Proceedings of the Joint Meeting of the B.C. Seed Dealers' Association and the Western Forest and Range Seed Council

June 2–4, 1993
Vernon, B.C.

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Canada

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Compiled by F.T. Portlock, Forestry Canada, Pacific Forestry Centre

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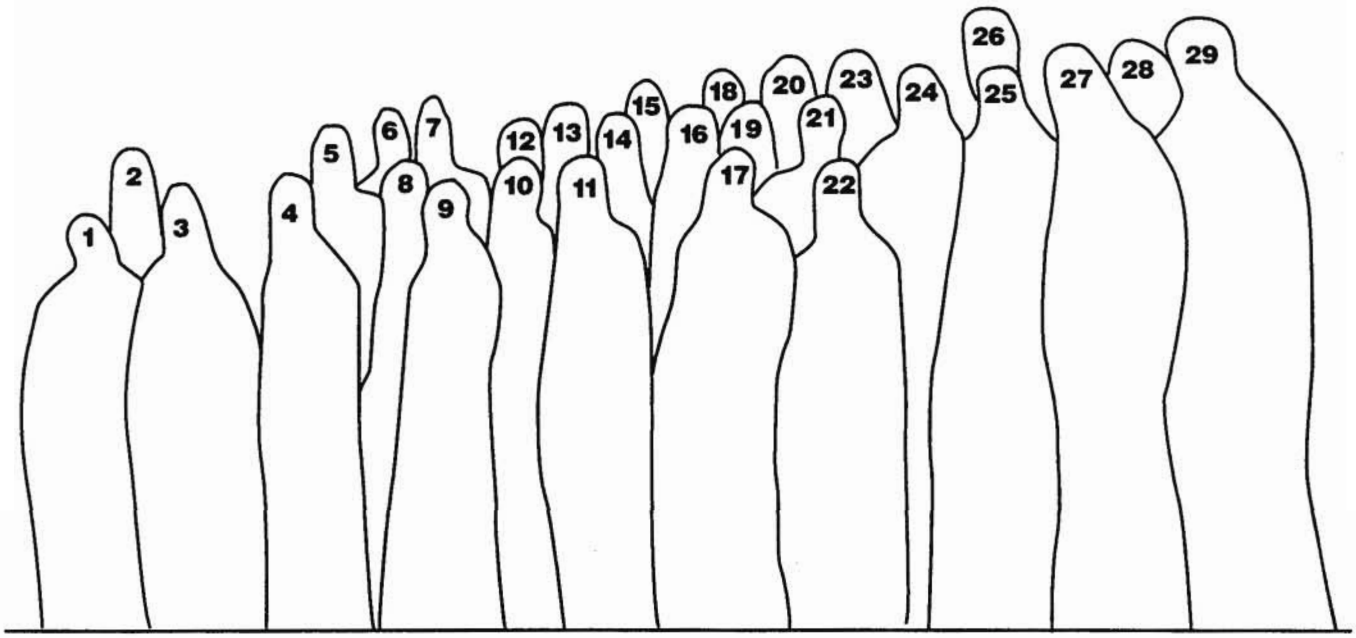

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29. Paulus Vrijmoed

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Preface

The meeting took place June 2–4 beginning with a tour of the BC Ministry of Forests Surrey Seed Centre. The participants then departed by bus for Vernon where the remainder of the meeting occurred. Two technical sessions were presented with afternoon tours to seed orchards, nurseries, and seed plants. A banquet was held with Henry Benskin, BC Ministry of Forests and John Revel, recently retired from the BC ministry of Forests as guest speakers. The final event was a pleasant stop beside Shuswap Lake where the group photograph was taken.

Forty-five individuals from Alberta, British Columbia, California, Ontario, Oregon, and Washington registered for the meeting.

Papers presented by Laurie Lippitt and Phil Cameron were not available at the time this publication was prepared.

The organizing committee would like to thank the following organizations for their financial support which greatly contributed to the success of this meeting:

BCC Silviculture Systems Inc.
B.C. Ministry of Forests
B.C. Tree Seed Dealers' Association
Forestry Canada (FRDA II)
Northwood Pulp and Timber Ltd.
Western Forest and Range Seed Council

In addition the support of the BC Cone and Seed Committee is gratefully acknowledged.

Organizing committee:

Don Pigott
Frank Portlock
Paulus Vrijmoed

CURRENT SEED USE AND FORECAST TO YEAR 2000

Jenji Konishi

Manager Seed Services Section
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Victoria, B.C.

Various options for procuring a purposeful seed supply for reforestation are considered. Options include collections from:

(a) natural stands,

(b) superior provenances within natural stands particularly in lodgepole pine, interior spruce, Sitka spruce, and interior and coastal Douglas-fir. Fortunately these species have been under a provenance testing program which has identified superior sources to guide natural stand cone collections,

(c) seed orchards. Orchards for major reforestation species were established 10-30 years ago on the coast and more recently in the interior.

Currently, (1993 sowing) 11% of the seed sown for the provincial reforestation program (226 million trees) originates from seed orchards. The balance, 89%, originates from natural stand seed collections.

More recently, and in the near term, advanced generation orchards providing for greater genetic (wood volume and quality) gains or insect or disease resistance will be established. It is estimated that by year 2000, more than 50% of the seed used for reforestation will originate from orchards.

Some of the impacts resulting from increases use of seed orchard seed or products of tree improvement programs are:

(a) smaller seedlot processing,

(b) nurseries may need to learn how to optimize seedling recovery when using orchard seed (may need to utilize day - length control) to produce uniform and balanced planting stock,

(c) increase in rate of growth (wood volume and quality),

(d) enable production of pest-resistant stock including rust resistant white pine and weevil resistant spruces (Sitka and Interior spruce),

(e) expediting mass production of pedigreed materials through vegetative propagation rather than from seed,

(f) demonstration planting of seed orchard and pedigreed materials in comparison to plantations resulting from natural stand seed to ensure adaptability and genetic and bio-diversity over time.

BRITISH COLUMBIA'S FOREST GENETICS RESEARCH PROGRAM

Micheal Carlson

BC Ministry of Forests
Kalamalka Forestry Centre
Vernon, BC

B.C.'s forest genetics program began in the late 1950's with the Douglas-fir project. Today there are 9 major species projects, 5 coastal (Douglas-fir, western hemlock, Sitka spruce, western white pine, and yellow cedar) and 4 interior (Douglas-fir, interior spruce, lodgepole pine, and western larch). All of our breeding projects attempt to select and breed for rapid volume growth and good stem form with certain projects also emphasizing relative wood density or pest resistance. To date seed orchards in B.C. produce about 10% of the seed currently needed for production of nursery stock. By about 2010 the bulk of the seed required of major species will be of seed orchard origins.

In addition to breeding projects, seed source testing (provenance) projects are underway for 10 conifer and hardwood species. Information from the longer standing provenance testing efforts has been used to develop seed transfer guidelines used by Ministry and industry forester's.

Understanding genetic diversity in our native tree species is an important part of what forest geneticists do. We believe that our seed orchards are structured in such a way so as to maintain high levels of genetic diversity in seed crops returning to the land. Forests geneticists are also involved in developing a gene conservation strategy for the province.

Genetically diverse seedlots from orchards may, for some species, be expected to behave somewhat differently than wild stand seedlots in the nursery. Some of these seedlot differences will be due to cultural techniques used in producing seed orchard seed (irrigation, fertilization, stressing treatments, etc.) and some will be the result of genetic traits directly or indirectly selected for in our breeding programs. Seedlot traits that may differ include germination rates, seedling height growth rates and duration of height growth. Potential behavioral differences between wild stand and orchard seedlots is currently being researched by the Forest Biology Section of the Research Branch of the M.O.F. The objective of this work is to identify and quantify differences in traits important to the nurseryman and field forester and to make recommendations for cultural changes so as to facilitate production of high quality and genetically diverse seedling crops for reforestation.

USING SEED ORCHARD SEED IN THE NURSERY; THE GROWERS POINT OF VIEW

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Back ground - improved seed comes from seed produced in the seed orchard programs that have been bred for a number of factors, but the single most important factor to the nursery person is the rate of growth, (height). Since we know that caliper and height are in a direct relation to each other, we can assume that we will now get a plant that has less caliper per unit of height than what we had from our wild collections.

This evidence, I believe, bears up in the greenhouse. We have adjusted our cultural practices to compensate, but not always successfully. The reaction time with orchard seed is much more critical than it was with wild seed or we might say, less forgiving. This means that we have had to arm ourselves with a lot more devices to control the crops to produce the product required by the field forester. This manipulation includes nutrients, water, light (extended photoperiod and blackout), sowing dates, temperatures, stratification (length, time, temperature), and block cell density. No single item will give a grower the desired end product but the manipulation of all of these items can.

Growers have gone through a long period where only seed has been used to produce seedlings. In resent years there has been a steady increase in the use of rooted cuttings (stecklings) and now we are at the cutting edge of embryo genetics, to produce emblings. All of this material is from a genetics program to meet the need in the field and the grower has had to be adaptable to handle these different stock types.

We are seeing the elimination of multi-seed sowing and the introduction of sowing by families/clones. This is being done to prevent the loss of genetic diversity in the greenhouse because of old standard practices that could be eliminating families by removing them. If you multi-seed sow and thin you could be removing families at this point by the fact that some families germinate slower than others and we tend to leave the larger germinats at time of thinning.

Single sowing may lessen this but there is still the germination variation in the bulked seedlot between families. We may be eliminating some families at the time we grade the seedlings, again if a family in the bulk seedlot germinates a week and in some cases 2 weeks after the earliest seed, they never catch up. All these factors lead to more expensive seedlings. Oversow factors go up as you plant only one seed per cavity and the creation of many small seedlots by family sowing will also increase costs.

In the near future I see a few things that will help lessen the impact of both single seed sowing and single family sowing. A new generation seeding line that will be able to sow pregerminated seed. The use of miniplugs to sow single seed and then transplant. Transplanting even aged germinates means less culling at harvest and the ability to have every cell in the green house full. All these items will cut down on the amount of excess cells required to achieve requested seedlings, thus decreasing the seedling cost.

Change has been the key throughout and it will be in the future. The nursery people have adapted quickly to meet the present field needs and are eagerly looking to the future to continue meeting the needs in forestry.

NURSERY EXPERIENCE WITH SEED ORCHARD SEED - SPRUCE

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Considerable concern has been expressed over the growth differences in seed orchard spruce vs. wild collection spruce seed. In an attempt to give expression to these concerns I have interviewed the staff from three nurseries:

Bill Taylor and John Watson: Skimikin Nursery (BCMF)
Kent Stralbiski: K & C Silviculture Farms
Dave Swain & Grant Cummins: Harrop Nursery (PRTI)

My thanks to these gentlemen for their time and efforts to provide some light of experience on this topic. Please be aware that the comments from these growers are not research results but are based on their records and experiences. These interview results are then to be viewed in this sense and may help guide more thorough investigations into this important topic area.

1. Does Seed Orchard seed appear different than wild seed?

   All replies were that seed orchard seed varies little from wild seed in appearance and size, especially when compared with more recent wild collections. Handling characteristics of the seed was similar and all spruce seed is fairly clean.

2. Do germination characteristics appear similar to wild seed?

   a) Time from sowing to start of germination: all nurseries reported the time from sowing to initiation of germination was similar to the experience with wild seed.
   b) Speed of germination: germination was substantially complete (95%) after 14 days from sowing. This, however, is similar to many wild seedlots as well.
   c) Germination %: both wild and seed orchard seed have very good germination rates. The Seed Centre lists the average germination % for wild collections as 92% and for seed orchard seed as 91%. Nursery experience shows seed orchard seed has usually a 2-4% higher germination rate compared to lab rate while wild seed usually achieves lab rate.

3. Does early growth appear faster in seed orchard crops?

Nurseries responded that there was very little in early growth to distinguish the seed orchard spruce from other wild spruce seedlots. Some noted slightly longer stem development. There was very little difference in seed coat shedding and the development of cotyledon leaves and secondary foliage.

4. Was the exponential growth phase of seedlings similar?

   Harrop: growth appeared similar but variability increased with some vigorous plants well above the canopy average.

   K&C: orchard lots tend to behave more like wet belt seedlots or Rocky Mountain provenances (Golden-Invermere area). Orchard lots are within the range of growth of wild stand seedlots but at the top of the range.

   Skimikin: growth was similar until approximately 12 weeks of age. From 12 to 16 weeks wild stand seedlots grew 3cm (mean), orchard seedlots grew 6 cm (mean). Also some reflushing in orchard lots was experienced.

5. Is bud set and frost hardiness/dormancy development similar?

   a) Cessation of foliar growth, maturation of foliage and budset: all nurseries noted that seedings from seed orchard seedlots generally take longer to set buds and achieve frost hardiness.

   Harrop: orchard seedlots generally exhibit later bud set, longer growth period, lighter colour, and a less waxy cuticle on the foliage resulting in frost protection occurring later in the fall. Some seedlings in the population set buds early.

   K & C: the seed orchard seedlots are variable, some seedlings setting buds early but over 50% growing and hardening later than wild seedlots. The 2+0 summer seedlots were shipped at 2 times because of this. The early set up crop was shipped out 6 to 7 weeks earlier than the balance of the same seedlot that kept growing.

   Skimikin: the seed orchard lots develop buds and harden off in both 1+0 and 2+0 crops one month later than wild stand seedlots. Wild seedlot crops start bud set in early August, while seed orchard lots start bud set in late August to early September. Once buds are set there is little height growth (stretching under the bud) but root collar diameter can still increase by 0.4 to 0.8 mm to time of lift in 1+0 crops.

b) Dormancy: most nurseries suspect dormancy development occurs later in seed orchard seedlots than in wild collections as a result of late season growth and later bud set. Storability testing of the portion of the seed orchard crops that develop bud set late supports this. Foliar damage was greater in the storability tests for these late growers than in the mid to late October test. At time of lift results were similar.

6. Are there morphological differences between seed orchard crops and wild seed crops?

a) Dry weight and shoot root/ratios: nursery responses here range from no observations to the acknowledgment that seed orchard stock generally has greater dry weight but that these weights are within the range for wild seedlots, albeit at the upper end of this range. Shoot/root ratios in wild seedlots were more favorable at Skimikin with an 8 lot range of 3.0 to 3.2 as compared to an 8 lot range of seed orchard seed of 3.2 to 3.8.

b) Height: all nurseries responded that height was very variable. Harrop observed that it differs from other late season growers, such as Golden-Invermere Rocky Mountain spruce, in that portions of the seed orchard lots stay small with early bud set. The range, therefore, is greater.

c) Root collar diameter: root collar diameters were achievable in most crops although some growers experienced diameters closer to the minimums than targets.

7. Did you experience difficulty in growing seed orchard crops and how would you manage for these difficulties?

All nurseries responded to the question that they did experience difficulty in growing seed orchard seedlots generally because of the taller nature of the seedlings that grew on longer. The current standards were not perceived to be a great problem yet due to variability of crops there is some concern.

All nurseries agreed that growing the seed orchard lots would be best accomplished in larger size cavities. PSB313A should not be used as only 10% were target trees (root collar diameter) while 40% in 313B were target tree (Skimikin). Harrop suggested 410 and 415D were more appropriate than 313B and 415B. The investment in improved seed has been substantial and this should not be lost by selection of too small a stock type.

Management strategies include:

a) possibly sow crops later than wild seed.
b) lower nutritional feeding program (i.e. 80 ppm N).
c) grow dryer.
d) grow cooler - remove side walls.
e) removal of poly - full light.
f) provide as much air as possible.
g) to set buds use black out system, however some vigorous wild lots did not respond to black out. These lots could be the same. Some experimentation with hours of darkness and duration of black out may be required.

8. Any other comment on seed orchard spruce?

Harrop: it would be useful to have access to the histories and make up of the seedlots through the local Nursery Services office. Knowing the crosses and what characteristic the trees were selected for could help in understanding and planning in the nursery phase.

K&C: despite difficulties seed orchard seed appears easier to grow than SXS.

Skimikin: collections may also make a difference in seed orchard seed. What is blended to make a seedlot? Will this blend appear again as a different seedlot next year? Block size is an option to handling seed orchard seed. Timing of delivery could still be a problem for summer 2+0 crops.

Western Forest and Tree Seed Council and
Tree Seed Dealers Association Meeting June 2-4,1993

Collecting, processing, and storing desert seeds
Notes from an innocent abroad

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Happy is he who learns the causes of things. VIRGIL

1. Introduction

State and federal laws in the U.S. are increasingly requiring sites disturbed by mines, highways, and other construction projects to be revegetated with native plants. I have been involved with the research and development of planting methods for desert sites since 1981. Like many of the biologists and ecologists working on these problems I had no training in college involving landscaping, forestry, or seeds. Like many other self-taught restoration planners and researchers I learned as I went and by applying ecological training (which sadly landscapers and foresters often miss) have been successful in developing plant preparation and planting methods which work on extreme sites, <3 inches of rain annually, temperatures >90°F possible every month, high winds and low humidity (Bainbridge and Virginia, 1990; Bainbridge, 1991; Bainbridge et al., 1993).

But along the way we ran into many problems with seeds, and it is only recently that we have advanced our knowledge of seed collection, evaluation, storage and treatment (Fidelibus and Bainbridge, 1993) . I would hope that by sharing this experience with you it will make it easier for you to better understand and serve your clients (whether other agencies or private companies).

2. Harvesting

While some seed is available in the "trade" the number of species and particularly site identified species is very limited. We have collected our own seed, contracted for seed collection, and purchased seed from vendors. Results have been variable with all methods. Collecting our own seed is preferred as it gives us the best control, but it is expensive and challenging. In some cases contracted collectors have damaged plants during collection and they are also often unable to collect quality seed because of timing problems. And vendors are unable or reluctant to site identify seed source. Ideally we would like to maintain a seed bank for desert seeds, with detailed site data (figure 1).

Seed quality in desert species is highly variable from year to year (table 1) and must be evaluated before collecting large quantities of seed. We have been delighted with the data provided by cooperative research with the Seed Lab operated by the California Department of Forestry and Fire Protection.

Table 1. Seed viability in *Cleome isomeris* collected at Red Rock Canyon State Park

Year	% Good seed, dark seeds	% Good seed, light seeds
1992	62	4
1991	0	0
1990	97	45

Lippitt, 1992b.

One of the biggest challenges is harvesting seeds from a diverse population to maintain genetic diversity. We are particularly concerned about this in vendor collections -- where the pressure to economize is greatest. We have fallen prey to the same pressures, when seed is spotty and we have only an hour or two free to collect. We like to select seeds from different stands in a range of comparable sites if possible.

Some of the desert species appear to produce stress crops with more, higher quality seed. When it is too dry however, they may produce little seed and supplemental water may be helpful. Native stands of Jojoba (*Simmondsia chinensis*) produced many more seeds when provided with supplemental water from micro-catchment basins (Ehrler et al., 1978).

Careful site identification (including soil characteristics -- pH, EC, TKN, P, etc.) is desirable but has been difficult to develop. Local genotypes are most likely to succeed and more critically, to successfully reseed.

Timing of seed collection can be crucial for desert plants. Ripe seed may be available for only a few days before predators and high winds scatter it. We have found that seeds that ripen and fall quickly can be collected by placing the seed head in a section of nylon stocking, cheese cloth, or netting. This has worked very well for collecting ocotillo seeds.

When we have had no other choice we have collected seed from the soil surface, but it is usually of low quality, requires excessive cleaning, and is more commonly contaminated with pests and disease (Young & Young, 1986).

3. Processing

Seeds often require cleaning and processing. As a typical under-equipped collector we often clean seeds simply by hand screening, rubbing on concrete, running over seed with vehicles and other equally refined methods. We originally processed all of our own seed by hand (i.e. cutting off pods) but now rely on vendors as much as possible. The expertise and equipment at the CDF&FP Lab in Davis has provided many lessons about the potential for and value of mechanical processing. Hand separating *Prosopis* seeds from pods can produce several hundred clean seeds per hour, compared to many thousands of seeds per hour using a modified meat grinder. Because of their high sugar content, the fleshy pods must be thoroughly dried or thoroughly wetted before processing.

Some types of desert seed can also be placed in a mesh bag (or a plastic bag with a few small holes in it) and compressed air jets used to blow the wings off seeds (Lippitt, 1992). We have done much of our seed quality improvement by hand sorting, but if possible we now use commercial facilities air separators and sorting equipment.

4. Storage

Bruchids, a boring insect, can usually be controlled by drying the pods immediately after collecting and then freezing them to kill the larvae (Bainbridge & Clark, 1987). When possible we refrigerate our seeds, but we have limited space and often must store seed at room temperature. This doesn't always work and large quantities of seeds have been lost to insects by us and other desert nurseries.

We would now suggest using insecticides as necessary. One of our vendors dips seed in a 20% solution of Malathion in water followed by a drying period and a subsequent dusting with 5% Sevin (Desert Enterprises, 1992). Kay et al. (1984) used Phostox (aluminum phosphide) to protect the seeds of Mojave desert shrubs.

Desert species appear to be very susceptible to fungi and disease. They are used to growing in soil which has been sterilized by solar radiation and heat (Bainbridge, 1990). Seeds can often be sterilized by soaking in a 40% solution of household bleach in tap water (2 parts bleach in 3 parts tap water) for ten minutes, then rinsing thoroughly in running water for at least 48 hours. Unfortunately, bleach can be phytotoxic. A long running water rinse (48 hours) may reduce levels of pathogenic fungi to a similar extent without affecting seed viability (Lippitt, 1992). For the running water rinse, a shower head is placed in the bottom of a bucket, and an aquarium bubbler is used to increase the concentration of dissolved oxygen and promote water circulation.

Although desert seeds are often long-lived and may exhibit multiple dormancy, many seeds have their best germination potential at the moment they reach maturity. Proper storage conditions are critical to maintain seed viability over an extended period of time. Post drying moisture content of seeds from a variety of Mojave desert shrub species ranged from 1.5%-9.4% (Kay et al., 1984).

Seed dormancy is ecologically important in desert species. It can be a difficult obstacle to revegetation efforts where prompt, uniform, and complete germination is desirable. Impermeability of the seed coat or protective fuzz and jackets, are probably the most common form of seed dormancy. Many of these species are adapted to scarification in flood events or wind abrasion.

We scarify small batches of seeds by hand, using a file or razor knife to make a nick or slice in the seed coat. We have also scarified seed by sanding, but they showed increased susceptibility to fungus and mold, presumably from the presence of the small particles of seed coat.

Boiling water dips or soaks can often provide similar results. The boiling water dip is safer than acid scarification, and seed coat thickness is less of a problem. The same length of treatment can be used from year to year which is risky with acid.

Many desert seeds require exposure to either high or low temperatures before being placed in conditions favorable for germination. Many desert seeds have water soluble growth inhibitors that prevent the seed from germinating unless there is sufficient moisture to establish a seedling. If all of the inhibitor is not washed away at once, the seed produces more inhibitor (Bryant, 1985). Graves et al. (1975) found that *Ambrosia dumosa* (Mojave desert seed sources) seed germination was improved by stratification in activated charcoal or moist sand at 36°F (2°C) for 30 days.

Other species may require high temperature 120°F (50°C) stratification rather than the low temperature/moist stratification commonly used (Capon & Van Asdall, 1966). If a seed lot is to be planted during the same season that it is collected, it may be beneficial to try high temperature stratification. If the seed needs to be stored for longer periods of time, lower temperatures may be desirable.

5. Seed evaluation/germination testing

We have learned, the hard way, that we should test every seed batch for purity and percentage of sound seed after processing, periodically during storage, and again just before sowing. We are not always able to do this, although we would like to. We have learned through back testing that many early failures (some costly in terms of time) were probably caused by poor seed quality.

Percentage of sound seeds can be determined by different methods depending upon the species. Many can be evaluated by eye, but if possible we now send them out for X-ray evaluation, a non-destructive method of assessing seed fill and potential viability. By combining X-rays with cutting tests it is possible to relatively quickly determine seed quality. Determination of desert seed quality can be challenging because even dry seeds may be viable.

While tetrazolium tests can be very fast and effective on some species, lack of uniformity of staining, failure to detect seeds that will germinate abnormally, and difficulty in interpreting different degrees of staining are important drawbacks. Tetrazolium stains have proven to be uncertain on seeds with very effective dormancy -- which includes most desert seeds. They may work better on these seeds following stratification.

The most reliable method of determining potential germination is to germinate a representative sample of the seed lot, but this is only effective when the stratification and scarification requirements are relatively well understood. We have rarely been able to do this on the level we would like to because of limitations of personnel, equipment, and space. The proper germination temperature is species specific and needs to be determined by experimentation.

6. Conclusions

High quality site-adapted native seeds are essential for successful revegetation projects. Many people involved in revegetation and restoration project planning have had little experience and training in seed collection, testing, and management. Vendors can improve their effectiveness by providing more guidance to these customers. Planners and designers can improve their chances of success by specifying seed collections that insure high quality, mature seed from healthy, local stands with a sufficiently broad genetic base. Careful identification of the site characteristics (including much greater detail than is now collected) and tracking seed viability over time is desirable. Cleaning, and upgrading seed before storage can improve the storage life, increase germination, and make production and planting easier. Multiple dormancy is common in the seeds of many desert species and experimentation is often necessary to determine the best way to break seed dormancy. This can be complicated by year to year and plant to plant variation. Seed lots should be tested for viability before storage, periodically during storage, and prior to sowing.

Improving seed literacy is important for improving revegetation success. Quality seed is one of the foundations of a successful revegetation or restoration program.

Quality seed doesn't cost -- it pays.

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INTRODUCTION TO COLLECTING QUALITY SEEDS

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Tree seed is the foundation upon which almost all reforestation programs are based, although the cost is minor compared to all other aspects of reforestation.

Seed costs for even the most expensive improved seed rarely exceeds 2% of the total cost of reforestation. *See Fig. 1.*

Due to its very high importance and low cost we should take every opportunity to ensure that we provide the very best quality seed possible to the users.

Degradation of seed quality can occur in a number of ways, including the following;

> premature collection, damage from pests, improper handling and storage, or combinations of these factors.

PREMATURE COLLECTION

It is generally accepted that the more mature seeds are when collected, the better the germination and vigour. Cones collected too early are prone to mould, store poorly, may be damaged by internal heating, require longer kiln times, and may not open properly.

Immature seeds often fail to germinate, may germinate very slowly or exhibit poor vigour.

Collection timing is one of the most difficult aspects to predict. Although careful monitoring and historical data are useful, rate of maturity and variation within the crop are beyond our control.

Monitoring and preparedness are the keys to success. Ensure that once the crop is mature that you have the resources to collect as quickly and efficiently as possible.

PESTS

Insect activity is usually obvious well before cone maturity. Once again sampling and monitoring are of the utmost importance.

PESTS, cont'd:

Which pests are present? What is their life-cycle? What kind of damage, and when is it complete? Is control possible?

These are the kinds of questions you should ask to determine what kind of yield you can expect or whether you should collect at all.

HANDLING

Cones are tree eggs! Reasonable care must be used from the time the cones leave the tree until the seed is extracted.

Dropping sacks of cones from trees while climbing should be minimized.

Cones collected from felled trees, by helicopter or from squirrel caches should be gathered as quickly as possible to avoid premature opening, moulds, or fungal activity.

Ensure that the cones are as free from debris as possible to minimize handling during extraction and risk damage to the seed.

Excessive amounts of foliage may also encourage moulds and create lethal temperatures within sacks.

Every attempt should be made to keep cones well ventilated and dry at the collection site prior to delivery to interim storage.

STORAGE

Although interim storage is a minor component of seed collection cost, it is one of the most important, and often poorly addressed.

Interim storage is often required for several weeks prior to shipment to the extractory.

Adequate storage should be arranged prior to commencement of collection.

Very simple inexpensive structures are required to provide adequate shade and ventilation. Supplemental ventilation is beneficial. Traps for mice or food alternatives for other rodents may be required. *See Table* 2.

Turning of sacks periodically not only improves drying but may expose potential problems.

TRANSPORTATION

Transport from the collection site to interim storage and from there to the extractory must be done as quickly as possible. Open flat-decks with pallets every two layers of cones are advisable particularly for fresh collected cones.

SUMMARY

The cost of collecting seed is insignificant considering the gains achieved in the nursery by having good quality seed.

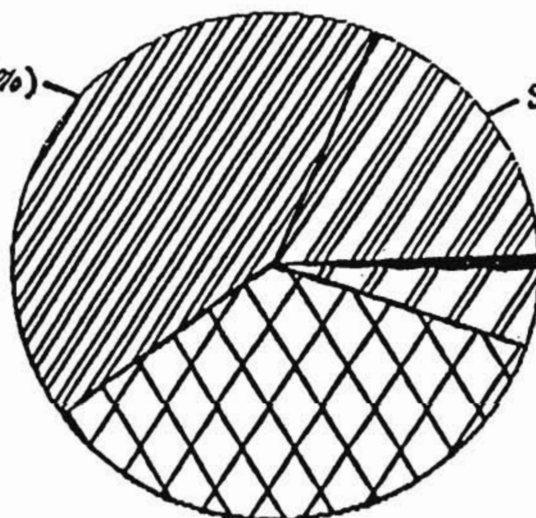
Careful monitoring and handling are essential at all stages of the collection process to ensure success.

It is much easier to collect seed properly in the first place than to try to correct problems during or after extraction.

* REFORESTATION COSTS (1156 $/ha)

Based on planting 950 stems/ ha

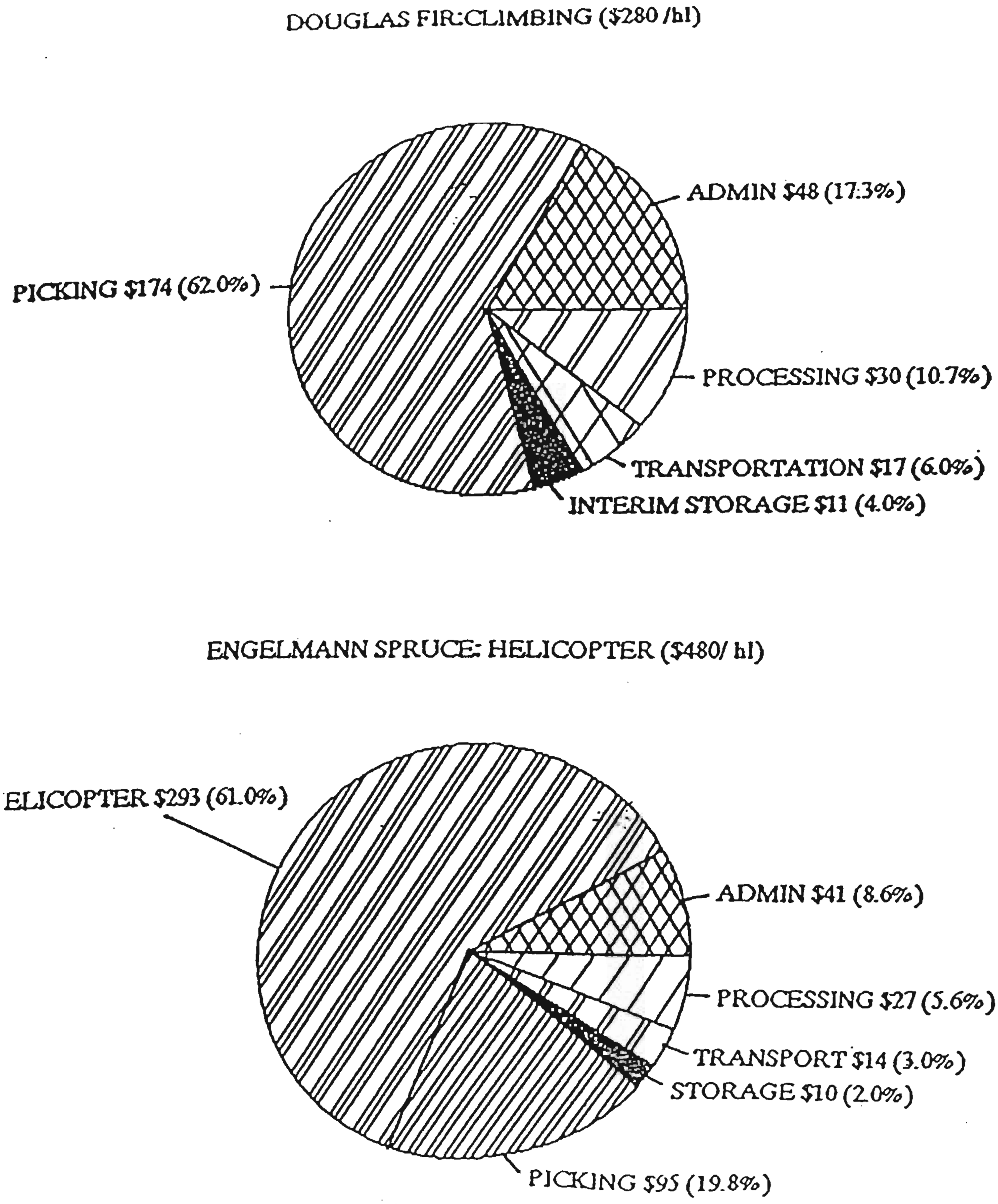
Fig. 1



* Costs are from private forest company averages on Vancouver Island 1991 - 1992

Fig. 2

CONE COLLECTION COSTS



RECOGNIZING SEED QUALITY: CHECKLISTS FOR CONE CROP MONITORING & QUALITY CONTROL

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Below is a checklist that can be used to develop a cone crop monitoring program, from site selection through to the actual pick, handling & interim storage. While the checklists include more detail than may be actually implemented, they provide a guideline of the features to evaluate to maintain seed crop quality. Ultimately, the success of a cone collection is not in the hectoliters of cones collected, but in the yield of high quality seed.

Monitoring for Site selection & Cone Collection Timing.
(Timing of monitering is species and location dependant.)

Frequency:

Late June -- July: Every 2 Weeks
Early/mid August: Weekly
Late August: Every 3 days

Sampling Intensity:

10 cones/tree.
5-10 trees/site.
Increase sampling intensity as picking time approaches, and for sites where there is a great deal of variation among trees in cone quality.

Site Data:

Longitude, latitude, elevation.
Access, slope, site description.
Stand health.
Crop rating by species: heavy, medium, light.

Cone Data:

Moisture content.
External appearance.
Filled seed count (1/2 cone).
Cone length.
Insects/diseases.

<u>Maturity Indices:</u>

Cone colour.
Cone scales flexing.
Abscission layer at cone/stem base.

Embryo visible.
Seed coat developed.
Seed wing colour; tan/brown.
Central cylinder visible.
Embryo visible
Embryo Length: 50, 75, 90+%.

Megagametophyte Condition: As the seed develops, the megagametophyte goes from a transparent "tear-drop" texture to becoming firm and white. The embryo cavity will form before the embryo is visible. Often if there is inadequate fertilization, megagametophytes will begin development, then shrivel and abort.

Seed cutting tests.
Seed moisture content.
Germination tests.

As the cone drop reaches maturity, standard seed cutting, moisture, and germination tests become applicable on seed hand-extracted from the cone. The final stages of development are associated with a rapid decline (desiccation phase) in seed moisture.

Monitoring for Quality Control During Pick & Interim Storage.

<u>Selection of Trees:</u>

Either with helicopter pilot, prior to pick or select acceptable tree tops at the landing site.
Cone cutting test for every tree included in seedlot.

<u>Landing Site (picked & bagged):</u>

Moisture content at time of pick.
Bag temperature not to exceed 20 celsius.
Sample at least 10% of bags on landing: cone cutting test.
Intervene if moulding, signs of heat damage, squirrels feeding, etc.

Interim Storage:

Temperature -- max. & min. should be monitored.
Moisture Content -- rate of drying, equilibrium point should be monitored.
Incubation & germination tests conducted during post-harvest-maturation.
Weekly cutting tests -- note moulding, smell, heat damage.
If ventilation problems -- increase frequency of monitoring.
Maintain monitoring through to transport to extraction facility.

A HISTORICAL OVERVIEW OF SEED UPGRADING TECHNIQUES AND ON TO NEW ROADS OF DISCOVERY

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As the title indicates, this presentation is in two parts. The review of seed upgrading techniques will focus on the so-called IDS process, while the "new roads" will deal with the new biodiversity research work.

The IDS (Incubating, Drying, Separating) procedure was described by Simak (1981, 1984), and has been expanded by the studies of Bergsten (1987). A more recent review can be found in Bergsten (1993). The process relies on the ability of vigorously- viable seeds to retain moisture when dried, while weakly-viable (or dead) seeds dry more quickly, after a mixture of the two has been soaked in water. After an optimum drying period, when the mixture is returned to a container of water, the wetter, vigorously-viable (good) seeds sink while the drier, weak (poor) seeds float, making separation easy. The process has been used in the laboratory to significantly improved the quality of numerous seedlots of species native to British Columbia and the Pacific Northwest (Edwards and Banerjee 1989) and the process, or a variant of it, is being used operationally.

Our main efforts were focussed on the drying step which we found to be the most critical. Following numerous trials we found that mixtures of good and bad seeds that had been hydrated for 24 hours at room temperature, incubated for 72 hours at 15°C, could be dried for 8 hours at 25°C and then easily separated in a container of water as sinkers and floaters. For most lots, germination in the sinkers was considerably higher than before separation. The floater fraction also contained germinable seeds; we have not been able to "capture" every good seed in the sinkers, but by drying the floaters and carrying out a second IDS separation more of the viable seeds were recovered. The main goal was to find a separation which maximized the difference in germination between the sinkers and the floaters. In most instances, the highest germination (often close to 100%) in the sinkers was achieved only at the cost of having a fairly high germination in the floaters. This was reached by drying the seeds further than the optimum; more weakly-viable seeds floated after drying, were separated as floaters and, therby, increased the quality of the sinkers. Thus, the separation objective has to be defined: maximum recovery of viable seeds (usually the largest difference in germination between sinkers and floaters) or maximum germination in the sinkers (irrespective of what viable seeds were "lost" in the floater fraction).

Our work included Douglas-fir, true fir, lodgepole pine, but most of our efforts were spent with white/Engelmann spruce which was found to give less "clean" separation into good/poor seeds than fir or pine. The poorer the seedlot to begin with, the more improvement was possible. For example, a Douglas-fir seedlot that had been damaged in processing was improved from a germination capacity of 17% to 96% by this process. Even a "good" quality lot, e.g. lodgepole pine at 85% germination capacity, was improved to 96.5% by this simple technique. In some species, drying at 15°C proved to be optimum, but the drying period required was usually longer that 8 hours.

Shorter drying, at higher temperatures, is now recommended by Bergsten (1993).

Following separation, the volume or weight of seeds retained (the sinkers) is less than the original. In our work, the breakdown into sinkers and floaters varied widely from seedlot to seedlot even when applying a standardized procedure. A 50:50 sinkers:floaters split was not uncommon. Higher quality lots would separate at 70:30 or 80:20. Poorer lots tended to separate at 40:60 or lower ratios. The Douglas-fir lot referred to above separated at 5:95. While this may seem extreme, if it is placed in the context of marketability, such a separation is not unwarranted. Thus, if this lot had weighed 100kg to begin with, it would have been unsaleable at 17% germination. The IDS process recovered approximately 5% of the original bulk, that is, about 5kg out of the original 100kg, and this could have have been sold since the germination capacity was then 96%.

The question whether IDS-processed seeds could be dried and returned to cold storage, or if the procedure had to be applied just prior to seed sowing, was posed early in the research program. Samples from 20 seedlots of interior spruce have been IDS-processed, the sinkers dried to approximately 8% moisture content, then bagged and placed in refigerated (0°C) storage. All seedlots showed no significant decreases in germination capacity after being stored for 2 years. Some lots (where there were sufficient seeds) were stored for 6 years, and although decreases in germination were noted, all seeds were at least as good as the unprocessed control seeds at the beginning of the experiment.

Since termination (1991) of the seed research program new work has been initiated on forest biodiversity, the main focus being genetic diversity and its conservation. Two projects are underway, and the following is an overview of those aspects concerning germination and seed dormancy.

The first project, "Ex-situ conservation of forest biodiversity in B.C.", is aimed at studying what happens to the genetic base of a seed crop when the seeds are stored. By means of simulated long-term ageing, also known as accelerated ageing, this project challenges the assumption that the genetic integrity of stored tree seeds does not change over time. Accelerated ageing involves subjecting seeds to high temperatures (around 40°C), at a saturated humidity, for periods of up to 3 weeks; agricultural research has shown that germination after a given period of simulated ageing closely predicts viability following traditional cold storage, although similar correlations for tree seeds have not been determined. All the coniferous species under domestication in this region, plus a minor species, mountain hemlock, and a representative broad-leaved species, red alder, will be studied.

Genetic differences in germination parameters and dormancy have been found in Douglas-fir (El-Kassaby et al. 1992), Sitka spruce (Chaisurisri et al. 1992) and western redcedar (El-Kassaby et al. 1993). Evidence of strong genetic (maternal) control (h_b^2 [heritability] > 0.5) has been found for Douglas-fir, Sitka spruce, western redcedar (El-Kassaby et al. 1993) and mountain hemlock (in preparation). The unique structure of coniferous seeds dictates this strong maternal effect (4:1 maternal:paternal) (El-Kassaby et al. 1992). A novel interpretation of germination parameters has also been reported (Thompson and El-Kassaby 1993).

Since strong genetic control over germinability/dormancy has been established, similar differences in rate of seed deterioration can be expected. Genotype-specific differences in rate of deterioration under simulated ageing have been documented for Sitka spruce (Chaisurisri et al. 1993) and in Douglas-fir (in preparation); work has begun on western hemlock, mountain hemlock and lodgepole pine. These results indicate that the genetic makeup of a seedlot before/after simulated ageing will be different. During this work, the same two phases of accelerated ageing, the "conditioning" phase followed by the "deterioration" phase, reported by numerous agricultural researchers, have been observed. The conditioning phase is marked by an increase in germinability following the initial few days of ageing treatment; during the deterioration phase, germination drops rapidly to zero. Biochemical analyses are underway to establish the protein matrix for fresh, untreated seeds of Douglas-fir and lodgepole pine, and to determine changes caused by simulated ageing.

The second project is entitled "Genetic diversity in mountain hemlock". With current timber harvesting extending further into the sub-alpine elevations, it is important to obtain and understand the traits and characteristics of high-montane species, their range, diversity, regeneration potential and reproductive success, and to relate this information to the harvesting method that best maintains the species. Mountain hemlock was selected because little is known about this species and because the funding source encouraged the study of minor species

A literature search has located about 5 dozen articles on mountain hemlock, but only scattered information on reproductive morphology, reproductive method, hybridization and genetic variation has been found, confirming our initial view that this species warrants a lot more attention. This annotated bibliography will be published in 1993.

We are in the process of testing 12 coastal mountain hemlock seed sources on a thermogradient system (courtesy Dr. C.L. Leadem, BC Ministry of Forests) to determine what environmental conditions are needed for successful reproduction. The thermogradient system allows us to study several temperature regimes in combination with several dormancy-breaking treatments on several seed sources all at the same time. We are testing 5 temperature regimes - constant 20°C, alternating 25/15° (8h day)/(16h night), 20/15°, 20/10° and 15/10°, and 4 stratification durations 0, 4, 8 and 12 weeks. All germination tests are being run without light.

Results indicate that mountain hemlock germination is very temperature sensitive. For seeds that had undergone 12 weeks of stratification, a treatment that might have simulated natural exposure under the snow pack, germination under the coolest -15/10°- temperature was neither rapid nor complete, even after two months in the incubator. When the day temperature was raised by 5°, from 15/10° to 20/10°, germination was more nearly complete, but germinants were still appearing at the end of the 2 month test period. When the night temperature was raised by 5°, to 20/15°, germination was quite rapid, and was essentially complete within three weeks. Raising the day temperature by a further 5°, to 25/15°, gave more rapid germination, but the best result was obtained under a constant 20°.

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OPERATIONAL DENSITY SEPARATION PROCESSING (DSP) AT THE BCFS TREE SEED CENTRE (TSC) - 1993

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Introduction

The TSC initiated density separation processing (DSP) on a limited operational scale as part of the preparation for sowing program. The results of this program are the topic of this presentation.

The 1993 program objectives were as follows:

1. To establish initial seedlot selection criteria and use this criteria to select seedlots suitable for density separation processing.
2. To implement DSP operationally, on selected seedlots for which improvements in overall seedlot quality would result in the need to sow less seeds per cavity.
3. To gather information related to costs and feasibility of offering this service on a large operational scale.

Density Separation Processing (DSP) is a term coined by the Ministry of Forests to describe a method of enhanced separation under development at the Tree Seed Centre. Conventional separation methods such as, specific gravity tables, aspirators and fanning mills are also based on differences in density, but are used on seed which is within a relatively narrow moisture content range (i.e. 4-10%). Conventional methods are most efficient for seedlots where a distinct difference between size and density of filled/empty and extraneous material exists. Enhanced separation methods such as DSP or Incubation-Dry-Separate (IDS) are performed on seed at higher moisture contents; the basis for these methods is that potentially viable seed will actively bind moisture and therefore be more dense in comparison to seed which is not potentially viable. The point of separation is when the potentially viable seed are denser than water and sink, while the non-viable seed are still lighter than water and float. The use of this physiological property of viable and non-viable seeds allows for more efficient separations where discrete differences between viable and non-viable seed exist. Published information on the long term storability of enhanced separated seed is lacking and therefore, most enhanced separation is currently performed as part of the stratification treatment just prior to sowing.

Much of the interest in enhanced separation methods was based on Dr. George Edwards work on white spruce, lodgepole pine and Douglas-fir (Edwards *et al.*, 1986). In 1987 the Tree Seed Centre (TSC) initiated the construction of lab and production fluidized bed dryers, separation columns and performed a feasibility study on introducing enhanced separation methods (Furber 1987). In 1991, the TSC initiated a study on the nursery performance of density separation processed (DSP) spruce seed which provided encouraging results for this upgrading method (Banerjee and Scagel, 1992).

Selection Criteria

Given the narrow time frames to process sowing requests and considering that this was our first year of service, the TSC selected seedlots rather than processing on a client requested basis. There were several levels of seedlot selection which began with the following criteria:

1. **Species:** Amabilis Fir (Ba), Subalpine Fir (Bl), Douglas-fir (Fd), interior lodgepole pine (Pli), interior spruce (Sx), Sitka X interior spruce hybrids (SxS) and western white pine (Pw)

2. **Germination Capacity:** less than 70%

3. **Active Seedlot Balance:** greater than 5000 grams for all species with the exception of western white pine where a minimum seedlot balance of 1000 grams was used.

4. **Seedlot usage:** to reduce the risk of performing DSP on provenance's for which there was no longer a need, the number of years a seedlot was requested for operational use[1] since 1986 was established as a selection criteria. The following was used:

    - more than 3 years: Ba, Sx
    - more than 2 years: Fd, Pli
    - more than 1 year: Bl, Pw

The seedlots which met this selection criteria, were then evaluated for DSP suitability. An assessment of the seedlots x-ray radiograph was made and if the seedlot was declared a potential candidate for DSP, a cutting test was then performed. The results of the cutting test in combination with the x-ray analysis enabled technicians to characterize a seedlot and its DSP suitability using the following classes:

Class 1.	Empties > 20%
Class 2.	Damaged and Discoloured > 20%
Class 3.	Immature > 30%
Class 4.	Germination < 30%

[1]operational use meant that the seedlot had been requested for crown land reforestation purposes

Based on discussions with those staff members who had past experience and/or were actively involved in DSP, it was suggested that DSP would be more successful on seedlots from Class 1 or 2. The exception to this was with western white pine in order to accommodate a number of client requests. At this point, technicians began routine screening of operational sowing request schedules, to identify suitable seedlots requested for use in the 1993 program. The selection process is summarized in Figure 1 as follows:

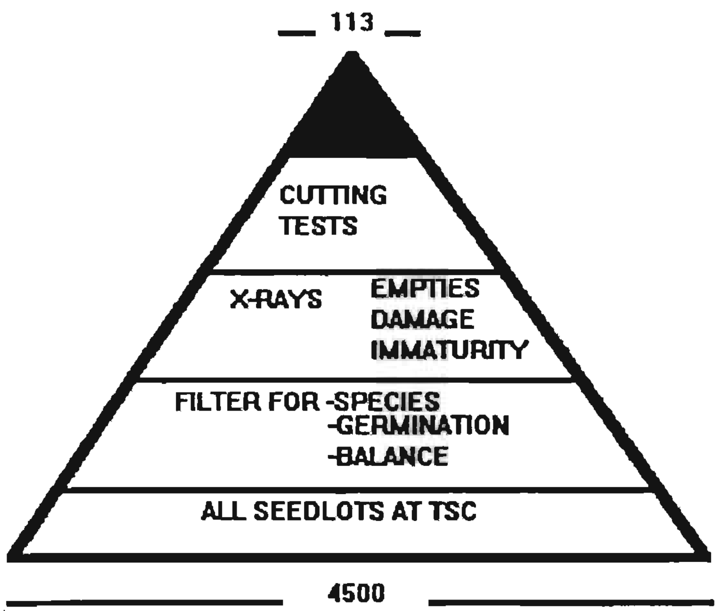

Figure 1. The reduction in number of potential seedlots, from initial number of seedlots at base, to final number of potential seedlots indicated in black.

Density Separation Processing Methods

The TSC is developing two processing methods: imbibitional and dehydrational. Neither method incorporates an incubation step and both methods are based on the ability of potentially viable seed to actively bind moisture, while non-viable seed do not, creating differences in specific gravity thereby affecting separations. The methods on an operational scale, require the ability to quickly separate viable and non-viable seed. To predict viability, seed cutting tests are used as answers are immediate, no special equipment is required and the cost is relatively low. Such tests can be time consuming and subjective, however the continuous cross-referencing of seed types usually leads to consensus for categorization among technicians.

The ability to distinguish floaters from sinkers is usually not a problem, but it is important that the seed is mixed thoroughly in the water to ensure that the surface tension of the water is broken so that viable seed are allowed to sink. Once separations occur, the fraction weight is determined and samples from each fraction are used for cutting tests, moisture content determination and germination testing. For specific details on the equipment used please contact the author directly.

Imbibitional DSP

In this method, dry seed (5-10% MC) was placed in a tank of aerated water. If a seedlot contained damaged seed coats or impurities such as resin and cone scales they were the first materials to sink. The time for this initial separation ranged from one hour for spruce to 12 hours for Amabilis Fir. These initial sinkers were removed as discard material and soaking of the seedlot continued until an acceptable separation between sinkers and floaters occurred. Acceptable separation of viable seed (sinkers) and non-viable seed (floaters) was determined by periodic seed cutting tests.

Dehydrational DSP

This method, is based on the differences in drying rates between viable and non-viable seed. Viable seed is able to actively bind and retain water much longer than non-viable seed during the drying step. The first step in upgrading with this method was to determine the 'target' of improvement. The results of cutting tests were used to estimate the proportion of viable seed. For example, if a cutting test showed that 60% of the seed was well developed, mature and in good condition, this was assumed to be potentially viable, therefore the target separation was 60% sinkers and 40% floaters.

After determining the target of improvement seed was soaked until all of it sank. If some floaters remained after an extended period they were evaluated, however this portion usually contained non-viable seed. If these floaters comprised a large proportion of the seedlot then the sinkers were reevaluated and given a new 'target' based on cutting tests. The sinker fraction was then dried back using a fluidized bed dryer. Drying times and target moisture contents varied and were influenced by seedlot characteristics, batch size and ambient conditions. During the drying step, technicians performed sink/float tests to confirm when seed was uniformly dried and moisture content differences between viable and non viable seed were such that a target separation was possible and once reached seed was removed from the dryer and placed in the separation tank and the separation completed within minutes.

A flowchart example of pathways to further separation is presented in Figure 2. This diagram is general to both methods, but the initial removal of impurities is only possible using dry seed or seed at a moisture content in which all materials float.

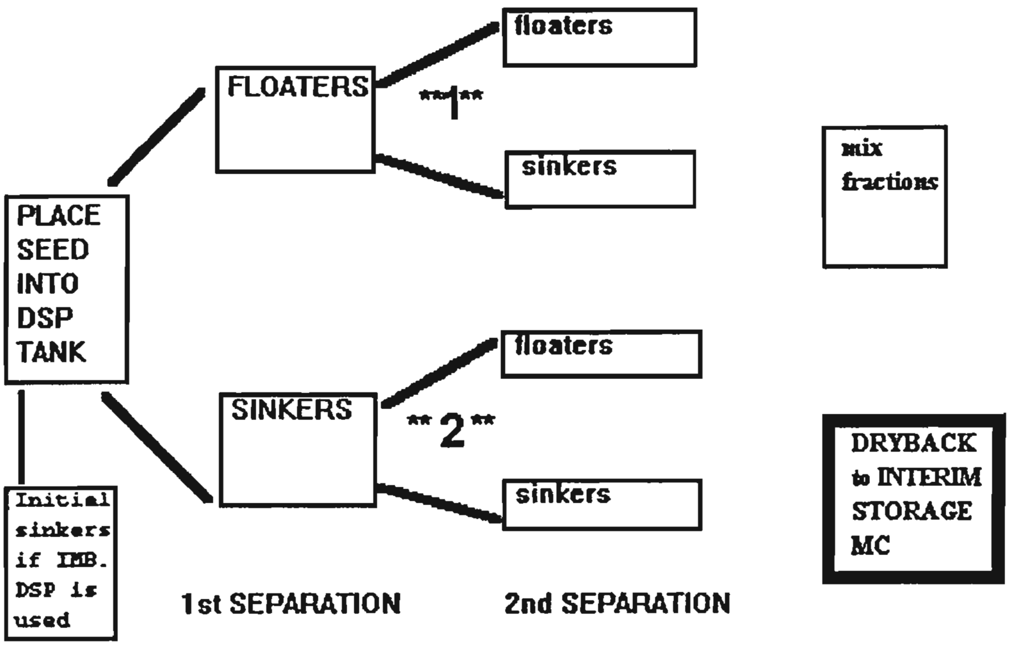

Figure 2. The pathways of seed upgrading to arrive at multiple fractions of seed.

The first separation may not produce an adequate separation and further separation is required due to:

****1**. too many potentially viable seed in the floating fraction**

In this situation we can (i) continue soaking the seed and separate it imbibitionally or (ii) soak the seed until it all sinks, determine the target for this fraction, dry the seed back until we reach our target and perform the separation.

****2**. too many non-viable seed in the sinking fraction**

In this situation we would perform a cutting test to determine the target ratio for these sinkers. They would then be dried back until we reach our target and perform the separation.

The number of separations required was linked to the types of seed present in a seedlot. The easiest separations occurred where only one type of non-viable seed was present and usually resulted in two fractions. For most seedlots there were many classes of non-viable seed: empty, immature and various types of deteriorated seed with differing abilities to retain moisture or different specific gravities depending on the level of deterioration. The economics of further separation to isolate as many viable seed as possible was balanced by the additional time required and placed into context by comparing the weight of the fraction to be further separated to the total request weight.

If numerous fractions were obtained and of similar germination they were mixed if they did not differ in the sowing factor (number of seeds per cavity) prescribed by the Ministry of Forests (MOF) sowing rules. Feedback from clients indicated that it was desirable to minimize the number of fractions sent to the nursery.

DSP Results and Discussion

A total of 131 Kg of seed was Density Separation Processed during the TSC 1993 preparation for sowing program as detailed in Table 1. This volume represented 28 seedlots over 42 sowing requests of which the dehydrational to imbibitional ratio was 33 to 9. The volume processed was significantly less than originally estimated due to normal start up difficulties and DSP staff were frequently reassigned to standard preparation activities to meet operational demands.

Table 1. The number of requests, seedlots, type of upgrading, and proportion of total weight processed for each species which received Density Separation Processing (DSP)

SPECIES[2]	#REQUESTS	#SEEDLOTS	DEHY. DSP	IMB. DSP	% WEIGHT
Ba	18	12	14	4	68.1
Bl	4	4	4	0	13.5
Fdi	4	2	3	1	3.2
Pli	2	2	1	1	4.4
Pw	6	3	3	3	1.9
Sx	6	4	6	0	7.7
Sxs	2	1	2	0	1.2
	42	28	33	9	100.0

The success of DSP was evaluated using three criteria:

I. The gain/loss in germination % (best fraction vs. average)

The germination of the best fraction versus the control has been used as a measure of the success of DSP. A density separation was considered a success if the germination of the best fraction compared to the most recent test of this seedlot was such that the number of

[2]Species definitions: Ba - Amabilis fir; Bl - subalpine fir; Fdi - interior Douglas-fir; Pli - interior lodgeploe pine; Pw - western white pine; Sx - interior spruce and SxS - Sitka X interior spruce hybrids.

seeds sown per cavity could be decreased. The gain or loss in germination is especially informative if only two fractions exist, but can be misleading if many fractions are present after DSP or if the best fraction represents a minor small proportion of the request. In these situations it may be useful to look at the germination of the usable fractions weighted by their mass to arrive at a mean germination. In this paper the germination of the best fraction is used in conjunction with the number of potential seedlings to evaluate DSP.

II. The gain/loss in potential number of seedlings

The Ministry of Forests Container Sowing Rules provide information to growers on seedlot sowing oversow and seeds per cavity by germination and genetic class. The Seed Planning and Registry System (SPAR) uses these rules to describe the seedling potential of registered seedlots. DSP success was declared if the number of potential seedlings increased after processing. The number of potential seedlings is an integral part of the current sowing system and provides an estimate of gains or losses in easily understandable terms.

III. The Efficiency of the separation

The third criteria, efficiency, is useful in evaluating the success of the separation from the opposite end (i.e.) how good are the floaters or what proportion of filled seed is being wasted? The efficiency of the separation is calculated as, 100% minus the germination% of the waste seed fractions. In a successful separation, the less seed wasted during processing the higher the efficiency. The separation efficiency can only be calculated if all waste fractions are tested for germination.

The results of our experience with DSP are presented in Table 2 which presents the gain or loss of DSP in relation to the above mentioned criteria as well as some ecological information on each seedlot. The discussion of results to follow will be presented on a species basis.

<u>Interior spruce (Sx)</u>
All separations were performed dehydrationally and resulted in increases in germination averaging 20%. The best fraction was above 80% germination for all DSP'd seedlots. The average increase in potential seedlings was 18 %. Spruce was considered a success story as all requests increased the Germination capacity (GC) and number of potential seedlings however, the efficiencies were slightly lower (mean=88%) than other species. The gains with spruce could have been higher with further separation of viable seed from floaters; it was felt that such gains would not be significant to warrant time and labour required.

<u>Sitka X white spruce</u>
For Sitka X interior spruce only one seedlot was processed twice dehydrationally. Both separations resulted in increased germination averaging 14%, but one had a loss in potential seedlings, the other a gain.

<u>Western White Pine</u>
The other extreme of the DSP program was western white pine in which all six sowing requests processed resulted in a loss of potential seedlings and a reduction in germination of

the best fraction in five of the requests. Half of the requests were performed imbibitionally and the other half dehydrationally. All seedlots were graded as class 3 and the high proportion of immaturity is perhaps responsible for the lack of DSP success. The class 3 seedlots were DSP'd because of a great deal of client interest in improving western white pine germination. Seedlots with a large proportion of immature seed appear to also exhibit a high degree of variability in maturity and specific gravity. Processing such lots resulted in continuous (non-discrete) separations of sinkers and floaters and therefore lower gains and efficiencies compared to fully mature seedlots.

Cutting tests were not reliable for western white pine as many seedlots had discoloured, thought to be damaged megagametophyte tissue. The use of DSP on white pine was discontinued during the 1993 sowing season.

Amabilis fir

A total of 15 out of 18 requests were performed dehydrationally. In six of the 18 requests the separations resulted in a loss of potential seedlings. For the remaining 12 sowing requests there was an average gain in germination of 24% and an increase in potential seedlings of 48%.

Subalpine fir

Of the four requests performed dehydrationally two had an increase in both germination and potential seedlings. The cutting tests were not satisfactory for this species due to the mushiness of the seeds after a 48 hour soak. Shorter soaking times will be investigated for operational soaking of Bl.

Douglas-fir

Three of the four requests were performed dehydrationally. The results for Douglas-fir were encouraging with germination gains in all cases and an average 10% improvement. One request resulted in a small 105 potential seedling but given the request size, this would not be considered significant at the nursery level. Seed cutting tests were poor predictors of germination in Douglas-fir; the cause is not known, but present thinking is that more reliable criteria for cutting tests is required for this species.

Interior Lodgepole pine

One request was performed dehydrationally and one was performed imbibitionally. The two requests both had a gain in germination for the best fraction, averaging 15%. One of these requests resulted in a gain and one in a loss of potential seedlings.

In comparing the evaluation criteria it is evident that while many sowing requests had gains in germination of the best fraction many of these still had losses in terms of potential seedlings. The potential seedling calculation seems to be more descriptive, as it takes into consideration all usable fractions rather than just the best fraction. A further explanation for losses of potential seedlings is due to the amount of seed required for testing purposes (i.e.) germination, moisture content determination and cutting tests. An average of 106 grams of seed was required for testing, the impact of which was proportional to the size of the request being processed.

DSP Summary

- For the seedlots investigated in 1993, dehydrational DSP appeared to be a much better technique. Imbibitional DSP had three requests with best fractions which lost more than 20% in GC and had an overall average loss in germination for the nine sowing requests processed in this manner.
- Interior spruce and Amabilis Fir were the species which responded best to DSP.
- With current techniques western white pine is not considered to be a good candidate for DSP.
- Present cutting test classification procedures were adequate for Amabilis fir, lodgepole pine, and the spruce species.
- Improvements in cutting tests are needed for subalpine fir, Douglas-fir and western white pine.
- The selection criteria for DSP which the TSC used is one of an infinite number available. The seedlots which would provide the greatest service to nurseries after upgrading will vary by nursery and their philosophy on seedling culture. The following are some factors worth considering in evaluating seedlot selection criteria for DSP.

    The ability to perform single seed sowing.
    The desire to perform single seed sowing.
    The minimum level of upgrading required.
    The maximum number of fractions desired.
    The ability to take advantage of increases in available seedlings.

ACKNOWLEDGMENTS
The DSP program has involved many people and the following deserve acknowledgment for their respective roles. Mishtu Banerjee, Scientificals Consulting provided start up training and documented instructions as technicians assigned to this project had no previous experience with DSP. Murugi Larsen provided considerable assistance in developing selection criteria as well as performing seedlot evaluations to define DSP suitability with the assistance of Barb Marples. Technicians assigned to DSP were Barb Marples, Ron Sharp and Malcolm Dunphy, all of which contributed to the development of this process.

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TABLE ABBREVIATIONS

SP. =Species
Ba = amabilis fir = Abies amabilis (Dougl.) Forbes
Bl = subalpine fir = Abies lasciocarpa (Hook) Nutt.
Fdi = interior Douglas-fir = Pseudotsuga Menziesii var. glauca (Beissn.) Franco
Pli = interior lodgepole pine = Pinus contorta var. latifolia Dougl. ex Loud.
Pw = western white pine = Pinus monticola Dougl. ex D.Don
Sx = interior spruce = Picea glauca (Moench) Voss, Picea engelmannii Parry ex Engelm and hybrids
SxS = Sitka X interior spruce hybrid = Picea X lutzii Little

DSP TYPE =type of DSP performed — DEHY = dehydrational; IMB = imbibitional

SPAR GERM = germination capacity (%) in the Seed Planning and Registry (SPAR) system -used for the calculation of sowing request grams and potential seedlings (recommended seeds/cavity in brackets)

DSP GERM = germination capacity (%)of the best fraction following DSP.

GERM GAIN = the gain in germination of the best fraction as a result of DSP

SPAR POT. = the number of potential seedlings in this request calculated by the Ministry of Forests Sowing Rules

DSP POT. = the number of potential seedlings following DSP calculated using the Ministry of Forests Sowing Rules

GAIN POT.# = the gain in the potential number of seedlings following DSP

%GAIN POT = the percentage gain in potential seedlings relative the the initial sowing request. This allows for a comparison of changes in potential seedlings for various separations regardless of request size.

EFF % = the efficiency of the separation and is equivalent to 100 minus the germination percentage(s) of the waste fraction(s). In many cases efficiencies are unknown as germination tests were not conducted on all fractions.

ELEV (m) = the mean elevation of the collection site

LAT = the latitude in degrees and minutes

LONG = the longitude in degrees and minutes

BGCU = the biogeoclimatic zone, subzone and variant

COLL. DATE = the collection date for this seedlot

SPZ = the seed planning zone for which the seed is to be used

Table 2. The results of the 1993 Density Separation Processing (DSP) at the Tree Seed Centre.

SP.	SEED LOT	DSP TYPE	SPAR GERM	DSP GERM	GERM GAIN	SPAR POT.	DSP POT.	GAIN POT#	%GAIN POT#	EFF. %	ELEV (m)	LAT	LONG	BGCU	COLL. DATE	SPZ
Ba	4139	DEHY	59(4)	87(2)	28	6300	10425	4125	65.48	89.4	790	48 55	124 44	CWH vm 2	9/4/79	M
Ba	7726	DEHY	46(4)	89(2)	43	22100	37397	15297	69.22	97.6	800	48 40	124 50	CWH vm 2	9/22/82	M
Ba	7726	DEHY	46(4)	86(2)	40	7700	14154	6454	83.82		800	48 40	124 50	CWH vm 2	9/22/82	M
Ba	7726	IMB	46(4)	83(3)	37	3800	5348	1548	40.74	95.0	800	48 40	124 50	CWH vm 2	9/22/82	M
Ba	7939	DEHY	68(3)	78(3)	10	15400	14558	-842	-5.47	97.5	125	50 37	127 34	CWH vm 1	9/10/86	M
Ba	8643	DEHY	31(4)	27(4)	-4	10000	12060	2060	20.60	83.0	700	54 19	128 45	CWH ws 2	8/26/87	SM
Ba	9959	DEHY	63(4)	82(3)	19	15300	20294	4994	32.64	87.3	700	50 20	127 10	CWH vm 2	9/22/82	M
Ba	9959	DEHY	63(4)	87(2)	24	27600	48767	21167	76.69	94.4	700	50 20	127 10	CWH vm 2	9/22/82	M
Ba	9959	DEHY	63(4)	81(3)	18	5000	6905	1905	38.10		700	50 20	127 10	CWH vm 2	9/22/82	M
Ba	20157	DEHY	58(4)	74(3)	16	2800	3395	595	21.25		1096	49 25	122 5	CWH vm 2	9/13/88	M
Ba	20158	IMB	68(3)	70(3)	2	6000	5158	-842	-14.03		1127	49 25	121 43	MH mm 1	9/14/88	M
Ba	20158	DEHY	68(3)	71(3)	3	60000	52971	-7029	-11.72	88.1	1127	49 25	121 43	MH mm 1	9/14/88	M
Ba	20159	IMB	65(4)	34(4)	-31	22600	20913	-1687	-7.46		1127	49 25	121 43	MH mm 1	9/14/88	M
Ba	31953	DEHY	76(3)	72(3)	-4	15000	14244	-766	-5.04	79.3	750	49 7	121 8	CWH vm 2	9/12/90	M
Ba	31954	DEHY	65(4)	77(3)	12	77000	99382	22382	29.07	94.0	825	49 70	121 80	CWH vm 2	9/12/90	M
Ba	31954	DEHY	65(4)	**		4000	6795	2795	69.88	94.0	825	49 70	121 80	CWH vm 2	9/12/90	M
Ba	35006	DEHY	37(4)	82(3)	45	50000	65432	15432	30.86	91.2	550	55 5	127 56	ICH g	8/17/90	NST
Ba	35007	DEHY	53(4)	65(4)	12	26000	19837	-6163	-23.70	84.2	700	55 5	128 0	CWH ws 2	8/16/90	NST
Bl	32732	DEHY	66(3)	72(3)	6	119100	112303	-6797	-5.71	99.2	320	55 48	129 10	ICH g 4	8/18/90	NST
Bl	32999	DEHY	51(4)	65(4)	14	16900	17160	260	1.54		900	54 52	126 42	ESSF k	8/21/90	BLK
Bl	35022	DEHY	59(4)	57(4)	-2	52700	54467	1767	3.35	84.3	850	56 25	128 10	ICH g	8/21/90	NST
Bl	35029	DEHY	60(4)	45(4)	-15	60100	57583	-2517	-4.19	93.8	1100	54 50	126 15	SBS mc	8/24/90	BLK
Fdi	1371	DEHY	55(4)	69(3)	14	35000	45828	10828	30.94	85.7	1158	50 15	120 00		8/22/66	TOA
Fdi	1371	DEHY	55(4)	70(3)	15	9000	12396	3396	37.73	89.1	1158	50 15	120 00		8/22/66	TOA
Fdi	1371	DEHY	55(4)	57(4)	2	14800	14695	-105	-0.71	80.5	1158	50 15	120 00		8/22/66	TOA
Fdi	5555	IMB	62(4)	72(3)	10	12400	12701	301	2.43	88.7	1372	49 44	117 40	ICH a	8/21/88	WK
Pli	2484	IMB	68(3)	79(3)	11	30300	27659	-2641	-8.72	91.7	1372	51 10	116 22		10/1/74	EK
Pli	32582	DEHY	73(3)	92(2)	19	417254	451592	34338	8.23	96.7	900	51 30	117 11	ICH a 2	12/8/89	BSH
Pw	8193	IMB	60(3)	39(4)	-21	5000	4729	-271	-5.42		1300	50 15	118 25	ICH mw 2	9/8/88	SA
Pw	33329	DEHY	68(3)	80(3)	12	5000	4589	-411	-8.22		650	50 58	118 10	ICH b	8/28/90	WK
Pw	33329	IMB	68(3)	52(4)	-16	4000	2693	-1307	-32.68		650	50 58	118 10	ICH b	8/28/90	WK
Pw	33329	IMB	68(3)	41(4)	-27	2000	1330	-670	-33.50		650	50 58	118 10	ICH b	8/28/90	WK
Pw	33330	DEHY	68(3)	54(4)	-14	7100	4723	-2377	-33.48	98.8	660	51 2	118 1	ICH b	8/28/90	WK
Pw	33330	DEHY	68(3)	40(4)	-28	7100	4472	-2628	-37.01	99.8	660	51 2	118 1	ICH b	8/28/90	WK
Sx	4130	DEHY	68(3)	86(2)	18	87100	105237	18137	20.82	84.8	960	53 24	122 14		8/20/79	MGR
Sx	4306	DEHY	56(4)	81(3)	23	163400	192345	28945	17.71	94.6	1405	53 90	122 10		8/22/79	NCH
Sx	4306	DEHY	56(4)	81(3)	23	128400	164943	36543	28.46	91.0	1405	53 90	122 10		8/22/79	NCH
Sx	25580	DEHY	67(3)	83(3)	16	193300	198147	4847	2.51	88.0	1219	51 44	120 23		8/23/82	SA
Sx	29127	DEHY	63(4)	82(3)	19	119400	140644	21244	17.80	86.0	1200	55 21	123 55		8/26/82	FIN
Sx	29127	DEHY	63(4)	82(3)	19	140000	165103	26103	17.90	86.0	1200	55 21	123 55		8/26/82	FIN
SxS	14586	DEHY	73(3)	84(3)	11	53000	49245	-3755	-7.08	91.5	535	55 35	128 35		9/3/88	NST
SxS	14586	DEHY	73(3)	90(2)	17	101400	117286	15886	15.67	89.6	535	55 35	128 35		9/3/88	NST

** calculation of potential seedlings for this sowing request was based on cutting tests as no Quality Assurance germination testing was performed.

SEED DRYING FUNDAMENTALS AND PRACTICAL CONSIDERATIONS.

R. A. Furber, MSc., PEng.

First of all, what are we trying to accomplish? Remove surface moisture? Reduce the moisture inside the seed? Expose the seed to very uniform drying conditions for subsequent separation? Reduce it to a fairly low level for long term storage? A system that is good for one may not be good for the other.

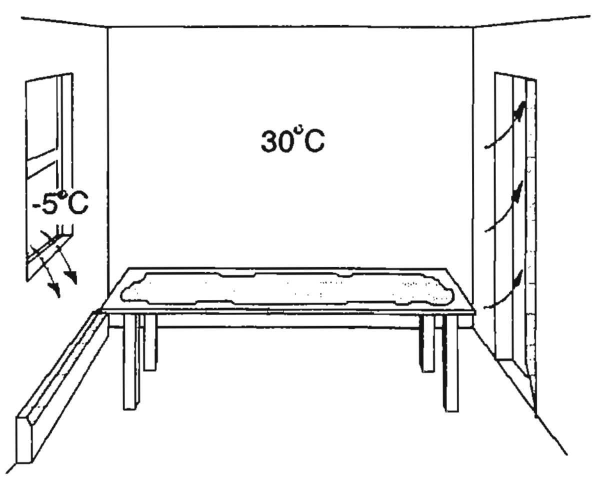

Fig. 1 - Table Top Seed Dryer

If we consider the table top seed dryer which we all know (Fig. 1), we can examine some of the factors involved in drying:

Absorbtion. Surface water from the bottom of the bed is absorbed by the paper towels lining the table. This can be significant when drying a small, singlĕ layer batch of seed.

Evaporative drying, into the room air. After a while, the top of the bed can be quite dry, yet, just below the surface it can be quite wet.

Diffusion of water molecules from the depth of the bed to the surface (Fig. 2). This is slow. Of course, drying can be speeded up with stirring to expose moist seed to the drying surface. The moisture is physically moved to the drying surface instead of waiting for diffusion.

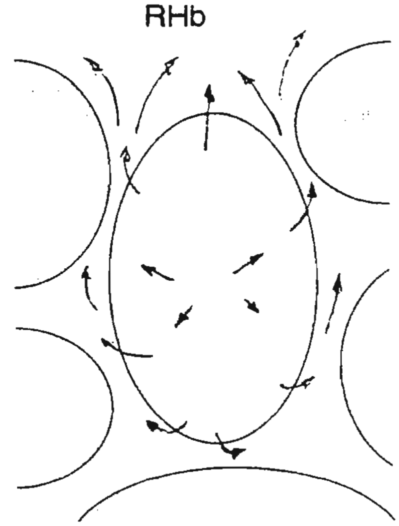

Fig. 2 - Moisture Diffusion Out of Seed and Out of Bed

Diffusion of water from within the seed and out (Fig. 2). This is exceedingly slow.

Relative humidity is the driving force outside of the seed. This is a function the vapor pressure of water, which is a very strong function of temperature. For instance, at 5 deg. C, saturated air or air at 100% RH contains just under 7 g of water vapour. At 15 deg. C, it almost doubles to just under 13 g. At 25 deg.C, it almost doubles agin at 23 gm, and so on. Rule of thumb: the amount of water required to saturate air doubles every 10 deg. C in this temperature range. Another way of looking at this: That air that was saturated at 5 deg. C becomes, relatively speaking, quite dry when heated to 25 degrees: Its RH is reduced to about 25%.

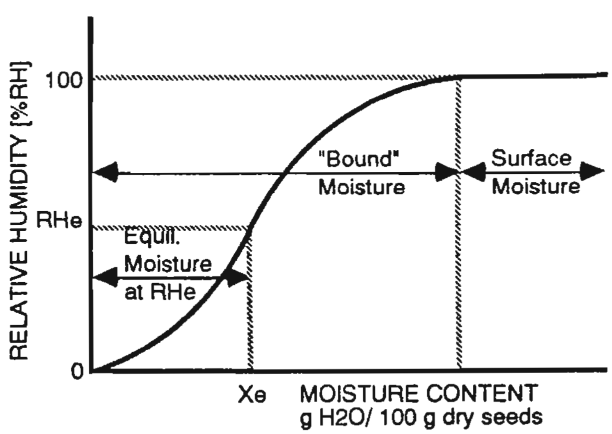

Fig. 3 - Equilibrium Moisture Curve

Temperature provides a double effect. Not only does it decrease the relative humidity and increase the driving force, but it also increases the speed with which water molecules diffuse to the drying surface.

Drying depends on the surface area exposed to the drying air, the depth of the bed and the flow of air over the bed. Spread the bed so it is twice the area and half the depth and drying will increase dramatically. Leave it in still air and the air just above the seed bed will saturate and drying will virtually stop. Turn on the fan, and drying will accelerate.

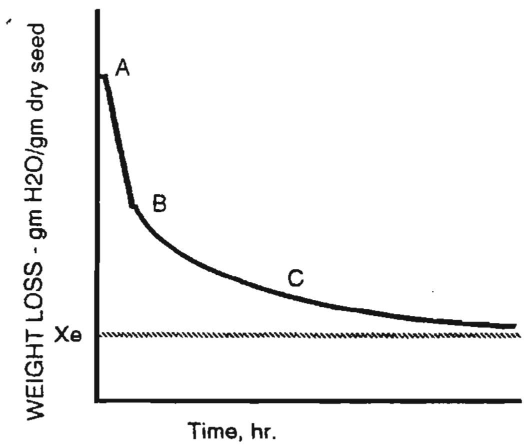

Fig. 4 - Typical Drying Curve

Fig. 4 is a typical drying curve. After the initial blip where temperatures adjust, weight loss follows a straight line: The drying rate is constant as long as there is ample water at the top of the seed bed. However, as the top of the bed drys, there is less and less free moisture exposed to the drying air, and the drying rate starts to decrease. Then, moisture must migrate from deeper down in the bed, and the drying rate decreases further. Finally, moisture must diffuse out of the seed, and through the bed, and, as a consequence, the drying rate becomes very slow.

Drying can be speeded up considerably by forcing the warm dry air through the bed (Fig. 5). This eliminates one of the rate limiting factors: Diffusion of moisture out of the bed. Initially, the air will saturate very quickly with free moisture, and the top of the bed will be dry while there is still free moisture just below the surface.

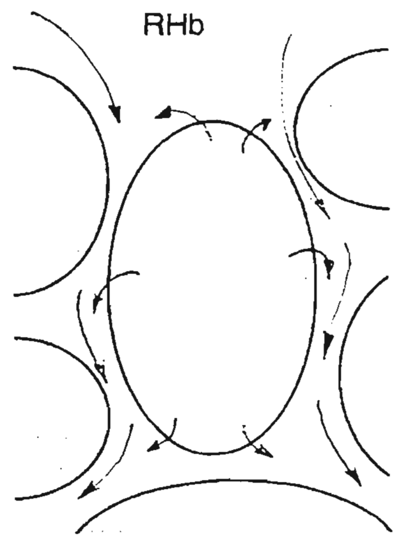

Fig. 5 - Flow Through Drying

As drying progresses and drying becomes limited by the diffusion of water through the seed and its membrane, the bed becomes much more uniform.

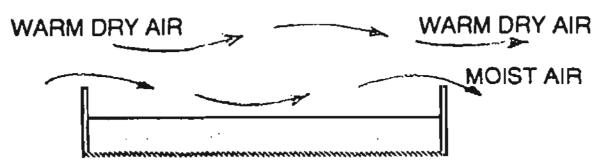

Fig. 6 - Flow By Drying Tray

Fig. 6 is a typical flow by or over bed drying tray. Drying is accomplished by the air flowing just above the bed. Most of the air flow does not contact the bed, and, has no effect.

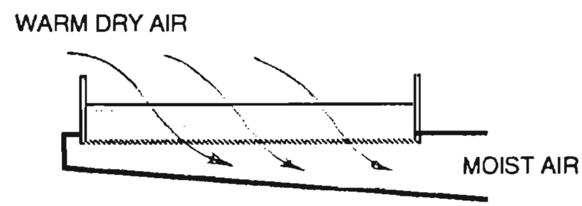

Fig. 7 - Flow Through Drying Tray

Fig. 7 is a flow through drying tray, where warm dry air is sucked through a bed of seed into a hollow shelf arrangement. Unlike the flow by arrangement, where furrows expose more surface to drying, here, air short circuits through the valleys and the peaks take longer to dry. A level bed is essential.

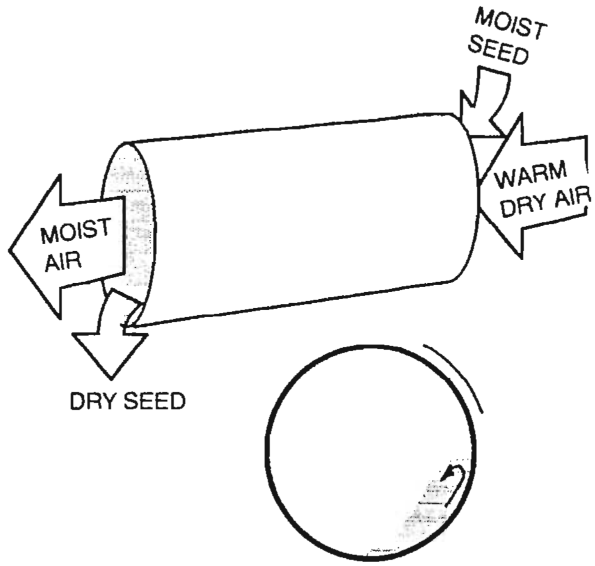

Fig. 8 - Rotary Kiln Dryer

In a rotating kiln dryer (Fig. 8), seed is fed into a large rotating tube with warm dry air. As the tube rotates, the bed of seed tumbles, exposing moist seed to the drying surface, similar to the table top dryer, but with continuous mixing. Sometimes, the kiln is fitted with lifters which lift moist seed and pour it through the column of drying air, exposing these seed to more intense, uniform drying conditions.

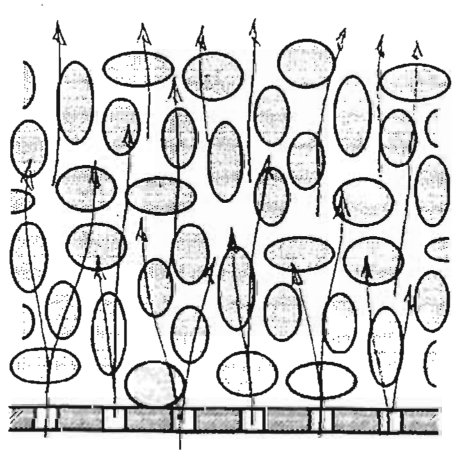

Fig. 9 - Fluidized Bed Dryer

In the fluid bed dryer (Fig. 9), a controlled amount of warm dry air is introduced very evenly into the bottom of the drying chamber to form a concentrated suspension of seed in the air, with excellent mixing. All the seeds are exposed to very uniform drying conditions. But, too much air, and the seeds are blown out of the chamber. Too little and the bed does not fluidize and the good mixing and high uniformity characteristics are lost.

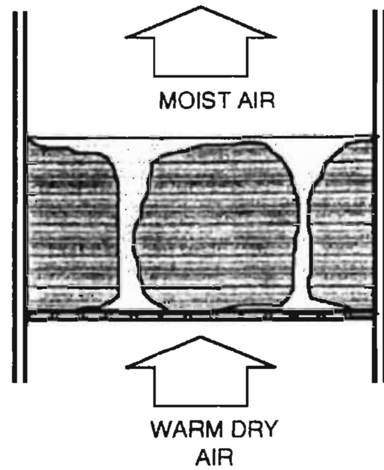

Fig. 10 - Air Channelling Through Wet Seed

Drying wet seed in a fluid bed dryer is a challenge. Because the wet seeds are sticky, it is like trying to blow bubbles in a mud pie: The air just blasts one or two holes and whistles right through, ignoring the bulk of the seed mass (Fig. 10). To get around this situation, the seed mass is vibrated in such a way as to collapse any channeling into small bubbles, and, to generate a rotating, twisting motion in the seed bed, promoting mixing (Fig. 11). Once the surface moisture is removed, the bed changes quite abruptly into a fluidized bed. This rolling action tends to polish the seed coat, improving the performance of the subsequent seeding operation - fewer misses and fewer doubles.

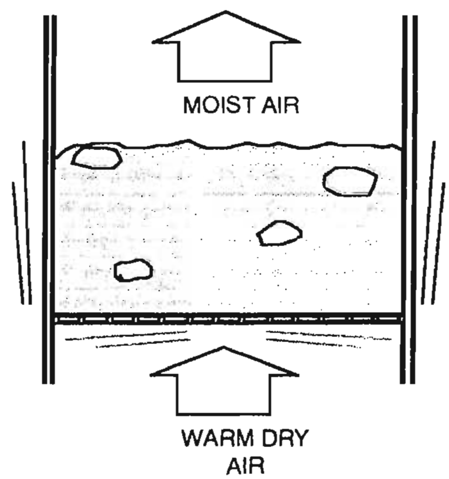

Fig. 11 - Vibration to Break Up Channeling and To Promote Mixing

Now, if the more complete drying system in Fig. 1 is considered, cool outside air is used, the room is warmed to reduce relative humidity or increase the amount of water that will be evaporated, and air is discharged to make room for more fresh air.

If it is a nice cool, crisp -5 deg. C day in January, the outside air will contain less than 4 gm of moisture. In the warm room, this air will be able to absorb potentially an additional 19 gm of water vapour at 25 deg. C and, almost double that at 35 deg. C. That is, the air that comes in contact with the surface of the seed bed. Much of the air will short circuit straight out the door.

However, on a hot muggy 25 deg. C day outside, no drying would occur in a room at 25 deg. C and the room would have to be heated.

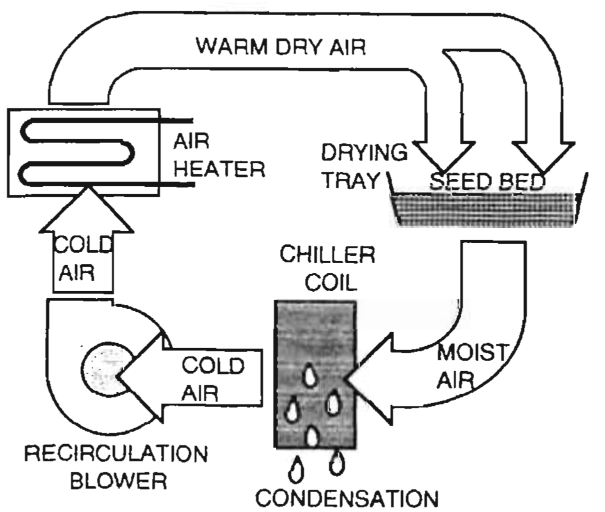

Fig. 11 - The Recirculating Dryer Concept

In order to isolate the drying system from outside air conditions, a recirculating system (Fig. 11) with dehumidification is sometimes used. Moist air is chilled to remove moisture then, reheated and passed through the seed bed to pick up more moisture. Moisture is transferred from the seed to the air and then, to the chiller coil, where it is removed from the system. The colder the chiller coil, the lower the relative humidity of the tempered air, and, the lower the attainable moisture in the seed. Such a system also enables conditioning and drying at temperatures as low as 10 deg. C or less, which could be useful for certain species. A schematic of a recirculation flow through tray dryer is shown in Fig. 12.

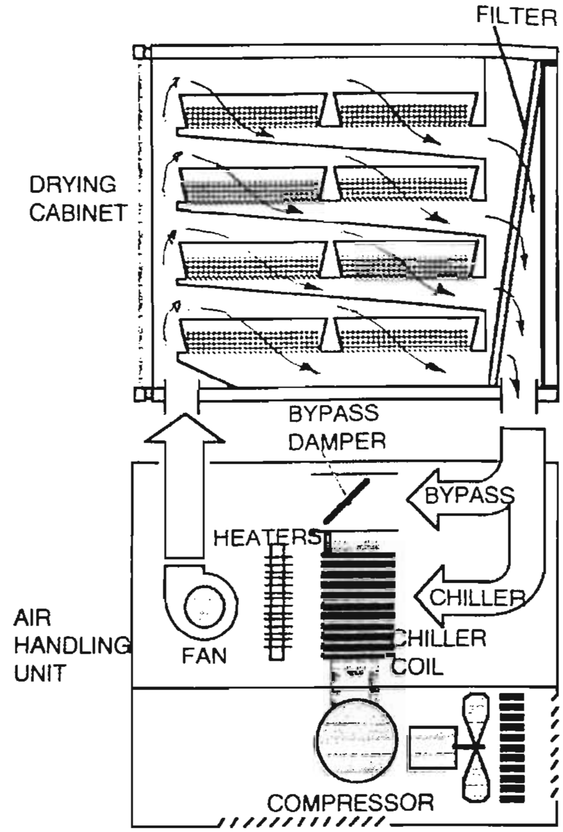

Fig. 12 - Recirculating Tray Dryer Schematic

The capital cost of a Flow By system can be low if a room with suitable ventillation and heating is available at no cost. A 100 litre batch Flow Through tray system will cost in the order of 15K$ or, about $150/L, depending on controls, dehumidification, etc.. A Fluid Bed Dryer system is an order of magnitude more costly, at about $1500/L, but it is much faster and it drys very uniformly. A Rotary Kiln Dryer typically costs about 15K$ and up, depending on size, controls, feeders, ducts, etc.. It would normally be used for continuous operation or large seedlots.

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SEED GERMINATION AND TEMPERATURE REQUIREMENTS OF WHITE SPRUCE (*Picea glauca*) AND DOUGLAS-FIR (*Pseudotsuga menziesii*).

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Temperature is a critical factor influencing conifer seed viability and germination success. With the assistance of FRDA funding, a prototype computer-controlled temperature gradient system (TGS) was designed and constructed for use in determining the optimal temperatures for seed germination. In the first application of the TGS, this paper reports on the effects of temperature and of systematic surveys planned for all major B.C. conifers to investigate the effects of temperature and other factors on seed germination.

Seeds from a single high quality source of white spruce received 4 stratification treatments (0, 3, 6 and 12 weeks), then were incubated under 16 C, 24 C, and 32 C constant temperature regimes. Of the 3 temperatures tested, seeds germinated best at 24 C, and at this temperature, there were no differences between 0, 3, and 6 weeks' stratification. At the sub-optimal 16 C, 3 to 6 weeks' stratification was required for best performance. Germination was poor under the 32 C constant temperature regime for all stratification treatments. Although these test results give some indication of germination temperature requirements, recommendations regarding optimal temperatures for white spruce cannot be made until additional seed sources have been tested.

Four seed sources of Douglas-fir ranging from 49 to 56 C were stratified for 3 weeks at 2 C, then incubated at 15 C, 20 C, 25 C and 30 C. At constant 20 C, seeds from all latitudes germinated most quickly and completely. Germination of seeds from higher latitude sources (53-56 C) tended to decline proportionately more at warmer temperatures than seeds collected from lower latitudes (49-52 C).

SEED QUALITY IMPROVEMENT IN RELATION TO FUTURE SILVICULTURE CHALLENGES

BY HENRY J. BENSKIN, R.P.F.
DIRECTOR
SILVICULTURE BRANCH
B.C. MINISTRY OF FORESTS
SPEAKING NOTES FOR JUNE 3, 1993

BANQUET FOR THE COMBINED B.C. TREE SEED DEALERS,
CONE AND SEED COMMITTEE,
AND WESTERN FOREST AND RANGE SEED COUNCIL MEETING

* Good evening, ladies and gentlemen. On behalf of the province of British Columbia, which is hosting the barbecue tonight, I welcome all of you to British Columbia.

* I wish to commend the three forest seed related groups for getting together and organizing this meeting.

* Particularly the tree seed dealers of British Columbia, the BC cone and seed committee, and the western forest and range seed council.

* Technological exchange to improve both physiological and genetic quality of the seed used for reforestation is of vital importance to our future forests. In B.C. currently 11% of the seed used for reforestation in the 1993 sowing* originated from seed orchard seed and it is projected that by the year 2000, 50% of the stock planted will be genetically improved.

* Tonight I wish to briefly relate your topic of seed quality improvement, whereby increasing amounts of genetically improved stock will be produced in the future, to the overall silviculture challenges we are facing.

* In looking to the future, inasmuch as 95% of the forest land in BC is Crown owned, we must offer government, for approval, silviculture strategies that provide for sustainable development, biological diversity, as well as genetic diversity, while maintaining a forest industry which is competitive in a global economy.

* The species profile for planting will continue to change in relation to the proportion of harvested area which is planted v. naturally regenerated and the amount of deciduous species harvested.

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*Total provincial sowing was approximately 226 million trees.

* In regard to increased seed production from orchards your group is best able to deal with the challenges this presents (refer to seed quality of orchard lots compared to natural stand seedlots.)

* In regard to growing rhythm differences between natural stand versus seed orchard seed, you need to work with colleagues in nurseries, tree breeders, and research physiologists to develop appropriate growing prescription to optimize seedling recovery from seed sown.

* Refer to current '93 sowing profile by species.

* Emphasize need to use caution in diversifying into use of alternate silvicultural practices which provide for natural regeneration in terms of cost-effectiveness and overall success over time.

* We must question the approach being taken by Ontario so that the Ontario model is not used as a solution for B.C. forestry.

* In the near future, B.C. will be introducing a forest practices code discussion paper to clarify and strenghten forest practices to meet future demands of society (i.e. sustainable development) while providing for responsible forest land stewardship.

* Also, in the near future the commission on resources and the environment, ("CORE"), which is examining land use issues, will be tabling a report to government on best options for the process to use in land use decisions.

* Let's work together to ensure that:

  (a) genetically improved stock is cost effectively and successfully deployed in providing for future forests.

  (b) level of planting is maintained into the future by demonstrating that quality seed in combination with quality stock and quality planting is most effective in providing for new forests over many ecosystem types in B.C.

  (c) maintain your technological exchange and communications in your specialized area of silviculture as well as keep in touch with the "big picture".

* Thank you for the opportunity to speak to you tonight and I hope the remainder of your meeting is as successful and informative as the previous two days.

JOINT MEETING OF THE BC TREE SEED DEALER'S ASSOCIATION AND THE WESTERN FOREST AND RANGE SEED COUNCIL

KEYNOTE ADDRESS

John Revel

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Prince George, B.C.

Welcome to Vernon, B.C. and I hope you enjoy your visit. I was born in Northern Ireland and as a fourteen year old boy, settled with my family in Enderby, B.C. in 1948. Enderby, at that time was a thriving town (city) based on the logging and farming industries. Enderby is only 24 miles north of Vernon, but has its differences. Enderby is on the Shuswap River which flows north and west to the Fraser River system, while Vernon is in the Okanagan drainage which flows into the Columbia River System. The great divide is two miles north of Armstrong. We have cultural and climatic differences; the "apple knockers" vs. the "loggers". The boundary was based on whether western red cedar could grow or not!

This evening my topic is "A Philosophical Overview of Forestry in British Columbia". I will very quickly deal with this topic and move to "safer ground" - The History of Reforestation in British Columbia. I am not an expert on forestry, timber management or economics and politics but have a reasonable background in reforestation.

Forestry started in B.C. right after the ice age was over. Native Indians used wood to their advantage; the totem poles of fame are just one of these uses.

On April 17, 1792, British Captain George Vancouver sailed into Nootka Sound on the West Coast of Vancouver Island. He needed and procured masts and spars from the tall straight trees of British Columbia. This was the first exploitation of B.C. timber. Of note: He had Menzies on as a Doctor who collected the first cones of Douglas fir.

British Columbia, with 93% of its timber still owned by the public (crown land), is a major world forest producer to the present time. Forest tenures have evolved over the years since the British Parliament. Pulp leases, S.T.L.'s (Special Timber Licenses), beach comer licenses, etc., indicate the tenure history of British Columbia. In 1885, the Canadian Pacific Railway agreed to link the west with the east of Canada. As an incentive, the Dominion Government set aside the "Railroad Belt" which led to major areas in timber berths. It was assigned to the province of British Columbia. The E&N land grant (Esquimalt and Nanaimo) on Vancouver Island has a similar history.

The B.C. Forest Service was established in 1912 and has had a major influence on timber management in British Columbia. Probably the most significant accomplishment was in 1956 when the sustained yield concept was brought in.

We have had a series of Royal Commissions in B.C. with the Slogan Commission (1956) as critical to forest practices in British Columbia. Recently, the Pearce Commission and The Forest Resources Commission have "Fine Tuned" things. We still have a way to go! From the landing of Captain Vancouver to the present, we, in British Columbia, like to think that we have emerged from "exploitation" to "forest management" with the future prosperity of our province high on our lists. Today we plant over 200 million seedlings annually and that indicates progress in forestry, particularly at +/- 80% field survival of seedlings.

I could get "wound up" about forest practices but will switch to a brief history of reforestation in British Columbia. The earliest history of reforestation in B.C. was the establishment of a research seedling nursery on Shelbourne Street in Victoria, B.C. in 1927. At that time, Shelbourne Street was "out in the country". Now it is highly populated with town houses and other urban sprawl.

The first plantations were established on Vancouver island and at Green Timbers in the Whalley area (lower Fraser Valley). In 1930, the Green Timbers Nursery was operational and plantations were planted at Green Timbers and in the Sayward Forest on Vancouver Island. The Sayward Forest is an 83,000 acre area of very high site land near Campbell River; part of an extensive forest fire which occurred in 1938. The older plantations have been pruned, commercially thinned and fertilized in recent years.

Following the initiation of Green Timbers Nursery, the Duncan and Quinsam Nurseries were developed to supply seedlings for the reforestation program on the Coast of B.C..

In the late 1950's, after efforts to secure forest regeneration by natural means in the Interior failed in most cases, the coastal reforestation program was moved into the Interior of B.C.. The small nursery in Telkwa, B. C. was reminiscent of the original Shelbourne Street Nursery. Nurseries at Aleza Lake, Hixon, Cranbrook, Rayleigh, etc., provided planting stock to the Interior reforestation program. We were so short of planting stock that we dug seedlings up from roadsides and mapped them in plantations as "wildings".

The first experimental plantations in the Prince George Forest Region were planted in 1956, (Scots pine and white spruce), with the first operational plantation in 1959. It wasn't until the late 1960's, that the "clear-cut, burn and plant philosophy" prevailed in the North Central part of British Columbia after harvesting on good sites.

In 1967, the Red Rock Nursery and Research Station was established just South of Prince George, it was a Canadian Centennial Project. This nursery had a 15 million "bareroot" seedling annual capacity. The program in the "North" has exceeded 80 million seedlings per year. Industrial Forestry Services Nurseries at Ness Lake, Ruffs Nursery and a "Cadillac" container nursery at Northwood Pulp and

Timber Ltd., all augment Red Rock. In other parts of the Interior similar developments have taken place.

In recent times, the public does not like clearcutting, slash burning, and forests with straight rows, or monoculture. Despite that these dislikes are "real", the future of British Columbians' forest values is interlocked with tree planting.

Well, I have outlined a "little idea" on forestry in B.C. without many facts and a little more about reforestation.

Our artificial regeneration program needs seed, - good seed. At this time, seed orchards are not producing in the quantity necessary to meet the reforestation needs in the North Interior of B.C.. It may take several more decades before these seed needs are met from seed orchards. In the Interior, wild stand seed collections will continue to prevail until seed needs are met by seed orchards.

As seed dealers, you have a major task to provide high quality seed from "superior" or "better than average" forest stands. We have come a long way but, with research and good ideas, things in the seed business will continue to improve! Maybe we'll re-invent the wheel sometime?

Thank you.

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