Research Report

BIODEGRADABLE CONTAINERS
FOR USE IN REVEGETATION OF
HIGHWAY RIGHT-OF-WAY

Public Transportation and Planning Division

No. WA - RD - 41.1

Washington State
Department of Transportation

In cooperation with
U. S. Department of Transportation
Federal Highway Administration

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
WA-RD-41.1		

4. Title and Subtitle	5. Report Date
BIODEGRADABLE CONTAINERS FOR USE IN REVEGETATION OF HIGHWAY RIGHT-OF-WAY	July 1981
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Russell N. Rosenthal and John M. Wirsing	
9. Performing Organization Name and Address	10. Work Unit No.
Highway Development, Location-Design, Highway Administration Building, Olympia, Washington 98504. Washington Department of Natural Resources, Forest Land Management Center, 9701 Blomberg St. S.W., Olympia, WA	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Washington State Transportation Commission Highway Administration Building Olympia, Washington 98504	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Study conducted in cooperation with the U.S. Department of Transportation Federal Highway Administration

16. Abstract

Experiments were conducted at four locations to determine if plants grown in biodegradable tube containers or standard types of containers would have higher survival rates than bare root grown plant material. Season of planting was also evaluated. Results indicated that bare root grown plant material had higher survival rates than container grown material. Spring planting was more successful than fall planting.

17. Key Words	18. Distribution Statement
Biodegradable containers; Landscape plant establishment; plant survival; tubelings.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
unclassified	unclassified		

Form DOT F 1700.7 (8-69)
HWY FORM 341-004 6/72

FINAL REPORT

July 1981

BIODEGRADABLE CONTAINERS

For Use In

REVEGETATION ON HIGHWAY RIGHT-OF-WAY

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

prepared in cooperation with the

U.S. Department of Transportation

July 1981

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SUMMARY

Experiments were conducted at four locations to determine the effectiveness of biodegradable tubes, standard tubes, milk cartons, and four inch fiber pots to increase survivability over bare root grown plant material. Fall vs. spring planting was also evaluated.

Douglas fir, ponderosa pine, big leaf maple, Douglas spirea, and burnet were propagated during the spring and summer of 1977. They were planted in the field during the spring and fall of 1978.

Results showed that survival was highest for spring planted material. In sites that had the coldest winters there was a larger difference in survival between spring and fall planted material. Bare root grown material had better survival than did container grown material.

CONCLUSIONS and RECOMMENDATIONS

1) Generally, spring plantings had higher survival rates than did fall plantings. In areas where winters are the coldest, such as Cle Elum and Republic, the difference in survival rates between spring and fall plantings was the greatest. Port Townsend, which had the mildest winters of the four sites studied, had the best survival rate from a fall planting. Recommendations- unirrigated liner plantings should be made in the early spring.

2) Bare root grown plant materials had higher survival rates than did materials grown in biodegradable tubes, styro-block tubes, milk cartons, or fiber pots. Recommendations - use bare root grown plant materials for unirrigated liner plantings.

IMPLEMENTATION

The recommendations proposed in this study will be incorporated into the design process of future revegetation projects. This should increase plant survival rates which will enable less materials to be planted. Since fewer plant materials will be required the potential benefits from implementing these results will be a decrease cost per project. The results of this study will be incorporated into the Department of Transportation Design Manual.

INTRODUCTION

For many years liner plant materials have been used along highway right-of-way for revegetation purposes in suburban and rural areas. Initially, bare root plants were used. Practices similar to those used successfully by the timber industry for revegetation of clear cuts were followed. Because the growing conditions along the highway are more severe than those occurring in a clear-cut area, and because the types of plant materials used are much more extensive than the monoculture reforestation program used by the timber industry, the Department initiated a research project in 1970 entitled "Vegetative Cover for Highway Rights-of-Way." The purpose of the project was to evaluate the impact of various micro-climates on the survival of bare root liners. The result of this project showed that north and west exposures had better plant survival rates than did south and east exposures. The highest survival rates obtained were in the range of 40-50% for evergreen plant materials, and 25-30% for deciduous plant materials (Rosenthal 1976). During the course of this project, the timber industry began using tubeling grown plant materials to increase plant survival.

Then biodegradable tube containers became available. A biodegradable container is one which will decompose when exposed to warm temperatures and moisture. This type of container appears to have the following advantages over conventional type containers:

1) The plant material root system is never exposed to the air. This will reduce planting shock and thereby increase plant survival.
2) The planting process is reduced by two steps: removal of the plants from the container, and collection of the empty containers.
3) The cost of the biodegradable containers plus soil mix is about equal to non-biodegradable containers plus soil mix.

4. The speed of the biodegradation process can be regulated during container manufacture. At the present time, the programmed biodegradation range is between 6 and 24 months.

The Department of Transportation has utilized peat pot containers, a biodegradable product. These containers were used in irrigated areas. The shell design of the peat pot made it impractical to use in unirrigated areas because survival of plant materials is dependent upon the pot being surrounded by natural soil moisture, which is lost to the plant during dry periods of the year. With a tubeling container, the root system is deeper in the soil, where moisture is likely to be retained longer than at the depths at which peat pots are planted. Biodegradable tube containers should provide an even higher rate of plant survival than the non-biodegradable tube.

This project was set up as a cooperative study between the Washington State Department of Transportation and the Washington State Department of Natural Resources in 1977 to evaluate the use of biodegradable containers for revegetation of disturbed areas.

LITERATURE REVIEW

During the highway construction process large cut and fill slopes are produced; as these slopes are seeded to produce a thick stand of grass which effectively controls soil erosion. Due to competition, these grass stands, also slow down the process of natural revegetation of trees and shrubs. The most effective way of establishing trees and shrubs is to plant them. Studies have shown that the major factors affecting the survival and growth of seedlings are those which influence soil moisture. These studies have reported that intensity of sunlight influences soil temperature, which in turn influences soil moisture (Hursh 1949, Wang 1953, and Cooper 1961 and Rosenthal 1976). In arid areas shrubs have been shown to be useful in soil stabilization (Horton 1949, Plummer 1974, McArthur et.al. 1974, McKell 1975 and Tiedemann et.al. 1976). Shrub plantings in disturbed areas have also been used for reestablishing wildlife habitat (Holgren 1952 and 1956, Hubbard 1956 and Brown 1959). All of these studies have used bare root grown plant materials. More recent studies have indicated that tubeling grown plants have been useful for revegetating disturbed land (Colby 1973, Hodder 1971 and Rosenthal 1977).

OBJECTIVES

The objectives of the research project were:

1. To evaluate the survival of rooted cuttings or seedlings of trees and shrubs on highway rights-of-way and pit sites.

2. Compare effectiveness of bare root grown material with biodegradable tubeling and standard types of container grown material.

EXPERIMENTAL PROCEDURES

The experimental procedures consisted of two parts: progagation and planting.

Propagation. During the spring and summer of 1977 plant materials were propagated at the Department of Natural Resources facility at Bellingham. Seed from Douglas fir (Psedotsuga menziesii), Ponderosa pine (Pinus ponderosa), and Burnet (Sanguisorba occidentalis), and rooted cuttings from Douglas spirea (Spiraea douglasii) and big leaf maple (Acer macrophyllum) were planted into biodegradable tubes (PCL), styro-block tubes, four inch fiber pots, quart milk cartons, and the field. Figure 1 shows the containers used in the study. The fir seed was collected from seed zone[y] Numbers 412 and 012 and the pine seed from zone 642. The PCL tubes were donated by Union Carbide Corporation, Terrytown, New York.

Planting. During the spring and fall of 1978 plantings were made at four unirrigated locations around the state. Figure 2 shows these locations. The Nisqually site located along the northbound lane of Interstate 5 at Mile Post 113.39. The site was on a north facing 2:1 slope.

The Port Townsend site was located on a west facing 2:1 slope on SR 101 at Mile Post 283.73. The Cle Elum site was located along Interstate 90 on a south facing 2:1 slope at Mile Post 80.22. The Republic site was located in a pit site next to SR 20 at Mile Post 295.08. This site was on a 3:1 north facing slope. The PCL tubes and milk cartons were planted with the plant materials. Plant materials were removed from the fiber pots and styro-block tubes before planting. Planting was accomplished in the same manner as specified on State Department of Transportation revegetation projects. The planting process is outlined in Appendix A.

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y Seed zones established by the Western Forest Tree Seed Council 1973

Data Collection. Standard methods were used to make survival and growth comparisons between containerized and bare root stock (Owston and Stein 1974).

All plantings were made in a random order with two replications. Each replication had twenty-five plants per treatment. For each treatment (container and bare root grown materials) percent survival, height, caliper, air dried root and top weight and vigor data were taken.

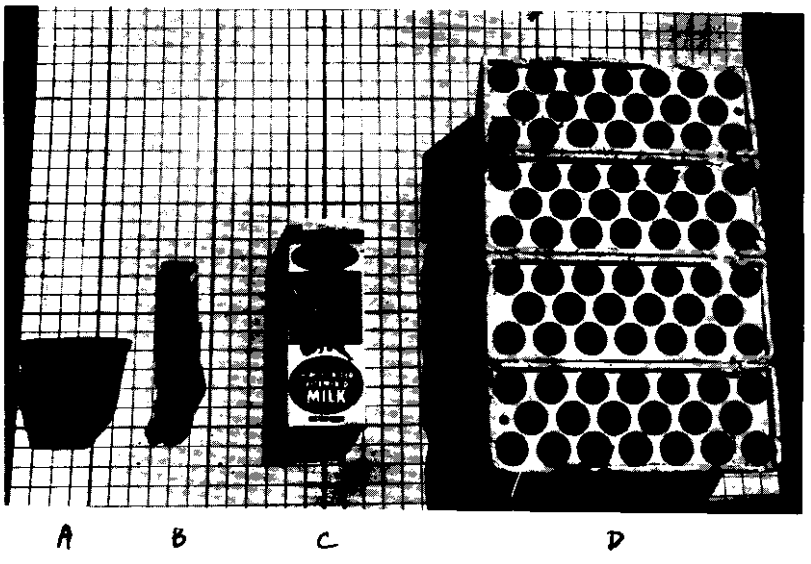

Figure 1. Examples of containers used in study.

A) Fiber pot, 4" (10.1 cm) side width x 4" (10.1 cm) depth.

B) PCL - biodegradable tube, 1 5/8" (4.2 cm) diameter hexagon x 9" (22.9 cm) depth.

c) Milk carton, 3 5/8" (9.2 cm) side width x 7 5/8" (19.4 cm) depth.

D) Styro-block, containing eighty cavities, each measuring 1.5" x 6.25" (2.75 cm x 15.63 cm) top diameter and depth respectively.

The plant vigor rating was a visual assessment of plant vigor on a scale of one to ten with ten being the highest rating. Analysis of variance was conducted on all data, except survival, and Duncan's multiple range test was applied where significant differences were indicated.

In all tables, unless otherwise noted, means within columns followed by the same letter are not significantly different at the 1% level.

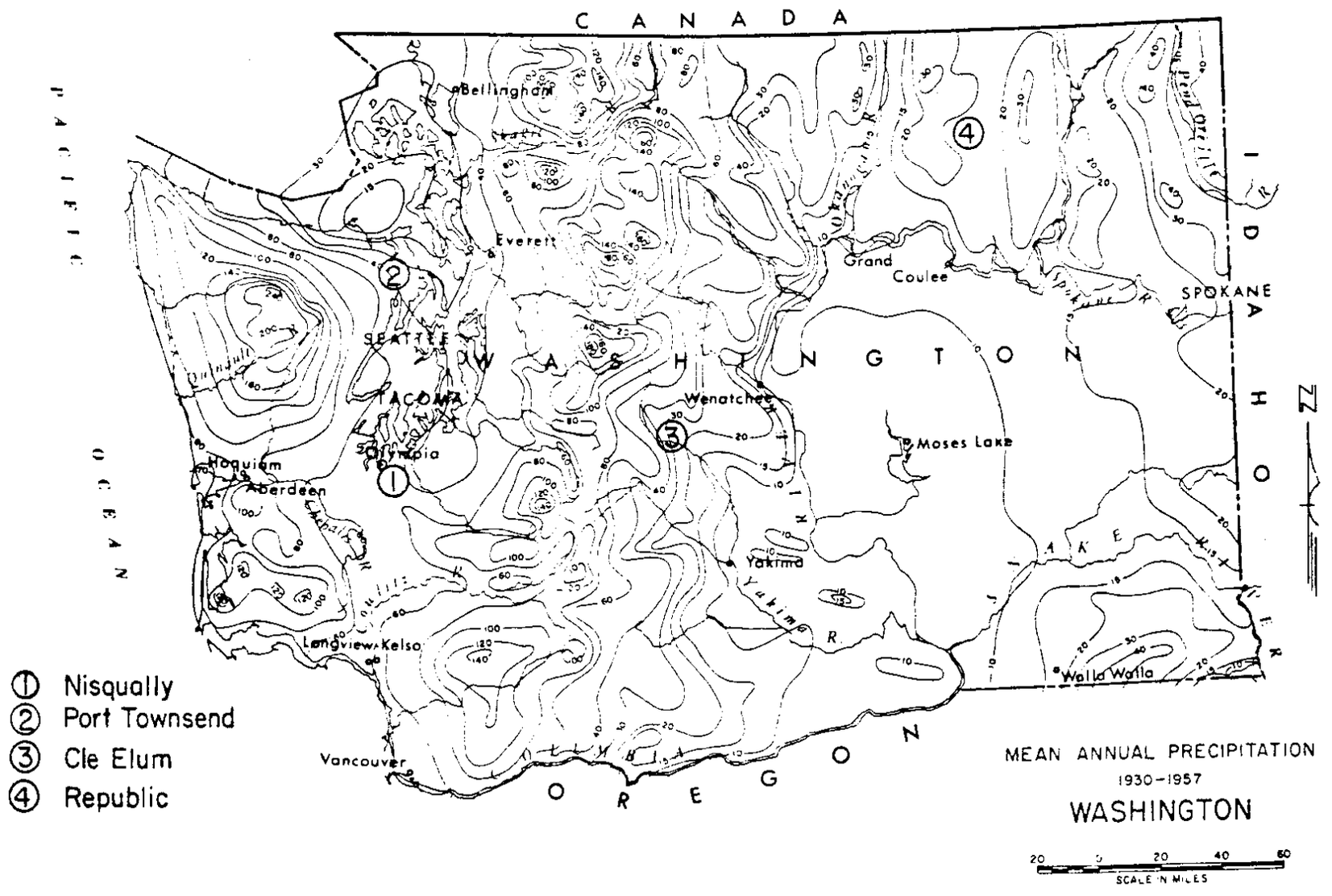

Figure 2. Map of Washington State showing location of experiments.

RESULTS

Spring planted materials had higher survival rates than fall planted materials at Nisqually, Republic and Cle Elum (Table 1). The reverse was the case for Port Townsend. Spring planted bare root grown Douglas fir and Ponderosa Pine survival was equal to or better than PCL, fiber pot, styro or milk carton grown materials.

Nisqually. After three years' growth, Douglas fir grown bare root was significantly taller than plants grown and planted in milk cartons for spring and fall plantings (Table 2). Vigor ratings after three years were statistically equal for bare root, PCL, fiber pot, and the styro-block (Table 2). Fall planted Douglas spirea which were grown in the styro-block had significantly lower heights and lower root weights after three years than did those with other treatments (Table 3).

Figure 3 shows the root system development after three years' growth for Douglas spirea planted bare root and in the PCL biodegradable tube, milk carton, and fiber pot.

After three years' growth, caliper readings, root weights, and vigor readings for spring planted Ponderosa pine were significantly larger for the bare root and fiber pot treatments (Table 4).

Table 1. Percent survival of plant material for Nisqually, Republic, Port Townsend, and Cle Elum.

		Percent Survival									
		Fall Planted					Spring Planted				
LOCATION	SPECIES	Bare Root	PCL	Fiber Pot	Styro	Milk Carton	Bare Root	PCL	Fiber Pot	Styro	Milk Carton
NISQUALLY	Douglas fir	60	-	8	-	54	92	90	92	94	68
	Ponderosa Pine	100	-	50	4	43	100	96	96	95	78
	Burnet	-	-	52	-	45	-	-	-	-	-
	Douglas spirea	38	71	18	46	70	48	-	90	8	98
REPUBLIC	Douglas fir	-	-	-	-	-	90	86	82	80	56
	Ponderosa Pine	8	4	18	2	6	90	96	94	96	82
	Burnet	10	28	2	18	9	64	-	91	-	82
PORT TOWNSEND	Douglas fir	68	8	24	26	10	12	10	16	22	42
	Big Leaf Maple	62	24	10	4	46	-	-	-	-	-
	Burnet	74	68	54	68	78	16	53	46	-	82
CLE ELUM	Ponderosa Pine	10	-	12	-	-	46	12	36	8	10
	Burnet	-	4	2	2	2	-	48	22	4	26

y The species that were planted at the various locations were selected as to their potential to survive based on past experience. Therefore, all sites were not planted with the same species. Plants were used as indicators to compare bare root grown material to material grown in various types of containers.

Table 2 . Height, caliper, root weight, top weight, and vigor ratings for fall and spring planted Douglas fir. Nisqually.

Container Type	Fall Planted		Spring Planted		
	Av. Height (cm) 3 yr.	Av. Caliper (mm) 3 yr.	Av. Height (cm) 3 yr.	Av. Caliper (mm) 3 yr.	Av. Vigor at 3 yr.
Bare root	44.6 a[z]	6.8 b	45.2 a	8.6 a	6.6 a
PCL	-	-	38.2 ab	6.6 bc	6.4 a
Fiber Pot	32.8 ab	9.8 a	35.2 b	5.6 c	6.3 a
Styro	-	-	43.0 ab	7.3 ab	7.2 a
Milk Carton	21.5 b	4.3 c	22.1 c	2.8 d	3.1 b

[z] means within a column followed by the same letter are not significantly different at the 1% level as determined by Duncan's multiple range test.

Table 3. Height, root weight, and top weight of fall planted Douglas Spirea. Nisqually.

Container Type	Average Height (cm) at 3 years	Average Root Weight (gms) at 3 years	Average Top Weight (gms) at 3 years
Bare Root	47.9 a[z]	10.1 b	8.9 b
PCL	40.1 a	6.2 bc	5.3 bc
Fiber Pot	48.8 a	23.4 a	15.6 a
Styro	26.9 b	2.2 c	2.1 c
Milk Carton	47.4 a	10.8 b	6.6 b

[z] means within a column followed by the same letter are not significantly different at the 1% level as determined by Duncan's multiple range test.

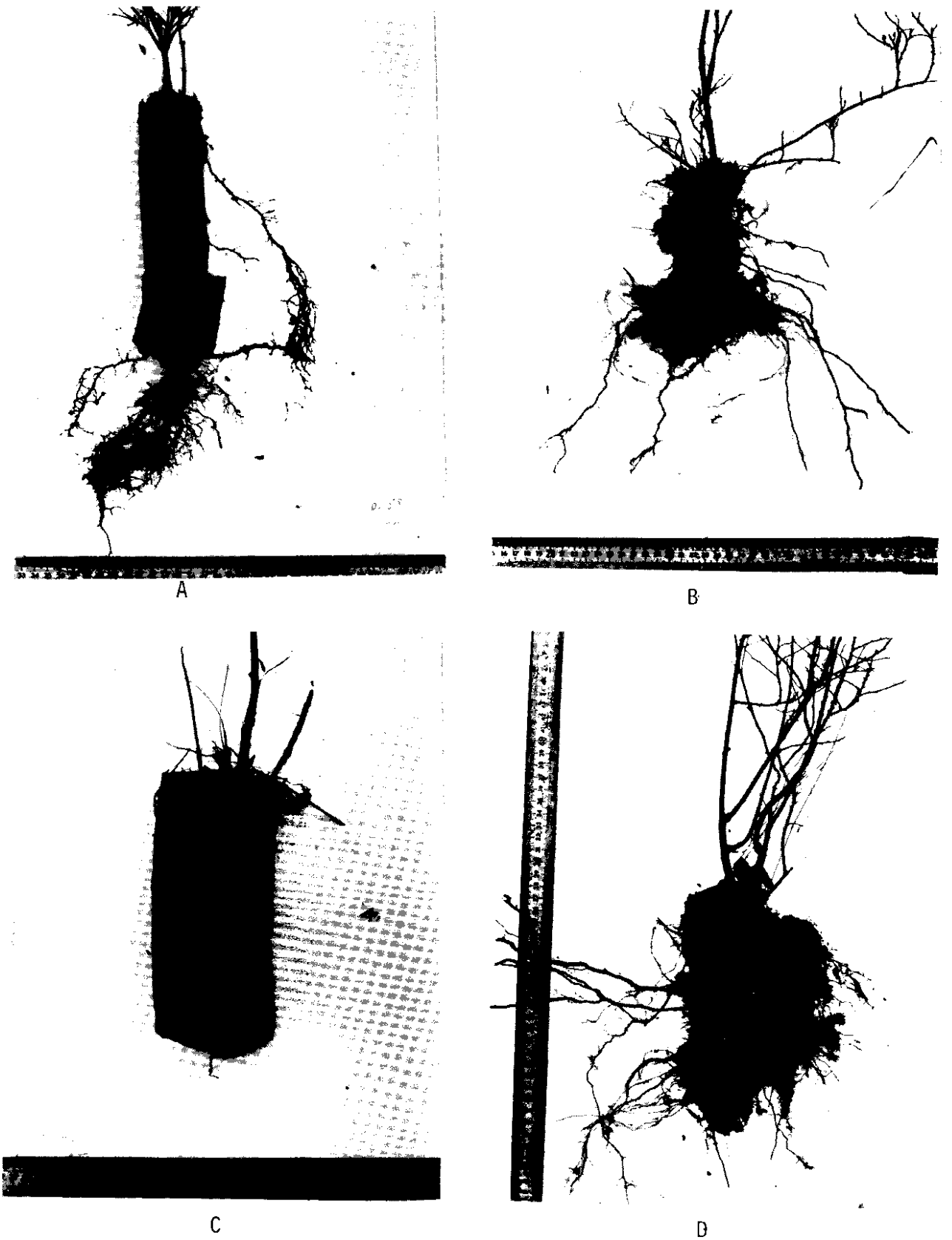

Figure 3. Example of root system development after three years growth for spring planted Douglas Spirea.

Nisqually. A) PCL B) Bare root C) Milk Carton D) Fiber pot

Table 4 . Height, Caliper, Root Weight, Top Weight, and Vigor Ratings for Spring and Fall Planted Ponderosa Pine. Nisqually.

Container Type	FALL PLANTED					SPRING PLANTED				
	Av. Height (cm) at 3 years	Av. Caliper (mm) at 3 years	Av. Root Wt (gms) at 2 years	Av. Top Wt. (gms) at 2 years	Av. Vigor at 3 years	Av. Height (cm) at 3 years	Av. Caliper (mm) at 3 years	Av. Root Wt. (gms) at 2 years	Av. Top Wt. (gms) at 2 years	Av. Vigor at 3 years
Bare Root	28.0 a[z]	8.0 b	5.9 b	14.4 b	6.0 a	35.8 a	7.6 a	9.9 a	34.7 a	7.7 a
PCL	-	-	-	-	-	19.5 c	4.0 c	3.8 c	11.4 c	4.1 c
Fiber Pot	31.1 a	11.1 a	12.8 a	25.6 a	6.6 a	24.7 b	7.2 a	8.9 a	26.8 ab	7.4 a
Styro	21.0 ab	6.0 bc	-	-	4.0 ab	23.0 bc	5.4 b	6.5 b	23.1 b	5.3 b
Milk Carton	15.6 b	4.2 c	2.5 b	4.6 c	3.5 b	12.3 d	2.1 d	2.0 c	4.2 c	3.2 c

[z] means within a column followed by the same letter are not significantly different at the 10% level as determined by Duncan's multiple range test.

Republic. After three years' growth, spring planted Douglas fir grown bare root was significantly taller and had significantly higher vigor ratings than did those with the other treatments. Caliper readings, root weight, and top weights for spring planted Douglas fir grown bare root and in fiber pots were significantly better than were those with the other treatments (Table 5). The height of spring planted ponderosa pine grown in PCL and fiber pots were significantly better than were those with the other treatments which had similar readings (Table 6).

Table 5. Height, Caliper, Root Weight, Top Weight, and Vigor Ratings for Spring Planted Douglas Fir. Republic.

Container Type	Av. Height (cm) at 3 years	Av. Caliper (mm) at 3 years	Av. Root Wt. (gms) at 2 years	Av. Top Wt. (gms) at 2 years	Av. Vigor at 3 years
Bare Root	33.6 a[z]	4.6 a	4.8 a	10.5 a	4.9 a
PCL	21.1 b	2.3 c	2.2 b	4.9 b	3.0 b
Fiber Pot	22.7 b	4.4 a	5.9 a	9.3 a	3.1 b
Styro	14.4 c	3.5 b	2.1 b	4.2 b	3.1 b
Milk Carton	11.9 c	2.3 c	1.6 b	3.1 b	3.1 b

[z] means within a column followed by the same letter are not significantly different at the 10% level as determined by Duncan's multiple range test.

Table 6. Height, Caliper, Root Weight, Top Weight, and Vigor Ratings for Spring Planted Ponderosa Pine. Republic.

Container Type	Av. Height (cm) at 3 years	Av. Caliper (mm) at 3 years	Av. Root Wt. (gms) at 2 years	Av. Top Wt. (gms) at 2 years	Av. Vigor at 3 years
Bare Root	14.7 b[z]	4.3 b	3.5 b	6.1 c	4.2 b
PCL	19.5 a	4.3 b	3.5 b	9.4 bc	5.9 a
Fiber Pot	19.7 a	7.0 a	6.4 a	13.8 a	5.7 a
Styro	15.5 b	3.2 c	2.6 b	6.0 c	5.0 ab
Milk Carton	13.4 b	4.1 b	3.7 b	9.9 b	5.0 ab

[z] means within a column followed by the same letter are not significantly different at the 10% level as determined by Duncan's multiple range test.

Port Townsend. Bare root grown fall planted Douglas fir had significantly higher recordings for height, caliper, root weight, top weight, and vigor than those with the other treatments (Table 7). Fall planted big leaf maple showed similar results (Table 8).

Table 7. Height, Caliper, Root Weight, Top Weight, and Vigor Ratings for Fall and Spring Planted Douglas Fir. Port Townsend

Container Type	Av. Height (cm) at 3 years	Av. Caliper (mm) at 3 years	Av. Root Wt. (gms) at 2 years	Av. Top Wt. (gms) at 2 years	Av. Vigor at 3 years
Bare Root	60.4 a[z]	10.8 a[z]	20.5 a[z]	50.2 a[y]	6.9 a[z]
PCL	25.0 b	3.8 b	-	-	3.0 b
Fiber Pot	32.1 b	4.8 b	5.1 b	10.2 b	4.1 b
Styro	19.1 b	3.3 b	3.1 b	5.4 b	2.6 b
Milk Carton	27.6 b	5.6 b	-	-	4.0 b

z means within a column followed by the same letter are not significantly different at the 1% level as determined by Duncan's multiple range test.

y means within a column followed by the same letter are not significantly different at the 5% level as determined by Duncan's multiple range test.

Table 8. Root Weight and Top Weight for Fall Planted Big Leaf Maple. Port Townsend.

Container Type	Average Root Weight (gm) at 2 years	Average Top Weight (cm) at 2 years
Bare Root	19.5 a[z]	16.0 a[z]
PCL	4.9 b	3.7 b
Fiber Pot	-	-
Styro	-	-
Milk Carton	7.1 b	4.8 b

[z] means within a column followed by the same letter are not significantly different at the 1% level as determined by Duncan's multiple range test.

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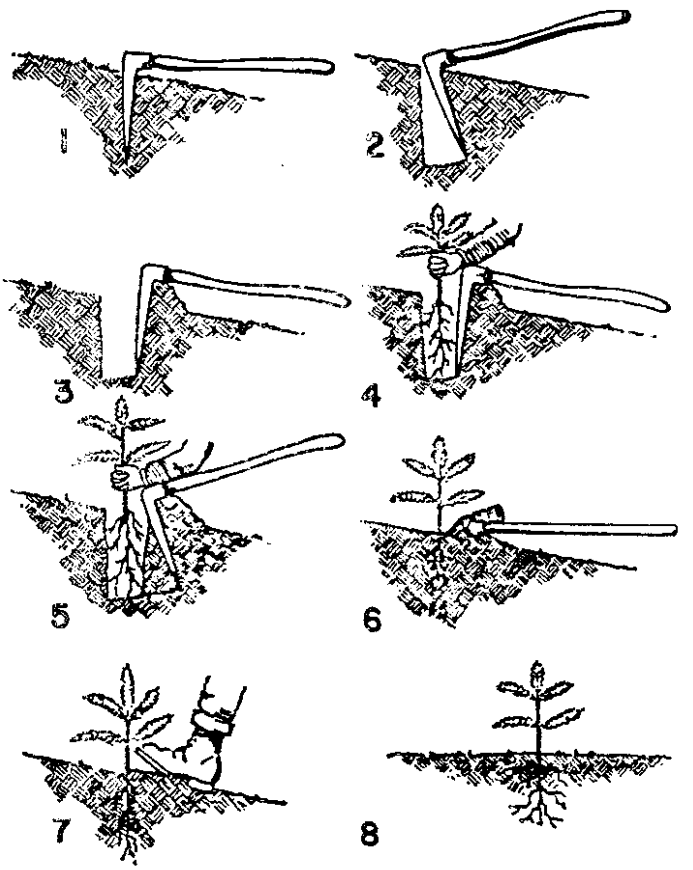
Appendix A

Planting procedures used in this study

THE EIGHT STEPS OF PLANTING



Front view of planted material

BARE ROOT **STYRO, PCL** **FIBER POT** **MILK CARTON**

y Plant material grown in fiber pots and styro-blocks were removed from these containers before planting. The materials grown in PCL and milk cartons were not removed before planting.