successful, dead could not be assessed)		40	8	--	--
NURSERY STOCK Center-planted	100	40	30	40	30
NURSERY STOCK	100	40	40	40	20
Average of planting stock (Direct seed is excluded)			21	52	27

Chi square test for:	df	chi square	sig. 2/
2-1 LDA All planting stock	18	86.82	**
2-2 LDA Tinus, Hillson, Ferdinand (Ferd.) and Canadian Styroblock (CSB)	6	5.49	ns
2-3 LDA Tinus, Hillson, Ferd. CSB. Nursery Stock	10	10.71	ns
2-4 LDA Combined Tinus, Hillson, Ferd., CSB. Nursery stock vs combined Conwed, Peat Blocks, and Direct Seed.	2	67.1	**

1/ see Table 1

2/ see Table 1

Table 3.--Survival of Ferdinand, Canadian Styroblock, direct seed and nursery stock on south, southeast and east aspects.

Planting Stock (substrates not considered)	Age (weeks)	No. trees planted	Trees living 1/	Dead Environment 1/ %	Dead animal 1/
FERDINAND	16	137	32	37	31
FERDINAND	12	130	19	49	32
CANADIAN STYRO-BLOCK	16	126	29	46	25
CANADIAN STYRO-BLOCK	12	125	22	55	23
DIRECT SEED (record is % successful, dead could not be assessed)		70	11	--	--
NURSERY STOCK Center-planted	100	40	13	75	12
NURSERY STOCK Side-planted	100	30	10	80	10
Average of planting stock (Direct seed is excluded)			21	57	22

Chi square tests for:	df	chi square	sig. 2/
3-1 LDA All planting stocks	12	75.44	**
3-2 LDA Combined Ferd. vs. combined CSB	2	3.56	ns
3-3 LDA Combined Ferd. vs. combined CSB vs combined nursery stock	4	26.76	**
3-4 LDA Ferd. 16 week vs Ferd. 12 week	2	6.53	**
3-5 LDA CSB 16 week vs CSB 12 week	2	1.94	ns

1/see Table 1

2/see Table 1

Planting design four--(Table 4) is a summary of four kinds of ponderosa pine planting stock on study plots 10, 11, and 13. The comparison is among two container types (Ferdinand and Canadian Styroblock), direct seed, and nursery stock.

A comparison of all planting stock in design four shows that survival is very different among the treatments (chi square test 4-1). The survival of the Ferdinand and Canadian Styroblock containers was similar (chi square test 4-2), but each had lower survival than the nursery stock

Table 4.--Survival of Ferdinand, Canadian Styroblock, direct seed and nursery stock on east aspects.

Planting Stock (substrates not considered)	Age (weeks)	No. trees planted	Trees living 1/	Dead Environment 1/ %	Dead animal 1/
FERDINAND	12	120	16	52	32
CANADIAN STYRO-BLOCK	12	120	12	61	27
DIRECT SEED (record is % successful, dead could not be assessed)		30	0	--	--
NURSERY STOCK Center-planted		30	40	47	13
Average of planting stock (Direct seed is excluded)			23	53	24

Chi square tests for:	df	chi square	sig. 2/
4-1 LDA All planting stock	6	39.54	**
4-2 LDA Ferd. 12 vs. CSB 12	2	1.84	ns
4-3 LDA Ferd. 12 vs. Nursery	2	9.82	**
4-4 LDA CSB 12 vs. Nursery	2	13.90	**

1/see Table 1

2/see Table 1

(chi square test 4-3 and 4-4). One reason for the low survival rates with the containers could be the age of seedlings. In Table 3 the 12-week-old Ferdinand had lower survival than the 16-week. The 12-week-old stock may not be an acceptable age of containerized seedling on the Lincoln Forest.

Planting design five--(Table 5) is a summary of three kinds of ponderosa pine planting stock on study plots 1 and 5. The comparison is between two container types (Tinus and Hillson) and the nursery stock.

A comparison of survival across all planting stock for design five shows great differences in the performance of treatments.

The Tinus group has similar survival for the different substrates tested (chi square test 5-2). A similar comparison for the Hillson group shows they also have comparable survival for substrates tested (chi square test

Table 5.--Survival of Tinus, Hillson and nursery stock on north aspects.

Planting Stock Substrate	No. of trees planted	Trees 1/ living	Dead Environment 1/	Dead animal 1/
		%	%	%
TINUS 20 week Silva: 2 vermiculite	19	11	47	42
TINUS 20 week 2 silva: vermiculite	20	5	55	40
TINUS 20 week Silva: 2 peat	20	25	60	15
TINUS 20 week 2 silva: peat	20	5	50	45
HILLSON 20 week Soil: vermiculite	20	20	30	50
HILLSON 20 week Soil: 2 vermiculite	19	11	21	68
HILLSON 20 week Soil: peat	20	35	20	45
HILLSON 20 week Soil: 2 peat	18	44	17	39
NURSERY STOCK Center-Plant 100 week	20	65	30	5
NURSERY STOCK Side-plant 100 week	20	30	25	45
Average of planting stock		25	35	40

Chi square test for:	df	chi square	sig. 2/
5-1 LDA All planting stock	18	53.14	**
5-2 LDA Tinus	6	8.27	ns
5-3 LDA Hillson	6	7.39	ns
5-4 LDA Combined Tinus vs Comb. Hillson	2	17.18	**
5-5 LDA Combined Tinus vs Comb. Nursery stock	2	19.55	**
5-6 LDA Comb. Hillson vs. nursery stock	2	7.61	**
5-7 LD- Comb. Hillson vs. nursery stock	1	0.45	ns

1/see Table 1

2/see Table 2

Table 6.--Survival of Tinus, Hillson, Ferdinand, Canadian Styroblock and nursery stock on south aspects.

Planting Stock Substrate	No. of trees planted	Trees 1/ living	Dead Environment 1/	Dead animal 1/
		%	%	%
TINUS 20 week Silva: peat	16	6	88	6
TINUS 20 week Silva: vermiculite	20	5	75	20
HILLSON 20 week Silva: peat	20	15	70	15
HILLSON 20 week Silva: vermiculite	18	17	66	17
FERDINAND 16 week Silva: peat	19	21	53	26
FERDINAND 16 week Silva: vermiculite	20	20	65	15
CANADIAN STYROBLOCK 16 week Silva: peat	10	30	70	0
CANADIAN STYROBLOCK 16 week Silva: vermiculite	20	0	85	15
NURSERY STOCK Center-planted 100 week	20	30	55	15
NURSERY STOCK Side-planted 100 week	20	30	45	25
Average of planting stock		17	68	15

Chi square test for:	df	chi square	sig. 2/
6-1 LDA All planting stock	18	21.17	ns

1/see Table 1

2/see Table 2

5-3). The Hillson group has a higher survival than the Tinus group (chi square test 5-4), but both have lower survival rates than nursery stock (chi square test 5-5 and 5-6).

The difference between the Hillson and nursery stock is not so much in the living and death from environment columns but largely a result of animal damage differences.

Some of the differences in the Tinus survival as compared to the Hillson could be explained by substrate differences. The soil

mixes could have provided a mycorrhizal source not supplied by the substrates used to grow the Tinus containers.

The high animal damage to the containerized seedlings which accounts for some of the reduced survival in comparison to the nursery stock indicates the need for control to establish effective reforestation programs.

Planting design six--(Table 6) is a summary of five kinds of ponderosa pine planting stock on study plots 3 and 7. The comparison is between four container types (Tinus, Hillson, Ferdinand, and Canadian Styroblock) and the nursery stock.

The planting stock for this design has very similar survival rates (chi square test 6-1). The design is similar to Table 2 except that it is on south aspects. The Tinus group has the lowest survival which probably accounts for the difference in the living and death from environment columns (chi square test 6-2). With a few exceptions the survival is very similar for the containers in this design as compared to planting design two (Table 2). However, the survival for both designs 2 and 6 is lower than for planting design 5 (Table 5). One container that seems very consistent on the different plots is the Hilison.

SUMMARY AND CONCLUSIONS

The most important factor to overcome on the Lincoln National Forest is inadequate soil water. This forest is not unique to the problem of low soil water availability, but may well be one of the most challenging. The rainfall pattern of this region includes a drought in the early growing season that is mainly survived from the water stored as winter precipitation. In years that winter precipitation is below normal, spring planting of any kind will generally fail. Planning for a nursery stock operation cannot always foresee a dry winter two years in advance. It does seem possible, however, that a containerized seedling operation could be initiated in December for the Lincoln Forest if above normal winter precipitation is occurring.

This study has provided information showing that in most cases containerized seedlings can compare to nursery stock on the Lincoln Forest. The best results were obtained with the Book Planter types and the Canadian Styroblock.

The other container types tested (Conwed tubes and peat blocks) should not be considered as acceptable techniques in the Southwest. Direct seeding in most areas will give poor stocking rates.

RECOMMENDATIONS

1. The Hillson Book Planter is considered to be the best adapted for sites that have deep or rock-free soils.

2. The Canadian Styroblock and Ferdinand Book Planters are well suited to the rocky soil sites. The Ferdinand is preferred because it is easier to work with in the field than the Styroblock.

3. The best substrate for ease of packing, handling, and survival is a 1:1:1 (dry weight basis) mixture of peat, vermiculite, and soil.

4. Some effort should be made to control animal damage. There is usually a higher damage to containerized stock than to nursery stock.

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