WORKING PLAN

SX85604V

OPERATIONAL CROP MANAGEMENT OF WESTERN HEMLOCK

ANITA R. WOLFE
SEED ORCHARD PROJECTS COORDINATOR

MINISTRY OF FORESTS
COASTAL SEED ORCHARDS
DUNCAN, B.C.

JUNE 1985
TABLE OF CONTENTS

1.0 INTRODUCTION .................................................. 1
2.0 OBJECTIVES ................................................... 2
3.0 FLOWER INDUCTION .............................................. 3
   3.1 STUDIES ..................................................... 3
      3.11 PROBLEM STATEMENTS .................................... 3
      3.12 RESPONSES TO BE MEASURED ......................... 3
      3.13 FACTORS ................................................. 3
      3.14 DESIGN .................................................. 4
         3.141 STUDY A ............................................... 4
         3.142 STUDY B ............................................... 5
         3.143 STUDY C ............................................... 5
      3.15 DATA COLLECTION ........................................ 6
      3.16 ANALYSIS ................................................ 7
   3.2 PROCEDURES ................................................ 9
   3.3 PRODUCTIVITY ............................................. 9
4.0 POLLEN MANAGEMENT ........................................... 10
   4.1 PHENOLOGY .................................................. 10
   4.2 POLLEN COLLECTION ....................................... 10
   4.3 POLLEN EXTRACTION AND STORAGE ................. 10
   4.4 POLLEN BOOSTING ....................................... 11
   4.5 PROCEDURES ............................................... 12
   4.6 PRODUCTIVITY ............................................. 12
5.0 CONE COLLECTION .............................................. 13
   5.1 CONE COLLECTION METHODOLOGY ...................... 13
   5.2 PROCEDURES ............................................... 13
   5.3 PRODUCTIVITY ............................................. 13
6.0 RESPONSIBILITIES ............................................. 14
7.0 SCHEDULE OF ACTIVITIES ................................... 15
8.0 COST ESTIMATES .............................................. 19
9.0 ACKNOWLEDGEMENTS .......................................... 20
10.0 REFERENCES .................................................. 21

TABLES

   TABLE 1 ANALYSIS OF VARIANCE - FLOWER INDUCTION ........ 8

FIGURES

   1 COBBLE HILL PLANTATION LAYOUT ....................... 22
   2 LOCATION OF STUDY A TREES ............................. 23
   3 LOCATION OF STUDY B TREES ............................. 24
   4 CIP/NOOTKA SEED ORCHARDS LAYOUT .................... 25
   5 LOCATION OF STUDY C TREES ............................. 26
   6 PHENOLOGICAL DEVELOPMENT OF HW SEED-CONE BUDS .... 27
1.0 INTRODUCTION

The western hemlock seed orchard program is the second largest in the B.C. Coastal Seed Orchards Program. There are seven established and developing western hemlock orchards on 6 sites. This compares to the entire Coastal Seed Orchard program of 31 orchards on 12 sites for 8 species.

A primary objective of seed orchard management is to maximize the production of 'broadly adapted' seed for each orchard. The results from this project will assist managers to meet this objective by providing OPERATIONAL procedures and technical information for seed production in western hemlock orchards during the transition from the established to producing phase.

The need for this project stems from the lack of previous OPERATIONAL experience in western hemlock crop management. The products of this project include operational procedures and productivity of western hemlock crop production. They will be produced through the combination of 'hands-on' experience, consultation with researchers in the field of western hemlock reproductive physiology, and research of available information.

This working plan looks at the following areas of western hemlock crop management;

   FLOWER INDUCTION
   POLLEN MANAGEMENT
   CONE COLLECTION.
2.0 OBJECTIVES

The objectives of this study are:

2.1 To gain hands-on operational experience in western hemlock crop management.

2.2 To gather technical data needed for crop management and future orchard planning for coastal seed orchard administration.

2.3 To document preliminary operational procedures.

2.4 To develop baseline productivity data for western hemlock crop management.

3.0 FLOWER INDUCTION

To provide the necessary learning and technical information base, three flower induction studies will be conducted on two sites. The treatments involve the application of gibberellic acid A4 and A7 mixture (GA 4/7), a plant hormone which has shown positive research results in promoting flowering in western hemlock (Brix & Portlock, 1982). Hands on experience gained through these studies will provide the basis of the operational procedures and productivity estimates which will be compiled as part of this project.

3.1 STUDIES

Two studies (A & B) will be carried out at the Canadian Forestry Service western hemlock clone bank in Cobble Hill (Figure 1). This clonal test site provides the oldest (17 years) and largest (up to 7m height) readily accessible western hemlock material. The clonal test was established in 1972 with cuttings rooted in 1968. (Pfiesch, 1974)

The third study (C) will be carried out at CIP/Nootka western hemlock seed orchard #36 at Hovey Road in Saanich (Figure 4). The ramets at CIP/Nootka seed orchard are a mixture of rooted cuttings and grafts which were outplanted over several years (1975 - 1985). Most of the ramets included in this test were outplanted between 1975 and 1977.

The three studies are summarized below:

<table>
<thead>
<tr>
<th>STUDY</th>
<th>OBJECT OF STUDY</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study A</td>
<td>effect of gibberellic acids (GA 4/7)</td>
<td>Cobble Hill</td>
</tr>
<tr>
<td>Study B</td>
<td>effect of top pruning and GA 4/7 treatment</td>
<td>Cobble Hill</td>
</tr>
<tr>
<td>Study C</td>
<td>effect of gibberellic acids (GA 4/7)</td>
<td>CIP/Nootka</td>
</tr>
</tbody>
</table>

Conditions of the test to be met during GA 4/7 application are specified in Appendix 1. They are included to provide quality control within the studies.
3.1 STUDIES

3.11 Problem Statements

1) What is the effect of GA 4/7 application on flower, cone, and pollen production?
2) What is the potential change in cone crop due to top pruning treatments in combination with GA 4/7 application?
3) Are shoot development during GA 4/7 application and the amount of MALEness or FEMALEness in the 'induced' cone crop correlated?

The actual crop production is more important to Coastal Seed Orchards than the EFFECT of one treatment or another.

3.12 Responses to be measured

Number of seed-cones per tree.
Intensity of pollen-cones or pollen clusters per tree.
Number of cones and hectolitres of cones per tree (this will later be converted to number and weight of filled seeds per tree and grams of seed per tree),
Length of shoot elongation at each GA 4/7 application and final shoot elongation length.

3.13 Factors

The same two factors are involved in each of Studies A and C. The first is the TREATMENT factor, the application of GA 4/7. The two treatments are

TO NO APPLICATION OF GA 4/7
T1 APPLICATION OF GA 4/7

The other factor in these studies is CLONE.

Two factors will be assessed in Study B. This study looks at the interaction of top pruning and GA 4/7 on the study trees. All trees receive GA 4/7, and the level of top pruning varies - the TREATMENT factor. The three levels of treatment are

P0 NO TOP PRUNING
P1 PRUNING UPPER 25% OF TOTAL LIVE CROWN
P2 PRUNING UPPER 50% OF TOTAL LIVE CROWN.

The other factor in this study is CLONE.
3.14 DESIGN

The studies described below will be repeated for several (2 or 3) years in order to develop and refine the OPERATIONAL experience. Individual trees will not receive GA 4/7 application in consecutive years. Either different clones or different sites will be selected for repeated studies in future years. Studies A & B may be repeated in 1986 at Lost Lake Seed Orchard on E.P. 944.01 (top pruning & GA 4/7) trees, before returning to the Cobble Hill site for induction treatment in 1987.

3.141 STUDY A

GA 4/7 treatment of untopped, fertilized clonal pairs

This is a 'clone crossed with treatment' study. This study will be conducted on UNTOPPED trees in E.P. 944.02 and 'other' trees that are situated within Clonal Test Block 2 at Cobble Hill (see Figure 1). There are 19 UNTOPPED trees in E.P. 944.02 (one ramet per clone). Study A trees will be selected by matching 'other' trees in Block 2 with these 19 trees through visual comparison of tree height, diameter, and form. Because of the limited number of remaining ramets of 'other' available trees, the final selection of homogeneous pairs of ramets within clones will likely be obtainable for fifteen (15) clones.

The TREATMENT factor, GA 4/7, will be applied at two levels

<table>
<thead>
<tr>
<th></th>
<th>T0</th>
<th>0 mg/litre</th>
<th>15 'other' trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>200 mg/litre</td>
<td>15 trees (from E.P. 944.02/Study B)</td>
<td></td>
</tr>
</tbody>
</table>

The 15 treated (T1) trees will receive GA 4/7 application as follows;

weekly application of GA 4/7 at 200 mg per litre for 6 weeks commencing when 50% of the trees reach vegetative bud burst. The GA 4/7 will be applied with a SOLO backpack sprayer.

All 30 trees (2 ramets X 15 clones) will be fertilized with 200 kg/ha nitrogen applied to the equivalent area within their crown diameter.

The location of Study A trees is illustrated on the Clonal Test Block 2 map in Figure 2.
3.142 STUDY B

Topping treatment of GA 4/7 treated, and fertilized clonal triplets

This is a 'clone crossed with treatment' study. The fifty-seven (57) trees in this study are all included in E.P. 944.02. Tree selection, design and treatment are described in E.P. 944.01 Working Plan (Ross, 1982). Three ramets of uniform height and diameter were selected for each of 19 clones in Clonal Test Block 2 at Cobble Hill. Three top pruning treatments were completed in March, 1983 (Ross, 1984). One ramet of each clone received one of the three levels of top pruning TREATMENT.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Number of Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>No top pruning</td>
<td>19</td>
</tr>
<tr>
<td>P1</td>
<td>25% of live crown top pruned</td>
<td>19</td>
</tr>
<tr>
<td>P2</td>
<td>50% of live crown top pruned</td>
<td>19</td>
</tr>
</tbody>
</table>

All 57 trees (3 ramets X 19 clones) will receive GA 4/7 application as follows:

weekly application with 200 mg GA 4/7 per litre for 6 weeks commencing when 50% of the trees reach vegetative bud burst. The GA 4/7 will be applied with a SOLO backpack sprayer.

All 57 trees will be fertilized prior to vegetative bud burst with 200 kg/ha nitrogen applied to the equivalent area within their crown diameter.

Study B tree locations are identified on the map of Clonal Test Block 2 in Figure 3. NOTE that 15 of the 19 P0 trees in Study B are also the T1 trees in Study A.

3.143 STUDY C

GA 4/7 treatment of fertilized clonal pairs

This is a 'clone crossed with treatment' study. The clones were selected from available material in CIP/Nootka seed orchard #36. Each clone must have a minimum of two ramets capable of sustaining a cone crop (healthy ramets as visually assessed by foliage colour and crown density, and at least 2 metres in height). The final selection of twenty-four (24) homogeneous pairs of ramets for inclusion in this study will be made by matching height and diameter among the candidate ramets. Selection of the untreated (TO) tree in the clonal pair will be made randomly by the flip of a coin.

The TREATMENT factor, GA 4/7, will be applied at two levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Number of Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>0 mg/litre</td>
<td>24</td>
</tr>
<tr>
<td>T1</td>
<td>200 mg/litre</td>
<td>24</td>
</tr>
</tbody>
</table>
Twenty-four trees (one ramet per clone) will not receive any GA 4/7 (T0). The matched ramet for each clone are the twenty-four T1 trees.

The 24 treated (T1) trees will receive GA 4/7 application as follows; weekly application with 200 mg GA 4/7 per litre for 6 weeks commencing when 50% of the trees reach vegetative bud burst. The GA 4/7 will be applied with a SOLO backpack sprayer.

All 48 trees (2 ramets X 24 clones) will be fertilized prior to vegetative bud burst with 200 kg/ha nitrogen applied to the equivalent area within their crown diameter.

The map in Figure 3 shows the location of the Study C trees at CIP/Nootka seed orchard #36.

3.15 DATA COLLECTION

The following information will be collected for each ramet in each study;

1) Number of female flowers per tree measured in the spring following GA 4/7 application. The flower counts per tree will be assessed by a subsample. A procedure for subsampling individual tree flower counts will be developed prior to the first year of flower assessment. The subsampling procedure should be accurate to 10% of total flower count at 95% confidence. This procedure will later be expanded for operational use to estimate the size of total orchard crop.

2) Intensity of pollen crop. This will be assessed once the induced pollen crop is visible. The intensity of pollen production within the pollen producing section of the tree (commonly the lower 1/2 of crown) will be measured for several (5-10) study trees. The measurement will be 'number of pollen-cones per 50 cm or 1 metre of lineal branch', and will provide an operational standard for defining LOW, MEDIUM, and HEAVY pollen crop production.

3) Number and volume of cones per ramet. Cones will be collected and forwarded to Cowichan Lake Research Station (CLRS) for seed extraction to determine the number of filled seeds and weight of seeds per tree.

4) Each ramet will be photographed in early summer of the first year. All E.P. 944 trees will be photographed each year of GA 4/7 application. A scale will be included in each photograph to provide a visual estimate of tree height and a general appreciation of the biomass of each tree.

5) Average shoot elongation for each ramet at time of each GA 4/7 application, and final average shoot elongation at the end of the current growing season.

6) Previous or current pollen and flower production (yes/no) assessed for each study tree.
3.16 ANALYSIS

Pollen-cone production, seed-cone production, and cone & seed yield data for each tree and each clone will all be subjected to two way analysis of variance (ANOVA) models at
   two levels for Study A (GA 4/7)
   three levels for Study B (top pruning)
   two levels for Study C (GA 4/7).

Table 1 provides the ANOVA model for the flower induction studies.

The treatment effect and any interaction between treatments and clones will be determined in the analysis. The error is expected to be minimized by selection of matched (homogeneous) pairs or triplets of clones.

The results of Studies A & C (effect of GA 4/7) and Study B (top pruning in combination with GA 4/7) will be analyzed separately. Repeated studies over several years and sites will also be analyzed separately. The variability between years cannot be quantified and conclusively explained to allow for meaningful combination of data or results.

The flower production for each clone will be combined for the two or three observations per clone for each study. The production for each clone will then be ranked and plotted on a bar graph. This will provide a graphic demonstration of clonal variation in cone production.

Crop production for all ramets will be correlated to timing of GA 4/7 application in relation to shoot elongation. This information may help in narrowing down the 6 week treatment period.
TABLE 1. ANALYSIS OF VARIANCE TABLES FOR FLOWER INDUCTION STUDIES

STUDY A

Two Way ANOVA (two levels) F-test at 0.05
Total number of observations = 30

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibberellic Acid (T)</td>
<td>1</td>
<td>MS1</td>
<td>MS1/MS3</td>
</tr>
<tr>
<td>Clone (C)</td>
<td>14</td>
<td>MS2</td>
<td>(a)</td>
</tr>
<tr>
<td>T x C = Error</td>
<td>14</td>
<td>MS3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STUDY B

Two Way ANOVA (two levels) F-test at 0.05
Total number of observations = 57

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Pruning (P)</td>
<td>2</td>
<td>MS1</td>
<td>MS1/MS3</td>
</tr>
<tr>
<td>Clone (C)</td>
<td>18</td>
<td>MS2</td>
<td>(a)</td>
</tr>
<tr>
<td>T x C = Error</td>
<td>36</td>
<td>MS3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STUDY C

Two Way ANOVA (two levels) F-test at 0.05
Total number of observations = 48

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibberellic Acid (T)</td>
<td>1</td>
<td>MS1</td>
<td>MS1/MS3</td>
</tr>
<tr>
<td>Clone (C)</td>
<td>23</td>
<td>MS2</td>
<td>(a)</td>
</tr>
<tr>
<td>T x C = Error</td>
<td>23</td>
<td>MS3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) The significance of the effect of the factor CLONE cannot be tested in this mixed model where there is only one observation per cell.
3.2 PROCEDURES

Once experience is gained following the first season of GA 4/7 application operational procedures will be documented which describe 'How to Apply Gibberellic Acids'.

These procedures will include;

1) preparation of stock & working solutions for both backpack and ULV applicators
2) effect of surfactant and oil in the solutions
3) storage and handling of GA 4/7, stock, and working solutions
4) preventing GA 4/7 from going out of solution
5) procedures for returning GA 4/7 back into solution
6) calibration of working solution and amounts of GA 4/7 applied for study trees (ULV and backpack)
7) optimal weather conditions for GA 4/7 application
8) brief description of GA 4/7 and how it affects conifer growth and reproduction
9) miscellaneous notes which can influence the applicator's methodology or handling/treatment of GA 4/7
10) personal safety regarding handling of GA 4/7
11) optimum time of application in relation to tree physiology, presence of current year's flowers, shoot elongation (emphasis on western hemlock)

3.3 PRODUCTIVITY

Baseline productivity data on the application of gibberellic acids will be collected for each application over the 6 week period. This information includes;

1) Time required to prepare stock and working solutions and calibrate & test equipment.
2) volume of working solution applied to individual trees (by size of tree and application method)
3) amount of GA 4/7 (grams) required per tree (by size of tree and application method)
4) time required (hours or minutes) for application (by size of tree and application method).
4.0 POLLEN MANAGEMENT

The following areas of pollen management will be studied on the western hemlock trees at the Cobble Hill Clone Bank (Test Blocks 1 & 2);

phenology
pollen collection
pollen extraction and storage
pollen boosting
pollen fertility

Pollen management procedures and productivity will be documented following hands-on experience in these five areas of study.

4.1 PHENOLOGY

The flower and pollen phenology will be monitored as the 'induced' flower crop develops. The flower phenology (date of first receptivity and length of receptive period) both within tree (bottom third, mid third, and top third of the crown) and among the clones in the studies at Cobble Hill Test Block 2 will be plotted over time. The date of first pollen shed for each clone will be documented and may be graphically overlaid on flower phenology. This will be compared with previous information obtained for clones in Cobble Hill Test Block 1 (Colangel, 1985). This information will be used operationally to provide a general idea of the 'window' of flower receptivity for pollen boosting.

4.2 POLLEN COLLECTION

Fresh pollen will be collected for current and future pollen boosting. Most pollen will be collected from flower induction study trees, but collection may extend into other orchard or clone bank trees as time, pollen crop, and manpower are available.

One of the objectives of this part of the trial is to develop methodology and procedures for OPERATIONAL pollen collection. Pruners, clippers, buckets, bags, and any other feasible alternatives will be tried for collecting pollen. After evaluating each method for quality and efficiency the best method will be selected, and the operational procedure will be documented.

4.3 POLLEN EXTRACTION AND STORAGE

Collected pollen will be extracted at Koksilah Seed Orchard. Pollen will then either be used for boosting the current flower crop or stored for future use. Operational procedures for pollen extraction and storage will be documented following an information search on handling and storage of western hemlock pollen, and after gaining hands-on experience.
4.4 POLLEN BOOSTING

The induced flower crop on all flower induction study trees will be pollen boosted. There will NOT be any separate pollen-protector bagging except for testing pollen fertility as described in 4.5.

The boosting pollen will be a combination of fresh and stored pollen, depending upon availability. Pollen for Cobble Hill trees may be available at University of Victoria, and CIP/Nootka seed orchards may have stored pollen for orchard #36. A minimum of eight pollen parents will be used in any pollen mix.

Each entire tree will be boosted with pollen using a SOLO backpack sprayer equipped with a dusting kit. Each flowering tree will be boosted twice. The first boosting on be applied when 20% of the total flowers on the tree are receptive, and the second boosting will be applied when 50% of the flowers are receptive. The receptive stages of western hemlock flowers is illustrated in the Ministry of Forests Western Hemlock Pollination Poster.

4.5 POLLEN FERTILITY

The fertility of the pollen used for boosting will be tested. One tree per clone included in the flower induction studies will be randomly selected, and two flower clusters each with a minimum of four flowers will be bagged after removing any males within the bag area. Since the fertility of the pollen used for boosting will be tested in this section of the trial, the flowers will be bagged prior to bud burst, and pollen applied twice during receptivity (the first boost will be applied when the flowers are first receptive and the second boost will be applied two days thereafter). The pollen bags will be kept on the trees until the end of the receptive period. They will be replaced with insect bags until cone collection.

The seed yield of the pollen fertility test cones will be compared to that of the 'wind-pollinated-&-operationally-boosted' cones. These comparison cones will come from two other randomly selected flower clusters from the fertility test trees. The flower clusters will be covered with insect bags shortly after operational pollen boosting described in 4.4.

Both fresh and stored pollen will be used for boosting, and the fertility testing will be done for all 'lots' of pollen used. The TOTAL number of bags used will remain at two bags per tree per clone. The fertility of each pollen lot will be measured by the number of filled seeds per cone for the test cones, separated by pollen lot and clone.

\[\text{^FEMALE BUD BURST} \quad \text{^BOOST} \quad \text{^BOOST} \quad \text{^END OF RECEPTIVITY}\]

---------------------------------------------XXXXX----XXXXX---------------------------------------------

Bagged ------
Exposed XXXXXXX
4.5 PROCEDURES

Procedures for western hemlock pollen management will include operationally oriented information for orchard managers.

A brief description of the length of time in which female flowers are receptive (within and among ramets and clones) and length of female receptivity overlap with pollen shedding will be included. Data should be collected for several years in order to comment on the variability between years and weather patterns. Colangelo (1985) has collected this information in 1983 for some Cobble Hill clones.

Pollen collection, extraction, and storage procedures will include the following information:
- optimum pollen cluster development stage for collection
- pollen collection method
- pollen extraction conditions (humidity and temperature)
- pollen drying time
- pollen storage

Pollen boosting application method will be noted. This section will focus on handling of pollen, and use of the sprayer.

The results of fertility tests of the between the 'wind-pollinated & operationally-boosted cones' and 'fertility test' cones will be included in these procedures. Conclusions which will influence operational activities will also be noted.

4.6 PRODUCTIVITY

The following productivity data will be documented for use by coastal seed orchard operations as baseline productivity figures for pollen management;

- pollen collection productivity which includes yield of pollen per litre of bud material, an estimate of average pollen yield per tree, and time required to collect a litre of bud material
- pollen extraction and storage productivity which includes yield of pollen per litre of bud material, time to extract and store a litre of pollen
- amount of pollen applied per tree (by tree size and cone crop)
- time required for pollen boosting (by tree size and cone crop).
5.0 CONE COLLECTION

An objective of this section of the trial is the documentation of operational western hemlock cone collection procedures and productivity data. This will include information gathered from 'hands on' experience and local resources (Research Branch & Seed Centre) and will document cone collection method, productivity, and cone & seed yields.

5.1 CONE COLLECTION METHODOLOGY

Several methods will be assessed for their feasibility and productivity in western hemlock cone collection. In search of an operationally suitable collection method, cones will be collected by:

- hand,
- using a rake,
- wringer adaptation (still to be developed),
- and any other reasonable method.

Cones from all trees in the flower induction studies will be collected by hand. Cones will be collected from trees outside the flower induction studies via other methods.

In the event there are no trees with sufficient cones for collection using 'other' methods, 20 trees will be treated with GA 4/7 specifically for cone collection experience in subsequent years.

Cones will be forwarded to CLRS for extraction. Each method will be assessed by cone quality, yield, cone collection productivity (time), and suitability to specific terrain, equipment, and crop intensity. The results of each method will be noted, and the best methods chosen based upon the above criteria.

5.2 PROCEDURES

Once the best cone collection methods are selected, the methodology of western hemlock cone collection will be documented in procedures. Cone collection, handling, and storage procedures will include information on cone physiology which can influence operational collection.
5.3 PRODUCTIVITY

Cone and seed quality and yield data will be noted for each cone collection method and will include the:
- number & volume of cones per tree (or group of trees)
- number & weight of filled seeds per tree.

Cone collection productivity for each method will include:
- time (hours) to collect a litre of cones
- time (hours) to collect cones from a tree (or group of trees).

The average and range of time required to collect cones from study trees on the two sites (Cobble Hill and CIP/Nootka seed orchard) will be used as baseline operational productivity data.

6.0 RESPONSIBILITY

6.1 Silviculture Branch - Coastal Seed Orchard office
   Project Coordinator - A. Wolfe
   - Develop data collection and productivity sheets for:
     - GA 4/7 applications
     - pollen/flower phenology monitoring
     - cone collection
   - Apply treatments
   - Collect data
   - Develop yield and productivity figures
   - Interpret data analysis (A. Wolfe, C. Bartram)
   - Author reports & procedures

6.2 Research Branch
   - Treatment recommendations and technical advice (Physiologists)
   - Input on data collection method (A. Eastham)
   - Assist in interpretation of data analysis (D. Errico)
   - Seed extraction (CLRS)

6.3 Review Committee
   - S. Ross - MOF Research Branch
   - J. Webber - MOF Research Branch
   - M. Crown - MOF Silviculture Branch
   - A. Colangelo - University of Victoria
7.0 SCHEDULE OF ACTIVITIES

Definitions: Induction Year - year of GA application
Crop Production Year - year cones mature

7.1 1985 Activities

SPRING FIELD WORK

- Flower Induction
  - calibrate Solo sprayer
  - prepare GA 4/7 stock solutions
  - identify study trees, tag & label
  - fertilizer application
  - GA 4/7 application (6 weekly applications, working solution preparation, shoot measurements)
  - photograph trees
  estimated man-days
  - Subtotal 16.8

FALL FIELD WORK

- Flower Induction
  - final shoot elongation measurements
  - preliminary site/tree selection for 1986 GA 4/7 application
  - Subtotal 4.0

3) Data Analysis & Report Writing

- Data
  - enter 1985 flower induction data on computer
  - Report
  - first progress report
  - How To Apply Gibberelic Acids Procedures
  - Subtotal 5.0

7.2 1986 Activities

SPRING FIELD WORK

- Flower Induction
  - develop subsampling technique for female flower count
  - develop pollen crop intensity standards
  - collect data on female flowering & male crop production on 1985 induced trees
  - calibrate Solo sprayer
  - prepare GA 4/7 stock solutions
  - identify study trees, tag & label
  - fertilizer application (6 weekly applications, working solution preparation, shoot measurements)
  - photograph trees
  estimated man-days
  - Subtotal 29.5
(1986 Spring Field Work Cont'd)

Pollen Management
- phenology assessments 5.0
- bag flower clusters for pollen fertility tests 1.0
- pollen collection & extraction 5.0
- pollen boosting 3.0
- pollen storage 0.5

Subtotal 14.5

Cone Collection
- identify trees for cone induction/collection 0.5
- GA 4/7 (+fertilizer) on cone collection trees 2.0
- identify trees with suitable cone crop for fall collection 0.5

Subtotal 3.0

FALL FIELD WORK

Flower Induction
- collect cones from 1985 induced trees 4.0
- cone extraction (CLRS) (?)
- final shoot elongation for current (1986) trees 0.7

Subtotal 4.7

Cone Collection
- collect cones by several different methods 6.0

DATA ANALYSIS & REPORT WRITING 1986
- subsampling techniques for female & male crop estimates 2.0
- second progress report (includes analysis & report) on results of 1985 flower induction studies 9.0
- enter 1986 flower induction data on computer 0.5
- phenology graphs 1.0
- pollen management productivity & procedures 5.0
- cone collection productivity & procedures 3.0

Subtotal 20.5

7.3 1987 ACTIVITIES

SPRING FIELD WORK

Flower Induction
- collect data on female flowering & male crop production on 1986 induced trees 5.0
- calibrate Solo sprayer 1.5
- prepare GA 4/7 stock solutions 2.0
- identify study trees, tag & label 2.0
- fertilizer application 0.3
- GA 4/7 application (6 weekly applications, working solution preparation, shoot measurements) 10.0
- photograph trees 1.0

Subtotal 21.8
(1987 Spring Field Work Cont'd)

Pollen Management
- phenology assessments 5.0
- bag flower clusters for pollen fertility tests 1.0
- pollen collection & extraction 5.0
- pollen boosting 3.0
- pollen storage 0.5
Subtotal 14.5

Cone Collection
- identify trees for cone induction/collection 0.5
- GA 4/7 (+fertilizer) on cone collection trees 2.0
- identify trees with suitable cone crop for fall collection 0.5
Subtotal 3.0

FALL FIELD WORK

Flower Induction
- collect cones from 1986 induced trees 4.0
- cone extraction (CLRS) (?)
- final shoot elongation for current (1987 induced) study trees 0.7
Subtotal 4.7

Cone Collection
- collect cones by several different methods 6.0

DATA ANALYSIS & REPORT WRITING 1987
- third progress report (includes analysis & report) on results of 1986 flower induction studies 9.0
- enter 1987 flower induction data on computer 0.5
- phenology graphs 1.0
- refine pollen management productivity & procedures 1.5
- refine cone collection productivity & procedures 1.5
Subtotal 13.5
7.4 1988 ACTIVITIES

SPRING FIELD WORK

Pollen Management
boost induced trees (flower induction studies & cone collection trees) 2.0
pollen collection, extraction & storage 3.5
Subtotal 5.5

FALL FIELD WORK

Flower Induction
collect cones from 1987 induced trees 4.0
cone extraction (CLRS) (?)

Cone Collection
collect cones by several different methods 4.0

DATA ANALYSIS & REPORT WRITING

refine pollen management productivity & procedures 2.5
refine cone collection productivity & procedures 2.5
final report (including results of 1987 induced trees & overall review of flower induction studies) 15.0
Subtotal 20.0
### 8.0 COST ESTIMATES

<table>
<thead>
<tr>
<th>Year/Season</th>
<th>Activity</th>
<th>Man-Days</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>Flower Induction</td>
<td>16.8</td>
<td>$1800</td>
</tr>
<tr>
<td>Fall</td>
<td>Flower Induction</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Fall/Winter</td>
<td>Data Analysis &amp; Report Writing</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td><strong>1985 SUBTOTAL</strong></td>
<td></td>
<td><strong>22.8</strong></td>
<td><strong>$1800</strong></td>
</tr>
<tr>
<td>1986</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>Flower Induction</td>
<td>29.5</td>
<td>$1800</td>
</tr>
<tr>
<td></td>
<td>Pollen Management</td>
<td>14.5</td>
<td>$100</td>
</tr>
<tr>
<td></td>
<td>Cone Collection</td>
<td>3.0</td>
<td>$150</td>
</tr>
<tr>
<td>Fall</td>
<td>Flower Induction</td>
<td>4.7</td>
<td>$200</td>
</tr>
<tr>
<td></td>
<td>CLRS Cone extraction</td>
<td></td>
<td>$2500</td>
</tr>
<tr>
<td></td>
<td>Cone Collection</td>
<td>6.0</td>
<td>$600</td>
</tr>
<tr>
<td>Fall/Winter</td>
<td>Data Collection &amp; Report Writing</td>
<td>20.5</td>
<td>$200</td>
</tr>
<tr>
<td><strong>1986 SUBTOTAL</strong></td>
<td></td>
<td><strong>78.2</strong></td>
<td><strong>$5550</strong></td>
</tr>
<tr>
<td>1987</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>Flower Induction</td>
<td>21.8</td>
<td>$1800</td>
</tr>
<tr>
<td></td>
<td>Pollen Management</td>
<td>14.5</td>
<td>$100</td>
</tr>
<tr>
<td></td>
<td>Cone Collection</td>
<td>3.0</td>
<td>$150</td>
</tr>
<tr>
<td>Fall</td>
<td>Flower Induction</td>
<td>4.7</td>
<td>$200</td>
</tr>
<tr>
<td></td>
<td>CLRS Cone Extraction</td>
<td></td>
<td>$2500</td>
</tr>
<tr>
<td></td>
<td>Cone Collection</td>
<td>4.0</td>
<td>$400</td>
</tr>
<tr>
<td>Fall/Winter</td>
<td>Data Analysis &amp; Report Writing</td>
<td>13.5</td>
<td>$200</td>
</tr>
<tr>
<td><strong>1987 SUBTOTAL</strong></td>
<td></td>
<td><strong>61.5</strong></td>
<td><strong>$5350</strong></td>
</tr>
<tr>
<td>1988</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>Pollen Management</td>
<td>5.5</td>
<td>$600</td>
</tr>
<tr>
<td>Fall</td>
<td>Flower Induction</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CLRS Cone Extraction</td>
<td></td>
<td>$2500</td>
</tr>
<tr>
<td></td>
<td>Cone Collection</td>
<td>4.0</td>
<td>$400</td>
</tr>
<tr>
<td>Fall/Winter</td>
<td>Data Analysis &amp; Report Writing</td>
<td>20.0</td>
<td>$500</td>
</tr>
<tr>
<td><strong>1988 SUBTOTAL</strong></td>
<td></td>
<td><strong>33.5</strong></td>
<td><strong>$4000</strong></td>
</tr>
<tr>
<td><strong>TOTAL (ALL YEARS)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>196 man-days</td>
<td>$29,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>material</td>
<td>$16,700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Cost</td>
<td>$46,100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9.0 ACKNOWLEDGEMENTS

The author appreciates the technical advice provided by C. Bartram, A. Colangeli, M. Crown, A. Eastham, D. Errico, M. Meagher, S. Ross and J. Webber in preparation of this project proposal.

A. Wolfe
Seed Orchard Projects Coordinator
Coast
June 1985
10.0 REFERENCES


FIGURES
FIGURE 1

COBBLE HILL PLANTATION LAYOUT
FIGURE 2

LOCATION OF STUDY A TREE
FIGURE 3

LOCATION OF STUDY B TREES
FIGURE 4

CIP/NOOTKAY SEED ORCHARDS LAYOUT
FIGURE 5

LOCATION OF STUDY C TREES
FIGURE 6

PHENOLOGICAL DEVELOPMENT OF WESTERN HEMLOCK SEED-CONE BUDS
APPENDIX 1

CONDITIONS OF THE TEST (APPLICATION OF GIBBERELLC ACIDS)

1. All trees in EP 944.02 receive the same treatment. Sufficient solution will be used for adequate coverage of each tree without dripping excess solution off trees. Care will be taken to avoid double spraying of individual trees during any one application.

2. No precipitation 8 hours following application.

3. Proper calibration of equipment to accommodate variation in tree size within each site.

4. Document weather conditions at day of application
   - Wind
   - Sun/cloud
   - Next precipitation (time)
   Optimum conditions for application are either early morning of a cool, misty day when stomata are open for maximum uptake and minimum evaporative loss, or windless evening when temperature is cooling and there is minimal chance of precipitation.

5. Document phenological state of vegetative buds/shoots-
   - bud burst, flush
   - shoot elongation.

6. Complete data collection sheet at each application.

7. Precautions in handling GA 4/7 and safety gear as necessary.