Seed Use Efficiency Meeting

Langley, BC July 30 & 31, 2008

Abstracts

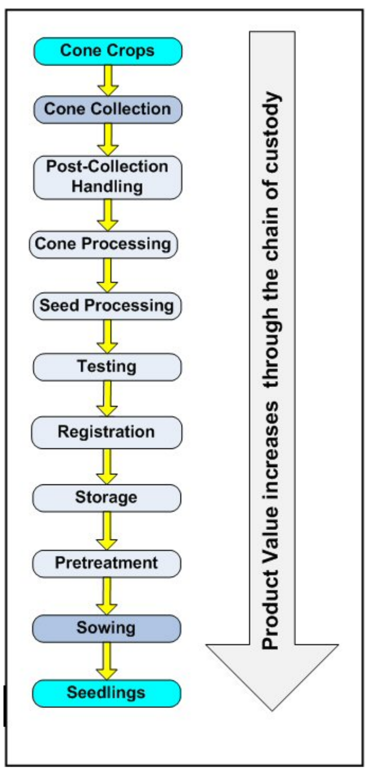
Dave Kolotelo
Tree Improvement Branch

Introduction

The objectives of the Seed Use Efficiency meeting were:

- To promote activities to increase seed use efficiency.
- To provide a dedicated forum for the exchange of information spanning the entire Seed Handling System.
- To better understand each others business', the drivers and bottlenecks (both financial and biological) and
- To celebrate the Tree Seed Centre's 50th Anniversary

The scope of the meeting was the Seed Handling System spanning all activities from cone collection (or cone induction for seed orchard operations) to the sowing of seed in the nursery. This chain of custody involves a variety of businesses with different drivers and bottlenecks. An appreciation of the entire system is important as any previous link can impact the quality of the product you are trying to produce. It is also important to appreciate that product value increases through the system as 'investments' are made to go from reproductive buds to the seedlings we desire for reforestation.



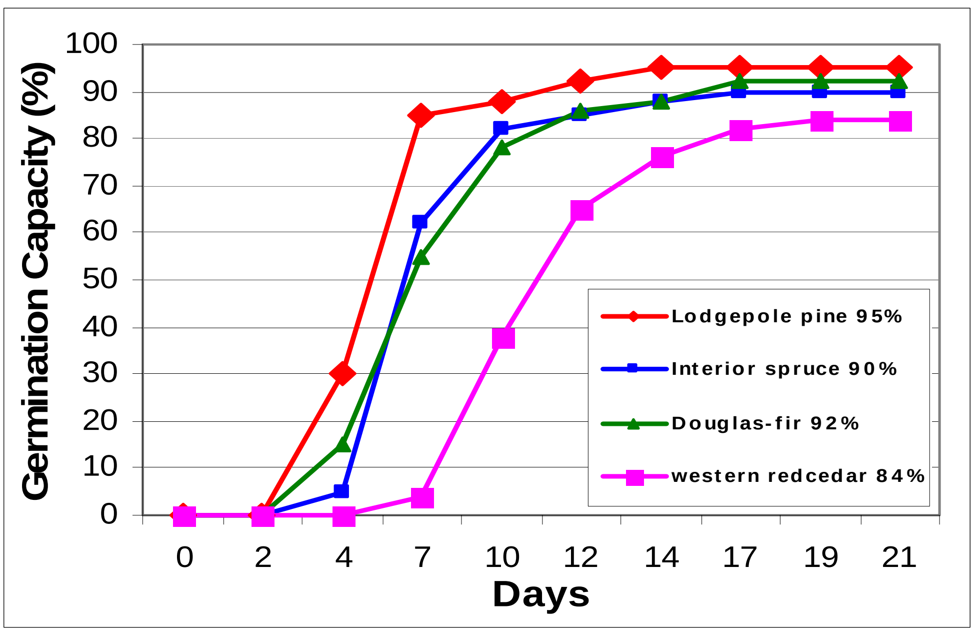
Dave Kolotelo
Tree Improvement Branch

Introduction …*continued*

Conifers are extremely variable organisms and this diversity is a very good thing for these long-lived species. It is also this variability that complicates direct adoption of seed treatments designed for low variability agricultural crops. One of the fundamental tenants of quality assurance is to reduce variability and to some extend seed is part of a sophisticated material handling system. The trick is to not remove any genetic variability as we try to make the system more efficient.

I'll initially provide some broad context to seed use in BC and then briefly seed characteristics of our major reforestation species. In 2008, provincial sowing was 214 Million seedlings - down substantially from 265 million in 2007, but approximately equal to our 15-year average. Seed orchard seed accounted for 46% of sowing in 2008 and is expected to continue to rise to approximately 70% by 2013. In British Columbia, there are approximately twenty one tree species used in commercial forestry, but lodgepole pine and interior spruce together account for 78% of the provinces sowing. Adding Douglas-fir and western red-cedar to the mix we have the "Big Four" accounting for 93% of provincial sowing.

The germination patterns of these four illustrate the extremely rapid germination of lodgepole pine and delayed germination of western redcedar.



Seeds per gram, used to describe seed 'size' is the other seedlot input, in addition to germination capacity, that translates orders for trees into grams of seed to withdraw, possibly treat and ship to nurseries. Seeds per gram (SPG) averages are shown for the Big 4 species by genetic class (orchard or wild stand) and a ratio indicating relative difference. The largest difference in seed size between orchard and wild seed is found with lodgepole pine.

Dave Kolotelo
Tree Improvement Branch

Introduction …*continued*

Species	Orchard SPG	Wild SPG	Orchard/ Wild
Lodgepole pine	253	338	0.75
Interior spruce	390	459	0.85
Douglas-fir	87	96	0.91
Western redcedar	751	805	0.93

As we move through the seed handling system it is important to address what the largest sources of variability or bottlenecks are. Path analysis is suggested as a good means to address this quantification. A system that is complicated with different business drivers also will include some unforeseen feedback loops. If anyone has seen the 'gorilla' video you will understand "you can miss some really big things if you are focused too much in one area" and I think that is worth considering. I'll also offer the following favourite quote "Most mistakes in thinking are inadequacies of perception rather than mistakes of logic". Enjoy the meeting!

Dave Hodgin
Weyerhaeuser

An Integrated Seed-Seedling Supply System

The subject of efficient use of seed, in particular A class seed, has arisen twice at Weyerhaeuser. The first time was in the early 1980's, with the initial production phase of our seed orchards, when supply was limited and the goal was to maximize the breadth of acreage that we were able to impact with genetically improved stock. When our seed supply capacity exceeded our requirements, the emphasis refocused on seedling quality and order volume, frequently at the expense of efficient use of seed. This was particularly true as we initiated development of new stock types, where the growing processes were as yet poorly defined.

The increasing use of A class seed, and its increased cost structure, necessitates that growing facilities review their growing processes for improvements which will lead to more efficient use of seed. The seed cost as a component of total seedling cost is a significant proportion, even in an internal supply system, and in particular when an end-user is purchasing A class seed. This component of total seedling cost is often overlooked when the seed is supplied to a contract growing facility by the end-user.

All seed producers, growers and foresters strive to do the very best job possible. Each has their own metrics of success, but sometimes don't include the success of the next in line customer. For

Dave Hodgin
Weyerhaeuser

An Integrated Seed-Seedling Supply System …*continued*

the seed producer it is volume of cones harvested and seed yielded, the grower achieving order and seedling specification targets and the forester achieving a target number of trees /land unit and planting cost. These are all good metrics, but are intermediate or component metrics. The absolute measurement of success is the right genetics delivered to a specific unit and survival of the seedlings to free to grow, at the least possible cost. Only then will forestry operations achieve a return on investment that warrants continued investment, particularly in the private sector

At Weyerhaeuser each component of the supply system has their intermediate metrics, but we are collectively held accountable to each other to achieve the successful establishment of the plantations. Each year seed producers and seedling growers visit each internal customer to review the successes and failures of the last and previous planting seasons. In cooperation with each other, and including the nursery and silvicultural scientists, courses of corrective actions are developed to address weak performance. We communicate across the spectrum of the delivery system.

Corrective actions can and do span across each discipline and frequently are articulated from outside the discipline. We have control over our seed, both supply dependability and genetics. We know more about the seedlot attributes than germination, but also its grow habits and frost susceptibility. Growth curves and yields are tracked by seed type and growing prescriptions and growing locations are modified to compensate. We have developed focused physiological requirements for stock types and planting environments. We have achieved, and been able to achieve this because we operate as a system, each held accountable to the other. We have achieved this through good communication.

Brian Barber, MA, RPF
A/Director, Tree Improvement Branch, BC Forest Service

Policy and Genetic Resource Management Directions: or *Who moved my seed*?

There are a number of provincial issues and policies influencing – or will influence - seed use in BC. These include state of the BC forest sector, the mountain pine beetle (MPB) epidemic, climate change and policy responses to them.

A weak US housing market, strong Canadian $, increased energy costs have reduced softwood lumber sales in 2007 (–24% compared to 2006, and –36% to 2003). As a result, only 80% of the provincial annual allowable cut (AAC) of 80 million m^3 is being harvested. Reduced harvest levels equates to fewer areas being reforested. Seedlings requested for planting in 2007 was 270 million. However, seedling requests for sowing in 2008 were only 214 million seedlings. Reforestation of areas denuded by the MPB and planting for increased fibre production through government funded

Brian Barber, MA, RPF
A/Director, Tree Improvement Branch, BC Forest Service

Policy and Genetic Resource Management Directions: or *Who moved my seed*? …*continued*

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programs such as Forests for Tomorrow are, however, expected to increase planting and seed use over the next five years. Issuance of new tenures, to communities and First Nations, are also increasing the number and diversity of seed uses. As a result, there will be continued demand for seed of high quality - but with increased pressure to reduce costs and optimize seed use efficiency.

The BC Government has introduced aggressive greenhouse gas emission (GHG) reduction targets. They have also committed to achieve *net zero deforestation* (conversion of forestland to other uses, e.g. housing) in B.C. by 2012. The role of forests in offsetting GHG emissions under a regional cap and trade system has yet to be determined. Managing forests for carbon storage and biofuels is being considered and these will likely become new forest values.

Managing forests in response to climate change (adaptation) is also a focus of the Ministry of Forests and Range (MFR) under the Future Forest Ecosystem Initiative (FFEI). http://www.for.gov.bc.ca/hts/Future_Forests/ . Changes to species selection guidelines and seed transfer standards are being examined so planted forests may be better adapted to future climates. Research in assisted migration is underway with the intent of introducing a new climate-based seed transfer system within 3-5 years (see O'Neill's summary). In the interim, minor changes to the elevational transfer limits for several species are being considered for the fall of 2008. Information and updates regarding changes to seed transfer will be posted at: http://www.for.gov.bc.ca/hti/climate_change/index.htm

Changes to species selection and seed transfer will have significant impacts on seed supply and use over the coming years. Increasing species diversity in plantations may increase seed demand for broadleaf species. Tree breeding programs and seed orchards may need to shift focus – and locations – as the climate warms. Seed crops in orchards and wild stands may also face increased incidence of insect and disease damage. Seed ownership and inventories will also need to move as the seed suitable for one operating area shifts over time. The utility of some seed sources will increase and the utility of others will diminish.

In response to the state of the forest industry, MPB, climate change and other drivers, the Forest Genetics Council of BC (FGC), Tree Improvement Branch and Research Branch undertook at *Challenge Dialogue*™ with members of the genetic resource management (GRM) community of practice and stakeholders in 2006-08. The purpose of this dialogue was to create a collective vision and strategy for managing and conserving BC' forest tree genetic resources. This goal was accomplished and objectives for the 3 main components of GRM (Conservation, Resilience and Value) were identified. The final GRM report can be downloaded at: http://www.for.gov.bc.ca/hti/grm/grm_dialogue.htm
This report will guide the establishment of the FGC's next 5-year strategic plan, which will include performance measures for the identified objectives.

In changing times and climes, seed demand and use will continue to change. To avoid surprises, take note of the sage advice offered by Stephen Johnson in his parable *Who moved my cheese?*

Brian Barber, MA, RPF
A/Director, Tree Improvement Branch, BC Forest Service

Policy and Genetic Resource Management Directions: or *Who moved my seed*? …*continued*

Change happens - *they keep moving the seed*. **Anticipate change** - *get ready for the seed to move.* **Monitor change** – *check the seed often so you know when it is getting old.* **Adapt to change quickly** - *the quicker you let go of old seed, the sooner you can enjoy new seed.* **Change** - *move with the seed.* **Enjoy change! -** savor the adventure and enjoy the new seed! **Be ready to change quickly and enjoy it again & again** - *keep moving the seed.*

Congratulations to the Tree Seed Centre in celebrating 50 years of excellence in cone and seed services.

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Seed Use Efficiency: From the Forest to the Forest

Seed utilization is viewed as integral component of an inter-connected tree improvement delivery system. Investigating any component of the system, such as seed utilization, must be viewed holistically (i.e., it cannot be determined or explained by its component parts alone; instead, the system as a whole determines in an important way how the parts behave). Thus, efficient seed utilization is affected by the phenotypic selection of superior individuals forming the breeding population; the intricacies of breeding → testing → genotypic selection of production populations' (seed orchards) parents; seed crop management practices (cone harvesting, processing, seed handling, storage and pre-treatments; and ends with the production of seedlings for reforestation). Changes in genetic gain and diversity were monitored throughout the system, indicating that the interaction between genetics (the magnitude of genetic control over reproductive phenology and output, germination speed, dormancy and aging) and management practices (e.g., individual vs. bulk seed harvesting, single vs. multiple sowing) could impart significant unintentional directional selection where genetic gain and diversity could be drastically affected.

Jack Woods
Program Manager, Forest Genetics Council of BC

Forest Genetics Council of BC: Seed Planning Structure

Provincial objectives set by the multi-stakeholder Forest Genetics Council of British Columbia (FGC) call for 75% select[1] seed use by 2013, and for an average genetic worth for growth of 20% by 2020. With annual provincial planting averaging about 225 million seedlings per year across over 14 species, priority setting and seed planning are significant tasks.

The planning process involves a series of steps. Initially, there is a process for setting priorities amoung various seed planning units[2] (SPU). For SPU that meet criteria for breeding and seed orchard investments, seed needs within each zone are forecast. Historic orchard production curves are developed, and based on these, total orchard size needs are predicted. Seed use and orchard production figures are tracked and presented annually to aid orchard managers in the development of specific orchards, and to help broader planning to ensure provincial objectives are met. Breeding investments are guided by SPU priorities and by orchard development timing. Orchard roguing decisions are made by individual owners, but cooperative planning and discussions provide them with the information they need to make informed decisions. Provincial financial support for boosting seed orchard quality (seedlot genetic worth) and for adjustments to meet FGC objectives provide added incentive for orchard operaters to undertake management that will ultimately support FGC objectives.

In the multi-stakeholder system in BC, orchards are owned and operated by both the public and private sectors. Providing good information on seed needs, on annual production, and on forecast production is a key element to ensuring open discussion and cooperation among participants and to the development of a comprehensive seed-production system that meets broader stakeholder objectives.

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[1] Select seed is seed from trees that have been genetically selected from natural populations, including orchard seed from parents with known and positive breeding values and seed from provenances with known superior traits. No seed used in BC is genetically modified.

[2] A seed planning unit is a unique combination of species, seed zone, and elevation band which is used for seed planning and which have specific breeding and seed orchard populations. An example would be Douglas-fir in the maritime seed zone under 700 meters elevation.

Gregory A. O'Neill and Nicholas K. Ukrainetz
Research Branch, MoFR

Climate-based Seed Transfer

Background

A well designed seed transfer system maximizes plantation productivity and wood quality, ensures the capture of genetic gains, and minimizes the risk of maladaptation due to pests, disease and climate change by ensuring that trees are well adapted to their planting location.

A revolution in the field of genecology relating to the development of new climate models, geographic information systems (GIS), the availability of mature provenance data, and new statistical techniques, makes it possible to develop an improved seed transfer system. A new climate-based seed transfer (CBST) system will greatly enable effective implementation of assisting migration of seed (i.e., planting seed adapted to future climates), which has been widely regarded as a key climate change adaptation strategy in forestry.[3]

Research Branch has initiated a project to develop a CBST system that will identify seedlots that are best suited climatically to each plantation over the course of the rotation. The system will be operationally simple, will apply to both selected (class A) and wildstand (class B) seed, and will be well suited for implementing measures to mitigate the impacts of climate change.

Methods

Five fixed-zone seed transfer systems were developed and compared with BC's current B class seed transfer system to assess the degree of adaptation and deployability that each system would provide. Five zonation systems were created, each dividing British Columbia into 12 climate zones. The zonation systems were based on: mean annual temperature (MAT); MAT and mean annual precipitation (MAT x MAP); two principal components which consolidated eight climate variables; two principal components which were clustered using a hierarchical clustering procedure to minimize climatic variation among clusters; and BC's forested biogeoclimatic zones. The MAT x MAP zonation system is illustrated in Fig. 1.

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[3] A small degree of assisted migration can be accommodated within the current seed transfer system. In September 2008 Research Branch will recommend minor changes to the current system to encourage assisted migration.

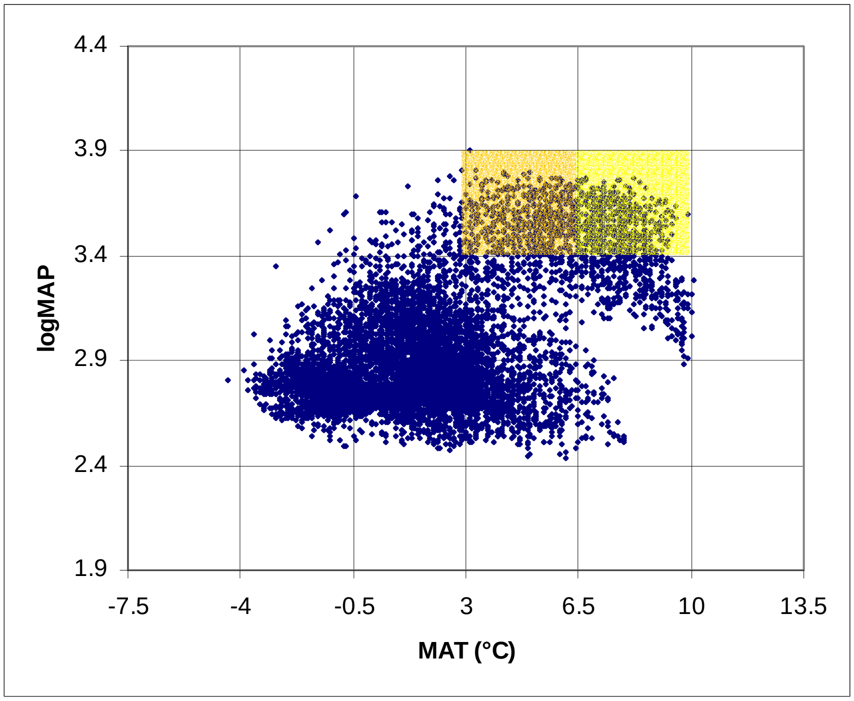

Fig. 1. An example of one of the five climate-based seed transfer systems examined. Twelve fixed-zone climate zones were created for British Columbia on the basis of mean annual temperature (MAT) and log of mean annual precipitation (logMAP).

The level of maladaptation (and associated disease, pest, stem deformation and growth losses) associated with seed transfer increases with climatic transfer distance. Therefore, to evaluate the level of adaptation that would be inherent in each zonation system, a large number of hypothetical seed transfers was created within each zone of each system, and the climatic transfer distance determined for each transfer. Climatic transfer distance was then averaged over each zone and zonation system. To assess deployability, the areal extent of each zone of each system was determined using a geographical information system.

Results and Discussion

Climate transfer distance of seed transfers was substantially shorter in the zonation systems that were based on MAT x MAP, PC and PC cluster than the systems based on MAT, biogeoclimatic zones, or the current class B zonation system (Fig. 2).

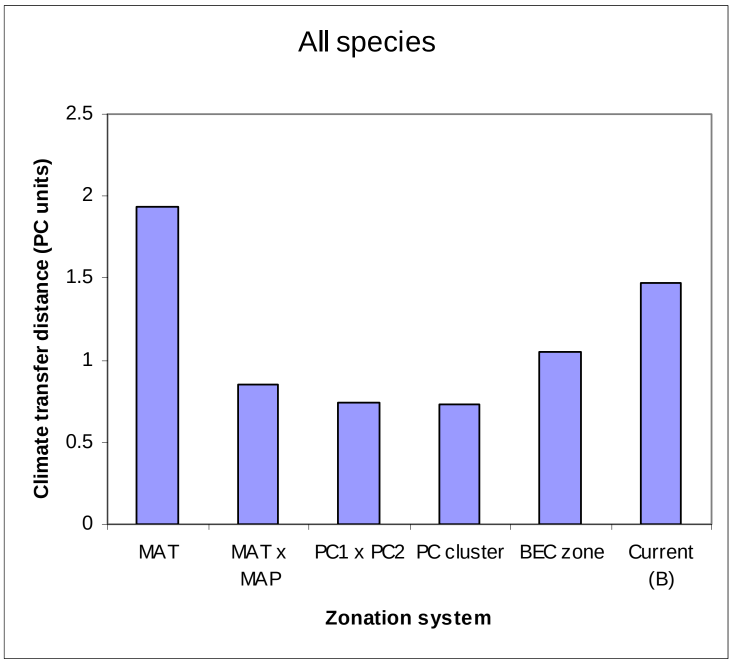

Fig. 2. Results of analysis to estimate the level of adaptation expected to be associated with seed transfers from five climate-based seed transfer systems and the current class B seed transfer system in British Columbia. Climate transfer distance is used as a surrogate measure of maladaptation.

Deployability was considerably greater for all five zonation systems compared with the current class B zonation system (Fig. 3). These results suggest that a new seed transfer system based on fixed zones developed from MAT x MAP, PC, or PC clusters would provide substantial improvements in adaptation and seed deployability. In addition, these systems would facilitate the implementation of a system of assisted migration that could be incorporated incrementally and without the need to revise zone boundaries.

Gregory A. O'Neill and Nicholas K. Ukrainetz
Research Branch, MoFR

Climate-based Seed Transfer …*continued*

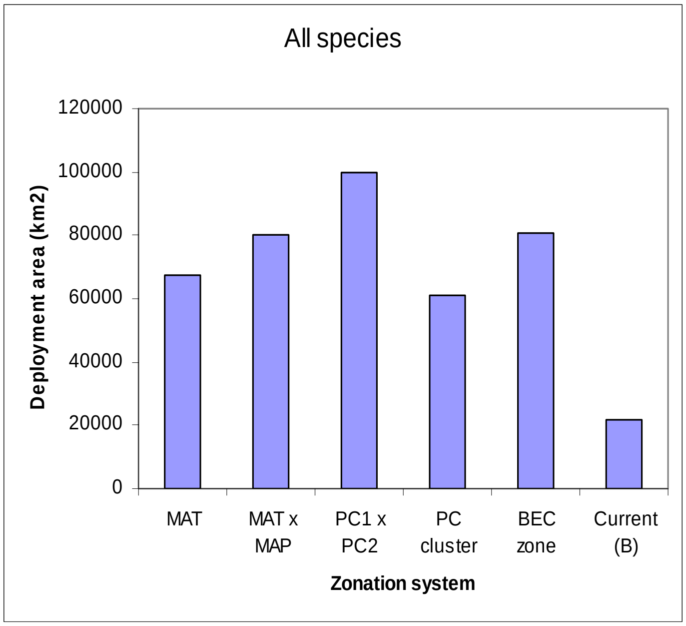

Fig. 3. Results of an analysis to estimate the level of deployability expected to be associated with seed transfers from five climate-based seed transfer systems and the current class B seed transfer system in British Columbia. Deployability is the spatial extent (km^2) to which each seedlot can be transferred.

Research Branch staff of the Ministry of Forests and Range intend to complete analyses required to propose a new climate-based seed transfer system by mid 2009. Tree Improvement Branch will then review and implement the recommended system. To minimize disruption in seed planning for licensees, a "roll-out" period (3-5 years) is being considered to provide time for stakeholders to adjust seed inventories.

Emile Begin, RPF

Natural Stand Seed Production, Wild Seed, Class B - Cone Collection

ABSTRACT

The presentation reviews most aspects of Class "B" cone collection including; legislation, natural seed planning zones, Lodgepole pine biology, mountain pine beetle considerations and operational activities with costs leading to SPAR registration. The focus is on Lodgepole pine, collections within the Prince George Business Area including defining many challenges and solutions for consideration in preparing and undertaking a cone collection program. A draft process currently in use with BCTS Prince George is provided and can be used to develop a cone collection program from harvesting to collections. BCTS Prince George is currently collecting over 20 years of Lodgepole pine seed in each seed planning zone, including seed from other species supporting BC Timber Sales meeting legal reforestation obligations.

Annette van Niejenhuis RPF

Western Forest Products Inc. Tree Improvement Forester

Coastal Seed Orchard Production

The expert staff at the coastal seed orchard production facilities deliver orchard seed of high genetic quality and good viability. Production reflects breeding programs status and delivers to meet most coastal needs. Long-term plan implementation will address current shortfalls. Costs of orchard seed are significantly greater than those of wild seed collections because of crop management inputs and cost-averaging that includes good and poor crops.

Orchard sites are selected for spring drought and low background pollen levels. Grafting selected parents, planting the orchard, and tending the trees to cone-bearing size requires irrigation, fertilization, and pest and competition control. Cone crops are induced by water stress, girdling, pruning, and hormone treatments. Seed set is improved with supplemental mass pollination. Timely cone harvest and curing, followed by seed extraction and seed lot registration results in seed for regeneration programs.

To meet the Chief Foresters Standards for Seed Use, effective population size and weighted average genetic worth of the parents contributing to the lot are calculated. Male contribution estimates employ pollen season data, and female contribution calculations use harvest measures.

Pesticides, including hormones, are infrequently labelled for use in conifer seed orchards. Pest control and induction options are therefore limited. Drainage is a challenge at some orchard sites, affecting orchard tree survival.

Annette van Niejenhuis RPF
Western Forest Products Inc. Tree Improvement Forester

Coastal Seed Orchard Production …*continued*

Advanced generation orchard seed is listed surplus in SPAR for low elevation western redcedar, low elevation Douglas-fir, low and high elevation western hemlock, and blister-rust tolerant western white pine. High elevation Douglas-fir and weevil-resistant Sitka spruce will come on stream as orchard production increases. US orchards supply seed for low elevation Douglas-fir needs.

Can high-value seed in short supply at present deliver more seedlings? Can client cost be unaffected, but the nursery price increase and the seed price decrease with the provision of less seed for seedling orders? High-value seed with high germination rates provides opportunity for negotiations among nursery service providers and clients.

Chris Walsh
Seed Orchard Manager
Kalamalka Seed Orchards
BC Ministry of Forests and Range

Seed Orchard Seed Production – Interior

Seed Orchards deliver improved seed for reforestation. Seed orchard efficiency in its simplest terms is concerned with how we can produce seed as economically as possible. Five facets are discussed regarding how seed orchards can affect the efficiency of the entire seed handling system. They are orchard planning and design, maximizing cones produced per orchard tree, maximizing seeds per cone, optimizing cone condition to maximize seed recovery at extraction, and maximizing germination capacity of seed produced. Orchard planning attempts to match orchard production to seedling needs. Cones per tree, seeds per cone, and seed recovery are affected by orchard management practices including cone induction, pest control, cultural treatments, and cone handling. Germination capacity is a large determiner of seed use efficiency in nurseries. Some observations are presented on how timing of collection relates to germination capacity.

Dave Kolotelo
Tree Improvement Branch

Seedlot Production

Seedlot production involves the steps of cone and seed processing, **seed testing**, **registration**, **storage**, pre-treatment and **distribution** for seedling production. In British Columbia the previously mentioned underlined items are considered stewardship responsibilities and costs not forwarded to clients. Cone and seed processing and seed pre-treatment are offered on a cost recovery basis. Quality Assurance (QA) will be emphasized and is defined as “the evaluation, monitoring and management of information and practices related to activities in the Seed handling System”. Our QA foundations are:

1. Avoid physical contamination (debris)
2. Avoid genetic contamination (between seedlots)
3. Information management (organization)
4. Handling a perishable product (care)

Considerations regarding quality begin at the stage of pre-collection evaluation when crop size is estimated to plan for required resources, the presence of pest problems determined and maturity level assessed to ensure cones are collected at the optimal time. Interim field storage is important to reduce moisture slowly in most crops, but serotinous lodgepole pine cones can be shipped immediately. Cutting tests or seed anatomy test are an important tool in assessing maturity, quality and determining if pests are an issue.

Cone processing consists of 1) a removal of seed already released from cones, 2) a kilning process for most species and 3) a separation of seed from cones through tumbling. Species containing resin vesicles (Abies spp., western redcedar and hemlock) are currently not kilned, but allowed to dry and flex their cones under cool conditioning. Lodgepole pine is kilned at a peak temperature of 60ºC and all other species kilned have a peak temperature of 40 ºC. The stage of tumbling is critical as it is the separation of seeds from cones, so monitoring is important to ensure all viable seeds are removed from cones.

Seed processing starts with a scalping stage to remove debris that can be abrasive, add moisture or contain pathogens. This stage also greatly reduces the volume of material subsequently handled. Dewinging is performed on all species except western redcedar and yellow cedar. For pine and spruce species, wet dewinging is employed as the wing connection is quite weak and wetting allows for efficient release of the wings from the seed. The remaining species have a stronger wing-seed connection and wings are removed solely through mechanical forces, although small wing fragments may be retained compared to wet dewinged species. Wings are removed by vacuum during the process and the process shifts from removing debris to removing non-viable seed during final cleaning. This can occur via pneumatic separators or the gravity table, but both separate seed into three fractions based on specific gravity. Equipment calibration and decisions regarding seed to include/exclude in seedlots is supported by cutting tests and seed evaluations. In contrast to other seed processes, some seed may go over final cleaning multiple times to ensure that viable and non-viable seeds are separated. Once final cleaning is completed the seedlot can be blended and then sampled for testing.

Seedlot sampling is conducted in accordance with ISTA sampling guidelines. Moisture content is first tested and if between 4.0 and 9.9% the seedlot can then be placed into long-term storage at -18°C. Seedlot purity is then determined and must be above 97% for registration. Moisture content and purity are legislated requirements under the Chief Foresters Standards for Seed Use in BC.

Dave Kolotelo
Tree Improvement Branch

Seedlot Production ...*continued*

The seed weight test is performed and in combination with seedlot purity the variable seeds per gram is calculated [seeds per gram -= purity% / Seed weight100 seeds]. Germination tests are also performed and the germination capacity and seeds per gram are the variables used to translate between seed and seedlings. Germination is retested at intervals in relation to the species deterioration rate, so a rapidly declining species like western redcedar is tested every 18 months, but a species with good storage longevity like Sitka spruce is only retested every 48 months.

In addition to the standard tests described above for seedlots, there are a variety of QA tests performed on a subset of a seedlot. These include moisture content of unkilned seed, pellet assessments, germination testing of sowing requests and returned seed.

Seedlot registration occurs following testing, confirmation of seedlot weight and for seed orchard crops calculation of the Genetic Worth (GW) and effective population size (Ne) for the seedlot. For seedling production seed pretreatments are equivalent to those used in testing. Activities involved in seed preparation are 1) scheduling (nursery sow date is what we work back from) 2) Manage changes 3) withdraw seed 4) prepare seed in one of the following ways – soak and stratify, pellet, or send dry to nursery 5) monitor during stratification especially with our species requiring long stratification periods and 6) ship seed to the nursery.

Susan Zedel
Seed Information Officer
Tree Improvement Branch

Sowing Guidelines, SPAR and Seed Use Efficiencies

The Seed Planning and Registry web application (SPAR) contains the registry of all seedlots from commercial forest species that are collected in British Columbia. Seedlots are registered following current BC Ministry of Forests and Range legislation and policy (*Chief Forester's Standards for Seed Use*). Seedlots are then be used to produce seedlings for reforestation of B.C. Crown land.

For each seedling request are entered in SPAR, a seedlot is selected for the request using default sowing guideline calculations. Sowing guidelines are a set of calculations that convert the amount of seedlings requested by forest professionals to the quantity of seed that needs to be removed from long-term freezer storage for a seedling request.

Sowing guidelines have evolved since the 1980's when very basic sowing rules existed (2, 3 or 4 seeds per cavity, and 1 seed/cavity for Class A lots) with > 90% germination, along with oversow factors. In 1996 a "Sowing Guideline Task group" was formed and recommended that the

Susan Zedel
Seed Information Officer
Tree Improvement Branch

Sowing Guidelines, SPAR and Seed Use Efficiencies …*continued*

difference between Class A and B rules removed and that seeds per cavity and sowing correction factors be adjusted.

1999 sowing guideline changes streamlined the allocation of seeds to correspond closely to germination capacity changes and fractional sowing was introduced (see Extension Note Vol 3 No 4). In 2001 the sowing guidelines refined the calculations of "seeds per seedling". Extension Note Vol 5 No 2 describes sowing guidelines and the calculation method. In 2007, reductions in seeds per seedling were made for interior lodgepole pine (Pli) only (see SPAR website).

The general business and information flow for seed and seedlings in SPAR is:

- Seedlots are registered on SPAR and stored at the Tree Seed Centre.
- Seedling Requests are entered by agencies (eg. licensees, BC Timber Sales, FFT, woodlots) for species, seedlot, quantity, stock type, planting year/season. Grams of seed required for each request are calculated using default sowing guidelines, based on seedlot germination capacity, seeds per gram and amount of seedlings requested. The SPAR calculations are used by many forest companies and nurseries, however, some adjust the grams of seed required (usually downwards) based on past experience or limitations placed on high-value seed by the owner.
- A nursery can also change sowing dates for requests assigned to them to stagger the time that will arrive at the nursery for sowing.
- Information flows between SPAR and CONSEP (local Tree Seed Centre system)
- Tree Seed Centre does seed withdrawal, preparation (some nurseries do stratification) and ships seed to nurseries based on sowing dates.
- Nurseries receive seed and sow in specified container type on appropriate sowing dates.

In terms of seed use efficiency, the quantity of seed saved by reducing grams for seedling requests is measured by the difference between seedlings requested and seedlings calculated.

For the 2008 sowing year, for all species, 214.4 million seedlings were requested. The gram amount calculates to 188 million seedlings, so seed for the potential of 26.4 6 million seedlings were saved.

For Pli only, in 2008 99.1 million seedlings were requested and 81.5 million calculated, so 17.6 million potential seedlings were saved.

Economic incentives to reduce seed quantities for request agencies are obvious as it reduces their seed costs, but economic incentives for reducing grams at the nursery are not as straight-forward. Discussions (negotiations) between the customer and nursery are encouraged and will result in greater seed-use efficiencies. Nurseries are encouraged to calculate the actual grams of seed required for their seedling requests based on their own practices and experience.

Susan Zedel
Seed Information Officer
Tree Improvement Branch

Sowing Guidelines, SPAR and Seed Use Efficiencies …*continued*

Thank you to those nurseries and seed owners who reduced grams of seed for seedling requests and saved valuable seed, which also reduced the amount of seed returned to the Tree Seed Centre, saving resources.

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Al McDonald
BC Timber Sales

Seed & Seedling Costs Over Time

Seedling Costs – seedling costs are based on the prices paid on competitive award contracts for seedlings grown for Ministry of Forests and Range programs over the previous ten years. Because of the large variety of species and container types, the two prevalent interior and coastal species with their predominant container types were chosen.

Interior examples – lodgepole pine 112's and 160's, interior spruce 77's and 112's.

Coastal examples – coastal Douglas fir 77's and 112's, western redcedar 77's and 112's.

These examples account for slightly more than 70% of all of the reforestation crops grown in the province over the last 10 years.

In spite of a constantly rising "BC Consumer Price Index", seedling prices have remained remarkably constant over the last decade, ranging from about $.11 for pine 160's to about $.33 for fir 77's.

Seed Costs – seed costs are based, for the most part, on the 'Surplus Seed' prices posted on the Tree Seed Centre website. These have been quite consistent with Ministry seed costs. However some adjustments need to be made, particularly in the case of lodgepole pine and some updated pine and interior fir prices have been calculated by Lee Charleson (Tree Improvement Branch). In pine, spruce, and fir, the seed costs have risen over the past 10 years as a result of the increasing use of seed orchard seed. As well, the increased cost of pine collections due to the escalating costs of helicopter collections has driven pine seed prices up.

Total Seedling Cost – the proportionate cost of nursery and seed in overall seedling costs varies with species and container sizes. In coastal Douglas fir, the seed price can be 30% the overall

Al McDonald
BC Timber Sales

Seed & Seedling Costs Over Time …*continued*

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seedling cost and in small container pine, it can be 25%. In terms of western redcedar in large containers, it is as low as 8%.

Nursery costs have remained very stable over the last 10 year in spite of dramatically rising fuel costs and the shortage of nursery space in 2006 and 2007 and so it's likely that they will remain fairly constant. Some seed however, is becoming increasingly valuable and represents a larger portion of the total seedling cost. Depending on species, it's becoming more important that nursery and seed costs are taken into account to ensure that decisions are made so that seed is used as efficiently as possible.

Jamie Farrer
Production Superintendent, PRT Campbell River

Upgrading Abies Seedlots

Overview:

- This topic is directly tied to the discussions we have been having on the need to better utilize our seed resources. Where as the overall reduction of certain types of seed is required to guarantee the long term sustainability of our industry, the upgrading of Abies seedlots is a good example of how nurseries have been trying to make the best use of the seed they get for upwards of fifteen years (the length of time we have been upgrading).
- Nurseries are currently expending a large amount of time and money working on better utilizing their seed resources, even on minor crops, such as Abies.

Abies Production in BC:

- Total production of forest seedlings in BC for 2008 is 214 million
- Total production of Abies is 2.2 million (approx 1% of total grown)

Reasons for Upgrading:

- The average germination capacity of BA/BL is 60%
- With the ministry sowing rules that gives us 4.3 seeds per cavity
    - This is operationally very difficult to sow accurately
    - The process of upgrading was developed to remove as much of the unproductive seed as possible to better facilitate the sowing and growing of the crop (4.3 seeds per cavity can often be upgraded down to 3.5 seeds per cavity)
    - Upgrading removes empty seeds and leaves less, but more productive seed that can be better distributed in the blocks during sowing.

Jamie Farrer
Production Superintendent, PRT Campbell River

Upgrading Abies Seedlots …*continued*

  - Better distributed seed leads to more uniform germination, less transplanting and a more consistent crop.

Limitations to the upgrading process:

- Upgrading cannot remove all seed issues. Empty seeds are easily removed in the process, but the following can still be present after the upgrading is complete:
  - Insect damage
  - Immature seed
  - Mechanical damage
  - Disease

Upgrading process:

- Planning is critical to the success of the operation
  - PRT is producing just over 950K Abies seedlings in 2008 (half of the total Abies production in the province).
  - There were roughly 123Kg of Abies seed that needed to be upgraded. All of this to produce trees for less than half of one percent of the total trees grown in 2008.

Upgrading process (con't):

  - Upgrading must be planned so that the process is complete and seed is at the desired nursery in time for it to be sown.
  - Equipment needs are minimal
    - Seed is soaked for 1-8hrs in clear Rubbermaid bins
    - As seed sinks, the percentage of filled seeds is checked to determine if the process is complete
    - Once the percentage of filled seed remaining floating is less than 10%, it is skimmed and discarded
    - The total seeds available is recalculated and a new seeds per cavity is generated for sowing

Robin Dawes
Nursery Manager
K&C Silviculture Ltd

Benefits of Thermal Priming and Other Seed Handling Practices

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Benefits of Thermal Priming and Other Seed Handling Practices

Nurseries play a large role in ensuring that seed is used “efficiently”. Often it is thought that the relationship of seed efficiency at the nursery level pertains primarily to how the seed is dispersed in the nursery (quantitative use of seed based on seeds sown per cavity and oversow decisions made at the nursery). Thermal priming of seed in the nursery prior to sowing demonstrates that the “nurturing” practices in a Nursery can have a large impact on germination rates and vigour. Up to two weeks reduction in germination time can be successfully achieved through this practice. This can contribute to both efficient use of energy and efficient use of seed and increased seedling health. This benefit has been achieved consistently without the use of genetic manipulation.

Efficient use of seed becomes more important as the genetic worth of seed, both in terms of cost of production and potential silvicultural gain, increase. In this sense the concept of “priming” seed (or achieving full benefit of prime seed) is broaden beyond just the concept of thermal priming and becomes a more generalized and universal goal.

If we have truly committed to the development of “prime” seed is it reasonable that we would extend this effort to the development of “prime” growing conditions, “prime” seedlings and “prime” forests. While we all purport to want this it is not always clear through our behaviour that we act in ways which reflect this objective. Short term economic decisions may be posing some dysfunctional constrictions on our long term objectives.

It has been clearly demonstrated in the past that the development of genetically improved seed is worthwhile. It has been demonstrated that planting larger stock types contributes to more rapid free to grow status. It has been demonstrated that good nurturing practices can enhance the growth of seedlings in the Nursery setting. It is our belief that there is a good business case for collaborating to produce “prime” seedlings from “prime” seed in order to reach the common objective of developing “prime” forests. Growing trees that have been engineered for “prime” performance and growth, enhancing the seeds performance in the nursery and subsequently restricting the growth potential by choosing to grow in ever smaller containers may not be conducive to our collective goal of enhance field performance. Might this be the equivalent of forcing the gene-(y) back into the bottle or binding the feet of our genetically superior progeny?

Fernando Reyes
PRT – Pelton

Mini-Plug Transplants

Mini-Plug Transplants is recognized to be one of the best production systems for optimizing seed use efficiency. In the container conifer seedling production, this system allows nurserymen to maximize seed usage by single-sowing any seedlot regardless of its germination capacity into mini trays and by transplanting them into bigger containers to produce the requested stocktypes. Other benefits this system offers to seedling production includes reduction of heating costs by increasing greenhouse space efficiency, and by reducing thinning and manual transplanting operations.

The implementation of the mini-plug technology into conifer seedling production at PRT-Pelton (Former Pelton Reforestation) however, has taken several years to develop. The adaptation of existing technology used in the horticulture sector had to overcome limitation such as compatibility with the Styroblock container system and the lack of cohesiveness of mini-plug conifer seedlings to withstand handling through the different phases of production. At PRT-Pelton we use a heat sensitive fibre (Fibreneth®) blended with Coir medium to fill the trays and pre-form the mini plugs before seeding.

A successful mini-plug transplant program starts with accurate single-sow seeding of mini trays to optimize use seed efficiency. For optimal germination and early growth of mini-plugs seedlings, we have set up a “growth chamber” with insolated walls and supplementary lighting at photosynthetic levels of intensity .These environmental conditions promotes the production of compact seedlings to facilitate the subsequent phases of mini-transplants. Depending on the seedlot germination capacity, the mini-trays can have a number of blank cells. As the machines would transplant every cell from the mini-tray to the destination Styroblock, the blank cells are removed and replaced (gapped-up) by other mini-seedlings. This operation is accomplished by running the mini-trays through scanning equipment to blowout the empties and through another scanner that directs the robotic arm to gap the blank cells with seedlings from another mini-tray to produce a 100% filled tray. Gapping up the mini-trays makes the transplanting operation more efficient.
Mini plug trays can also be used to manually backfill empty cavities in conventional single-sown Styroblocks, reducing transplanting shock and producing a more uniform stand.

Early results and experiences of implementing this technology into seedling production presented different challenges. Optimal conditions of medium density in the mini-plug trays for germinant radicle penetration, optimal growing conditions to promote compact-seedling growth in high density trays, algae, and liverwort control to eliminate scanning interference for gapping up, and customer’s acceptance of transplanted stock were some of the difficulties to overcome. Successful results of mini-plug transplants have included species like spruces, Douglas-fir, Western larch, Western hemlock, and Western red cedar. Using mini-plug transplants in 2008 has allowed us to produced extra seedlings from 80 to 300 K of spruces, Western larch and Douglas-fir over the conventional direct-seeded production system.

There are great advantages of using mini-plug transplants in the production of conifer such as: efficient use of seed, 100% cavity fills on styroblock containers, lower thinning costs, reduction/elimination of manual transplanting and reduction of heating costs. However, there are some limitations of the system that can discourage its implementation such as: high capital cost, limited production capacity (slow process), higher production risks from its high seedling density in a small growing area, precise scheduling requirements of the different stages of production and the limited stocktype availability. Moreover, the increasing trend for the demand of smaller stocktype seedlings would make the mini-plug transplant system less effective as a powerful tool to increase use seed efficiency.

Bevin Wigmor

Operational Seed Efficiency Gains with coastal Douglas-fir

TimberWest owns 796,000 acres of private land on Vancouver Island, most of which is used for forestry operations producing approximately 2.5 million m3 per year. The company also has a TFL with an annual allowable cut of 0.7 million m3 per year. TimberWest plants from 4.5 to 6.5 million seedlings per year, 85-90% of which are Douglas-fir.

As a company we are committed to tree improvement and we operate a seed orchard which provides most of our Douglas-fir seed, as well as minor species such as western Redcedar, western hemlock, and western white pine. We also purchase a quantity of high-gain Douglas-fir each year to increase the genetic gain on our private land base. The total value seed sown annually is approximately $500,000.

All TimberWest seedlings are grown on contract at private nurseries. Since 2004, we have been encouraging the nurseries to use seed efficiently to save costs, particularly with Douglas-fir as it is our primary species. We feel that the sowing guidelines in SPAR, while allowing nurseries to achieve complete cavity fill, result in too many seedlings being discarded as thinnings. We have also found that nurseries in other jurisdictions routinely use considerably less Douglas-fir seed than nurseries in BC are accustomed to receiving. Accordingly we have gradually reduced the amount of seed allocated per sowing request to a current level of 15 – 18% below SPAR guidelines.

The nurseries involved have all become supportive and worked to utilize seed more efficiently, through more precise sowing and/or transplanting to fill empty cavities. Seeds used per seedling has dropped from about 2.3 to 2.1, and it is expected that with this winter's lift we will get to 2.0. We are also pursuing single-sowing and reduced-sowing cost-sharing agreements that will benefit both us and the nursery.