Title: Container Density and Sun Exposure Trial - Interior Douglas Fir and Western Hemlock.

Report prepared by: A. L. Brazier (Signature) (Typed)

Report & distribution approved by: J. Sweeten (Signature) (for Regions - Silviculture Officer) (Typed)

(a) Wide Distribution
(b) Limited
   (i) Internal - Branch only
   (ii) External - Designated
   (iii) Ministry only

COPIES TO: Library

Approved:
Manager - (Signature) (for Regions - Forestry Manager) (Typed)

634.909/711/BCMFSIL/SX 85
BRAZIER, A.L.
CONTAINER DENSITY AND SUN EXPOSURE TRIAL: INTERIOR
CCLW c. 1 ma Main........
Container Density and Sun Exposure Trial
Interior Douglas Fir and Western Hemlock

A. L. Brazier
Project Officer
Ministry of Forests
March 23, 1983
Container Density and Sun Exposure Trial – Interior Douglas Fir and Western Hemlock

Technician i/c Shon Ostafew
Location Surrey

Objective: An investigation was undertaken with Interior Douglas Fir and Western Hemlock to see whether conditioning under full sun conditions would increase root weights, control top growth, reduce cull rate and condition stock for outplanting. As a further investigation trees were grown at reduced densities to determine the effect of top competition on overall seedling growth.

Final Report

Two densities of Interior Douglas Fir in styroblocks with three different full sun exposure dates were examined to determine any morphological effects. Results indicate no differences in height, or root collar diameter but root weights were significantly greater for the two earlier exposure for the 475 per square metre density (100 per styroblock). No significant differences were found with the density of 190 seedling per styroblock. The maximum number of trees reaching minimum planting specifications was recorded with the density of 932 per square metre (190 per block) and the August 1st exposure date.
In Western Hemlock 3 densities and 3 exposure dates were examined. The largest trees resulted from the 570 seedlings per square metre density (block) and the July 1st exposure date. Heights varied only slightly regardless of treatment. The greatest improvement in stock specifications recorded with the densest stock. The July 1st and August 1st exposure resulted in significantly greater top and root weights. The incidence of pyrytis caused mortality, was reduced by full sun exposure treatment.
Abstract: Two densities of Interior Douglas Fir in styroblocks with three different full sun exposure dates were examined to determine any morphological effects. Results indicate no differences in height, or root collar diameter but root weights were significantly greater for the two earlier exposure for the 475 per square metre density (100 per styroblock). No significant differences were found with the density of 190 seedlings per styroblock. The maximum number of trees reaching minimum planting specifications was recorded with the density of 932 per square metre (190 per block) and the August 1st exposure date.

In Western Hemlock 3 densities and 3 exposure dates were examined. The largest trees resulted from the 570 seedlings per square metre density (120/block) and the July 1st exposure date. Heights varied only slightly regardless of treatment. The greatest improvement in stock specifications was recorded with the densest stock. The July 1st and August 1st exposure date resulted in significantly greater top and root weights. The incidence of botrytis caused mortality, was reduced by full sun exposure treatment.
Introduction

They styroblock container system induces an extreme degree of competition among individual plants. Densities in styroblock 211's are 1,135 cavities per square metre and 313's are 932 per square metre. Competition for light is not restricted to between separate plants but exists also between the needles of the same plant.

High light levels have generally been credited with promoting root growth and increasing root/shoot ratios. Our nurseries have had indications that some species exhibit excessive elongation under reduced light conditions without compensating caliper or root growth. Light saturation levels vary with species but in general are less than 50% of full sun for tolerant (shade) trees and full sun plus for intolerant (sun) trees. Reaching the saturation light intensity for an individual species does not mean, however, that increased growth cannot be obtained by the reduction of intra and inter tree shading.

Shoots and roots not only compete between plants but also within the same plant. When light levels are high sufficient photosynthate is produced for both shoots and roots. If light is limiting top growth occurs at the expense of root growth especially in tolerant plants. Lower light levels late in the growing season, cause an overall reduction in growth rate but are particularly problematic since the large plant tops compete for photosynthate when the majority of root growth should occur.

Western Hemlock has been a constant problem when grown in stryroblocks due to its prostrate form and the resulting shading. Very low root weights and poorly formed plugs have been accepted as almost inevitable. Solarization has also been particularly severe in greenhouse grown Western Hemlock, and even occurs in the trasnplant beds. Photographs
1 and 2 show examples of outplanting plots at Surrey Nursery. The PSB +1 stock obviously has no problem establishing after a year of conditioning and growth in the transplant bed.

Photograph #1 Seedlot No. 2248, PSB 211 - Outplanted March 16th at Surrey Nursery. Only 6 plants out of 50 surviving.

Photograph #2 Seedlot No. 2249  PSB 211+1 - Outplanted February 26th at Surrey Nursery. Good survival.
With these problems in mind an investigation was undertaken with Interior Douglas Fir and Western Hemlock to see whether conditioning under full sun conditions would increase root weights, control top growth, reduce cull rate and condition stock for outplanting. As a further investigation trees were grown at reduced densities to determine the effect of top competition on overall seedling growth.

Methods

In the spring of 1982 the following blocks were sown in the normal manner.

Douglas Fir (Interior) S/L 1885                Hemlock (Western) S/L 3917
PSB 415B's - 15 blocks                        PSB 211's - 45 blocks
PSB 313's  - 30 blocks

This stock was germinated, placed in a greenhouse and watered and fertilized normally. At approximately 8 weeks the densities of some of the blocks were reduced as follows:

Douglas Fir (Interior)
PSB 313's  15 blocks reduced to 100 per block

Hemlock Western
PSB 311's  15 blocks reduced to 160 per block
         15 blocks reduced to 120 per block

On July 1, August 1, and September 1 some blocks of each treatment were moved outside to the compound in full sun. Blocks from each treatment were left in the greenhouse during the entire growing season.
Random heights, calipers and dry weights (top and root) were measured and recorded on FS 743-0's as 5 samples of 10 trees. Each block was only sampled once to avoid reduced growing densities. Table 1 outlines when samples were taken throughout the growing season.

Results

Interior Douglas Fir

Tables 2, 3, 4 and 5 record the morphological data by density and exposure treatment. The numbers of trees which achieved standards are also present as a percent of total trees. Figures 1, 2 and 3 show the same morphological data in histogram form and the entire seasons growth by treatment follows each figure.

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Height (cm)</th>
<th>Density 190/block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RCD(mm)</td>
</tr>
<tr>
<td>1. No full sun</td>
<td>16.0 NS</td>
<td>2.3 NS</td>
</tr>
<tr>
<td>2. Outside July 1</td>
<td>17.4 NS</td>
<td>2.5 NS</td>
</tr>
<tr>
<td>3. Outside August 1</td>
<td>17.2 NS</td>
<td>2.6 NS</td>
</tr>
<tr>
<td>4. Outside September 1</td>
<td>16.2 NS</td>
<td>2.2 NS</td>
</tr>
</tbody>
</table>

As the above table indicates there was no significant difference between any of the treatments. However the August 1st exposure date appears to have produced slightly larger stock.

A seemingly modest increase in root collar diameter of 2.0 mm to 2.5 mm is actually a 56% increase in cross-sectional area and is the difference between a sturdy stem and a stem which provides inadequate support.
<table>
<thead>
<tr>
<th></th>
<th>415B Inside</th>
<th>415B Outside</th>
<th>313 Inside</th>
<th>313 Outside</th>
<th>313 Inside</th>
<th>313 Outside</th>
<th>211 (120) Inside</th>
<th>211 (120) Outside</th>
<th>211 (160) Inside</th>
<th>211 (160) Outside</th>
<th>211 Inside</th>
<th>211 Outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing</td>
<td>15</td>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Thinning (8 weeks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 15</td>
<td>11*</td>
<td>4</td>
<td>11*</td>
<td>4</td>
<td>11*</td>
<td>4</td>
<td>11*</td>
<td>4</td>
<td>11*</td>
<td>4</td>
<td>11*</td>
<td>4</td>
</tr>
<tr>
<td>Aug. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug. 15</td>
<td>8*</td>
<td>4+3</td>
<td>8*</td>
<td>4+3</td>
<td>8*</td>
<td>4+3</td>
<td>8*</td>
<td>4+3</td>
<td>8*</td>
<td>4+3</td>
<td>8*</td>
<td>4+3</td>
</tr>
<tr>
<td>Sept. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept. 15</td>
<td>6*</td>
<td>4+3+2</td>
<td>6*</td>
<td>4+3+2</td>
<td>6*</td>
<td>4+3+2</td>
<td>6*</td>
<td>4+3+2</td>
<td>6*</td>
<td>4+3+2</td>
<td>6*</td>
<td>4+3+2</td>
</tr>
<tr>
<td>Oct. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct. 15</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
</tr>
<tr>
<td>Nov. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov. 15</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
<td>*</td>
<td>4+3+2</td>
</tr>
<tr>
<td>Untested Blocks Remaining</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

* Sampling - Random, Calipers, Dry Weights
. Random Heights
### Interior Douglas Fir  PSB 313

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Height(cm)</th>
<th>Density 100/block</th>
<th>RCD(mm)</th>
<th>TW(gms)</th>
<th>RW(gms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No full sun</td>
<td>13.0 B</td>
<td>2.6 NS</td>
<td>.60 b</td>
<td>.36 B</td>
<td></td>
</tr>
<tr>
<td>2. Outside July 1</td>
<td>15.0 B</td>
<td>2.7 NS</td>
<td>.63 b</td>
<td>.32 B</td>
<td></td>
</tr>
<tr>
<td>3. Outside August 1</td>
<td>17.6 A</td>
<td>2.9 NS</td>
<td>.88 a</td>
<td>.45 A</td>
<td></td>
</tr>
<tr>
<td>4. Outside September 1</td>
<td>15.8 A</td>
<td>2.7 NS</td>
<td>.81 a</td>
<td>.43 A</td>
<td></td>
</tr>
</tbody>
</table>

Measurements in each column which are followed by the same letter are not significant at .01.

Unlike the 190 trees per block density the heights, top weights, and root weights for the August 1st and September 1st full sun exposure treatment were significantly larger than the July 1st or no full sun treatment.

Overall the August 1st treatment appears to have produced the largest stock.

### Interior Douglas Fir  PSB 415B

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Height</th>
<th>Density 112/block</th>
<th>RCD</th>
<th>TW</th>
<th>RW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No full sun</td>
<td>17.0 NS</td>
<td>2.7 NS</td>
<td>.99 NS</td>
<td>.58 a</td>
<td></td>
</tr>
<tr>
<td>2. Outside July 1</td>
<td>16.5 NS</td>
<td>2.7 NS</td>
<td>.92 NS</td>
<td>.38 b</td>
<td></td>
</tr>
<tr>
<td>3. Outside August 1</td>
<td>17.0 NS</td>
<td>2.7 NS</td>
<td>.96 NS</td>
<td>.39 b</td>
<td></td>
</tr>
<tr>
<td>4. Outside September 1</td>
<td>17.2 NS</td>
<td>2.7 NS</td>
<td>1.00 NS</td>
<td>.42 b</td>
<td></td>
</tr>
</tbody>
</table>

The cultural regime did not result in the utilization of large sized container to capacity. The resulting trees were not different from the trees grown in 313's at 100 trees per block. None of the full sun exposure treatments were better than the greenhouse grown stock.
<table>
<thead>
<tr>
<th>Species</th>
<th>Density</th>
<th>Treatment</th>
<th>% Achieving Minimum Specs</th>
<th>% Achieving Target Specs</th>
<th>Cull%</th>
<th>Number Plantable per Blk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fi 1885</td>
<td>190</td>
<td>1</td>
<td>82</td>
<td>13</td>
<td>18</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>90</td>
<td>20</td>
<td>10</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>54</td>
<td>6</td>
<td>46</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>60</td>
<td>34</td>
<td>40</td>
<td>114</td>
</tr>
<tr>
<td>Fi 1885</td>
<td>100</td>
<td>1</td>
<td>64</td>
<td>16</td>
<td>36</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>80</td>
<td>48</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>84</td>
<td>56</td>
<td>16</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>48</td>
<td>14</td>
<td>52</td>
<td>48</td>
</tr>
<tr>
<td>Fi 1885</td>
<td>112</td>
<td>1</td>
<td>42</td>
<td>58</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>52</td>
<td>48</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>52</td>
<td>48</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>60</td>
<td>40</td>
<td>67</td>
<td>67</td>
</tr>
</tbody>
</table>

**Treatment**

1 - Moved outside July 1  
2 - Moved outside August 1  
3 - Moved outside September 1  
4 - Inside Greenhouse

**Specifications**

<table>
<thead>
<tr>
<th>Fi PSB 313 Minimum</th>
<th>12.0 cm x 2.2 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>15.0 cm x 3.0 mm</td>
</tr>
</tbody>
</table>

The above table indicated the PSB 415’s and the PSB 313's at 100 seedlings per block were not an advantage over the standard PSB 313 sowings. The August 1st exposure date at the 190 per block density produced the greatest percentage of seedlings which exceeded minimum specifications.

The number of plantable seedlings per block is by far the greatest in the 190 per block density with the July 1st or August 1st full sun exposure date.
The full sun exposure treatments do increase the percentage of trees attaining the current minimum sizes in PSB 313's. In the PSB 415B's there does not appear to have been any effect.

The heights of all treatments did not vary significantly except the no full sun treatment for the density 100 per block which were shorter as well as having reduced root weight. The reduction in density from 190 to 100 trees per block did not produce significant increases in growth and does not appear to be justified.

The root collar diameters of both the 190 and 100 density did not vary significantly between treatments and there is no real difference in either top weights or root weights. Some increase in size does occur at the 100 density but the great reduction in the number of seedlings per block makes this treatment uneconomic.

The 415's were not utilized to potential with the cultural regime used and the small number of seedlings per block and the minimal increase in size do not recommend this container.

This seedlot (1885) is an extreme northern seedlot and also was sown on May 6th which is far too late to expect optimum growth.

Figures 4 and 5 show two other seedlots which were grown at Surrey during 1982. The graphs are a result of the nursery's normal monitoring program. One of the seedlots (3363) was sown March 26th and was exposed to full sun July 2nd. These trees were about 12 centimeters at exposure time and the resulting shock caused temporary bud set. When sufficient height growth was achieved severe moisture stress was applied which successfully terminated height growth.
Seedlot: FL 1083, PSB 311
Sown: May 6, 1982
Density: 190/bag

EXPOSURE DATE
July 1 Aug. 1 Sept. 1 Control

HEIGHT cm
20-
15-
10-
5-
0-

TOP WEI GHT g
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
Nursery: Surrey
Seedlot: FI 1885 PSB 313
Reg. No.: 
Facility: Greenhouse 7
Sown: May 6, 1982
Misc.: 190/block Control

Static Sample Height
Random Sample Height
Root Collar Diameter

Weeks From Sowing

F.S. 744-0
Figure 2

Seedlot: FL 1885 PSE 313
Soil: May 6, 1982
Density: 100/block

HEIGHT cm

0-  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9  1.0

0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9  1.0

July 1 Aug. 1 Sept. 1 Control July 1 Aug. 1 Sept. 1 Control

EXPOSURE DATE
Nursery: Surrey
Seedlot: PI 1885 PSB 313
Reg. No.: 7
Facility: Greenhouse
Sown: May 6, 1987
M misc.: Thinned to 100, moved outside July 1.

Static Sample Height
Random Sample Height
Root Collar Diameter

Height cm

Top Weight
Root Weight

Weight g

Root Collar Diameter mm

Weeks From Sowing

F.S. 744-0
<table>
<thead>
<tr>
<th>Nursery</th>
<th>Surrey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedlot</td>
<td>F1 1885 PSB 313</td>
</tr>
<tr>
<td>Reg. No.</td>
<td></td>
</tr>
<tr>
<td>Facility</td>
<td>Greenhouse 7</td>
</tr>
<tr>
<td>Sown</td>
<td>May 6, 1982</td>
</tr>
<tr>
<td>Misc.</td>
<td>Thinned to 100/block, Moved outside August 1.</td>
</tr>
</tbody>
</table>

**Figure 2b**

**Graph Details:**
- Static Sample Height
- Random Sample Height
- Root Collar Diameter
- Top Weight
- Root Weight
- Height cm vs. Weeks From Sowing
- Root Collar Diameter mm vs. Weeks From Sowing

**Graph Notes:**
- FULL SUN
- Data points indicated by markers.
- Graph ranges from 0 to 20 weeks from sowing.
- Graph ranges from 0 to 15 cm for height.
- Graph ranges from 0 to 3 mm for root collar diameter.

**F.S. 744-o**
Nursery: Surrey
Seedlot: EF 1885, PSB 313
Reg. No.: 
Facility: Greenhouse 7
Sown: May 6, 1982
Misc.: Thinned to 100/block, moved outside September 1.

Static Sample Height
Random Sample Height
Root Collar Diameter

Top Weight:
Root Weight:

Height cm
Root Collar Diameter mm
Top Weight g
Root Weight g

Weeks From Sowing

F.S. 744-0
Nursery: Surrey
Seedlot: F1 1885 PSB 415B
Reg. No.: 
Facility: Greenhouse 7
Sown: May 6, 1982
Misc.: Moved outside July 1.

Static Sample Height
Random Sample Height
Root Collar Diameter

Height cm

Weeks From Sowing

Top Weight g
Root Weight g

Root Collar Diameter mm
Nursery: Surrey
Seedlot: FI 1885 PSB 415B
Reg. No.: 7
Facility: Greenhouse 7
Sown: May 5, 1982
Misc.: Moved outside August 1.

Graph showing:
- Static Sample Height
- Random Sample Height
- Root Collar Diameter

Graph axes:
- Height cm
- Root Collar Diameter mm

Graph with data points:
- Full Sun
- Top Weight
- Root Weight

Graph timeline:
- Weeks From Sowing

F.S. 744-0
The Figure No. 4 shows a seedlot which was sown May 7th and was exposed to full sun August 10th. Of interest in this graph is the sudden termination of growth coincided with the cessation of top growth which appears in the trial seedlot 1885.

The Interior Fir crop at Surrey was the best ever at that facility as the following bears out:

<table>
<thead>
<tr>
<th>Size</th>
<th>Request(k)</th>
<th>Cavities sown(k)</th>
<th>Lift(k)</th>
<th>Lift % Request</th>
<th>Lift % Cavities</th>
<th>Trees/Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>313</td>
<td>1188.4</td>
<td>1493.7</td>
<td>1103.1</td>
<td>92</td>
<td>74</td>
<td>146</td>
</tr>
<tr>
<td>211</td>
<td>180.0</td>
<td>224.9</td>
<td>177.9</td>
<td>99</td>
<td>79</td>
<td>190</td>
</tr>
</tbody>
</table>

For comparison Figures 6 and 7 show typical seedlot growth patterns for the 1981 crop. Of interest is the sudden termination of all growth with the cessation of height growth.
height growth has been achieved
Maintain for remainder of season

The full sun treatment appears to successfully avoid the stagnation of all growth which has plagued Interior Fir container crops.

2. A further note should be made concerning the risks of dealing with means. The 190 per block density no full sun exposure, appeared to have excellent specifications but when the number of trees exceeding minimums is examined this treatment falls far short of the exposure treatments.

In crops where a high cull rate is experienced the data from the plantable trees should be examined as well as the overall means when evaluating crop performance.

Results

Western Hemlock

The measured results are recorded in Table Numbers 6, 7, and 8 and Figures 8, 9, and 10.

Sun exposure did improve root weights, top weights and calipers but very little difference was recorded for heights. The most dramatic improvement was recorded for the densest blocks (223 per block).

The number of trees exceeding the minimum was maximized by exposing normally sown blocks at the earliest date. The lower the density the less limiting light intensity appears to be but substantial increases in growth were still achieved.
Table 6

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Density - 223 / block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height(cm)</td>
</tr>
<tr>
<td>1. No full sun</td>
<td>18.8 NS</td>
</tr>
<tr>
<td>2. Outside July 1</td>
<td>20.4 NS</td>
</tr>
<tr>
<td>3. Outside August 1</td>
<td>19.6 NS</td>
</tr>
<tr>
<td>4. Outside September 1</td>
<td>19.2 NS</td>
</tr>
</tbody>
</table>

Measurements in each column which are followed by the same letter are not significant at .01.

Since the 223 trees per block is the result of normal sowing in 211 styroblocks, this density was of the most interest to operations. The July 1st and August 1st full sun exposure treatments resulted in significantly increased root collar diameters, top weights and root weights when compared to the normal greenhouse grown stock.

An analysis of variance indicated a very strong interaction between density and treatment.

Table 7

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Density 160 / block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height (cm)</td>
</tr>
<tr>
<td>1. No full sun</td>
<td>20.0ab</td>
</tr>
<tr>
<td>2. Outside July 1</td>
<td>21.0a</td>
</tr>
<tr>
<td>3. Outside August 1</td>
<td>19.0b</td>
</tr>
<tr>
<td>4. Outside September 1</td>
<td>19.0b</td>
</tr>
</tbody>
</table>

Measurements in each column which are followed by the same letter are not significant at .01.

The July 1st full sun exposure treatment produced the largest seedlings but root collar diameter and root weight were not significantly different from the August 1st full sun exposure treatment.
The heights at 160 trees per block were not different from the 120 or the 223 trees per block density. The root collar diameters, top weights and root weights are slightly smaller than the 120 per block density and slightly larger than the 223 seedling per block density.

Table 8
Density - 120 / Block

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Height (cm)</th>
<th>RCD (mm)</th>
<th>TW (gm)</th>
<th>RW (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No full sun</td>
<td>19.2 NS</td>
<td>2.2 b</td>
<td>.57 b</td>
<td>.18 b</td>
</tr>
<tr>
<td>2. Outside July 1</td>
<td>19.0 NS</td>
<td>2.8 a</td>
<td>1.00 a</td>
<td>.48 a</td>
</tr>
<tr>
<td>3. Outside August 1</td>
<td>20.0 NS</td>
<td>2.8 a</td>
<td>.97 a</td>
<td>.45 a</td>
</tr>
<tr>
<td>4. Outside September 1</td>
<td>19.2 NS</td>
<td>2.5 b</td>
<td>.80 b</td>
<td>.25 b</td>
</tr>
</tbody>
</table>

Measurement in each column which are followed by the same letter are not significant at .01.

Maximum growth in Western Hemlock was achieved with this density and the July 1st full sun exposure. There was no significant difference between the July 1st and August 1st exposure but these treatments varied significantly from the no sun and September 1st exposure treatment. Surprisingly there was no significant differences in height by treatment.

This reduced density did result in increased top and root weights when compared to the 160 and 223 seedling per block density.
Nursery: Surrey
Seedlot: No. 3917 PSB-211
Reg. No.:
Facility: Greenhouse No. 4
Sown: March 16, 1982
Misc.: 223/block Moved outside July 1

Static Sample Height
Random Sample Height
Root Collar Diameter

Top Weight
Root Weight

Height cm
Root Collar Diameter mm
Top Weight g
Root Weight g

Weeks From Sowing

F.S. 744-0
Nursery: Surrey
Seedlot: Hw 3917 PSB 211
Reg. No.
Facility: Greenhouse 4
Sown: March 16, 1982
Misc.: Thinned to 120/block Moved outside July 1.

Static Sample Height
Random Sample Height
Root Collar Diameter

Height cm
0 5 10 15 20

Top Weight: g
Root Weight: g

Top Weight g
0 0.2 0.4 0.6 0.8 1.0

Root Weight g
0 0.2 0.4 0.6 0.8 1.0

Weeks From Sowing
0 4 8 12 16 20 24 28 32 36

F.S. 744-0
Nursery: Surrey
Seedlot: Hw 3917 PSB 211
Reg. No.:
Facility: Greenhouse 4
Sown: March 16, 1982
Misc.: Thinned to 120, moved outside September 1.

- Static Sample Height
- Random Sample Height
- Root Collar Diameter

Graph showing Height cm over Weeks From Sowing with data points.

Top Weight
Root Weight
Nursery: Surrey
Seedlot: HW 9917 PSB 211
Reg. No.: 
Facility: Greenhouse No. 4
Sown: March 16, 1982
Misc.: Thinned to 120 control.

Static Sample Height:
Random Sample Height:
Root Collar Diameter:

Height cm

Weeks From Sowing

Top Weight g

Root Weight g

F.S. 744-0

FIGURE 10d
Table 9

<table>
<thead>
<tr>
<th>Species</th>
<th>Density</th>
<th>Treatment</th>
<th>% Achieving Minimum Specs</th>
<th>% Achieving Target Specs</th>
<th>Cull%</th>
<th>Number Plantable per Bloc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hw 3917 PSB 211</td>
<td>223</td>
<td>1</td>
<td>74</td>
<td>58</td>
<td>26</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>62</td>
<td>26</td>
<td>38</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>62</td>
<td>34</td>
<td>38</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>41</td>
<td>24</td>
<td>59</td>
<td>91</td>
</tr>
<tr>
<td>Hw 3917 PSB 211</td>
<td>160</td>
<td>1</td>
<td>86</td>
<td>62</td>
<td>14</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>68</td>
<td>42</td>
<td>32</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>56</td>
<td>38</td>
<td>44</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>76</td>
<td>48</td>
<td>24</td>
<td>122</td>
</tr>
<tr>
<td>Hw 3917 PSB 211</td>
<td>120</td>
<td>1</td>
<td>86</td>
<td>54</td>
<td>14</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>96</td>
<td>60</td>
<td>4</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>72</td>
<td>40</td>
<td>28</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>54</td>
<td>28</td>
<td>46</td>
<td>65</td>
</tr>
</tbody>
</table>

Treatment  
1 - Moved outside July 1  
2 - Moved outside August 1  
3 - Moved outside September 1  
4 - Inside greenhouse

Specifications  
Hw PSB 211  
Minimum 14.0 cm x 2.2 mm  
Target 17.5 cm x 2.5 mm

Table No. 9 indicates that the reduced densities did increase the percentage of trees exceeding minimum specifications. However the number of plantables per block is greatest with 223 density and the July 1st full sun exposure. The 160 density with July 1st full sun exposure produced as many plantable seedlings as the 223 density and August 1st full sun exposure. All densities without sun exposure
produced few plantable trees per block.

The trees which were exposed early (July 1st) did not suffer solarization to any great extent however those that were exposed August 1st and September 1st did suffer solarization. This solarization was quickly overcome by all trees except the very small shaded trees which were killed. Since all trees have been conditioned to full sun conditions; solarization should not be a cause of mortality or stunted growth when planted.

Figures 11 to 13 show 3 seedlots grown at Surrey during 1982. Obviously the top weights and root weights are very low which is the result of two factors: late date of exposure - the end of August, 24 weeks after sowing and the use of means for crop measurement.

The trial seedlot 3917 which was seeded normally and exposed September 1st shows the same problem (Figure 8c).

This treatment had a high cull rate (38%) which was included in the means. The trees which made specifications averaged 2.6 mm root collar diameter.

The 1982 Western Hemlock crop at Surrey Nursery produced as follows:

<table>
<thead>
<tr>
<th>Size</th>
<th>Request(k)</th>
<th>Cavities Sown(k)</th>
<th>Lift(k)</th>
<th>Lift %</th>
<th>Lift % No. per Block Request Cavities</th>
</tr>
</thead>
<tbody>
<tr>
<td>211</td>
<td>650.0</td>
<td>873.4</td>
<td>502.2</td>
<td>77</td>
<td>57</td>
</tr>
</tbody>
</table>

This number of 138 per block is the exact number found in the test seedlot for the August and September exposures for the 223 seedling per block density.
Incidence of Botrytis Caused Mortality in Western Hemlock

<table>
<thead>
<tr>
<th>Treatment</th>
<th>120/block</th>
<th>160/block</th>
<th>223/block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Sun July 1</td>
<td>0.6%</td>
<td>0.5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Full Sun August 1</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Full Sun September 1</td>
<td>1.3%</td>
<td>3.1%</td>
<td>2.2%</td>
</tr>
<tr>
<td>No Full Sun</td>
<td>0.1%</td>
<td>1.7%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>

The above table indicates that reduced densities produce a reduced incidence of mortality. Early exposures in the two higher densities are also associated with reduced botrytis caused mortality. The increased incidence in mortality in the September 1st exposure was due to the death of very small shaded seedlings. It appeared that mortality due to solarization occurred first with botrytis being a saprophytic invader.

Fungicides Applied to Hemlock Seedlot No. 3917

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Rate(Product)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bravo 500</td>
<td>3.4 l/ha</td>
<td>June 9</td>
</tr>
<tr>
<td>Benlate 50 WP</td>
<td>1.1 kg/ha</td>
<td>June 9</td>
</tr>
<tr>
<td>Bravo 500</td>
<td>3.4 l/ha</td>
<td>September 17</td>
</tr>
<tr>
<td>Benlate 50 WP</td>
<td>1.1 kg/ha</td>
<td>December 23</td>
</tr>
<tr>
<td>Captan 50 WP</td>
<td>3.4 l/ha</td>
<td>December 23</td>
</tr>
</tbody>
</table>

The application of June 9th was applied as a preventative spray before canopy closure. The September 17th spray was only applied since this test stock happened to be placed with the Lodgepole Pine which did require spraying. The December 23rd application was the standard pre-packaging spray.

As compared to previous years the number of applications are greatly reduced. The conditioning period outside appears to have
increased the trees ability to resist botrytis infection.

Conclusions:

1. The earliest (July 1) full sun exposure date produced trees which greatly exceeded the greenhouse stock in root collar diameter, top weight and root weight, whereas heights were not significantly different.

   For example in the 223 per block density, the July 1st sun exposure treatment versus the no sun exposure treatment showed increases of:

   - Height + 8.5%
   - Caliper +19.0%
   - Top Weight +58.0%
   - Root Weight +55.0%

   A caliper increase of .4 mm may not seem great but this is actually a 42% increase in stem area.

2. The maximum number of seedlings exceeding minimum specifications was achieved with the density of 223 seedlings per block and the July 1st full sun exposure.

3. The treatment which achieved maximum size was the 120 trees per block density and the July 1st full sun exposure.

4. Cull rates were lowest in the 120 seedling per block - July 1st and August 1st exposure and the 160 density - July 1st exposure.

5. The number of seedlings achieving target specifications was maximized at a density of 160 and the July 1st full sun exposure treatment.
6. The full sun exposure treatment produced a stiffer stem and less succulent foliage. It is assumed that the stock from this treatment will not suffer solarization. The outplanting of this stock will be done in April, 1983.

7. Botrytis incidence was negligible in the stock when exposed to full sun July 1st or August 1st. The later exposure (September 1st) and the greenhouse stock was associated with increased botrytis infection. Decreased densities are generally associated with less botrytis problems.

8. The stock which was conditioned outside appeared less succulent than the greenhouse stock however this stock was not frost hardy as evidenced by the damage caused by a frost in early October.

Recommendations:

1. This data indicates that current minimum specifications can be most efficiently achieved by sowing early - February - March in PSB 211 blocks and exposing this stock to full sun conditions when the stock is less than 10 centimetres tall.

2. Increase in the current required stock specification can be achieved by decreasing the densities.

3. Sun exposure when the seedlings are 7 - 10 centimetres tall should be standard practice so that the seedlings are able to withstand outside conditions.

4. The maximum number of plantable per block was 165. This is clear indication that with the current densities of PSB 211 blocks a high cull rate is unavoidable. Most sowing utilizes a 25% correction factor and
is resulting in production figures well below request. There appears to be two possible choices to improve the situation, reduce densities to perhaps 160 seedlings per block or sow PSB 211's as is currently being done but use a correction factor of 60 per cent. A reduced density is recommended as being the best choice since gains in seedling size are attained along with reduced botrytis incidence.