



Forest Research Branch

Progress Report

A FIELD TEST OF BULLET
PLANTING IN ALBERTA

Project A-105

by

R. F. Ackerman

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INTRODUCTION

In 1962, 1963 and 1964 the Alberta Department of Lands and Forests, North Western Pulp and Power Ltd., Alberta Department of Agriculture and the Department of Forestry co-operated in the establishment of a series of experiments to assist in the development of container planting (Walters, 1961, 1963; McLean, 1959) as a regeneration method in Alberta. The experiments were designed to answer the following questions.

1. Is survival and growth of bullet-planted stock sufficiently good to warrant further development of the technique?
2. Is the method applicable to a variety of sites and seedbeds?
3. Can bullet planting be successfully employed throughout the frost-free season?

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4. What minimum age of stock will give a reasonable level of survival?

5. What is the best type of container?

The economic feasibility of bullet planting, or mass culture of container-grown seedlings is not directly investigated in this study. However, the possibility of continuous planting throughout the frost-free season and the rate of turnover at the nursery, as controlled by the age of stock, have a direct bearing on this question. Economic assessment will, of course, be necessary but uncertainties surrounding the choice of container and culture methods and the probability of rapidly changing techniques renders economic assessment of limited value at the present time.

The advantages of bullet planting over conventional, exposed-root planting and preliminary results of the 1962-63 experiments have been described in a previous report (Ackerman et al, 1964). The present report describes the results to September, 1964 and introduces the experiment initiated during the 1964 field season.

METHODS AND MATERIALS

Description of the Area, Site and Climate

The experiments are located in the Upper Foothills Section of the Boreal Forest Region of west-central Alberta (Rowe, 1959), on the western portion of the pulpwood lease area of Northwestern Pulp and Power Ltd., Hinton, Alberta. Characteristic topography in the experimental area is a series of high hills (4,000-6,000 feet) underlain by sandstone bedrock. Soils are generally light textured, of glacial or fluvial origin and show podzolic development.

All experimental areas are located on 10-chain clear-cut strips or large clear-cut blocks which carried either pure even-aged merchantable white spruce (Picea glauca (Moench) Voss var. albertiana (S. Brown) Sarg.) or lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) of fire origin.

The significant features of each location planted in 1962, 1963 and 1964 are shown in Table 1.

The planting areas are fairly representative of site conditions found in the Foothills Section, particularly of those found on light-textured till materials. Surface soil moisture varies from very dry to moist. Surface organic horizons vary from a thin mor on the drier locations to 6 inches of feather moss and raw humus on the more moist locations. Important sites found on the lease area that have not been planted would include various moisture regimes on heavy tills, aeolian deposits and lacustrine deposits.

Table 1. Description of Planting Locations

Item	1962 Planting	1963 Planting			1964 Planting	
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Cover type	lodgepole pine	lodgepole pine	white spruce	white spruce	lodgepole pine	lodgepole pine
Productivity Cords/acre	60	30	40	40	70	30
Logging date	1957-58	1960-61	1956-57	1961-62	1961-62 1963-64	1960-61 1963-64
Seedbed Treatment	Scarified	Scarified Undisturbed	Scarified Undisturbed	Scarified Undisturbed	Scarified Undisturbed	Scarified Undisturbed
Topographic Position	Top and upper slopes of secondary ridge	Mid-upper slope- main relief	Main valley bottom	Plateau top- main relief	Mid slope- main relief	Mid slope- main relief
Slope	0-15%	20%	Nil	3%	15%	15-25%
Aspect	N. and S.	S.20° W.	Nil	N.30° E.	N.20° E.	S.
Exposure	Variable	Exposed	Normal	Normal	Protected	Exposed
Soil Origin and Fabric	Sandy loam till	Sandy loam till	Coarse alluvium	Stony, sandy loam till	Sandy loam till	Sandy loam till
Depth to Water table	-	-	-	6'	-	-
Depth to Bedrock	6'	3-4'	-	-	4'	3-4'
Depth of Organic Horizons	3"	1"	1-2"	6"	3"	1"
Soil Moisture	Fresh	Dry	Dry	Moist	Fresh	Dry

Vegetative competition is not considered a severe problem to regeneration after logging in this area. The sites vary in this regard from a light herbaceous and grass cover on the dry sites to a fairly rich shrub and grass cover on the fresh sites, and include a deep feather moss on Site 4. With the possible exception of the deep moss the vegetative cover is considered advantageous on most areas because it provides much needed shelter for seedlings on the completely exposed clear-cut area.

Mean temperature and precipitation for the Hinton area during the summer months of 1962, 1963 and 1964 are given in Table 2. Since there are no long-term weather records available for Hinton, long-term averages and 1962, 1963 and 1964 data are also shown for Edson, approximately 50 miles east of Hinton.

Table 2. Mean Temperature and Precipitation - 1962, 1963 and 1964

Location	Year	Mean Temp. ° F.				Precipitation - inches				
		May	June	July	Aug.	May	June	July	Aug.	Total
Hinton	1962	45	54	57	56	2.22	2.62	3.48	1.83	10.15
	1963	46	53	59	59	1.12	0.28	2.59	3.24	7.23
	1964	46	55	58	54	2.18	2.91	2.16	2.87	10.12
Edson	1962	46	55	58	57	3.60	2.00	6.60	2.80	15.00
	1963	46	55	60	59	1.30	0.80	2.19	2.52	6.81
	1964	47	55	60	56	2.74	3.54	5.14	2.83	14.25
	Long-term	48	54	60	57	1.52	3.15	3.21	2.97	10.85

The climate of the region is characterized by winter-low, summer-high precipitation, with 2 to 3 inches each month of June, July

and August. The 1962 and 1964 seasons were moist, with frequent and abundant precipitation during all months. The 1963 season was relatively dry owing to somewhat low precipitation during most months but most particularly during June. The drought condition during June, 1963, preceded by a relatively dry May, is of particular interest.

Experimental Design

1962 Planting

The primary objective in the 1962 planting was to determine the effect of age of seedling and month of planting on survival. Accordingly, the following treatments were applied for white spruce and lodgepole pine on each of a north, level and south aspect of a secondary ridge that had been previously clearcut and scarified (Table 1, Site 1).

<u>Month of Planting</u>	<u>Age of Seedlings (Weeks from Seeding)</u>					<u>Transplants</u>
May 15	4					1-0
June 15	-	8				1-0
July 15	4	8	12			1-0
Aug. 15	4	8	12	16		1-0
Sept. 15	4	8	12	16	20	1-0

Although an orthogonal design would have been preferred, there was not sufficient time to produce the older seedlings for spring planting.

For each species a block containing 20 cells was located on each of the north level and south aspects of the site. The 20, age x planting month treatments were assigned randomly to the cells in each block. Block location and cell treatment for the 1962 experiment are shown in Appendix 1.

It was originally intended to set out 100 seedlings, at a minimum spacing of one foot, in each cell. This objective was not attained for a number of treatments because of germination and survival failures at the nursery. It was also intended that one-half of the seedlings in each cell should be placed in a mineral soil seedbed and the other half in undisturbed organic seedbed. This procedure was not effective for in some cells scalping or digging was required to obtain mineral soil, resulting in subsequent smothering of seedlings in the depressions. In other cells truly undisturbed organic seedbed was absent.

All stock in the 1962, 1963 and 1964 experiments was provided by the Provincial Tree Nursery of the Alberta Department of Agriculture, from seed of Hinton origin. The seedlings used in 1962 and 1963 were germinated in the containers in the nursery greenhouse under a misting system and then moved outside to sheltered flats until needed. The 1-0 stock was lifted from the nursery seedbeds and transplanted into the bullets in the spring and used throughout the summer as required.

The stock was small but well formed and of good color (Figures 1, 2 and 3).

The plastic bullet developed by Walters (1961) was used in the 1962 planting. This is molded styrene plastic, 1/16 inch thick, and measures 2 1/3 inches long by 7/8 inches outside diameter. The wall of the bullet is weakened by a narrow slit extending from the rim to a single hole near the tip (Figure 1).

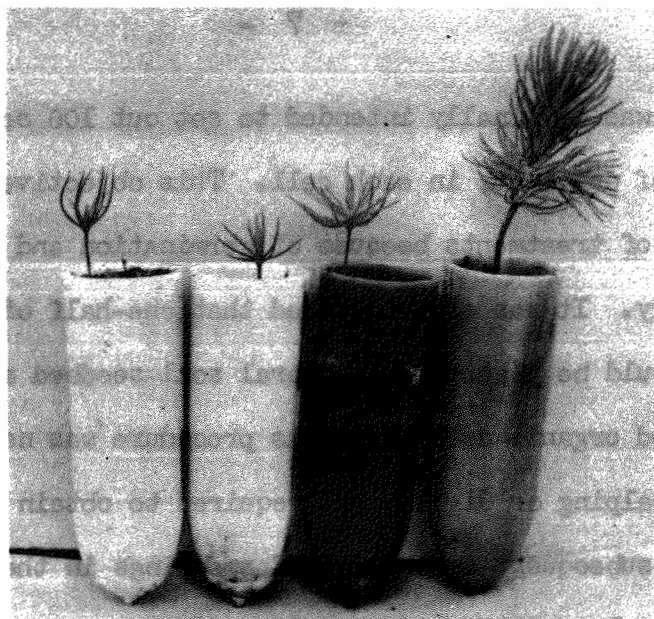


Figure 1. White spruce seedlings used in 1962 planting. Ages from left to right, 4 weeks, 8 weeks, 12 weeks and 1-0 transplants x 3/5.

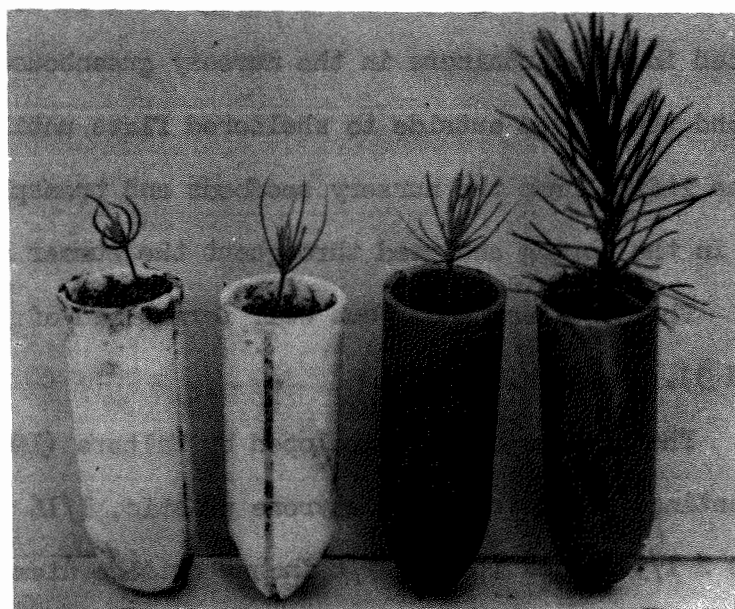


Figure 2. Lodgepole pine seedlings used in 1962 planting. Ages from left to right, 4 weeks, 8 weeks, 12 weeks and 1-0 transplants. x 3/5.

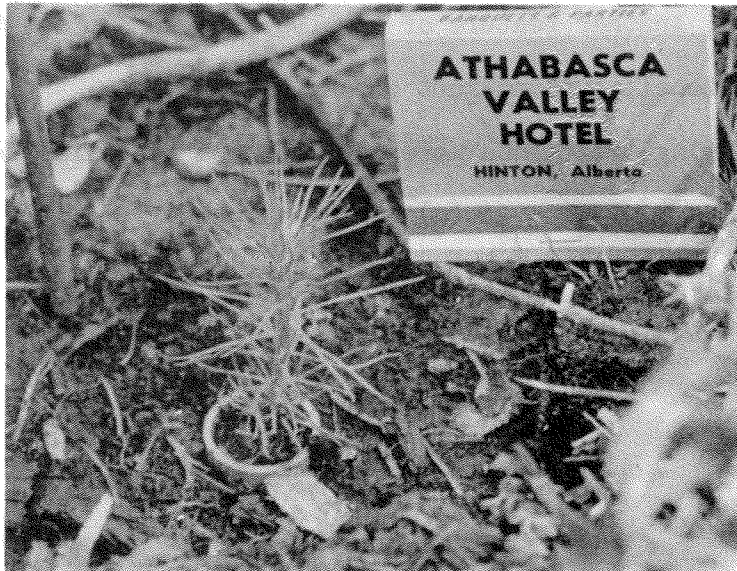


Figure 3. 1-0 lodgepole pine transplant set out in mineral soil seedbed - 1962 planting.

The soil used in the bullets in 1962 and 1963 was a nursery loam, capped with a sand mulch. No nutrients were added to the soil or irrigation water.

Planting in all experiments was accomplished with a dibble or punch designed to make a hole in the ground of a size and shape to accommodate the container.

Tallies of seedling survival were made once each month during 1962, in the spring and fall of 1963 and the fall of 1964.

1963 Planting

The 1963 planting was essentially an improved repetition of the 1962 experiment. However, an orthogonal, factorial design was

practical and it was possible to include a broader spectrum of site and seedbed conditions. Another feature of the 1963 experiment was the inclusion of 2-0 conventional, exposed-root stock.

The following treatments were applied in a factorial design.

1. Species
 - (a) white spruce
 - (b) lodgepole pine
2. Site
 - 3 sites (see Table 1)
3. Seedbed
 - (a) scarified
 - (b) not scarified
4. Month of planting
 - (a) June 1-7
 - (b) July 1-7
 - (c) August 1-7
 - (d) September 1-7
5. Age of Seedlings
 - (a) 8 weeks from seed-grown and
planted out in bullets
 - (b) 16 weeks from seed-grown and
planted out in bullets
 - (c) 1-0 seedlings transplanted
into bullets
 - (d) 2-0 conventional, exposed-root
stock

A block containing 36 cells was located on each site x seedbed unit (a total of 6 blocks). The 32, species x age of stock x planting month treatments were assigned randomly to the cells in each block.

Block locations and cell treatment are shown in Appendix 2.

The 1963 experiment was repeated on scarified and undisturbed areas. In both cases an attempt was made to place seedlings in situations that appeared to offer the best chance of survival, while maintaining a reasonable spacing. Thus, on the scarified areas advantage was taken, wherever possible, of favorable seedbed conditions created by that treatment, while on undisturbed areas the majority of seedlings were placed in undisturbed organic seedbed.

It was intended to plant 50 seedlings within each cell, at a spacing of approximately 4 feet. However, as in the 1962 planting, this objective was not achieved in all treatments owing to germination and survival failures at the nursery.

The container used in the 1963 planting was a slightly modified version of the 1962 bullet. The dimensions and material were the same but the thickness of the plastic shell was reduced to 1/20-inch and three additional holes were added near the tip.

Seedling culture techniques in 1963 were essentially the same as in 1962. One notable difference, that is reflected in the survival results, applies to the 1-0 transplants. In 1962 this stock was transplanted in early spring and was well established in the containers before planting out. This practice was not followed for all planting months in 1963 and in some cases the stock was not established in the container before planting out.

The 1963 container-grown stock was generally of very poor quality

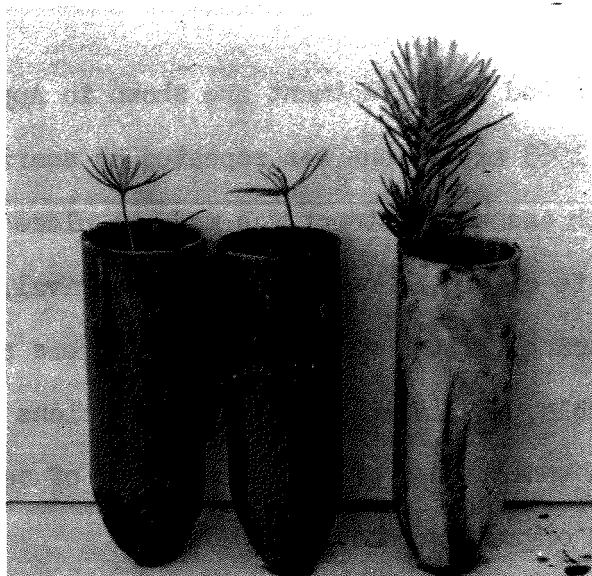


Figure 4. White spruce seedlings used in 1963 planting. From left to right 8 weeks, 16 weeks and 1-0 transplants. x 3/5.

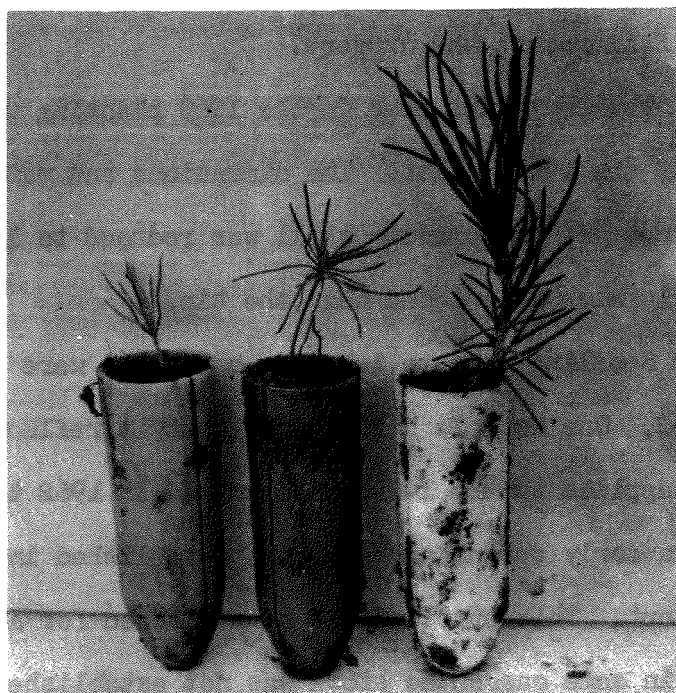


Figure 5. Lodgepole pine seedlings used in 1963 planting. From left to right 8 weeks, 16 weeks and 1-0 transplants. x 3/5.

(Figures 4 and 5). Seedlings were small, poorly formed and in some months there was little or no distinction in size between 8-week and 16-week seedlings.

The 2-0 conventional stock was lifted as required and taken to the planting site with as little delay as possible. Nevertheless, adoption of this practice resulted in the lifting and planting of actively growing stock during the months of June and July. Cold storage was considered as an alternative and rejected because of the long period of storage that would have been required and because of the unsatisfactory results of previous attempts at cold storage with the stock and facilities then available.

The 2-0 stock was set out with a planting bar, the method currently in use in the area.

Tallies of seedling survival were made once each month during 1963 and in the spring and fall of 1964.

1964 Planting

In both the 1962 and the 1963 plantings it was recognized that the plastic container used may not have been the most suitable in material and design. The main objective in the 1964 experiment was to field test a variety of container materials and designs.

A factorial experiment in a randomized block design with two replications of 50 seedlings was chosen.

The factors included were:

- | | |
|-------------------|-------------------------------------|
| 1. Species | (a) white spruce |
| | (b) lodgepole pine |
| 2. Planting month | (a) June |
| | (b) August |
| | (c) September |
| 3. Containers | 6; of varying designs and materials |
| 4. Seedbed | (a) scarified |
| | (b) not scarified |
| 5. Site | 2 sites (see Table 1) |

Two replicate blocks, each containing 36 cells were located on each of the 4 site x seedbed units (a total of 8 blocks). The 36, species x planting month x container treatments were assigned randomly to the cells in each block. Block locations and cell treatment for the 1964 planting are shown in Appendix 3.

The six containers used in the 1964 planting and the containers employed in the 1962 and 1963 planting are shown in Figure 6 and described in Table 3.

The 1964 stock was grown in a greenhouse in a sand and peat moss mixture, by sub-irrigation with a complete nutrient solution. The seedlings were racked in tanks to which the nutrient solution was automatically pumped on a predetermined cycle. An eight-week production period was used allowing one week for germination, 6 weeks for growth in the greenhouse and one of "toughening" in sheltered flats located out-of-doors. The stock is illustrated in Figures 7 to 16.

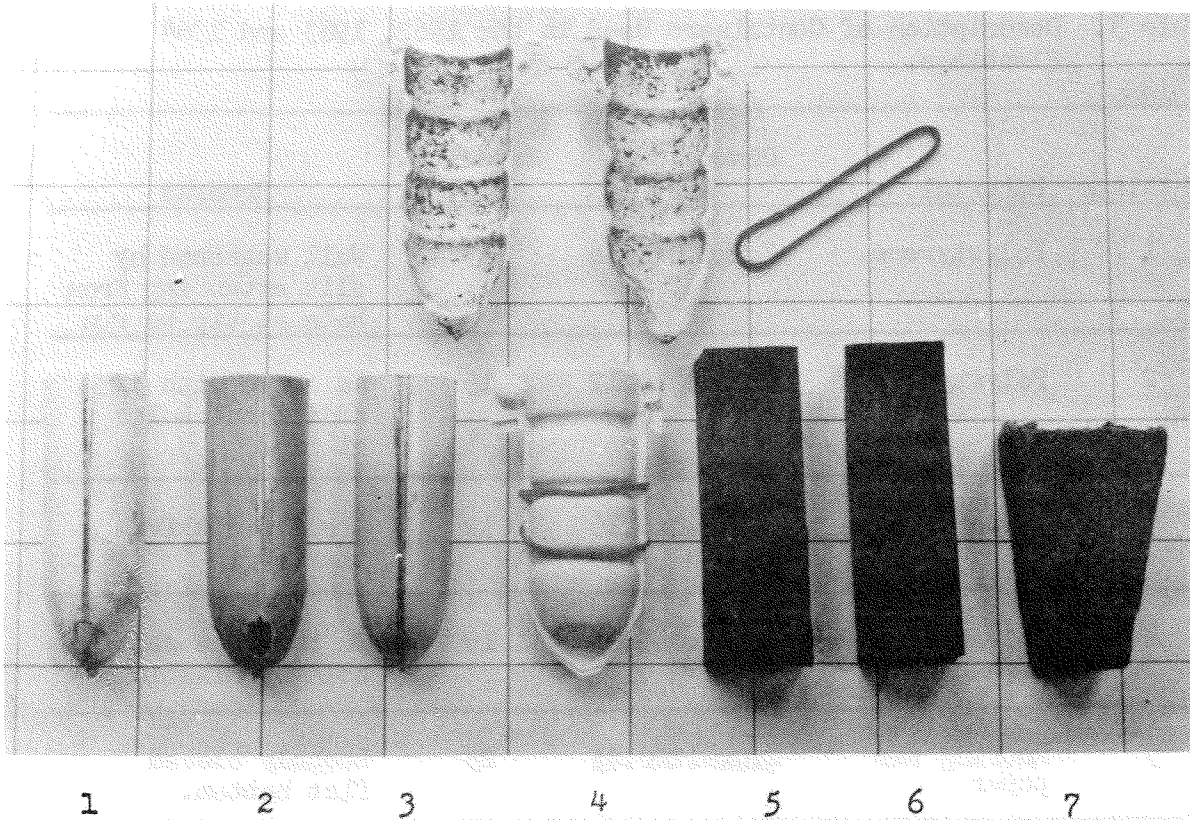


Figure 6. The containers used in the 1962(1), 1963(2) and 1964 (1, 3, 4, 5, 6, 7) plantings. x 3/5.

As a result of the addition of nutrients the 8-week seedlings planted in 1964 were larger than those produced in 1962 and 1963. Stock quality was still not good however. The spruce seedlings were smaller and less vigorous than expected while the pine seedlings varied considerable in size and condition from month to month.

The June pine seedlings, although larger than the August and September stock were very chlorotic. The reason for the chlorosis has not been determined.

Table 3. Description of Containers Used in the 1962, 1963 and 1964 Plantings.

Container	Material	Dimensions- Cms.	Capacity- C.C.	Remarks
1	Polystyrene	2.1x6.0x0.16	13	Wall weakened by slit extending from hole at tip to rim
2	Polystyrene	2.1x6.0x0.12	15	As above with 3 additional holes at tip
3	Polyethylene	2.1x6.0x0.16	12	4 slits cut from tip to rim
4	Polystyrene	2.1x6.0x0.05	19	In two free sections held by elastic band
5	Roofing tar paper	2.0x6.2x0.05	23	Loosely closed flat bottom.
6	Wax impregnated Kraft paper	2.0x6.2x0.08	23	As above
7	Pressed peat-Irish sturdy walls	3.0x4.7x0.20	13	-

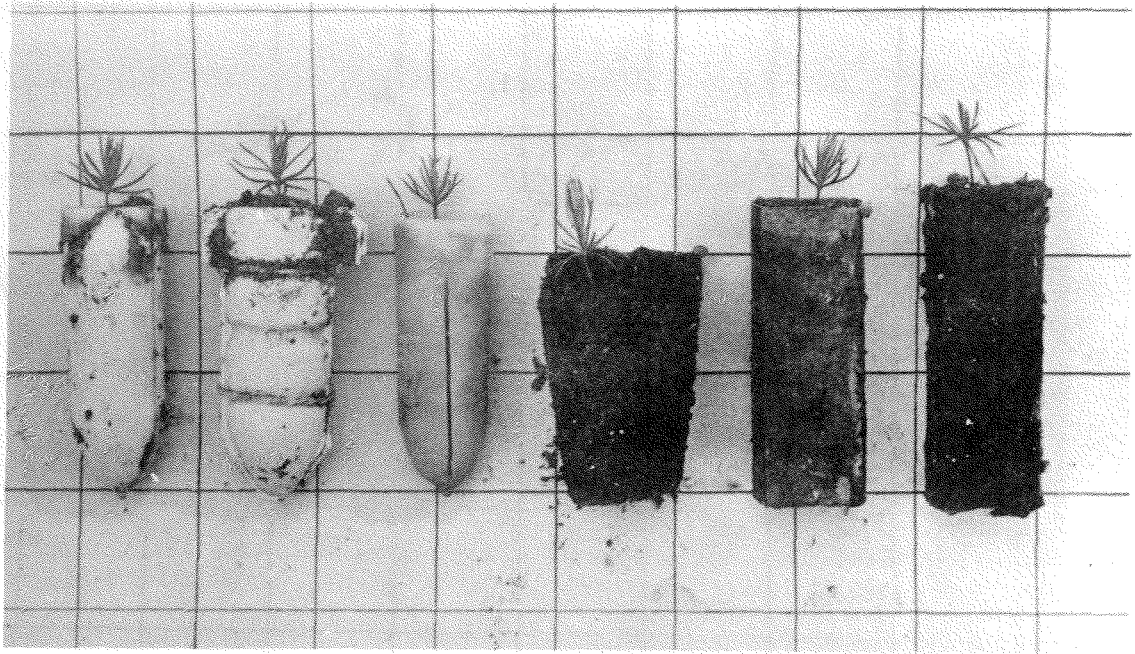


Figure 7. 8 week-old white spruce seedlings planted in June, 1964.
x 3/5.

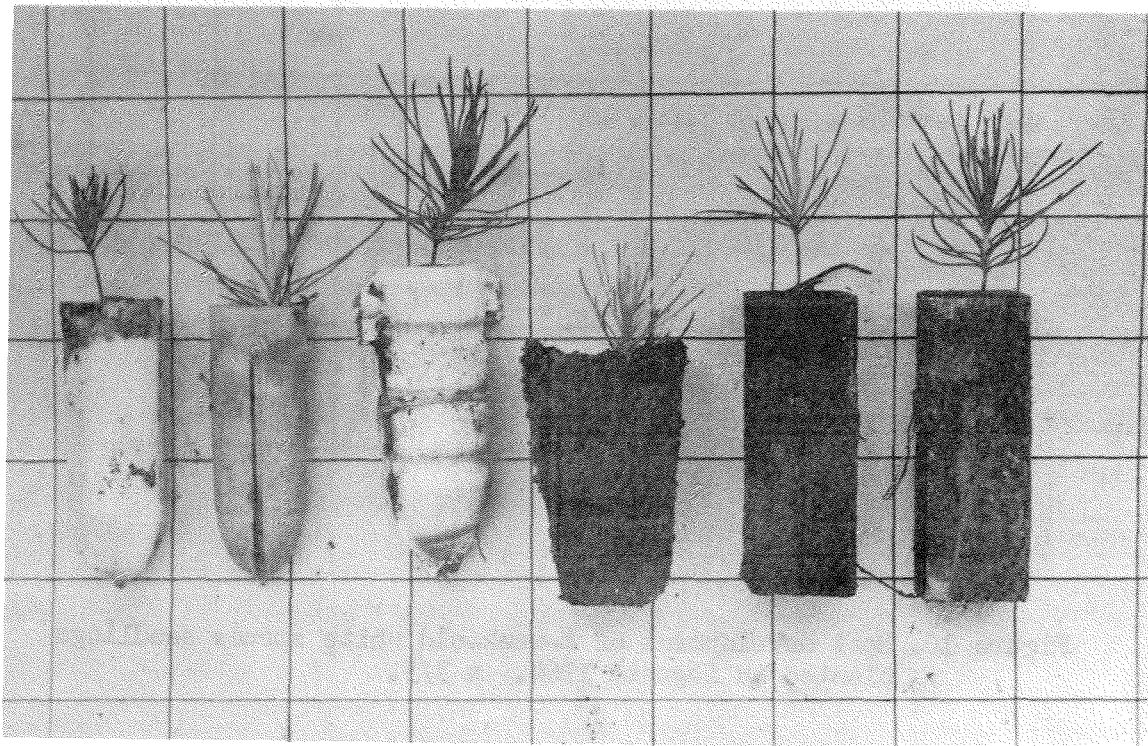


Figure 8. 8 week-old lodgepole pine seedlings planted in June, 1964.
x 3/5.

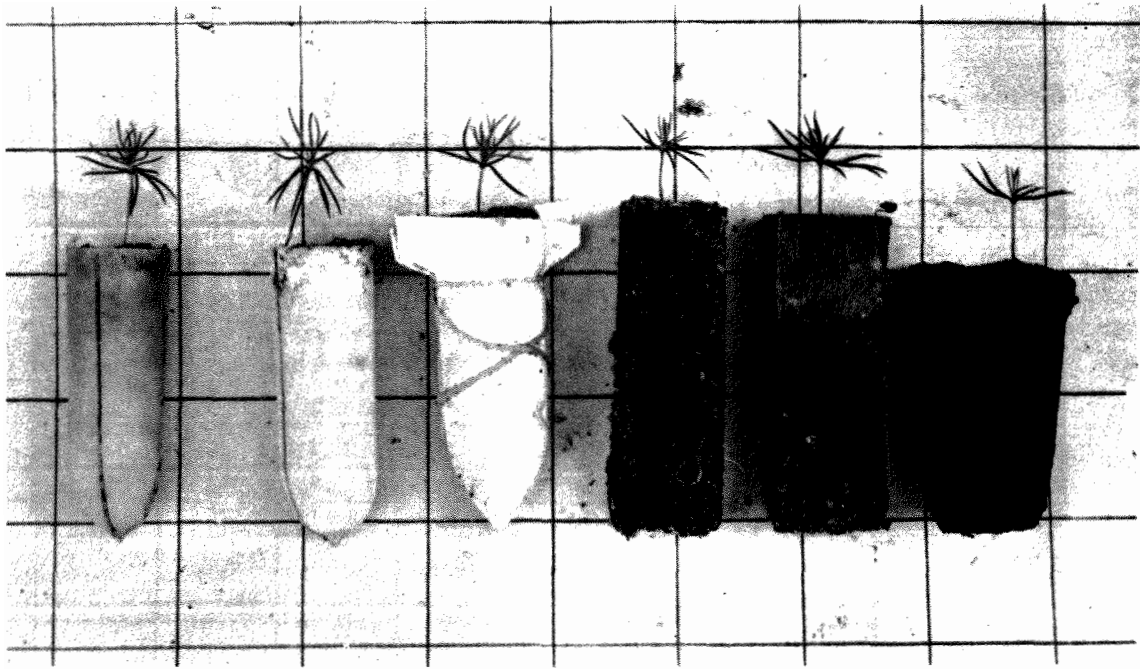


Figure 9. 8-week old white spruce seedlings planted in August, 1964.
x 3/5.

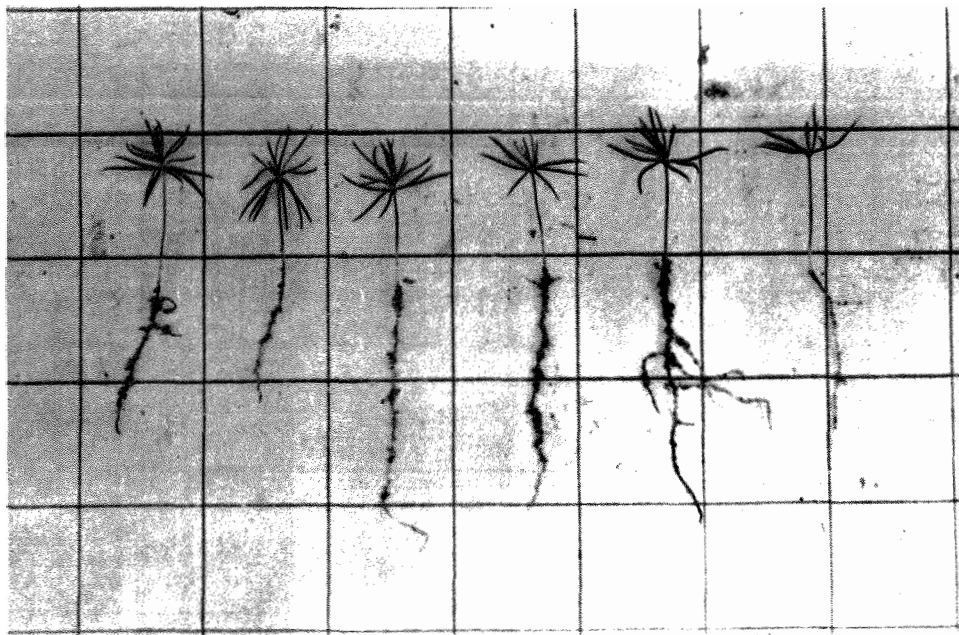


Figure 10. Root development of 8-week-old white spruce seedlings
planted in August, 1964. x 3/5.

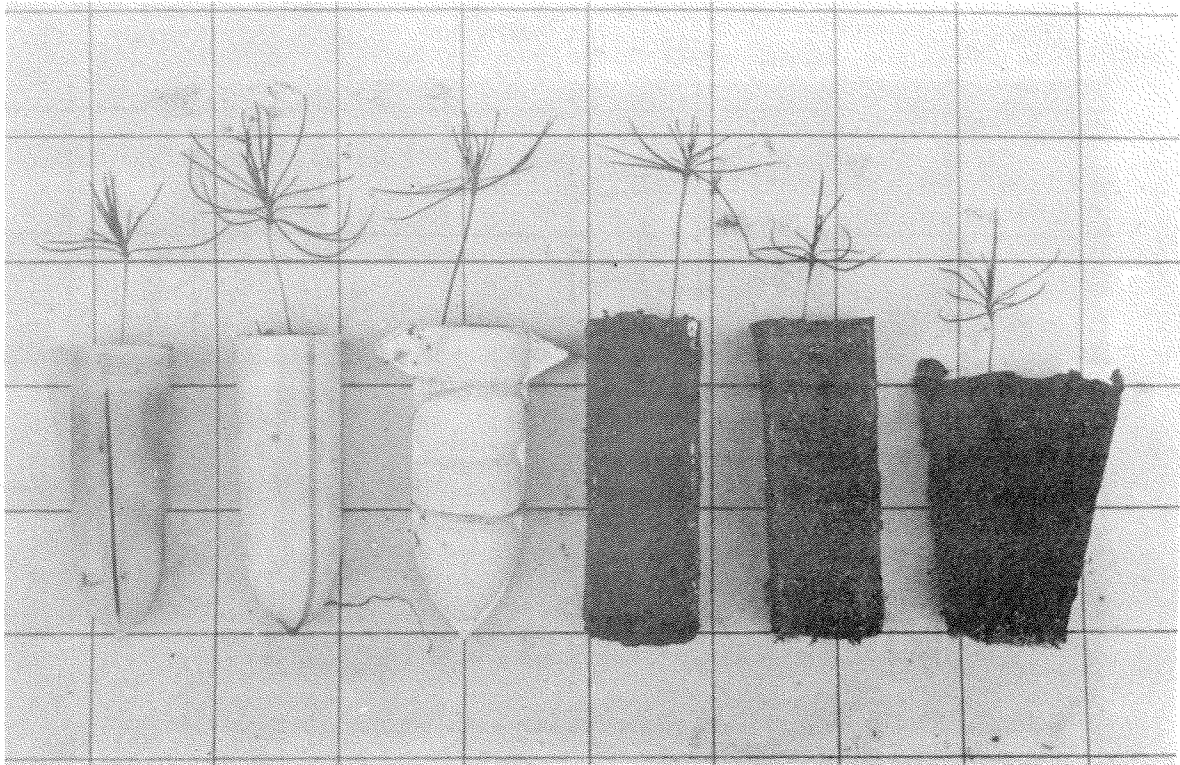


Figure 11. 8-week-old lodgepole pine seedlings planted in August, 1964.
x 3/5.

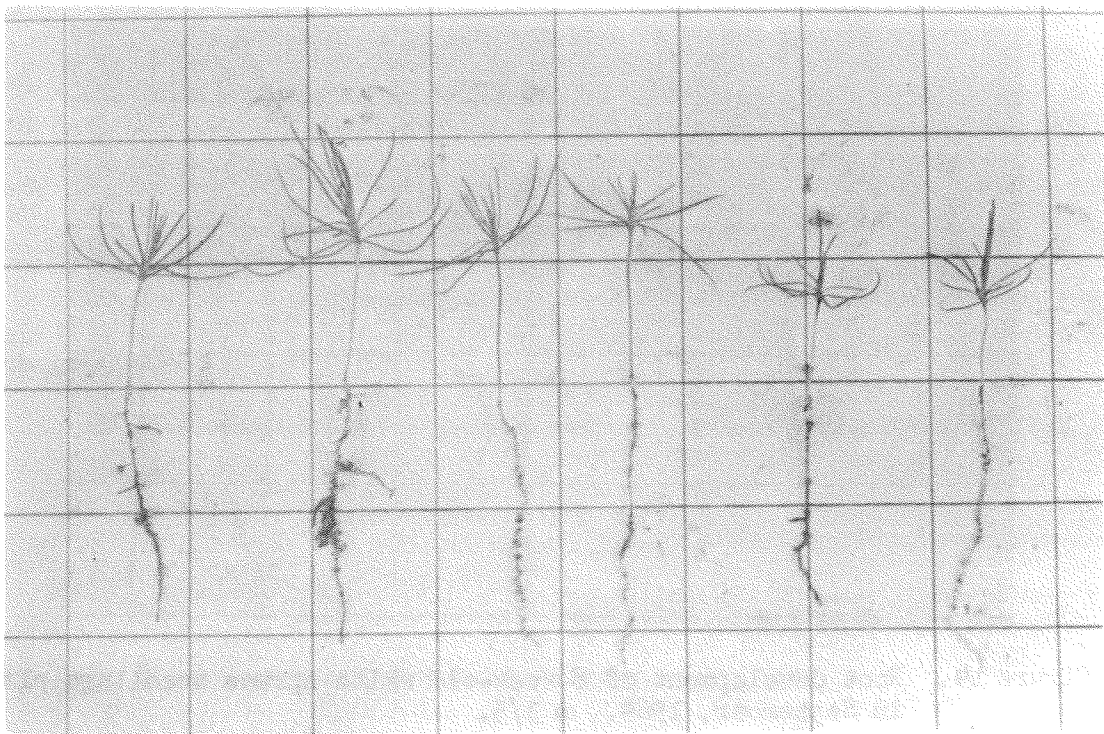


Figure 12. Root development of 8-week-old lodgepole pine seedlings
planted in August, 1964. x 3/5.

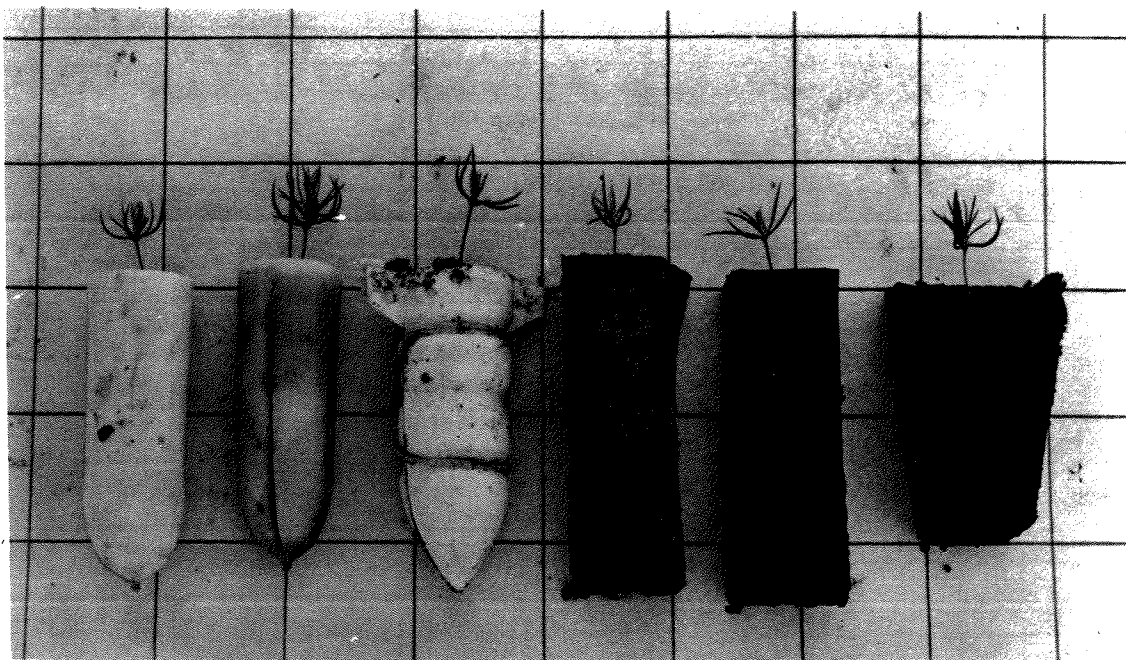


Figure 13. 8-week-old white spruce seedlings planted in September, 1964.
x 3/5.

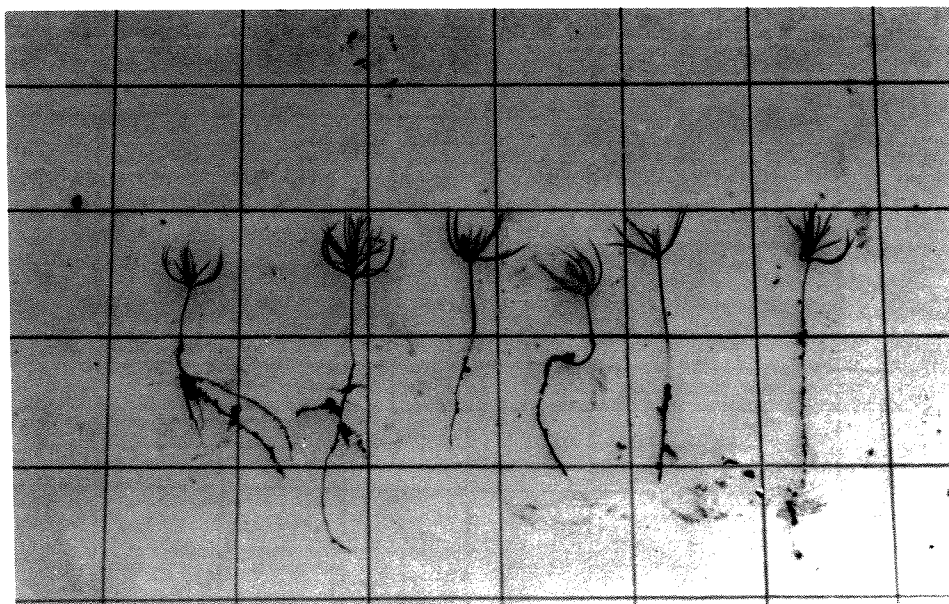


Figure 14. Root development of 8-week-old white spruce seedlings planted
in September, 1964. x 3/5.

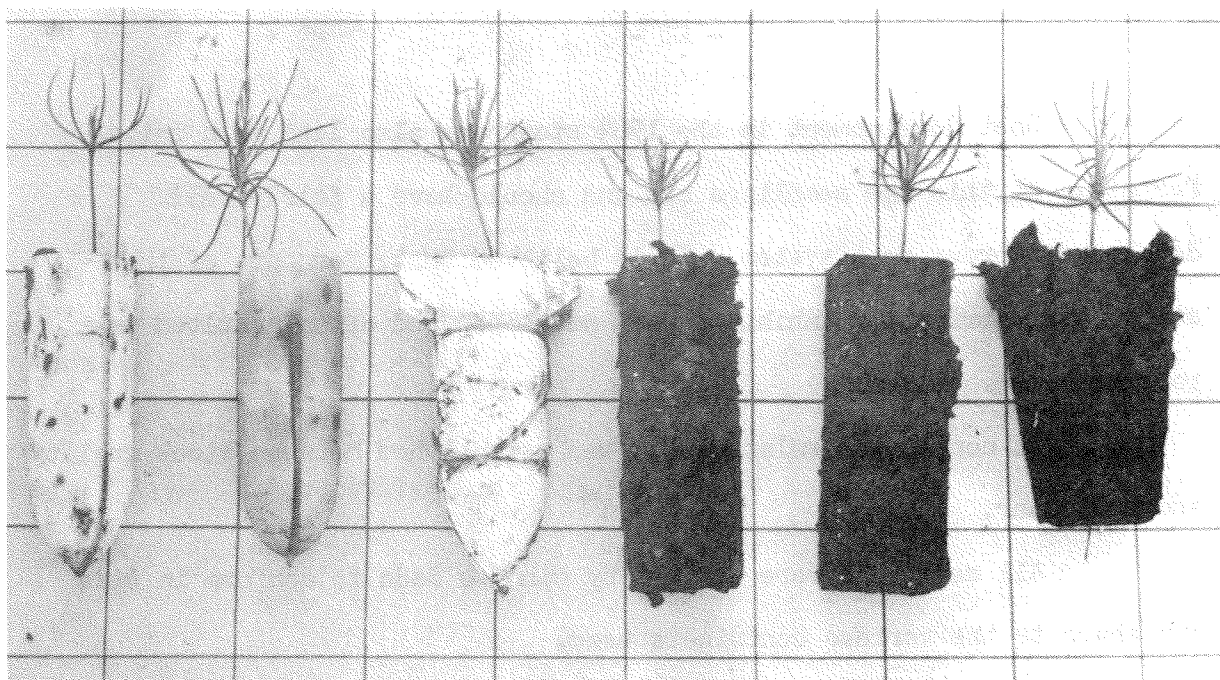


Figure 15. 8-week-old lodgepole pine seedlings planted in September, 1964.
x 3/5.

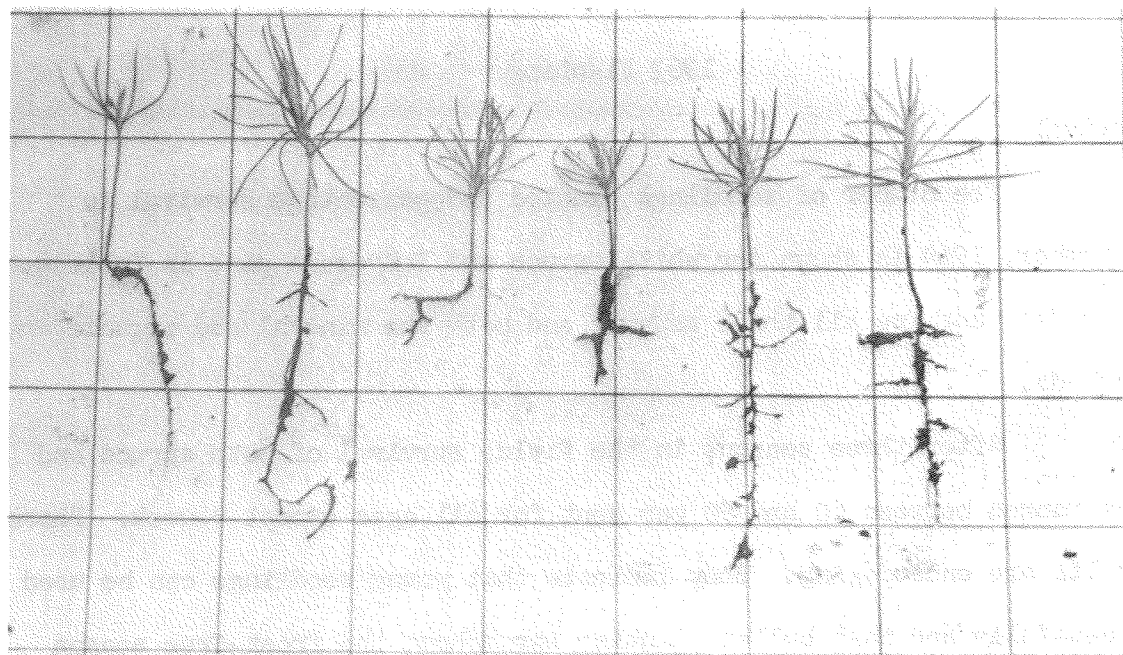


Figure 16. Root development of 8-week-old lodgepole pine seedlings
planted in September, 1964. x 3/5.

Root development in the 1964 stock was also less than satisfactory. At this age seedlings can and should have a fairly well developed fibrous root system. It is believed that, for most of the stock, over-irrigation inhibited root development and often resulted in root rot.

No consistent relationship was established between stock quality and container.

All seedlings were set out by dibbles made to conform in size and shape to the various containers used.

Measurements of survival, top and root growth will commence in 1965.

RESULTS

1962 Planting

Survival

The number of seedlings planted and percentage survival to September, 1964 is shown for white spruce and lodgepole pine in Table 4. These data combine all three aspects and both the mineral and organic seedbeds.

After three seasons in the field, survival of both spruce and pine ranges between 60 and 90 per cent for all ages except 4-week. These results are encouraging. They indicate that young seedlings can be used successfully and that bullet planting throughout the frost-free season is feasible.

Table 4. 1962 Planting - Percentage Survival of White Spruce and Lodgepole Pine to September, 1964. All Aspects and Seedbeds.

Age of Stock	Planting Month	White Spruce		Lodgepole Pine	
		No. Planted	Percentage Survival	No. Planted	Percentage Survival
4 week	May	216	22	78	20
	July	300	50	282	52
	Aug.	300	12	30	23
	Sept.	282	45	256	40
8 week	June	216	67	78	67
	July	180	80	30	67
	Aug.	300	76	282	64
	Sept.	97	46	34	82
12 week	July	216	81	78	63
	Aug.	180	79	30	80
	Sept.	292	85	282	82
16 week	Aug.	216	60	Insufficient Data	
	Sept.	180	85		
20 week	Sept.	216	75	Insufficient Data	
1-0 bullet transplants	May	300	69	300	86
	June	300	80	300	91
	July	300	90	300	92
	Aug.	300	86	300	86
	Sept.	294	88	298	91

Analysis of these data is made difficult by the non-orthogonal design of the experiment. Nevertheless the following features are evident.

1. Species. There is no consistent difference in survival between spruce and pine. Both species were subject to the same causes of mortality and, in most cases, to a similar degree. One possible exception is lodgepole pine--a larger more vigorous seedling, - it is less subject to smothering. This is most evident for the 1-0 transplants.
2. Age of Stock. The level of survival increases with age of stock in this experiment. The difference however, is most pronounced when comparisons are made between 4-week and older seedlings. If transplanting 1-0 stock into containers is considered impractical then these data indicate little advantage in the use of stock older than 8 weeks from seed.
3. Month of Planting. Confounding with age of stock obscures the effect of month of planting in this experiment. Nevertheless, with the exception of 4-week seedlings, month of planting had no consistent effect on survival. The variability in survival of the 4-week stock is attributed to frost damage which occurred shortly after planting in May and August.
4. Aspect. It has not been possible to demonstrate significant effects of aspect in the 1962 experiment. The soil is fresh and the 1962 season was moist with frequent and abundant rainfall during all months (Table 2). Both of these factors may have acted to obscure an independent effect of aspect on survival.

5. Seedbed. Survival of all seedlings planted on mineral soil averaged 69.4 per cent while survival of all seedlings planted on organic seedbed averaged 70.7 per cent. The lack of difference in the data is misleading however. The experimental area was machine-scarified prior to planting and, as a result, truly undisturbed organic seedbed was scarce or absent in some cells. The data were further confounded by the necessity, in many cells, of creating mineral soil by scalping or digging which resulted later in considerable loss to smothering. These factors preclude a valid comparison between planting of bullets on scarified and undisturbed seedbeds.

Mortality

It is difficult, without almost continuous observation, to ascertain with certainty what agent or agencies have contributed to the death of an individual seedling. Nevertheless, observation during survival tallies has indicated mortality due directly or indirectly to the following:

- (a) Frost
- (b) Rodents and/or insects
- (c) Smothering
- (d) Heaving
- (e) Exposure

(a) Frost - Both the May and August plantings were subjected to frost immediately after planting. The effect is most clearly seen in the low survival of 4-week-old seedlings. Seedlings 8 weeks and older

were not as susceptible, and although damage occurred, mortality seldom resulted.

(b) Rodents and Insects. A substantial number of seedlings were damaged by rodents and/or insects. This damage, however, was largely confined to 4-week-old seedlings immediately after planting. Eight-week seedlings, or 4-week seedlings that survived to the woody stage of development were apparently less palatable.

(c) Smothering. By September 1964 smothering by litter killed 10 per cent of the seedlings set out and is considered to have adversely affected the development of an additional 20 per cent. Mortality caused by smothering was most severe for 4-week seedlings (13 per cent loss) and least for the larger 1-0 transplants (4 per cent loss). It should be noted that smothering losses were to a large extent avoidable, for more than half of the mortality was a direct result of depressions made to place the bullets in mineral soil. Survival would have been approximately 5 per cent higher had this practice been avoided. The susceptibility of small seedlings to smothering is a strong argument for use of large vigorous stock.

(d) Frost Heaving. Approximately 20 per cent of all the bullets set out in 1962 were partially heaved and 3 per cent were totally heaved. Heaving has not, as yet, contributed significantly to mortality (1 per cent loss) but it is considered a severe check on root development and growth. Frost heaving is most severe on unsheltered mineral soil seedbeds, and this seedbed should be avoided in future planting of bullets.

(e) Exposure. Lack of shelter contributed to mortality in all plantings. The beneficial effects of shelter from pieces of slash and vegetation were obvious.

No mortality was observed that could be considered a direct result of soil drought. The soil of the experimental area is fresh and the 1962 season was moist with abundant precipitation during all months.

Top and root growth measurements will not commence for the 1962 planting until 1965. During 1963 however, several spruce and pine seedlings were excavated to determine if seedlings were rooting out of the containers. As might be expected, root development was found to vary as much as top development. In some instances the roots had not grown beyond the containers while in others, well developed root systems were found. Two examples of the best development observed are shown in Figure 17 and 18.

Conclusive evidence will not be obtained until 1965 but observations to date indicate that seedlings will root out of the container provided there is a suitable substratum. It is not yet known whether the roots will break the container when they are confined by the exit holes.

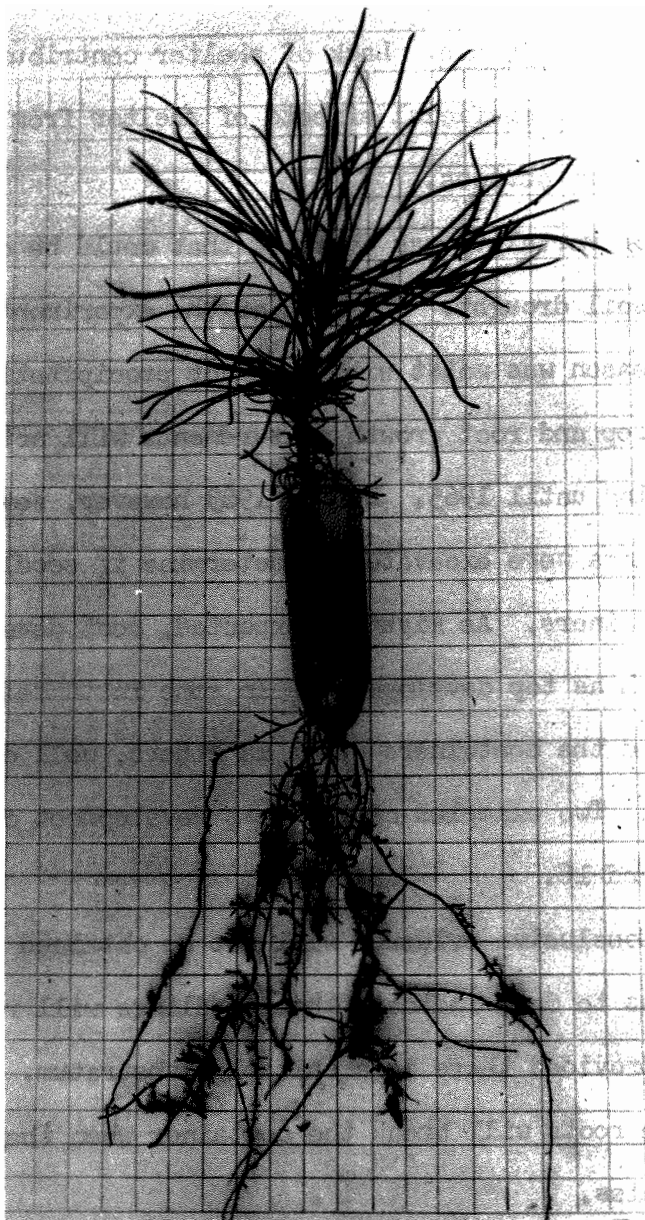


Figure 17. Root development of 1-0 lodgepole pine seedling planted in 1962 and excavated in 1963. x 1/2.

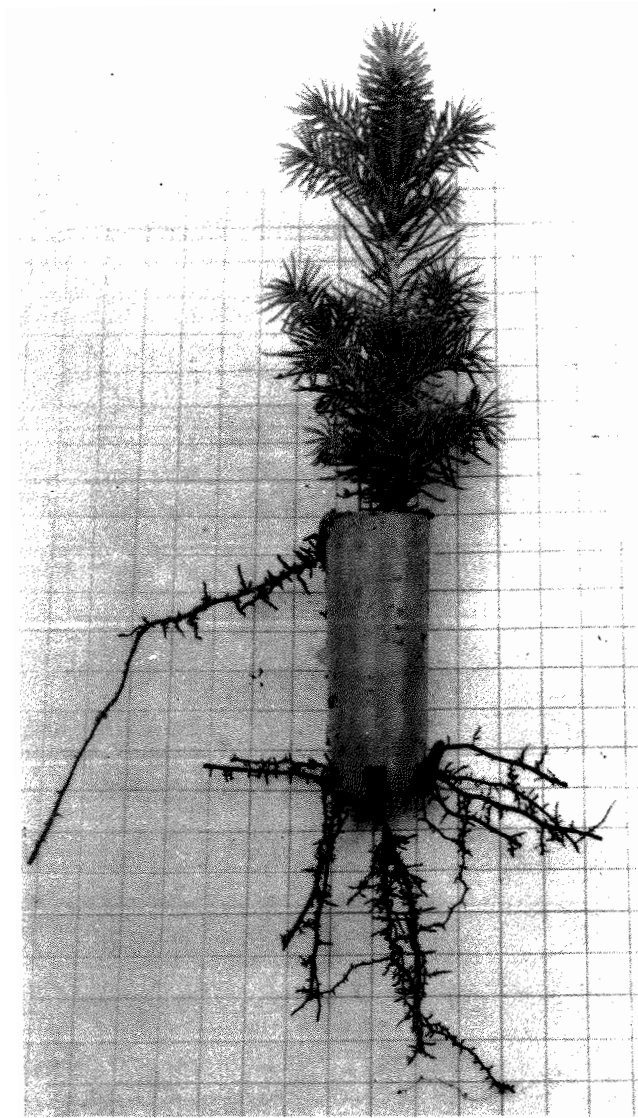


Figure 18. Root development of 1-0 white spruce seedling planted in 1962 and excavated in 1963. x 1/2.

1963 Planting

Survival

Percentage survival to September, 1964 is shown by species, month of planting and age of stock in Table 5.

Species - Percentage survival of pine was better than spruce for 8 and 16-week seedlings grown and planted in containers. However, spruce survival was better than pine for the 1-0 transplants and the 2-0 conventional stock.

Month of Planting - Survival of the June planting has been lower than that of the following three months. For most treatments this is considered a result of the drought that occurred.

Age of Stock - The best overall survival was obtained with 8-week and 16-week seedlings grown and planted out in bullets. Any advantage gained by the use of 16-week seedlings rather than 8-week is evident only for spruce planted during the drought period in June.

Mean survival of the 1-0 transplants, which did so well in the 1962 experiment, was no better and, in some cases well below, survival of 8-week and 16-week seedlings. This is believed to be largely a result of field planting before the seedlings were well established in the containers. It occurred for spruce and pine in June and for pine in August and September. This is also thought to have made the 1-0 transplants particularly sensitive to moisture stress during the June drought period.

Table 5. 1963 Planting. Percentage Survival in September, 1964 by Species, Planting Month and Age of Stock. - All Sites and Seedbeds.

Age of Stock	Planting Month - 1963				
	June	July	August	September	All
Spruce-Percentage Survival to September, 1964					
8-week	29	46	64	60	50
16-week	46	49	58	60	53
1-0	19	69	60	63	53
All bullets	31	55	61	61	51
2-0 conventional	23	7	33	24	22
Pine-Percentage Survival to September, 1964					
8-week	70	60	74	68	68
16-week	38	64	74	69	61
1-0	25	74	48	34	45
All bullets	44	66	65	57	58
2-0 conventional	5	8	20	21	14

The conventional, exposed-root planting of 2-0 stock was the least successful of all treatments. Many trees of the June and July planting were badly wilted when set out and simply failed to recover. The effect of lifting and planting during the growth period, aggravated by the June drought, no doubt contributed to the poor survival. Nevertheless survival of the August and September plantings, which more closely resemble a "normal" operation, was little better.

Site - Percentage survival by species, site and age of stock is shown in Table 6. Survival of all ages of stock was significantly lower on Site 3 (coarse, dry, alluvial gravel) than on Site 2 (warm, dry till slope) or Site 4 (cold, moist till plateau). Site 3 has a long history as a regeneration problem area. The results of scarification, seeding, conventional planting, and now bullet planting have been discouraging.

Seedbed - Survival, for all treatments, averaged approximately 6 per cent higher on scarified blocks than on undisturbed blocks. This result was characteristic of both species, all planting months, ages of stock and sites.

Table 6. 1963 Planting - Percentage Survival in September, 1964 by Species, Site and Age of Stock - All Planting Months and Seedbeds.

Age of Stock	Site (Camp)			
	3 (Camp 9)	2 (Camp 22)	4 (Camp 29)	All
Spruce - Percentage Survival to September 1964				
8-week	38	57	55	50
16-week	36	60	63	53
1-0	37	56	66	53
All Bullets	36	58	61	52
2-0 conventional	11	28	27	21
Pine - Percentage Survival to September, 1964				
8-week	51	79	75	68
16-week	40	71	72	61
1-0	37	47	52	45
All Bullets	43	66	66	58
2-0 conventional	6	15	20	14

Survival of container-grown and planted stock in the 1963 experiment, although not discouraging, is generally lower than in the 1962 experiment. Four factors are considered responsible.

1. Weather - the drought experienced in June, 1963.
2. Stock quality - the 1962 stock was considerably better than the 1963 stock.
3. Technique - in 1963 many of the 1-0 transplants seedlings were set out before they were properly established in the containers.
4. Site - The sites planted in 1963, although not atypical, represent much more difficult regeneration conditions than the site planted in 1962.

Mortality

Observation during survival measurement has indicated mortality as a result of the following:

- (a) Soil drought
- (b) Smothering
- (c) Frost heaving

(a) Soil drought - Lack of precipitation in June, 1963 affected the survival of all ages of stock. Although the frequency of occurrence of such drought periods in this area is not known, delaying planting operations until a predetermined level of precipitation has been recorded during the week prior to planting would probably minimize losses.

(b) Smothering - Smothering killed seven per cent of all bulleted seedlings planted in 1963 and is considered to have retarded the development of an additional 16 per cent. As in the 1962 planting, loss and damage was greater with the 8 and 16-week seedlings than with the larger 1-0 transplants. On most sites smothering occurred because of thoughtless placement of the seedlings in depressions. However, on Site 4 (Camp 29), with deep organic and moss horizons, losses occurred owing to sinking of the container or envelopment of the container by the moss. A longer container is recommended on this particular seedbed type.

(c) Frost Heaving - Approximately 13 per cent of the bulleted seedlings planted in 1963 were partially heaved and one per cent was totally heaved. Mortality seldom resulted, however, and losses as a direct result of heaving amount to only one per cent of the seedlings planted. Seventy-five per cent of the heaving losses occurred on the scarified areas.

No losses are attributed to frost, which did not occur during the 1963 planting period. Similarly, very little mortality has been attributed to rodents or insects for the majority of seedlings set out in 1963 were past the succulent stage of development.

1964 Planting

Establishment of the 1964 experiment was not completed until September, 1964. No data will be available until 1965. It can be noted, however, that losses are anticipated as a result of frost that occurred every month of the 1964 season. The June planting was completed on

June 20th - an air temperature of 28° F. was recorded on June 22nd. The August planting was completed on August 20th - an air temperature of 31° F. was recorded on August 22nd and 26° F. on August 24th. Frost occurred almost nightly during and following the September planting.

Considerations in the choice of container will include stability and ease of handling during culture, handling qualities in transport and during planting, and ease of planting. In the 1964 experiment, the plastic containers were superior in these respects to either the paper or peat. The paper containers dried more rapidly following removal from the culture tanks and were more difficult to plant because of the flat, square base. The peat pots were very fragile following removal from the culture tanks and considerable care was necessary to avoid breakage during transport, handling and planting. The fragility and shape of the peat container also made planting relatively difficult.

1965 WORK PLAN

In 1965 a single survival tally will be undertaken for all seedlings planted in 1962, 1963 and 1964. Also, where practical, the total height and the 1965 height increment will be measured for each surviving seedling.

In addition to the above a number of seedlings will be selected from each of the 1962, 1963 and 1964 experiments, excavated, and the following observations recorded:

1. Treatment, seedling number and history from previous observations.

2. General condition of seedling.
3. Rooting medium i.e. mineral soil, rotten wood etc.
4. Total height of seedling.
5. 1965 height increment.
6. Container condition.
7. A photographic record of root development inside and outside of the container.

Following these measurements the seedlings will be washed and dried and top and root weights determined.

Selection of a sample of seedlings from every strata in the 1962, 1963 and 1964 experiments would be impractical. It is therefore proposed to sample only from June plantings of 8-week, container-grown seedlings and 1-0 transplants. The sample from each recognized strata will consist of 5 seedlings selected without bias.

Following the above procedure the total sample will include the following:

1962 Planting

Species (2) x Age (2) x 5 = 20 seedlings

1963 Planting

Species (2) x Site (3) x Seedbed (2) x Age (2) x 5 = 120 seedlings

1964 Planting

Species (2) x Site (2) x Seedbed (2) x Container (6) x 5 = 240 seedlings

Total 380 seedlings

Natural regeneration is present on many of the experimental areas. It is proposed to obtain the above information for a sample of the natural regeneration to permit a comparison with container-grown and planted stock.

DISCUSSION

Considering the quality of stock employed and the site conditions planted, survival levels are considered promising. Continued development of the technique is therefore recommended. It is evident, however, that emphasis must now be placed on selection of a suitable container and development of culture techniques that will provide quality stock at minimum cost.

Container - The requirements of a suitable container are as follows:

1. The container must be of a material and design that does not inhibit root or top development during culture or after planting out.

In the experiments to date there has been little or no indication that the material or design of the containers so far tested need, in any way, affect growth and development during culture. The effect of container on growth after planting is most important, however, and the results of the field experiments initiated to date will be of great interest. Unfortunately these results will not be available for some time. In the meantime consideration should be given to field testing of any container design or material that appears to have merit.

2. The container should be of a material and design that does not present difficulties in handling during culture, transport and planting. Consideration should also be given to adaptability to machine or mechanical planting methods.

Of the containers tested, the plastic bullets have been superior in handling and planting to either the paper or peat. The peat, in particular has been difficult and unless proven superior in other respects, would be rejected on that basis.

3. The container should be of a size and shape consistent with the site conditions to be planted and the age of stock to be produced.

An experiment will be required to determine the optimum, minimum volume of container required for production of stock of a given size. This experiment should be initiated as soon as possible. There have also been indications that the length of container could be varied to accommodate the various site conditions encountered. Until there is opportunity to field-test this hypothesis it is reasonable to accept that there is advantage in the use of a longer container on sites with relatively deep unincorporated organic layers and proceed accordingly.

4. The container should be of minimum cost provided biological and handling requirements are satisfied.

Selection of a container on the basis of cost will not be possible until assurance is obtained that other requirements are satisfied.

Seedling Culture

Following germination, seedlings remain in a succulent condition for a period of approximately 4 weeks. During this stage the hypocotyl is tender, succulent and brittle and the root is straight and without branches. Passage of the seedlings from the succulent stage is of particular significance in bullet planting. The poor survival of 4-week seedlings in the 1962 planting is evidence of their fragility during this stage in their development.

The end of the succulent stage is marked by a collapse of the cortex and the hypocotyl becomes hard and wiry. Primary needles will be approximately one-half the length of cotyledons and root branching should commence. Continued growth for 3 weeks after the end of the succulent stage should result in seedlings with primary needles as long or longer than the cotyledons and with a well developed fibrous root system.

As yet, the type of seedling desired cannot be described quantitatively. However, spruce seedlings approaching the size illustrated in Figure 19 and pine seedlings similar in size to those shown in Figure 8 appear to be a reasonable objective for a growth period of seven or eight weeks.

The following problem areas are recognized in mass production of container grown stock.

1. Culture method
2. Seed selection

3. Seed germination
4. Soil medium
5. Damping-off
6. Irrigation schedules
7. Nutrition
8. Light requirements
9. Toughening procedures.

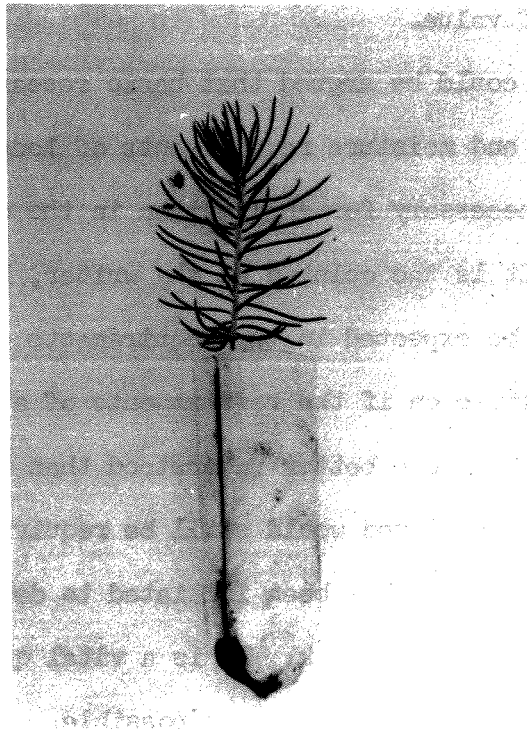


Figure 19. 8-week spruce seedling grown with nutrient amendments. x 3/5.

1. Culture Method - During the past three years, attempts at production of stock in the relatively well controlled greenhouse environment have met with less than complete success. Acceptance of the additi-

onal problems and risks associated with outside culture is not considered advisable until the problems are more clearly defined.

2. Seed Selection - Success of container planting will require a very high level of germination and survival in individual containers. An initial requirement is seed of very high quality and special cleaning to obtain seed that is virtually 100 per cent sound. No difficulty is foreseen in this procedure although research to determine the merits of seed selection by size may be of value.

3. Germination - It could be argued that basic research on the stratification, temperature and moisture requirements of lodgepole pine and white spruce seeds is necessary for application in the culture of container-grown seedlings. It is the opinion of the writer, however, that considerable variation can be expected in the requirements of different seed lots. As a result, even if the requirements of a species for prompt and complete germination were better understood than they now are, pre-testing of each seed lot employed would still be required.

4. Soil Medium - No research has been initiated to determine the best soil medium for container grown stock. It is a vital question however and this work should be initiated as soon as possible.

The characteristics of a good medium are as follows:

- (a) Promotes survival and growth after planting out.
- (b) Has good moisture retaining characteristics.
- (c) Inexpensive to obtain in quantity, uniform in characteristics and easily adapted to automatic loading of containers.

A wide variety of material is available including artificial, sterile materials such as perlite, vermiculite and quartz; various mixtures of sand and peat; mineral soils of a variety of textures and organic materials such as leaf moulds etc. In the work to date two materials have been used; a loam mineral soil fairly high in organic content and a sand-peat moss mix. Although they have not been employed in an experiment permitting valid comparison, better field survival has been obtained with the loam soil. The sand-peat mix was observed to dry very rapidly during transport and planting and was subject to washing after planting.

Little difficulty is anticipated in the production of quality stock in a wide variety of materials provided suitable irrigation and nutrient regimes are established. It is therefore suggested that selection of a medium should depend primarily on effects on growth and survival after planting out. In this connection, on many sites in the Foothills Section, seedlings may not root out of the container immediately after planting. Survival may therefore depend on the ability of the medium to provide moisture and nutrients for a period after planting. Under these circumstances a relatively sterile, artificial medium with poor moisture retaining characteristics would be of dubious value.

5. Damping-Off - Loss of seedlings to damping-off diseases was a serious problem during production of stock for the 1962, 1963 and 1964 planting. However, the problem was probably compounded by lack of rigid control of pH and soil moisture levels. If, after such control is introduced, a problem remains, experiments should be initiated to

investigate the use of fungicides, soil treatment etc. Particular attention should be given to the relatively new systemic fungicides.

6. Irrigation - Stock can be produced either by sub-irrigation in a tank culture or by an overhead system. Both methods can be automated to provide predescribed moisture levels without difficulty. An overhead irrigation system requires less capital investment than a tank culture but a tank culture permits more efficient use of nutrients provided in the irrigation system.

The irrigation schedule will depend on the type of culture and soil medium used.

7. Nutrition - There is little question that larger, more vigorous stock can be produced during culture by the use of fertilizers. Research is required, however, to determine the nutrients required and proper rate of application. It should be noted in this connection that an interaction can be expected between nutrient response and the soil medium employed.

8. Light Requirements - Research is required to determine the light requirements of lodgepole pine and white spruce during the seedling stage. The possibility, or limitations, in greenhouse culture, of production in tiers for more efficient utilization of space and facilities will have a significant effect on the economics of container planting.

9. Toughening Procedures - Radiation frost can be expected during any planting month in the Foothills Section of Alberta. Considerable seedling loss and damage has occurred in the plantings to date. The

survival pattern indicates a range of tolerance dependent upon age or stage of development of the seedlings. Research is required immediately to determine more precisely the effect of seedling age on tolerance to frost and to determine practicability and methods of "toughening" seedlings before planting out.

The research projects suggested in the foregoing discussion are summarized below:

1. Continued field testing of containers that appear to have merit.
2. Investigation of seed selection by size as a means of improving stock quality.
3. Determination of the best soil medium for container-grown and planted stock.
4. Investigation of means of controlling damping-off diseases during culture.
5. Investigation of fertilizers and rates of application during culture.
6. Investigation of the light requirements of lodgepole pine and white spruce during the seedling stage in order to determine the feasibility of production in tiers in greenhouse culture.
7. Determination of the frost tolerance of lodgepole pine and white spruce seedlings of various ages and the development of methods of "toughening" seedlings before planting out.

As the problems in production of container-grown stock are solved and good quality stock becomes available, field planting on a pilot scale should be initiated on a wide range of site conditions. Attention can also then be given to other promising areas of research and development. For instance, the technique of bullet planting immediately suggests the use of slow release fertilizers incorporated into the container or soil medium. Also, when selection of a container and soil medium is possible, consideration must be given to the problems associated with automation in the loading and handling of containers during culture and planting.

The four co-operating agencies presently involved in the development of container planting in Alberta have ceased active co-operation or sharing of duties and responsibilities, in specific projects such as the 1962, 1963 and 1964 plantings. Rather each organization will work independently on various aspects of the problem. It is anticipated that information will be shared and duplication avoided by frequent consultation.

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- McLEAN, M.M. 1951. Experimental planting of tubed seedlings. Ont. Dept. of Lands and Forests. Tech. Series Res. Rep. No. 39. 13 p.
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APPENDIX I

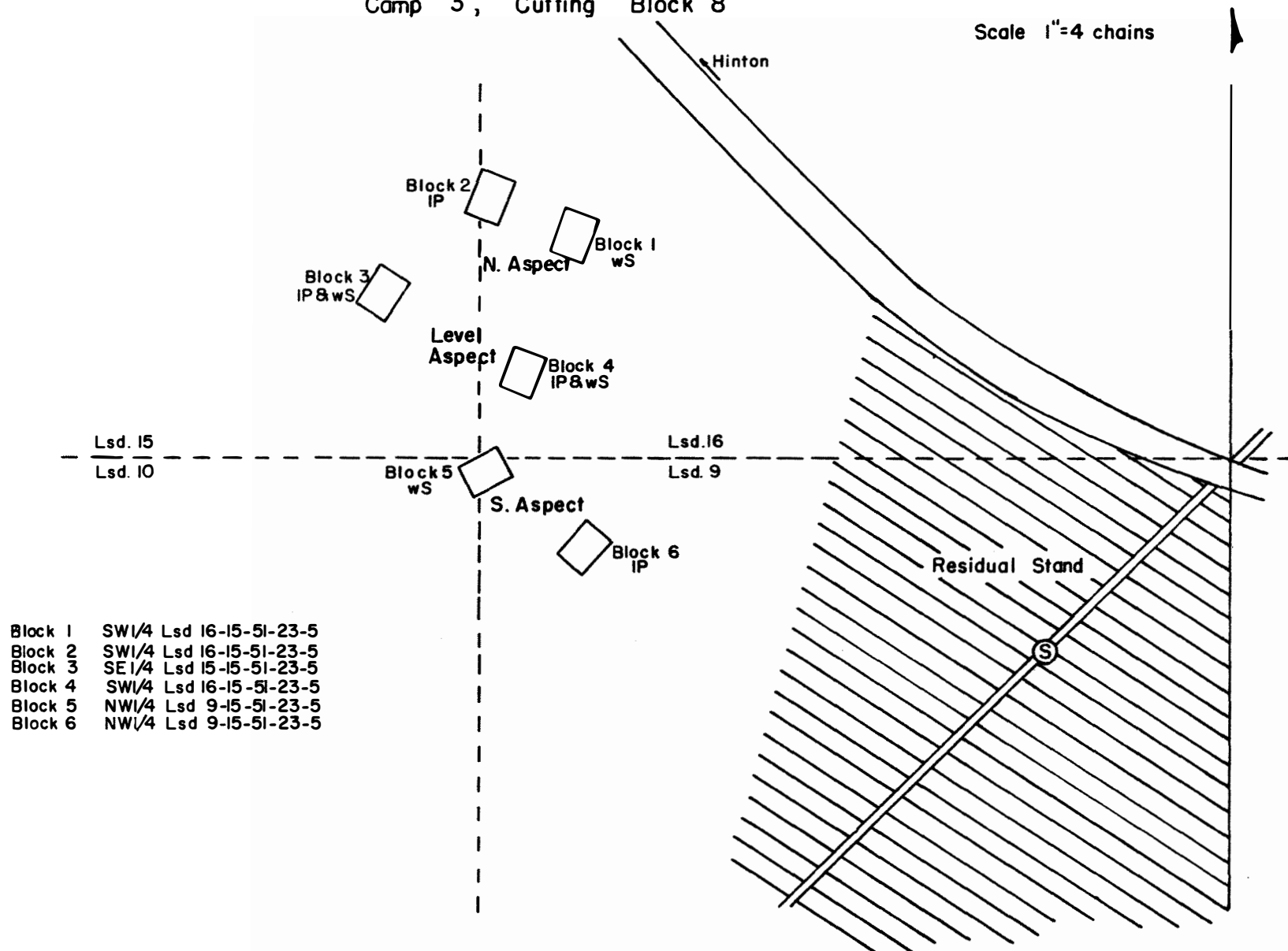
1962 Bullet Planting

Block Locations and Cell Treatment.

BLOCK LOCATIONS

1962 BULLET PLANTING
Camp 3, Cutting Block 8

Scale 1"=4 chains



1962 Bullet Planting — Cell Treatment
Blocks 1 and 2 — North Aspect

79'				
15'				
63'	1 4 weeks MAY	2 8 weeks AUG	3 4 weeks AUG	4 12 weeks AUG
	5 Not Planted	6 16 weeks AUG	7 4 weeks SEPT	8 12 weeks SEPT
	9 12 weeks JULY	10 1-0 AUG	11 4 weeks JULY	12 8 weeks JUNE
	13 1-0 MAY	14 1-0 SEPT	15 1-0 JULY	16 20 weeks SEPT
	17 16 weeks SEPT	18 1-0 JUNE	19 8 weeks JULY	20 Not Planted

Block 1 — wS

1 4 weeks MAY	2 8 weeks AUG	3 4 weeks AUG	4 12 weeks AUG	5 8 weeks SEPT
6 16 weeks AUG	7 4 weeks SEPT	8 12 weeks SEPT	9 12 weeks JULY	10 1-0 AUG
11 4 weeks JULY	12 8 weeks JUNE	13 1-0 MAY	14 1-0 SEPT	15 1-0 JULY
16 20 weeks SEPT	17 16 weeks SEPT	18 1-0 JUNE	19 8 weeks JULY	20 Not Planted

Block 2 — IP

1962 Bullet Planting — Cell Treatment
Blocks 3 and 4 — Level Aspect

1 4 weeks WS MAY	2 3 weeks IP AUG	3 4 weeks IP AUG	4 12 weeks IP AUG	5 8 weeks WS SEPT
6 16 weeks IP AUG	7 4 weeks WS SEPT	8 12 weeks WS SEPT	9 12 weeks WS JULY	10 1-0 IP AUG
11 4 weeks WS JULY	12 8 weeks WS JUNE	13 1-0 WS MAY	14 1-0 WS SEPT	15 1-0 WS JULY
16 20 weeks WS SEPT	17 16 weeks WS SEPT	18 1-0 WS JUNE	19 8 weeks WS JULY	20 Not Planted

Block 3

1 4 weeks IP MAY	2 8 weeks WS AUG	3 4 weeks WS AUG	4 12 weeks WS AUG	5 8 weeks IP SEPT
6 16 weeks WS AUG	7 4 weeks IP SEPT	8 12 weeks IP SEPT	9 12 weeks IP JULY	10 1-0 WS AUG
11 4 weeks IP JULY	12 8 weeks IP JUNE	13 1-0 IP MAY	14 1-0 IP SEPT	15 1-0 IP JULY
16 20 weeks IP SEPT	17 16 weeks IP SEPT	18 1-0 IP JUNE	19 8 weeks IP JULY	20 Not Planted

Block 4

1962 Bullet Planting — Cell Treatment
Blocks 5 and 6 — South Aspect

1 4 weeks MAY	2 8 weeks AUG	3 4 weeks AUG	4 12 weeks AUG	5 Not Planted
6 16 weeks AUG	7 4 weeks SEPT	8 12 weeks SEPT	9 12 weeks JULY	10 1-0 AUG
11 4 weeks JULY	12 8 weeks JUNE	13 1-0 MAY	14 1-0 SEPT	15 1-0 JULY
16 20 weeks SEPT	17 16 weeks SEPT	18 1-0 JUNE	19 8 weeks JULY	20 Not Planted

Block 5 - wS

1 4 weeks MAY	2 8 weeks AUG	3 4 weeks AUG	4 12 weeks AUG	5 8 weeks SEPT
6 16 weeks AUG	7 4 weeks SEPT	8 12 weeks SEPT	9 12 weeks JULY	10 1-0 AUG
11 4 weeks JULY	12 8 weeks JUNE	13 1-0 MAY	14 1-0 SEPT	15 1-0 JULY
16 20 weeks SEPT	17 16 weeks SEPT	18 1-0 JUNE	19 8 weeks JULY	20 Not Planted

Block 6 — IP

APPENDIX 2

1963 Bullet Planting

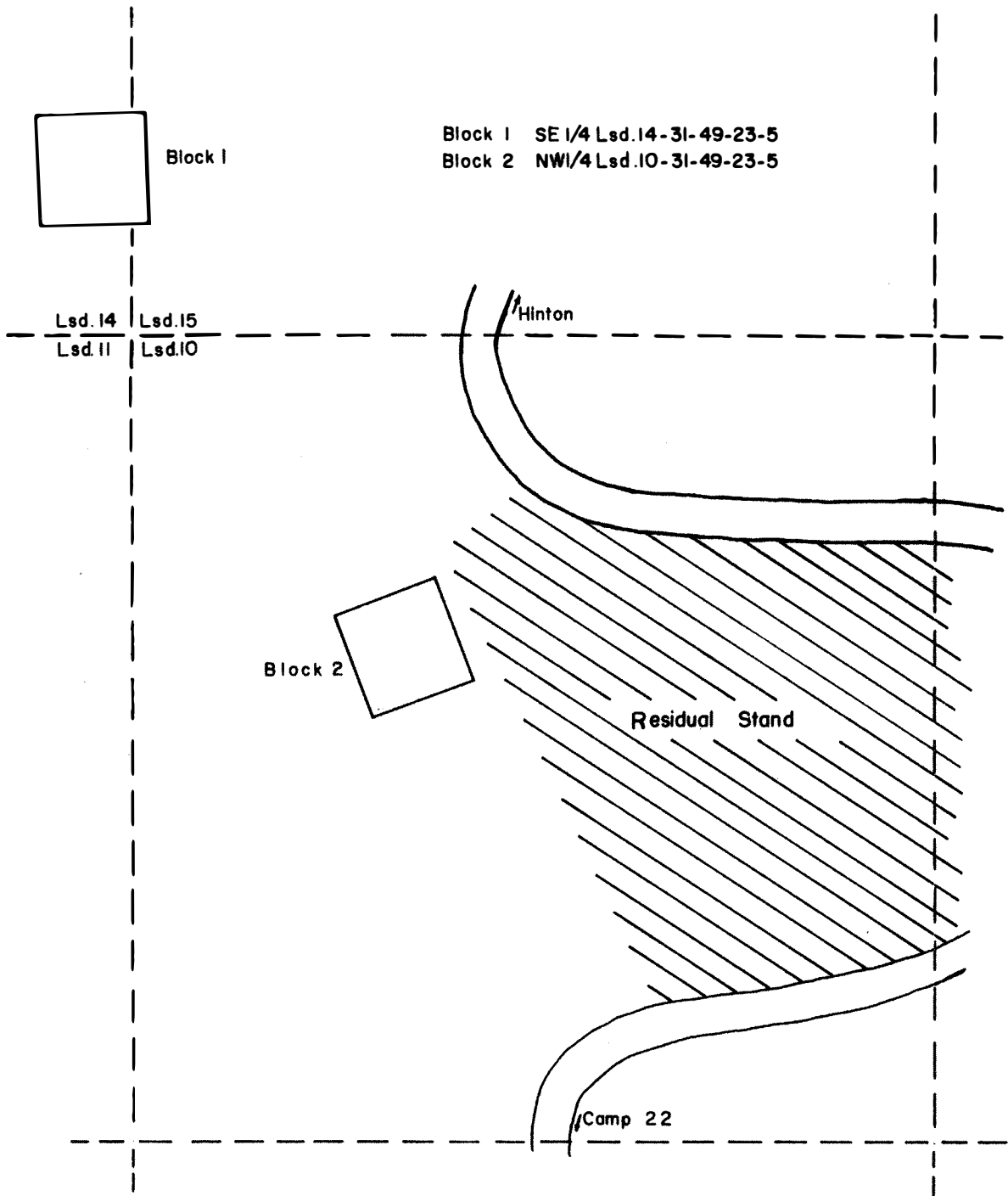
Block Locations and Cell Treatment

BLOCK LOCATIONS

1963 BULLET PLANTING

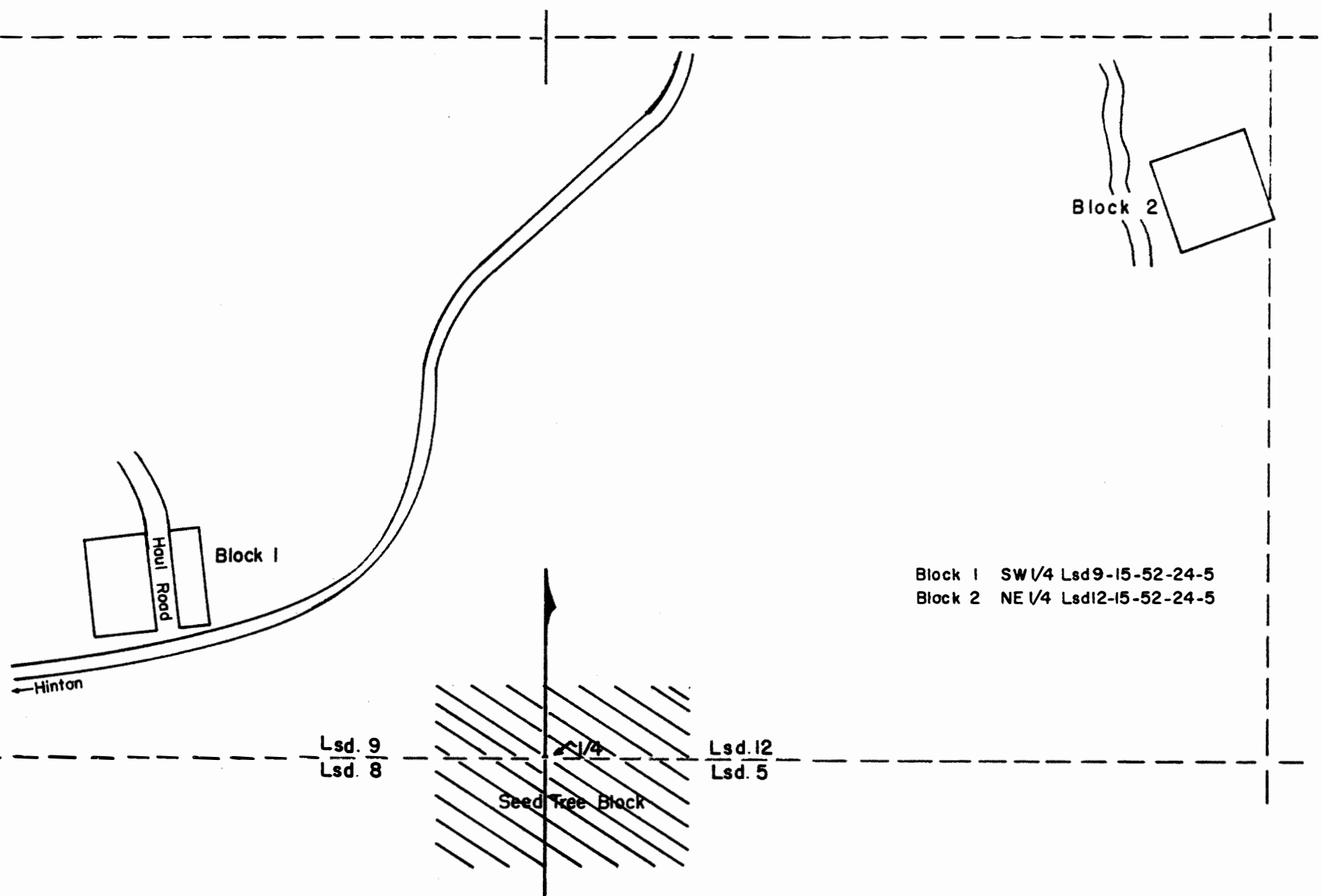
Camp 22, Cutting Block 139

Scale 1"=4 chains



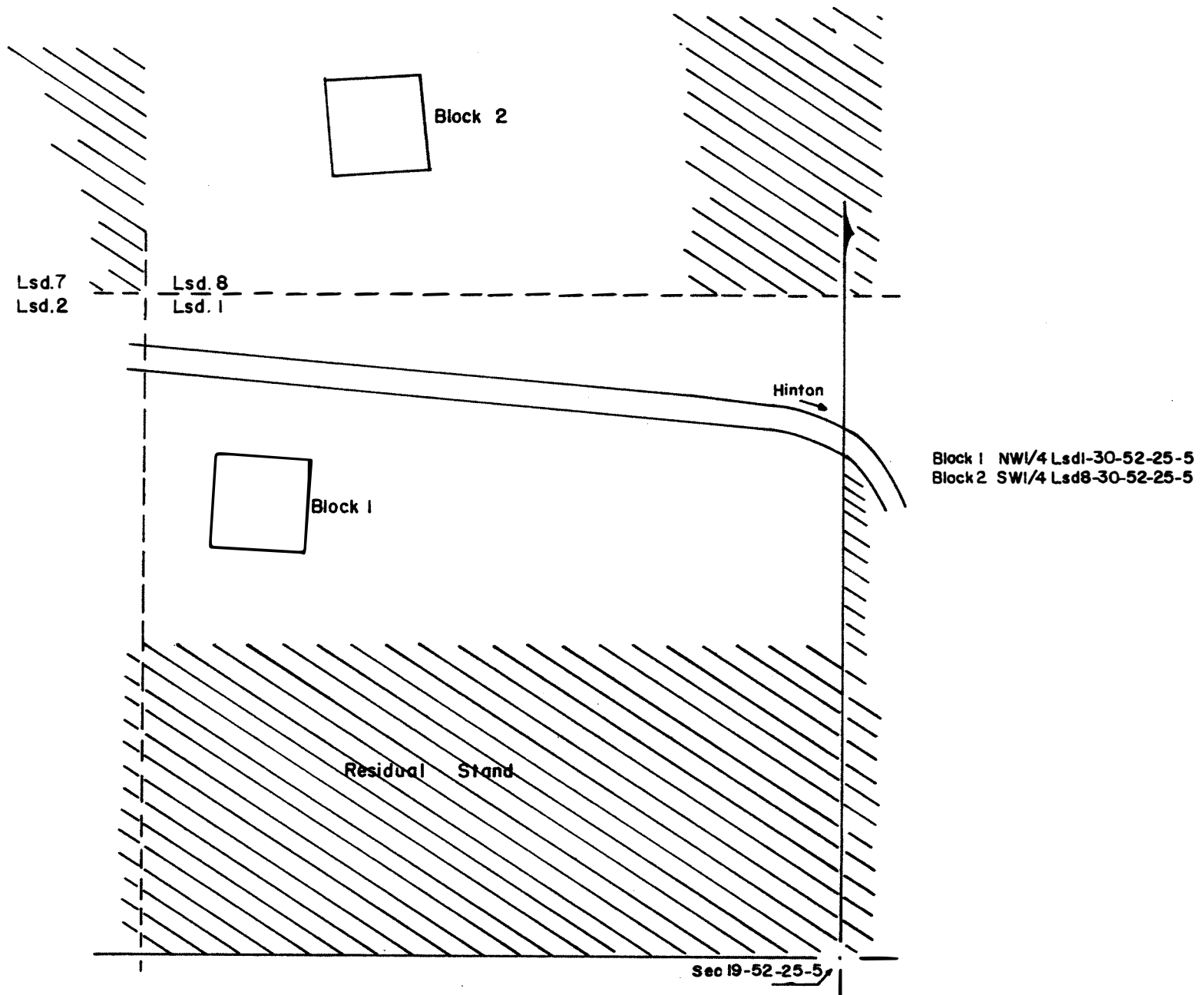
BLOCK LOCATIONS
1963 BULLET PLANTING
Camp 9 , Cutting Block

Scale 1" = 4 chains



BLOCK LOCATIONS
1963 BULLET PLANTING
Camp 29 , Cutting Blocks 30 & 121

Scale 1"=4chains



**1963 Bullet Planting -- Treatment Allocation
Site 2 (Camp 22) - Block 1 - Not Scarified**

<div style="display: flex; align-items: center;"> <div style="border-left: 1px solid black; border-right: 1px solid black; height: 180px; margin-right: 10px;"></div> <div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">180'</div> <div style="margin-bottom: 10px;">↓</div> <div style="margin-bottom: 10px;">30'</div> <div style="margin-bottom: 10px;">↓</div> </div> </div>	31 wS <i>8 weeks</i> AUG	32 wS <i>2-0</i> JULY	33 wS <i>16 weeks</i> JULY	34 wS <i>1-0</i> JUNE	35 wS <i>8 weeks</i> JUNE	36 Not Planted
	30 wS <i>2-0</i> JUNE	29 IP <i>16 weeks</i> JULY	28 wS <i>1-0</i> SEPT	27 Not Planted	26 wS <i>1-0</i> JULY	25 IP <i>16 weeks</i> SEPT
	19 Not Planted	20 IP <i>2-0</i> JUNE	21 wS <i>2-0</i> SEPT	22 Not Planted	23 wS <i>16 weeks</i> AUG	24 IP <i>16 weeks</i> AUG
	18 IP <i>8 weeks</i> AUG	17 wS <i>16 weeks</i> SEPT	16 IP <i>1-0</i> JULY	15 IP <i>2-0</i> JULY	14 IP <i>1-0</i> SEPT	13 IP <i>2-0</i> SEPT
	7 wS <i>2-0</i> AUG	8 IP <i>1-0</i> AUG	9 Not Planted	10 IP <i>1-0</i> JUNE	11 IP <i>16 weeks</i> JUNE	12 wS <i>8 weeks</i> JULY
	6 wS <i>1-0</i> AUG	5 IP <i>8 weeks</i> JUNE	4 IP <i>8 weeks</i> SEPT	3 IP <i>2-0</i> AUG	2 wS <i>16 weeks</i> JUNE	1 IP <i>8 weeks</i> JULY

Block 2 - Scarified

31 IP <i>1-0</i> AUG	32 wS <i>16 weeks</i> SEPT	33 IP <i>8 weeks</i> AUG	34 wS <i>2-0</i> JUNE	35 IP <i>16 weeks</i> JUNE	36 IP <i>2-0</i> JUNE
30 Not Planted	29 IP <i>8 weeks</i> JULY	28 wS <i>1-0</i> SEPT	27 wS <i>1-0</i> JUNE	26 IP <i>2-0</i> SEPT	25 wS <i>2-0</i> AUG
19 Not Planted	20 wS <i>2-0</i> SEPT	21 IP <i>16 week</i> SEPT	22 Not Planted	23 wS <i>2-0</i> JULY	24 IP <i>2-0</i> JULY
18 wS <i>16 weeks</i> AUG	17 wS <i>1-0</i> AUG	16 wS <i>1-0</i> JULY	15 IP <i>2-0</i> AUG	14 Not Planted	13 IP <i>16 weeks</i> AUG
7 IP <i>16 weeks</i> JULY	8 wS <i>8 weeks</i> JULY	9 IP <i>1-0</i> JUNE	10 wS <i>8 weeks</i> JUNE	11 Not Planted	12 IP <i>1-0</i> SEPT
6 IP <i>1-0</i> JULY	5 wS <i>8 weeks</i> JUNE	4 IP <i>8 weeks</i> SEPT	3 wS <i>16 weeks</i> JULY	2 IP <i>8 weeks</i> JUNE	1 wS <i>8 weeks</i> AUG

1963 Bullet Planting — Cell Treatment
Site 3 (Camp 9) — Block 1 - Not Scarified

31 WS <i>16 weeks</i>	32 WS <i>1-0</i>	33 IP <i>8 weeks</i>	34 WS <i>1-0</i>	Haul Road	35 WS <i>2-0</i>	36 Not Planted
AUG	SEPT	AUG	AUG		JUNE	
30 WS <i>8 weeks</i>	29 Not Planted	28 WS <i>2-0</i>	27 IP <i>16 weeks</i>		26 WS <i>16 weeks</i>	25 Not Planted
JUNE		SEPT	AUG		SEPT	
19 Not Planted	20 WS <i>2-0</i>	21 IP <i>16 weeks</i>	22 IP <i>8 weeks</i>		23 WS <i>8 weeks</i>	24 IP <i>16 weeks</i>
	AUG	JULY	JUNE		AUG	SEPT
18 IP <i>8 weeks</i>	17 IP <i>16 weeks</i>	16 WS <i>1-0</i>	15 IP <i>2-0</i>	Road Haul	14 WS <i>8 weeks</i>	13 IP <i>2-0</i>
SEPT	JUNE	JUNE	JULY		JULY	AUG
7 WS <i>1-0</i>	8 Not Planted	9 IP <i>1-0</i>	10 IP <i>1-0</i>		11 WS <i>2-0</i>	12 IP <i>8 weeks</i>
JULY		JUNE	SEPT		JULY	JULY
6 WS <i>16 weeks</i>	5 IP <i>2-0</i>	4 IP <i>1-0</i>	3 IP <i>2-0</i>		2 WS <i>16 weeks</i>	1 IP <i>1-0</i>
JULY	SEPT	AUG	JUNE		JUNE	JULY

Block 2 — Scarified

31 IP <i>1-0</i>	32 WS <i>8 weeks</i>	33 Not Planted	34 WS <i>16 weeks</i>	35 Not Planted	36 WS <i>16 weeks</i>
AUG	AUG		AUG		JULY
30 Not Planted	29 WS <i>2-0</i>	28 IP <i>1-0</i>	27 WS <i>1-0</i>	26 Not Planted	25 IP <i>2-0</i>
	JULY	JUNE	JUNE		SEPT
19 WS <i>1-0</i>	20 IP <i>8 weeks</i>	21 Not Planted	22 IP <i>1-0</i>	23 WS <i>8 weeks</i>	24 IP <i>1-0</i>
AUG	AUG		SEPT	JULY	JULY
18 WS <i>16 weeks</i>	17 IP <i>2-0</i>	16 IP <i>2-0</i>	15 IP <i>8 weeks</i>	14 IP <i>8 weeks</i>	13 WS <i>2-0</i>
SEPT	JUNE	JULY	JUNE	JULY	JUNE
7 IP <i>2-0</i>	8 IP <i>16 weeks</i>	9 WS <i>2-0</i>	10 IP <i>8 weeks</i>	11 IP <i>16 weeks</i>	12 WS <i>8 weeks</i>
AUG	AUG	SEPT	SEPT	SEPT	JUNE
6 IP <i>16 weeks</i>	5 IP <i>16 weeks</i>	4 WS <i>16 weeks</i>	3 WS <i>1-0</i>	2 WS <i>1-0</i>	1 WS <i>2-0</i>
JULY	JUNE	JUNE	JULY	SEPT	AUG

1963 Bullet Planting — Cell Treatment
Site 4 (Camp 29) — Block I - Not Scarified

31 WS 2-0 AUG	32 IP 1-0 JULY	33 Not Planted	34 WS 1-0 SEPT	35 WS 2-0 JUNE	36 IP 16 weeks AUG
30 WS 8 weeks JUNE	29 WS 8 weeks SEPT	28 IP 2-0 AUG	27 Not Planted	26 WS 8 weeks AUG	25 IP 2-0 SEPT
19 WS 2-0 SEPT	20 WS 1-0 AUG	21 WS 2-0 JULY	22 IP 8 weeks JUNE	23 IP 2-0 JULY	24 IP 1-0 SEPT
18 IP 16 weeks JULY	17 IP 16 weeks JUNE	16 WS 1-0 JUNE	15 Not Planted	14 IP 8 weeks JULY	13 Not Planted
7 WS 16 weeks SEPT	8 WS 8 weeks JULY	9 IP 1-0 JUNE	10 WS 16 weeks JULY	11 IP 8 weeks AUG	12 IP 1-0 AUG
6 WS 1-0 JULY	5 WS 16 weeks AUG	4 IP 8 weeks SEPT	3 IP 2-0 JUNE	2 WS 16 weeks JUNE	1 IP 16 weeks SEPT

Block 2 — Scarified

31 IP 16 weeks AUG	32 Not Planted	33 Not Planted	34 WS 16 weeks AUG	35 IP 16 weeks SEPT	36 IP 1-0 SEPT
30 IP 2-0 SEPT	29 WS 8 weeks JULY	28 IP 1-0 JUNE	27 WS 1-0 JUNE	26 Not Planted	25 Not Planted
19 WS 16 weeks JULY	20 WS 2-0 AUG	21 IP 16 weeks JULY	22 IP 1-0 AUG	23 WS 1-0 JULY	24 WS 1-0 AUG
18 WS 16 weeks SEPT	17 WS 8 weeks AUG	16 IP 2-0 JULY	15 IP 8 weeks JUNE	14 Not Planted	13 WS 2-0 JUNE
7 IP 2-0 JUNE	8 IP 8 weeks AUG	9 IP 8 weeks JULY	10 WS 2-0 SEPT	11 WS 1-0 SEPT	12 WS 8 weeks JUNE
6 IP 1-0 JULY	5 IP 16 weeks JUNE	4 WS 16 weeks JUNE	3 IP 2-0 AUG	2 IP 8 weeks SEPT	1 WS 2-0 JULY

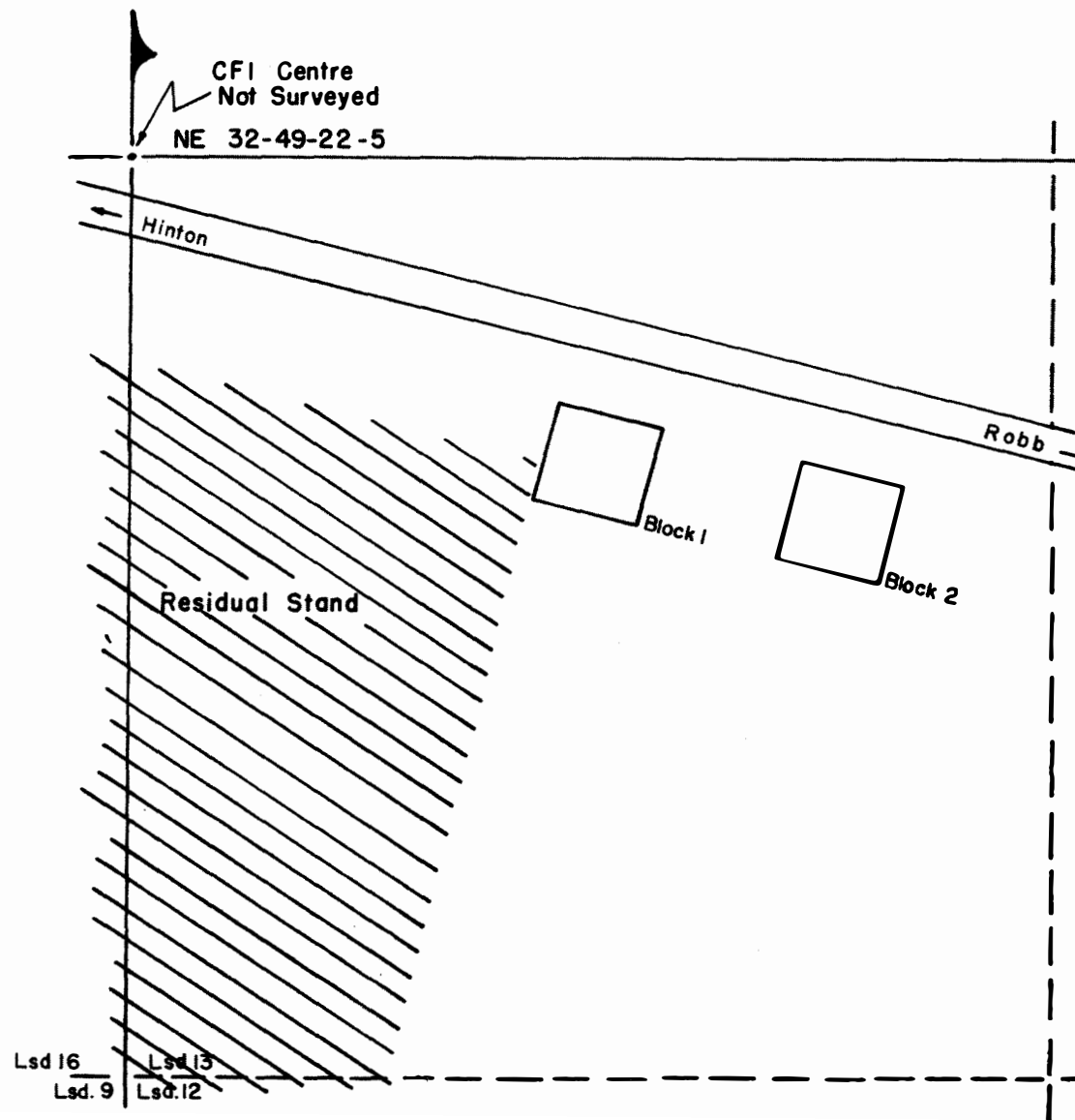
APPENDIX 3

1964 Bullet Planting

Block Locations and Cell Treatment

BLOCK LOCATIONS
1964 BULLET PLANTING
Camp 22, ~Cutting Block 130

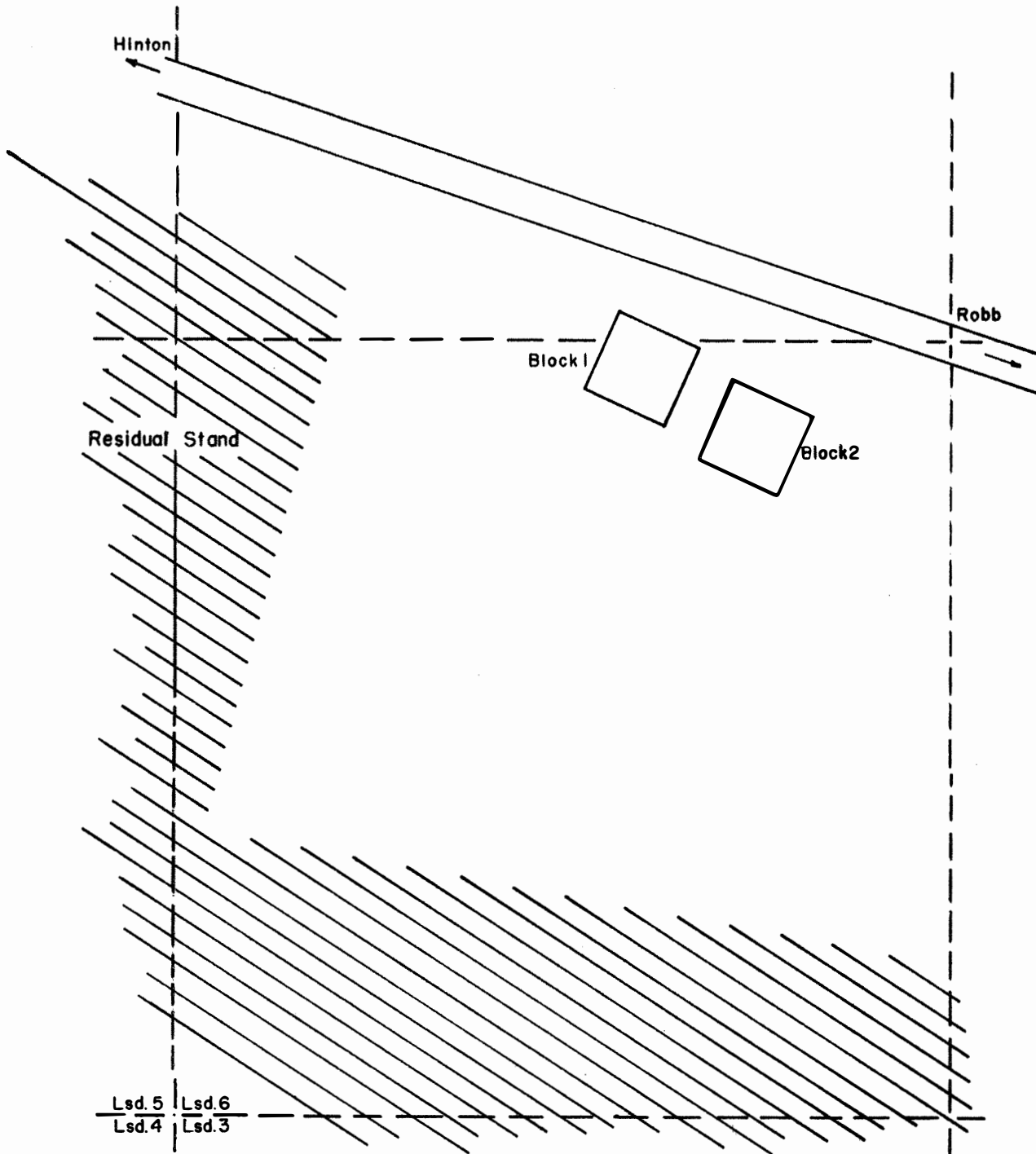
Scale 1" = 4 chains



BLOCKS 1 & 2
NE 1/4 Lsd. 13-32-49-22-5

BLOCK LOCATIONS
1964 BULLET PLANTING
Camp 22, Cutting Block 125

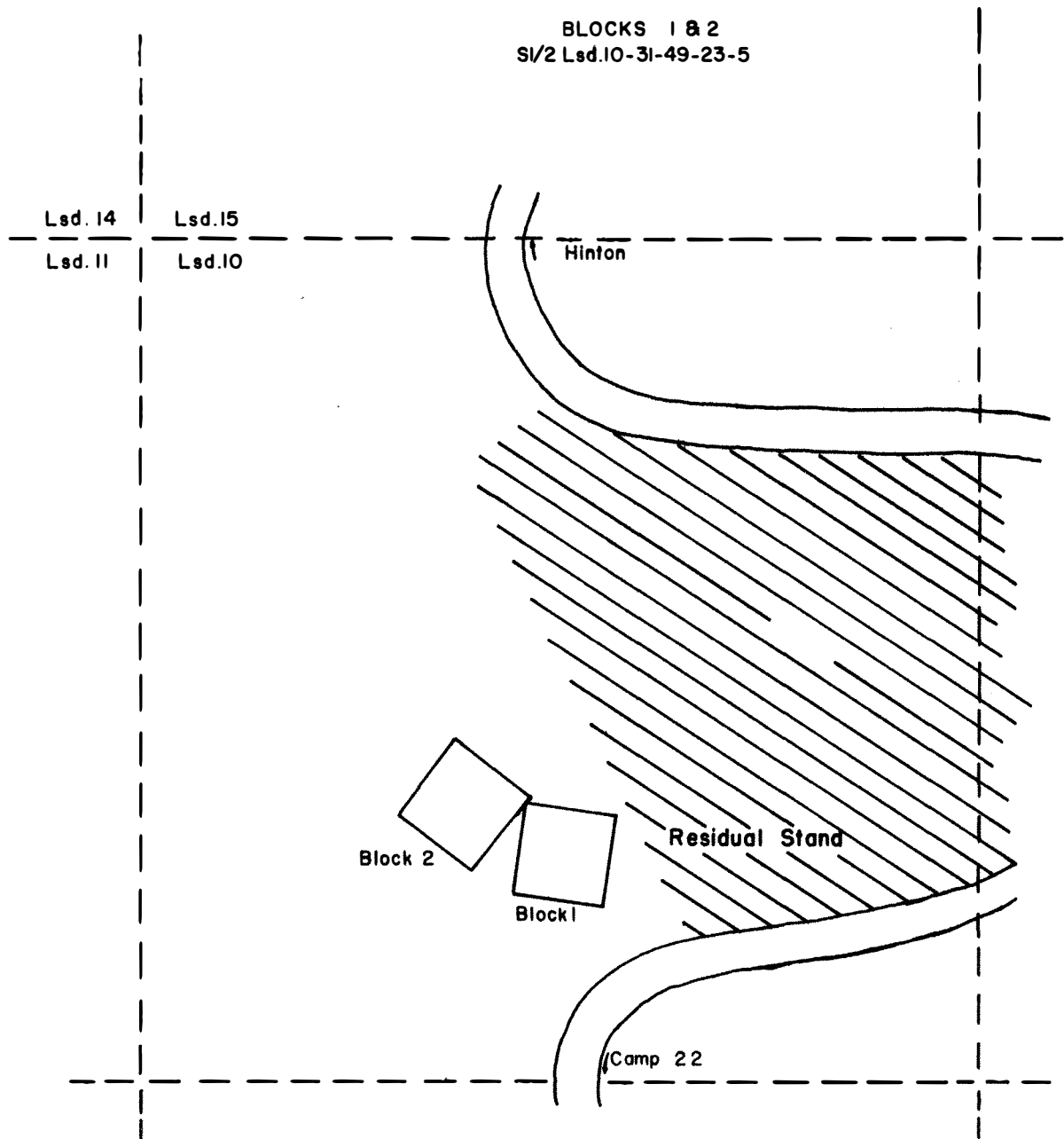
Scale 1" = 4 chains



BLOCKS 182
NE 1/4 Lsd. 6-34-49-22-5

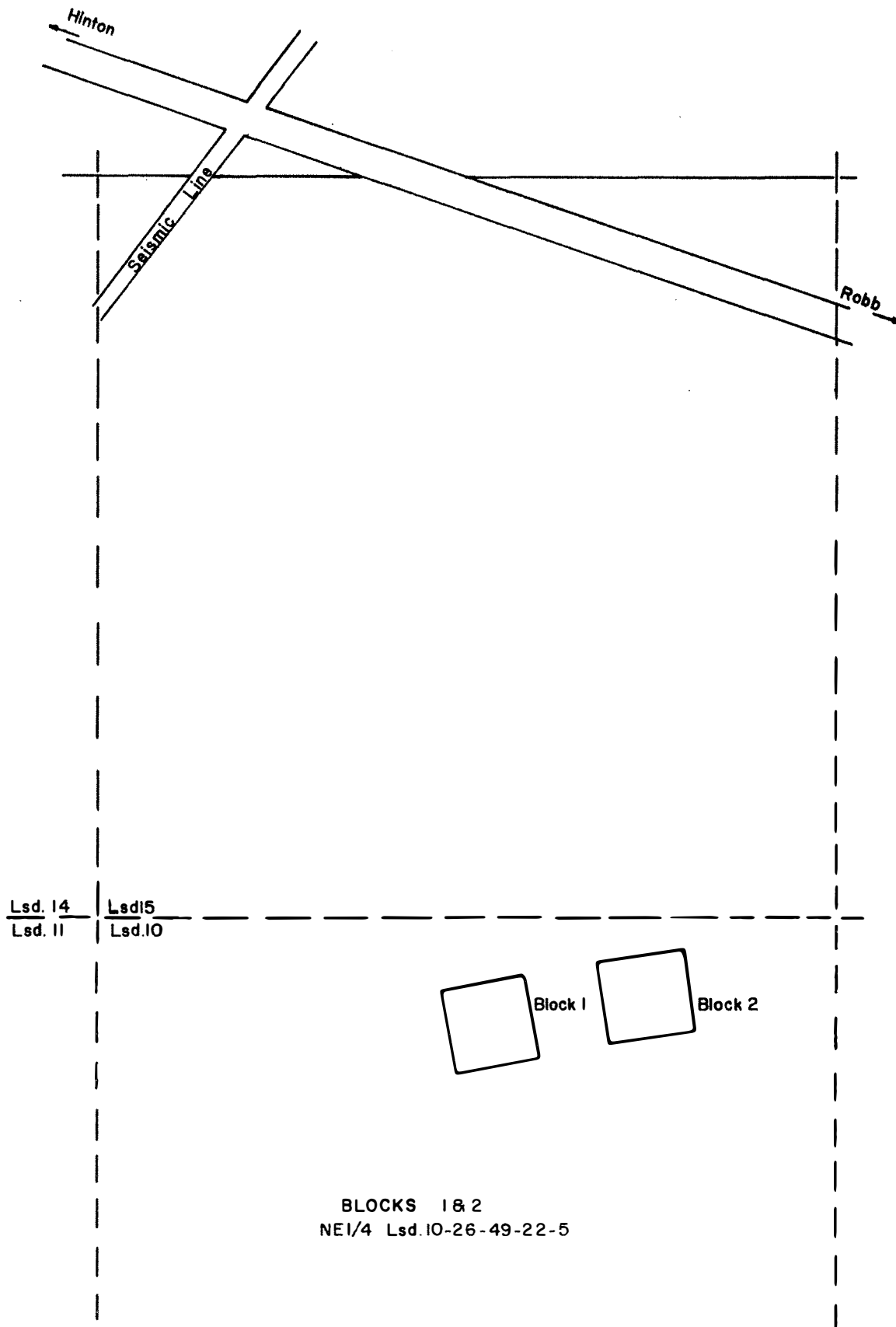
BLOCK LOCATIONS
1964 BULLET PLANTING
Camp 22, Cutting Block 139

Scale 1"=4 chains



BLOCK LOCATIONS
1964 BULLET PLANTING
Camp 22 , Cutting Block 119 A

Scale 1" = 4 chains



BLOCKS 1 & 2
NE 1/4 Lsd. 10-26-49-22-5

1964 BULLET PLANTING CELL TREATMENT
Site 5 - North Slope (Camp 22) Scarified Blocks

<div>25'</div> <div>150'</div>	31 wS Sept (7)	32 wS AUG (4)	33 wS SEPT (5)	34 IP SEPT (4)	35 IP SEPT (1)	36 wS SEPT (6)	<div>Container Code See Figure 6</div>
	30 wS AUG (7)	29 wS JUNE (1)	28 IP SEPT (5)	27 wS SEPT (3)	26 IP SEPT (3)	25 wS AUG (3)	
	19 IP AUG (6)	20 wS JUNE (6)	21 wS JUNE (4)	22 IP AUG (7)	23 IP AUG (1)	24 IP JUNE (4)	
	18 wS AUG (6)	17 IP JUNE (6)	16 wS JUNE (3)	15 wS AUG (5)	14 IP SEPT (6)	13 IP JUNE (7)	
	7 wS SEPT (4)	8 IP JUNE (5)	9 wS SEPT (1)	10 IP SEPT (7)	11 IP JUNE (3)	12 wS AUG (1)	
	6 IP AUG (3)	5 IP JUNE (5)	4 IP AUG (4)	3 IP AUG (5)	2 wS JUNE (7)	1 wS JUNE (5)	

Block 1

31 wS AUG (4)	32 IP JUNE (7)	33 IP SEPT (1)	34 IP AUG (3)	35 IP AUG (7)	36 IP AUG (4)	Block 2
30 wS JUNE (6)	29 wS SEPT (3)	28 wS AUG (5)	27 wS SEPT (6)	26 wS SEPT (1)	25 IP SEPT (3)	
19 wS JUNE (1)	20 IP SEPT (5)	21 IP AUG (6)	22 IP SEPT (6)	23 wS AUG (3)	24 wS JUNE (3)	
18 wS AUG (7)	17 IP SEPT (7)	16 IP JUNE (3)	15 wS JUNE (7)	14 IP AUG (1)	13 wS JUNE (5)	
7 IP JUNE (6)	8 IP AUG (5)	9 IP JUNE (4)	10 wS JUNE (4)	11 wS AUG (1)	12 wS SEPT (7)	
6 IP JUNE (5)	5 IP SEPT (4)	4 wS SEPT (4)	3 wS AUG (6)	2 IP JUNE (1)	1 wS SEPT (5)	

1964 BULLET PLANTING — CELL TREATMENT
 Site 5 - North Slope - (Camp 22) - Unscarified Blocks

31 IP JUNE (7)	32 WS JUNE (1)	33 WS SEPT (1)	34 WS JUNE (5)	35 WS AUG (5)	36 WS AUG (8)
30 IP SEPT (4)	29 WS SEPT (7)	28 WS JUNE (7)	27 IP AUG (7)	26 IP JUNE (4)	25 WS SEPT (3)
19 IP SEPT (3)	20 IP AUG (1)	21 WS SEPT (4)	22 WS JUNE (4)	23 IP JUNE (1)	24 IP JUNE (6)
18 IP JUNE (5)	17 WS AUG (1)	16 WS JUNE (3)	15 WS JUNE (6)	14 IP AUG (4)	13 WS SEPT (5)
7 IP AUG (5)	8 WS AUG (4)	9 WS AUG (7)	10 IP JUNE (3)	11 IP SEPT (6)	12 IP SEPT (7)
6 IP SEPT (1)	5 IP SEPT (5)	4 IP AUG (3)	3 WS SEPT (6)	2 WS AUG (3)	1 IP AUG (6)

Block 1

31 IP JUNE (1)	32 IP JUNE (3)	33 IP SEPT (4)	34 WS JUNE (1)	35 WS AUG (1)	36 WS SEPT (5)
30 WS SEPT (6)	29 WS SEPT (7)	28 IP JUNE (5)	27 IP AUG (1)	26 WS JUNE (5)	25 WS AUG (5)
19 WS JUNE (6)	20 WS JUNE (3)	21 WS AUG (6)	22 IP AUG (5)	23 IP SEPT (7)	24 WS SEPT (4)
18 WS AUG (7)	17 IP JUNE (4)	16 WS SEPT (3)	15 IP SEPT (5)	14 IP AUG (7)	13 IP SEPT (3)
7 IP AUG (4)	8 WS JUNE (7)	9 IP AUG (3)	10 IP SEPT (6)	11 WS AUG (3)	12 WS JUNE (4)
6 IP JUNE (6)	5 WS AUG (4)	4 IP AUG (6)	3 IP SEPT (1)	2 IP JUNE (7)	1 WS SEPT (1)

Block 2

1964 BULLET PLANTING — CELL TREATMENT
Site 6 — South Slope — (Camp 22) — Scarified Blocks

31 IP AUG (4)	32 IP JUNE (6)	33 wS AUG (3)	34 IP JUNE (4)	35 wS SEPT (6)	36 IP AUG (6)
30 IP SEPT (7)	29 wS JUNE (5)	28 IP SEPT (4)	27 wS JUNE (6)	26 wS JUNE (4)	25 IP SEPT (1)
19 wS SEPT (3)	20 wS SEPT (1)	21 wS AUG (1)	22 wS AUG (7)	23 wS AUG (5)	24 IP SEPT (5)
18 wS SEPT (7)	17 wS SEPT (5)	16 wS SEPT (4)	15 wS JUNE (7)	14 IP JUNE (7)	13 IP JUNE (3)
7 wS JUNE (1)	8 wS JUNE (3)	9 wS AUG (6)	10 IP JUNE (5)	11 IP JUNE (1)	12 IP SEPT (3)
6 IP AUG (5)	5 IP AUG (3)	4 IP AUG (7)	3 wS AUG (4)	2 IP SEPT (6)	1 IP AUG (1)

Block 1

31 wS AUG (3)	32 IP AUG (6)	33 wS SEPT (7)	34 wS JUNE (4)	35 wS SEPT (5)	36 IP SEPT (3)
30 wS AUG (5)	29 IP JUNE (5)	28 wS SEPT (1)	27 IP JUNE (1)	26 wS AUG (6)	25 IP SEPT (7)
19 IP AUG (1)	20 IP AUG (7)	21 IP AUG (5)	22 wS SEPT (6)	23 IP JUNE (4)	24 IP SEPT (1)
18 IP SEPT (6)	17 IP JUNE (7)	16 wS SEPT (3)	15 IP AUG (3)	14 wS JUNE (1)	13 wS JUNE (7)
7 IP SEPT (4)	8 wS SEPT (4)	9 wS AUG (4)	10 IP JUNE (3)	11 wS JUNE (6)	12 IP AUG (4)
6 wS AUG (7)	5 wS JUNE (5)	4 IP JUNE (6)	3 wS JUNE (3)	2 wS AUG (1)	1 IP SEPT (5)

Block 2

1964 BULLET PLANTING - CELL TREATMENT
Site 6 - South Slope - (Camp 22) - Unscarified Blocks

31 IP JUNE (5)	32 WS SEPT (7)	33 WS SEPT (4)	34 WS JUNE (5)	35 IP SEPT (4)	36 IP SEPT (5)
30 WS AUG (6)	29 WS SEPT (6)	28 WS JUNE (4)	27 IP SEPT (3)	26 IP AUG (7)	25 IP SEPT (7)
19 WS AUG (1)	20 IP JUNE (4)	21 IP AUG (6)	22 IP AUG (4)	23 IP SEPT (6)	24 IP JUNE (1)
18 WS AUG (3)	17 WS JUNE (7)	16 IP JUNE (3)	15 WS JUNE (1)	14 WS AUG (7)	13 WS SEPT (3)
7 IP JUNE (6)	8 IP JUNE (7)	9 IP AUG (5)	10 IP SEPT (1)	11 WS AUG (4)	12 IP AUG (3)
6 WS JUNE (6)	5 WS JUNE (3)	4 WS SEPT (5)	3 WS SEPT (1)	2 IP AUG (1)	1 WS AUG (5)

Block 1

31 IP JUNE (5)	32 WS AUG (3)	33 IP SEPT (7)	34 WS SEPT (7)	35 WS SEPT (5)	36 IP SEPT (1)
30 WS JUNE (7)	29 WS AUG (7)	28 WS AUG (1)	27 WS SEPT (3)	26 IP JUNE (3)	25 IP AUG (7)
19 IP SEPT (3)	20 WS JUNE (5)	21 IP AUG (1)	22 IP SEPT (5)	23 IP JUNE (6)	24 WS AUG (5)
18 IP JUNE (4)	17 IP AUG (4)	16 WS JUNE (1)	15 WS JUNE (3)	14 WS SEPT (1)	13 WS AUG (6)
7 IP SEPT (6)	8 WS JUNE (6)	9 WS JUNE (4)	10 WS AUG (4)	11 IP AUG (5)	12 WS SEPT (6)
6 IP AUG (3)	5 IP JUNE (7)	4 IP SEPT (4)	3 IP JUNE (1)	2 IP AUG (6)	1 WS SEPT (4)

Block 2