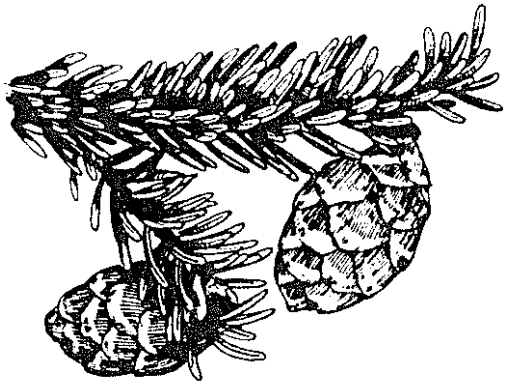
CANADIAN TREE IMPROVEMENT ASSOCIATION/
ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES



Tree Seed Working Group

Newsbulletin 15

No. 15 March 1991

FROM THE CHAIRMAN

Graham Powell, our Chairperson, is still in New Zealand but will return to New Brunswick with the start of the growing season. In his absents Ron Smith has been the sounding board for most of the Chairperson's responsibilities. Foremost among these responsibilities has been the arrangements for the Tree Seed Working Group's workshop at this years Canadian Tree Improvement Association Meeting (in Ottawa, August 19-23).

The workshop will occur on August 20 from 13:15 to 16:30. Having only a half-day for the workshop has placed a serious constraint on planning. The subject of the session is 'Crown Management': for sustained, easy to reach, cone production. There will be an invited speaker dealing with each of the following topics:

1. Reproductive Development at the Micro Level.
2. Reproductive Development at the Macro Level (Graham Powell).
3. Physiological Inputs into the Production of Reproductive Structures (Steve Ross).
4. An Overview of Research (Ron Smith).

An Encouraged Discussion (of what to do and not to do) will follow these presentations.

Because of the time restriction, there will be no offering of voluntary papers. However, everyone is encouraged to participate in the above indicated discussion. Also, poster presentations on crown management topics or any other seed related topics are most welcome. Contact Hugh Schooley (the Editor) regarding arrangements for poster presentations.

Following the workshop there will be a short business meeting. Everyone is urged to remain for this session. It is important that we talk about subject areas for future surveys and a theme for our next workshop. Also, a review of the Group's mandate would be timely.

NOTE THESE ADDRESSES

Chairman, TSWG, **Graham R. Powell**
Dept. Forest Resources
University of New Brunswick
Bag Service #44555
Fredericton, N.B., E3B 6C2

Coordinator, CSIWP, **Peter de Groot**
Forest Pest Management Institute
Forestry Canada
P.O. Box 490
Sault Ste. Marie, Ontario, P6A 5M7

Editor of the Newsbulletin, **Hugh O. Schooley**
Petawawa National Forestry Institute
Forestry Canada
Chalk River, Ontario, K0J 1J0

Queries, comments, and contributions to the "NEWSBULLETIN" are welcomed by the chairman or the editor.

EDITOR'S NOTES

In the last issue of the Newsbulletin my 'Notes' encouraged everyone to read the Bulletin's list of 'Recent Publications'. Then I went on to write that "Keeping up with what is being published is essential because it gives us the opportunity to learn from the experiences of others. This learning can simplify, increase precision, and narrow the focus of our work so that the end results of our efforts are more valuable". Surprisingly, I didn't receive one argument supporting or against this text. This was unusual because I normally receive comments on my 'Notes' from at least a couple of people.

If I had written "don't read the literature" do you think I would have got comments? Suppose following this instruction I had argued: Reading destroys your creativity. It channels your thoughts into well-worn grooves. Any ideas you have can seem insignificant in comparison to the finished studies you may read. Further, the sheer volume of material to read may intimidate you into abandoning any work on a new idea. Finally, it is often easier to spend your time reading-up on some subject area than it is to work on the solution to a problem in that subject area. Too much reading is frequently the reason why our progress is so slow.

Will this new point of view on reading draw comments from someone?

The point I'm trying to get across with the above text has nothing to do with whether or not you think the literature should be read. What I'm trying to point out is there are at least two approaches to every proposal. No matter what you say or do, someone out there will agree or disagree with your action. But to move forward in the right direction it is important to hear from the people who agree or disagree with your actions. We, as a Group, with interests in seed work, must do a better job of communicating with one another. Contributing to the Newsbulletin is one way - a good way - to improve communication. Remember, you shouldn't expect a pat on the back for a job well done, or voluntary help to solve a problem unless you inform people about what you are doing.

Hugh Schooley

LETTERS TO THE EDITOR

#1

Dear Hugh:

I read the article, "Artificial Seed-Soon to be Available for Spruces?" (CTIA, Tree Seed Working Group Newsbulletin 14:6-7, 1990), with great interest because we are working in the area of somatic embryogenesis of spruces and pines. We are successful in inducing embryogenic calli from mature zygotic embryos of black, white, and blue spruce and an attempt is being made to induce embryogenic calli from explants of saplings and mature trees.

The potential advantages of using somatic embryogenesis in tree improvement programs are immense if 1) clonal forestry is practical, 2) we know how to handle costly and genetically improved material, 3) seed which will germinate and grow into superior trees is identified from specific crosses and cost of seed production is high, 4) technology is developed in inducing embryogenic calli from explants of genetically proven superior genotypes, and 5) cost of producing somatic embryos and artificial seed is reasonable.

The advantages of using somatic embryogenesis in research are also immense. *In vitro* embryogenesis facilitates studies in 1) gene activation and deactivation during the process of embryo formation from embryogenic callus, through a suspensor-embryonal cell complex, proembryo stage, early embryo stage, and finally embryo stage with the initiation of cotyledons and maturation of embryos, 2) gene structure and function, 3) gene transfer to embryogenic cells, especially the embryonal cell in a suspensor-embryonal cell complex, 4) cell line selection for disease, heat, and cold resistance, 5) developmental embryology, and 6) physiological embryology.

It was stated "... the need for a seed orchard is by-passed". I do not think that people working on seed orchard, either research or management, have to worry about losing their jobs. THEY ARE NEEDED! Technology of somatic embryogenesis will help us only when it is coupled with selection, breeding, and management.

"The time taken to introduce genetically improved varieties of trees (sic) can be reduced by over 20 years". Do we have a firm grip on juvenile-mature correlation? Can we cryopreserve embryogenic calli for 20 years without losing their regeneration capacity? Are we ready for clonal forestry? Are we going to carry out advanced generation selection and breeding?

I do not think that artificial seed is going to be as good as the seed mother nature has given us. However, we should develop the artificial seed technology to produce seed with a reasonable shelf live in storage. Seed produced will be uniform and can facilitate automation for seed sowing.

Biotechnology is a tool for us to use, like a newly designed microscope which is being built. It is going to take some time for us to build this microscope.

Sincerely,
Rong H. Ho

(Editor's Note: The names of the authors of the article referred to in this letter were inadvertently omitted. They were Christine Ward and Pierre J. Charest of Petawawa National Forestry Institute. Please accept my apologies.)

#2

Mr. Schooley:

In answer to your request in the Newsbulletin No. 14, I would like to inform members of four publications by the Tree Improvement Service of the "Ministère de l'Énergie et des Ressources" of Quebec.

Two of them are Internal reports. Report No. 323 was written by a colleague of another Division of our Service; its objective is to give base information on the biology of pollen and suggest storage methods and viability tests to the geneticists of the "Division de l'amélioration génétique des arbres". Report No. 324 is intended to help technicians recognize the development stages of male and female flowers on different species in order to collect pollen at proper time, or force its maturation either in the field or inside. It also gives results of some trials made during the springs of 1988 and 1989.

Research Note No. 39 presents some data on cone production by six-year-old white spruce grafts located in a seed orchard. It has already been summarized in a short article in the same Newsbulletin previously mentioned.

Finally, with the contribution and comments of every manager, worker and other organizations involved in seed orchards all around the province, the "Guide for Establishment and Management of Seed Orchards in Quebec" was published to give a complete view of seed orchard operations. It is a tool to help orchard workers plan operations, decide which method is the best, what material and man-power is needed, where to buy the stock, and who is responsible for inspections for insects and diseases, etc. Other than specific informations, it also gives a general view of tree improvement, outlines progeny and clonal tests, and presents a literature survey adapted to our context and conceptions, of what should be done in the future as management practices to increase production in the seed orchards. It finally concludes with aspects of future generation seed orchards.

I think these references, which were written for internal and/or provincial needs, are of interest for comparing with methods used elsewhere, and for comparing results obtained from similar studies.

André Rainville, ing.f.

SUCCESS AT LAST!

Some of us older TSWG members remember how in the late-1960s Doug Skeates (now retired from the Ontario Ministry of Natural Resources at Maple) talked his boss into allowing him to purchase a cigarette-making machine. This had nothing to do with smoking. Doug was trying to develop a system to mass produce seedlings in paper tubes. The initial cigarette machine experiments didn't succeed and the work was abandoned. (Nevertheless Ontario has went on to become a world leader in container production using other technology).

Lo-and-behold a British company has picked up on Doug's ideas and made them work. An item in the magazine 'Landmark' (Vol 2(4):42) outlines how the company, which has specialized in soilless growing technologies for more than 15 years' has developed a method of mass producing propagation plugs for seeds and cuttings.

The "Grow Stick" from the Forest Regeneration Group is a cigarette-shaped plug produced on converted cigarette- or cigar-making machines. It has been developed for reforestation programs in which it is necessary for extremely large quantities of seeds to be propagated with a high success

rate. It can also be used for small-scale production of most types of plants for research and other purposes.

The Grow Stick, made with rockwool, is sterile and nontoxic and can be used for one or more seeds, cuttings or tissue cultured micropropagations. It has a covering sleeve of water-degradable paper which disintegrates after transplanting. Where required, the plugs can be supplied pre-seeded for immediate use.

Enquiries from potential licensees and joint-venture partners in Canada are welcomed.

Contact: Forest Regeneration Group, 12 The Turnways, Leeds, West Yorkshire, England LS6 3DU.

Hugh Schooley

ONTARIO FOREST RESEARCH INSTITUTE OPENS

Ontario Ministry of Natural Resources officially opened its new $19.5 million Forest Research Institute on December 14, 1990. When fully staffed, there will be more than 60 people at the Institute all working towards one goal - developing better trees and better ways to regenerate and manage the forests. The Institute has world class laboratory facilities, 3 computerized greenhouses, 25 growth chambers, nursery and a 86 ha arboretum.

Their research program involves four main categories:

1. forest renewal/nursery stock production
2. silviculture and forest stand dynamics
3. tree improvement and genetics
4. forest ecology and its impacts

They will focus on Ontario issues and tree species.

SEED TESTING AND PREPARATION RESEARCH IN B.C. GIVEN HIGH PRIORITY

In the past, costs associated with poor seed quality have been underestimated, because calculations have been based only on collection and processing costs. However, seed dormancy and poor seed vigour contribute greatly to seedling production shortfalls and nursery costs. The increased costs of container seedling production (250 M vs. 15 M bareroot) means there is a greater need to eliminate dormant and low vigour seeds than ever before, for if seeds must be multiple sown, seed costs are correspondingly increased, as are the thinning costs resulting from excess germinants. Including these factors, true seed costs can be as high as 20% of the cost of producing a seedling. Nursery efficiency is also directly related to seed quality; efficiency improves if seeds in the 40-80% germination class are increased to above 80%, since the blank cavities and thinning costs are both minimized. A substantial proportion (approaching 50%) of the interior spruce and lodgepole pine seeds currently in storage are below 80% viability; the replacement cost of spruce and lodgepole pine seeds with average to poor (40-60% germination) has been estimated at several million dollars.

Considering the costs directly related to dormancy and poor vigour, research to improve seed quality must be a high priority. More knowledge is required of seed dormancy and the factors (thermoperiod, temperature, light, moisture relations) which enhance seed performance--knowledge which will enable us to manipulate conditions to optimize seed quality, and to obtain better correspondence between laboratory and field results. The greater use of seed orchard seeds necessitates an improved understanding of the effects of orchard cultural practices on seed yields, quality, and seedling performance. The physiological bases for environmental and cultural effects on seed size, maturation, dormancy, deterioration, germination, and vigour, must be determined. The complexity of these issues will also require better integration of research activities, e.g., planning and coordinating sequential studies with geneticists and silviculturists.

Reliable procedures must be developed for monitoring seed processing operations, determining seed orchard efficiencies, especially as these relate to cultural practices, and forecasting seedling production. Seed assessment should encompass more than laboratory germination under a single condition, and there should be greater emphasis on correlations with field performance. Tests to measure seed vigour (with emphasis on those which lend themselves to automation) are needed for all stages of seed maturity, dormancy, and germination.

Recent advances in technology have created a favourable climate for solving many seed testing and preparation problems. A computer-controlled thermogradient testing system (funded by FRDA) has been developed to test temperature effects on seed performance, and to refine seed preparation procedures such as IDS and Prevac. The application of biochemical techniques (e.g., seed respiration and protein probes) to assess seed quality and dormancy appears promising. The BCMOF Seed Centre is incorporating a vigour index (germination value) into the provincial tree seed register. Procedures developed in France for storing seeds in the non-dormant state may substantially shorten preparation times for very dormant seeds.

With the addition of the forest biotechnology program at U. Vic. and the move of BCMOF Research Branch to U. Vic. campus, there are excellent opportunities for collaborative research in seed maturation, dormancy, and germination, both in anatomy (J. Owens, Dept. Biol., Univ. Vic.) and biochemistry (S. Misra, Dept. Biochem, Univ. Vic.). Graduate student projects in tree seed ecology/physiology have also been proposed by Univ. B.C. Drs. P. Burton (Forestry), C. Chanway (Forestry), and M.K. Upadhya (Plant Sci.).

Carole Leadem, Research Branch, BCMOF
Ev Vanm Eerden, Pacific Regeneration
George Edwards, Forestry Canada

COOPERATIVE RESEARCH VENTURE

The Seed Science group, Swedish University of Agricultural Sciences, Umeå, Sweden and the National Tree Seed Centre, Petawawa National Forestry Institute, Chalk River, Canada will soon complete a cooperative research venture investigating the use of the IDS technique on balsam fir

(*Abies balsamea*) seeds. The experiment has been conducted to investigate alternative liquid densities for separation and the use of the IDS sedimentation flume for grading such seeds. The seeds are too light to be separated according to conventional IDS techniques using water as the separation medium. The Seed Science group at Umeå is providing technical advice and services related to the IDS technique for BCC (Björkman Construction and Consulting AB), the current IDS patent holder in North America.

Ongoing research has been planned to look at the effectiveness of the IDS technique on hitherto untried Canadian coniferous species, as well as to try modifications of the technique on species that have proven problematic for conventional separation (eg. white spruce *Picea glauca*).

The two institutions are also collaborating on experiments designed to test the effectiveness of Pre-Vac, used to remove mechanically damaged seeds from seed bulks, on Canadian coniferous tree species of commercial value.

Ben Wang
Bruce Downie

SEED CLEANING TREATMENTS ON DOUGLAS-FIR

Nurseries in B.C. have become increasingly aware of the role of sanitation in combating pathogens that have commonly caused significant stock losses. With concerns over environmental issues, worker exposure and disease resistance, fungicide applications are now under constant review and over-reliance on these products is not compatible with long term gains. One organism that has caused major damage to conifer seedlings has been *Fusarium*; it may affect seedlings at a variety of stages and traditional control methods are proving ineffective.

One area that may help nurseries to minimize the devastating effects of this and other pathogens is the reduction of pathogen contamination on seeds. This is particularly effective in Douglas-fir which is highly susceptible to *Fusarium* infestation. Research has found that the level of disease may vary greatly among seedlots. For Douglas-fir and ponderosa pine, most of the seedlots tested had less than 10% seed-borne contamination with *Fusarium*. Although infection levels appear low, they may be sufficient to cause wide spread damage. Pathogenicity assays on Douglas-fir have demonstrated a high degree of virulence for a majority of the isolates from some *Fusarium* species.

Numerous methods have been suggested or evaluated in an effort to reduce or eliminate seed-borne contamination on a variety of tree species. One method has been to apply fungicides directly to the seedcoat. Unfortunately, these generally have adverse effects on germination and provide inconsistent results in controlling seed-borne pathogens. A second method has involved rinsing seed in running water for 24-48 hours to wash off fungal spores. A third method recommends soaking seed for a determined time period in chlorine bleach, ethanol or hydrogen peroxide to disinfect the seedcoat. These two latter methods give significant reductions in fungal inoculum while maintaining or enhancing germination percentages.

In 1989 a study was initiated on Douglas-fir seed to determine the effect of various seed cleaning techniques on seed germination, seedling performance and on reducing the incidence of seed-borne *Fusarium*. Preliminary results indicate that a pre-stratification running water soak reduced the incidence of *Fusarium* compared to a standing water imbibition. A post-stratification treatment of running water, sodium hypochlorite and hydrogen peroxide did not adversely affect germination in the laboratory or field. Seedlings sampled met Ministry standards for height, calliper and root quality. An ethanol treatment reduced seed germination by 50% and seedlings in the field were significantly smaller. The effect of these treatments on seed-borne *Fusarium* were not consistent for all the tested seedlots. Two seedlots with moderate levels of *Fusarium* contamination (1% and 2% of sampled seed) showed, in all but one case, reduced levels of *Fusarium* contamination in the treatments with running water imbibition. One seedlot with relatively low levels of *Fusarium* contamination (0.25% of sampled seed) showed little or no change in *Fusarium* levels regardless of the treatment compared to the control. Assays on a seedlot rated as having a high level of seed-borne *Fusarium* (11% of sampled seed) found that none of the treatments were successful in significantly reducing the degree of infestation. In addition, the percentage of contaminated seeds in the pre-stratification running water treatments were generally higher than the standing water treatments.

The above seedlots and treatments, with the exception of ethanol, are being reassessed this year.

Dave Trotter, (Source: B.C. Silviculture, Seed and Seedling Extension Topics. Vol. 3(2):12-13)

A NEW CATEGORY OF SEED STORAGE BEHAVIOUR

Seed storage behaviour is commonly grouped into two categories: orthodox and recalcitrant. Orthodox seeds are those that can be dried to a moisture content below 10% and stored at low temperatures. Most conifers and small-seeded hardwoods, are in this category. Recalcitrant seeds are those that require relatively high moisture content and high temperature for storage (e.g. Oak, silver maple).

It is interesting to note in a recently published article by Ellis et al., University of Reading, England that a third category of seed storage behaviour exhibited by four cultivars of Arabica coffee seeds. Their research results indicate that this new category has characteristics intermediate between orthodox and recalcitrant. The distinctive characteristics of this new category are sensitivity to dessication and low temperature storage. (Ellis, R.H.; Hong, T.D.; Robert, E.H. 1990. An intermediate category of seed storage behaviour? I. Coffee. Jour. of Exp. Bot. 41(230):1167-1174.)

Ben Wang

SEED ORCHARD SURVEYS

In the 1990 field season, Forestry Canada's Forest Insect and Disease Survey will begin a preliminary study to determine what pests (insect or disease) and abiotic problems are present in seed orchards in Ontario. Accordingly, each ranger in northern Ontario's Northwestern, North Central and Northern regions will examine four seed or clonal orchards. These examinations will consist of at least one orchard of each of black spruce, white spruce (*Picea glauca* [Moench] Voss) and jack pine (*Pinus banksiana* Lamb.). Two visits will be made to each orchard in order to observe the various pests and other problems that might be expected in these types of plantations. Cones will also be collected for dissection and analysis in order to determine the effects of pest damage on seed production and the agents responsible for the damage.

SEED LOSSES IN NEWFOUNDLAND WHITE SPRUCE FROM SPRUCE CONE MAGGOT

The spruce cone maggot, *Strobilomyia neanthracina* Michelson (Diptera: Anthomyiidae), is a major pest of white spruce (Sw), *Picea glauca* (Moench) Voss, cones, and is responsible for seed losses in all native spruces across North America. Females lay their eggs between cone scales in the early stage of cone development, and the larvae create a spiral feeding tunnel around the cone axis, damaging scales and seeds before exiting the cone in mid summer. This pest is of special concern in seed orchards, as there is no reliable control measure.

Information on the impact of insect on reproductive success is also of ecological interest, particularly in isolated populations of a tree species. In 1988, we quantified infestation levels in 4 trees from each of 6 small, isolated, natural stands of Sw scattered across central Newfoundland, and in 8 trees from each of 12 provenances established in a range-wide Sw provenance test also located in central Newfoundland. The components of variation in cone and seed trials were calculated in both the natural stands and the provenances, based on 4 samples of 4 cones/sample/tree for each of 3 damage classes (undamaged cones, cones showing the exit holes of the maggot, and cones with signs of insect feeding attributed to other cone pests).

Only 4% of the total variation in infestation level was attributable to differences among natural stands, while 60% was attributable to differences among trees within stands. In the provenance test, only about 4% of the total genetic variation was due to provenance differences, while up to 96% of the remaining genetic variation was due to differences between trees within provenances. Infestation levels in natural populations averaged from 6% to 19% of a stand's cone production, compared with a range of 1% to 5% infestation between different provenances. The large difference in infestation level between provenance and natural stands, seed sources suggests that the provenances may be less attractive to the cone maggot than local or native Sw. Local seed sources are generally expected to be better adapted to endemic insect pests than exotic provenances.

Seed losses from the cone maggot were significant. An over all average reduction in number of full seeds/cone of 61%, was attributable to maggot infestation. There was a significant ($p > 0.0001$) tree-to-tree variation in infestation levels in both natural stands and provenances. This large variation corresponds to the pattern of genetic variation generally observed for most conifer traits, and may be indicative of the large variation in susceptibility to pests occurring within natural stands. This reservoir of tree-to-tree variation is available for selection for pest tolerance in conifers.

An average reduction of about 4% was observed in the weight of full seeds remaining in cones infested by the maggot. This was a small, but significant ($p > 0.0021$), reduction in weight. Since early seedling growth performance in Sw has been correlated with seed weight, maggot damage may also reduce the viability or vigour of the full seed remaining within an infested cone. Maggot damage did not significantly ($p > 0.4722$) reduce cone biomass, suggesting that feeding on cone parts other than seeds may be limited. No significant ($p > 0.0907$) differences were observed between healthy and infested cones in the ratio of empty seeds/cone to full seeds/cone, indicating that the effects of other cone and seed insects were similar regardless of whether or not cones were infested by the maggot.

We measured infestation levels of the cone maggot during the bumper cone crop of 1988. Over the past 20 years, good cone crops have been rare and this has probably suppressed cone insect populations. Under these conditions, one would expect relatively low levels of infestation in a bumper crop like the one of 1988. Furthermore, the relative impact of the maggot would be expected to be much greater following a succession of average cone crops under which maggot populations could increase. The large seed losses observed in infested cones, demonstrates that the maggot should receive special attention in seed orchards managed for annual seed production. Here maggot populations could rapidly increase in response to the reliable food source and seed crops could be seriously threatened.

Alexander Mosseler and Paul Tricco

METASYSTOX-R AGAINST SPRUCE CONE AND SEED INSECTS

Early season surveys of female flowers (conelets) for insect eggs are now used routinely in Douglas-fir seed orchards to determine spring infestation rates by cone and seed insects. If an infestation is above a certain threshold, a treatment with a systemic insecticide is recommended. As a result of this process, insecticides are used less than 50% of the time in Douglas-fir seed orchards to control cone and seed pests.

In order to provide a similar service to spruce seed orchards, trials have been conducted over the past several years to determine damage thresholds and to obtain efficacy data for registration of insecticides against spruce cone and seed insects.

During 1989 a trial was conducted at an interior spruce seed orchard in an attempt to obtain efficacy data for

registration of the systemic insecticide Metasystox-R (MSR). A conelet survey had revealed a high infestation rate of a seed destroying insect, the spruce cone maggot (*Strobilomyia neanthracinum*).

Two application methods were used in the trial: a conventional spray application using a backpack sprayer, and a direct injection using a drill and syringe. Three spray application rates were tested, 0.125, 0.25 and 0.5% a.i./litre. Injections were made at full product strength with the insecticide applied directly into holes at 10 and 15 cm intervals around the base of the test trees. Untreated trees were also included.

Treatments were all successful in controlling the cone maggot without adversely affecting seed germination rate. The data will now be submitted to support registration for MSR for use against spruce cone and seed insects.

Don Summers and Bev McEntire, (Source: (BC Silvicultura Seed and Seedling Extension Topics. Vol 3(1):2-3))

A MULCHING TRIAL IN AN ONTARIO BLACK SPRUCE SEEDLING SEED ORCHARD

Ontario Tree Improvement Council cooperators in the Cochrane, Kirkland Lake, Timmins area of the Province have established a 35 hectare black spruce seedling seed orchard to meet their needs. The orchard soil type is a fine sand previously holding a jack pine/black spruce stand. The site was prepared with a Madge Landbreaker; breaking up the slash and incorporating the debris and duff in the top 15 cm of mineral soil. Planting occurred in the springs of 1988 and 1989 using overwintered container stock. The summer of '89 was hot and dry causing unacceptably high levels of mortality.

A replicated mulching trial using poplar chips, straw and pulp mill sludge was implemented in the spring of 1990. The mulches were applied in a circle approximately 40 cm in diameter, to a depth of 5 to 10 cm depending on the material, around each seedling. Soil temperatures at depths of 3 and 13 cm, and soil moisture content were determined at various times throughout the summer; current annual increment was measured; condition code and soil fertility changes were monitored.

Fortunately for the seed orchard, the summer of '90 provided an excellent growing season with adequate rainfall and reasonable temperatures except during the last 10 days of July when hot droughty conditions existed. During this period the mulches were effective as soil temperatures at 3 cm depth were substantially reduced and soil moisture content was noticeably higher (see figures 1 and 2).

There appeared to be little difference between the three mulches in their effect on soil temperature, soil moisture and current increment over the course of the season. However, poplar chips are readily available in the area at a reasonable cost and are much easier to handle and apply than either straw or mill sludge. Due to the beneficial effects, the cost and the ease of application, the entire orchard will be mulched with poplar chips in the spring of 1991.

For more information contact Chris Atack at (705) 235-2266.

POLLEN CONTAMINATION - ISLAND LAKE SEED ORCHARDS

Pollen contamination is an important problem to be faced by the seed orchard managers. "Wild" pollen from the surrounding natural stands can reduce the expected genetic gains. Conifers are wind-pollinated and thus the air-borne behaviour of pollen is of fundamental importance. However, this behaviour has rarely been studied. Researches at the University of Guelph, OFRI and Northern Region of the Ontario MNR, and Environment Canada have joined forces to commence a detailed investigation of pollen flight at MNR's Island Lake, Chapleau seed orchards.

The objectives of the study are: (1), to ascertain the behaviour of air-borne pollen as it leaves the surrounding natural stands and flows into the orchards, how concentrations are depleted en-route, and how the pollen finally comes to rest, especially on seed cones within the orchards; (2), to model these characteristics and test the model at an operating seed orchard; (3), to refine this model for use by the seed orchard managers to determine the efficacy of various methods of reducing pollen contamination; and (4), to train personnel to use the model.

For objectives 1, a grid of pollen traps, consisting of four-sided wooden blocks, with sticky slides attached to each side, were placed at a height of 1.3 m in the Island Lake seed orchards. Monitoring of pollen on a daily basis began in 1989.

This continued in 1990 with the addition of traps at 3 m height and on the ground. In 1990, assessments were also made of the 'effective' source strength of pollen at the upwind edge of the orchard. These assessments provided a direct measure of the concentration of contaminant pollen flowing into the orchard. Further, data on wind speed and direction were gathered. Using this data, transects were chosen across the orchard and the variation in pollen concentration along these transects was examined.

The results from 1989 showed a binomial distribution of pollen shedding in both jack pine and black spruce. Jack pine shedding began on June 1 and ended on June 25; the peak occurred on June 10 and had an average density of 86 grains per 32 mm^2. Pollen deposition on the slides had come from both the trees in the orchards and the surrounding stands.

In black spruce, pollen began shedding toward the end of May and did not end until June 20. The peak occurred on June 4 and had an average density of 10 grains per 32 mm^2. Pollen caught on the slides had come from trees in the surrounding stands since none of the spruce trees in the orchards had reached pollen producing age.

In 1990 jack pine began shedding pollen on June 1st. Shedding peaked on June 7th and became negligible by mid-June. Spruce pollen was not studied in as much detail as pine but flow of this pollen began approximately a week earlier and also peaked on June 7th. Generally, spruce pollen counts were 1/10 those of pine.

Figure 1: % SOIL MOISTURE CONTENT (g water/100 g soil)

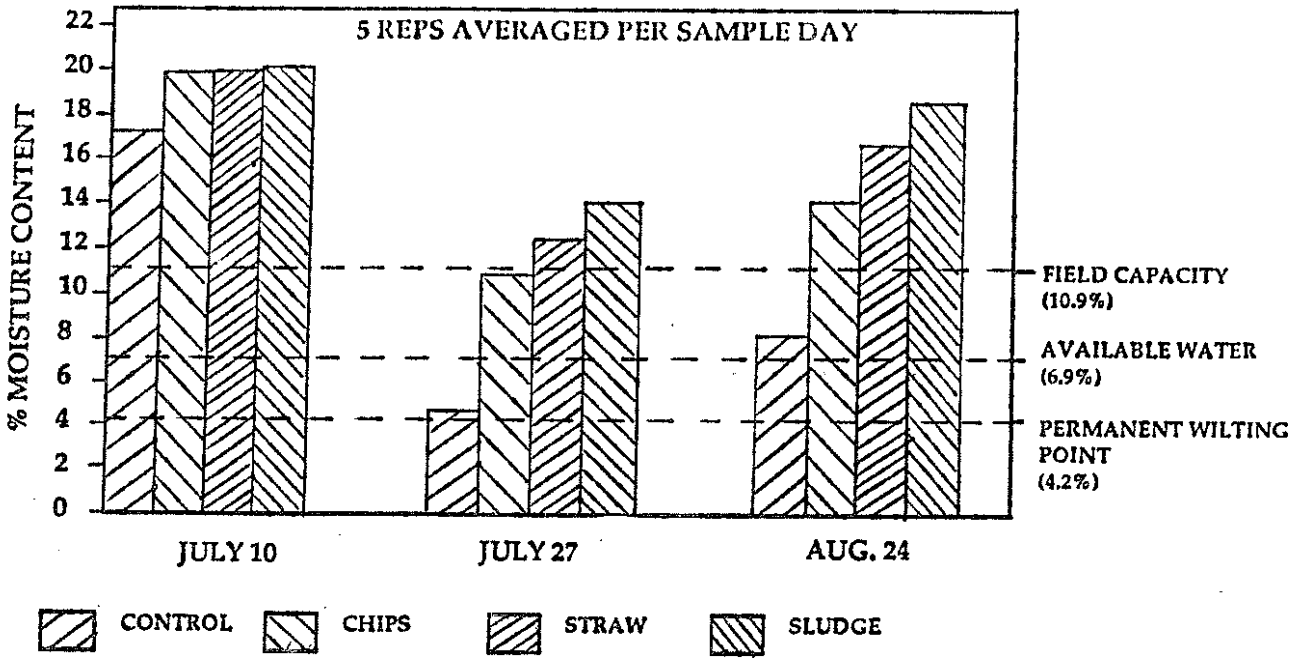
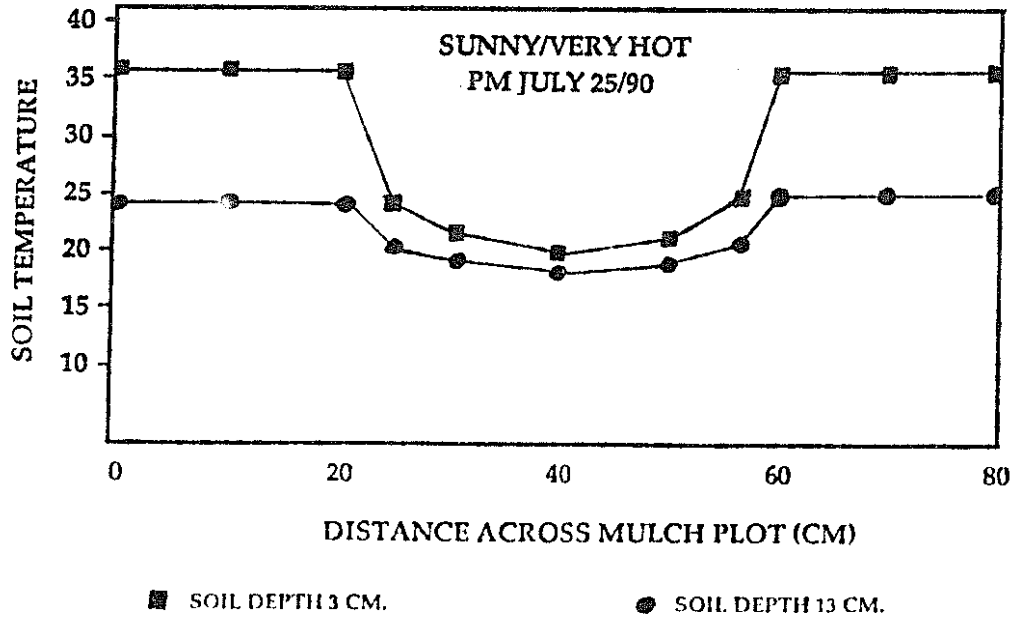


Figure 2: SOIL TEMPERATURE (C): POPLAR CHIP MULCH



In measuring aerial concentration we found that pine pollen counts did not decrease across the orchard due to the addition of orchard pollen. Jack pine in the orchards has been producing pollen for several years. Surprisingly, spruce pollen, which does not have a source within the orchards, did not decrease. It's aerial concentration varied in an irregular manner across the orchard and was possible indicative of being part of a regional background concentration.

The above work represents preliminary investigations. In the future we should release labelled pollen and trace its levels across the orchard. Pollen flow and concentrations will be measured at three levels within the orchard to derive profiles with height. Pollen deposition to branches within the orchard will be examined, as will the depletion of the aerial pollen cloud. This will provide information for designing an isolation strip for pollen filtration.

Enquiries concerning the above work should be addressed to Franco Di-Giovanni, Department of Environmental Biology, The University of Guelph, Guelph, Ontario N1G 2W1, (519) 824-4120 ext. 2479 or (co-author Rong Ho).

NEW BRUNSWICK SEED ORCHARD PRODUCTION

(from 8th Ann. Rpt. N.B. Tree Improvement Council)

Seed production has been increasing steadily as trees in seed orchards become larger and more orchard area comes into production (Table 1). Total production in 1990 for all species was over 175 million seed! Black spruce 1990 seed production increased 500% over the previous year. Jack pine production has been relatively stable for the last three years. Cones were collected from about 46 ha of black spruce and 30 ha of jack pine orchards, the majority of which have been rogued. All black and white spruce and jack pine seedlings grown in 1991 will be from genetically improved seed. A few agencies have several years' supply of black spruce seed in storage.

Table 1. Cone and seed production from seed orchards

Harvest year	Species	Volume of cones (L)	Weight of seed (kg)	Thousands of seeds
1984	Jack pine	370	3.515	880
	White spruce[1]	70	0.475	203
1986	Jack pine	3 044	35.235	9 285
	White spruce	25	0.062	33
1987	Jack pine	4 725	42.500	10 720
	Black spruce	680-	1.450	1 587
1988	Jack pine	12 000	131.355	31 211
	Black spruce	10 509	71.830	41 553
	White spruce	616	5.953	2 461
	Tamarack	770	1.000	287
1989	Jack pine	12 412	128.790	34 320
	Black spruce	13 216	49.600	28 875
	White spruce	454	2.910	1 244
	Tamarack	331	0.340	114
1990	Jack pine	12 320	124.100	30 717
	Black spruce	31 024	236.400	145 648
	White spruce	881	5.700	2 133
	Tamarack	590	0.084	27

[1]Ottawa Valley white spruce seedling seed orchard.

Monitoring cone and seed production over time for individual seed orchards can give an appreciation of annual fluctuations in production, reveal any trends, and show the impact of rogueing.

Dale Simpson

UTILIZATION OF *EPIOLOBIUM ANGUSTIFOLIUM* AS AN INDICATOR OF QUEBEC WHITE SPRUCE SEED MATURITY

Successful cone collection on white spruce depends on our capacity to know in advance when seed maturity will occur in order to efficiently plan the harvesting operation. Most indicators identified up to now (i.e. relative length of embryo, cone specific gravity, moisture content, etc.) can forecast, only with difficulty, the optimal moment for collecting cones. We have identified a phenological stage of development of Fireweed which is well synchronized with white spruce seed maturation and this can be used to forecast seed maturity.

It is possible to find fireweed near every collection stand because it is an ubiquitous species in Québec. The flowering pattern of this species follows the growing-degree-day total much like white spruce seed. Its inflorescence develops rapidly during the maturation period of white spruce seed. In a study the inflorescence was divided into three parts to more precisely predict their phenological stages. The development of each of these sections progresses successively from the base to the top with a delay of one week. Consequently, a specific stage of development of each section of the floral axis can be related with the progression of white spruce seed maturity. Weekly harvests, in five different stations throughout the distribution of white spruce in Québec, have shown a good correlation between the moment of white spruce seed maturation and the beginning of capsule bursting at the base of fireweed inflorescence. This phenological stage corresponds to 1 350 ± 45°C degree-days and 2 100 thermal units. Therefore, it is possible to forecast, 1 or 2 weeks in advance, the optimal moment for collecting cones by monitoring the acropetal progression of the floral axis of fire weed.

Stéphan Mercier

SEED PLANT BUGS

I am sure most are aware by this point in time, that the Ontario Tree Seed Plant underwent a major modernization project which was superficially completed by May of 1989. As with anything new there are naturally "bugs" which must be worked out of a system.

One such flaw caught us totally by surprise. This particular dilemma related to a germination problem that developed a jack pine which had been processed. Unusually low germination results were observed. It was suggested that this problem was related to poor environmental factors during initial seed development, but such a relationship could not be demonstrated. All flags went up and a complete system

evaluated plan was devised in order to determine if the cause was mechanical damage. The study involved comparing the previous extraction and cleaning methods to the new methods. No stone was left unturned to find and isolate this problem, in order to prevent future seed damage. It's curious to note, that only jack pine has been affected.

Since this study was very detailed and intense, I will leave further discussion for those interested parties to make contact for additional information. The study did isolate the problem area however, an approach to correct the problem is yet to be generated.

K.R. Creasey

INNOVATIONS IN SEEDING

Trailing Wheel Improves Simultaneous Seeding/Site Preparation Results

Experimental evidence has shown that manual tamping of seed spot microsites improves seedling emergence from direct seeding operations. A prototype wheel was developed to duplicate the manual tamping effect upon seed spot microsites. Following the successful field testing in the fall of 1989 of a prototype wheel mounted on a Bräcke scarifier/seeder, limited production units were operationally tested last spring at the Abitibi-Price Inc. Spruce River Forest, north of Thunder Bay. Simultaneous Bräcke scarification, direct seeding of jack pine, and the trailing wheel were compared against regular direct seeding with the Bräcke. In all tests, the new Bräcke Air Seeder was mounted on the scarifiers.

Both fall and spring tests showed significant gains (62% and 36%) in the percent of stocked scalps for rows treated with the wheel over the control rows. The scalps stabilized by the wheel reduce seed movement and burial. The soil capillary movement of water and seed soil contact is also enhanced by the pressing of the wheel.

For further information, contact: Laird Van Damme, KBM Forestry Consultants Inc., 360 Mooney Street, Thunder Bay, Ontario P7B 5R4

Regeneration Using Du Pont's Tree Eggs

In an effort to improve the cost effectiveness of forest operations, seeding is gaining favour as a method of regenerating forest lands. Low seedling survival rates, especially for black spruce, and the enormous quantities of seed used in operational seeding have resulted in increasing efforts to find practical methods of improving seed use efficiency and seedling survival.

Seed encapsulation is used to protect seed from fluctuating moisture levels during and immediately after germination as well as protecting if from predation without inhibiting germination. In addition, encapsulation facilitates precision sowing. Du Pont Inc. developed a new seed encapsulation technique. Called "Tree Eggs", these consist of a blend of polymers, dried and pressed into a pellet into which the desired seed is injected. When watered, it forms a protective gel or matrix around the seed.

A study was conducted to test the effectiveness of Du Pont's Tree Eggs for regenerating black spruce and jack pine in Northwestern Ontario, and to compare the germination and growth of seed using Tree Eggs with that using Cerkon shelter cones. Three sowing methods were used: surface placed Tree Egg; dibble hole planted Tree Egg; and Cerkon shelter cones. One and three seeds were injected into the pellets or placed in the Cerkon shelter cones.

Results indicate the Tree Eggs, in their current formulation, do not provide adequate germination or survival to be used for regenerating jack pine or black spruce in Northwestern Ontario. Modifications to the eggs followed by greenhouse studies have been recommended to Du Pont for further development trials in the future. Contact: Jamie Corcoran, Du Pont Canada Inc., R.R. #1, Simcoe, Ontario

Spruce Falls Seeders

#1 Spot Seeder

The device attached to the cab of a feller-buncher releases black spruce seed each time a tree is cut. The spot seeder consists of a seed container and a piston with a small seed pocket in it. When the piston is pushed up by the solenoid, the small seed pocket travels inside the container and is filled by five to eight seeds. When the piston is freed, it falls with the force of gravity and the seed ejects onto the surface of the ground.

The seed container will hold about 0.5 kg of seed (450,000) and will require filling after about 80,000 trees are cut (80 feller-buncher shifts). Operators are trained to recognize favourable microsites and can turn the device on or off as required. Compaction of the seed into the moss during the high flotation skidding or forwarding process will further increase seeding success. Currently seven machines are outfitted with this device.

#2 Aerial Seeder

A second method of seed dispersal designed by Spruce Falls is a black spruce aerial seeder. In the fall of 1985, woodlands employees Norman Iles and Larry Pennanen began designing a self-contained seeding unit which could easily be connected or disconnected to a helicopter by slinging it underneath the aircraft with the cargo hook. The advantage to having a removable seeder is that it can be quickly removed from the helicopter when seeding is not taking place and thus make the aircraft available for other work.Also, with a seeding unit that is mounted directly on the helicopter, certification from an aeronautical engineer would be required each time the unit was attached or removed. The best features of other seeders were incorporated and an innovative calibrating unit was designed to permit the seeder to apply an extremely low output of seed while maintaining a uniform distribution pattern.

In April of 1991, Forestry Services will be hooking up the Spruce Falls Sb Seeder to the company helicopter to carry out 645 hectares of aerial broadcast seeding. To apply the seed, the pilot flies back and forth in a series of parallel lines over the block at an altitude of 30 meters and a ground speed of 96 km/hr. A control switch activates the seeder which disperses the seeds in a 50 meter swath. A person on the ground helps

the pilot navigate and also verifies that the seeder is working properly. Spruce Falls normally carries out two applications in consecutive years at a rate of 50,000 viable seeds per hectare.

Jeff Leachs,
Spruce Falls Power and Paper Co., Kapuskasing, Ontario

FROM SEED TO SEEDLING

Experience is said to be the best teacher and with out a shadow of a doubt most will agree. 1990 was said to mark the beginning of the information wave and when you look around us it is easily noticed. It's now a time to focus on the environment that envelopes us and what roles we as individuals or groups can and will play in understanding various interactions of nature.

Awareness is the key and information transfer is the avenue. A video production entitled "From Seed to Seedling" that targets general interest groups, environmental groups and educators alike is now available. The video offers an explanation of the operations at the Ontario Tree Seed Plant and the role it performs in the overall regeneration program for Ontario.

Copies may be obtained by directing inquires to Ministry of Natural Resources, Communications Services Branch, Audio Visual Unit, Room 5440, Whitney Block, Queen's Park, 99 Wellesley St. West, Toronto, Ontario M7A 1W3, Telephone: 416-965-2756

CONGRATULATIONS

Dr. S.K. Kamra, Faculty of Forestry, Swedish University of Agricultural Sciences, Umeå, Sweden, has been nominated "MAN OF THE YEAR - 1990" by the American Biographical Institute in recognition of his research and other contributions to society. He has also been nominated Honorary Member of the Board of Governors of the American Biographical Institute Research Association.

UPCOMING MEETINGS

Seed Quality

The IUFRO, Project Group P2.04.00, Seed Problems is organizing a second symposium in Nanjing, China for Oct. 13-17, 1991. This meeting will be preceded by a Workshop on Seed Radiography, Oct. 9-12 and a post-meeting tour is planned for Oct. 18-22. The meeting will be held on the campus of Nanjing Forestry University where the Southern Tree Seed Inspection Centre is located. The deadline for submission of papers is May 1, 1991. Contact: Mr. Gao Handong, Secretariat, Southern Tree Seed Inspection Centre, Nanjing Forestry University, Nanjing, 210037, China.

Sowing the Seeds - Conference on Direct Seeding and Natural Regeneration, 22 to 25 May 1991, Adelaide, Australia

Direct seeding and the encouragement of natural regeneration of vegetation are useful, low-cost technologies in the battle against land degradation. Greening Australia is organizing a conference on these topics, with sponsorship from the Australian Government. Participants will be land-care professionals, farmers, mining-industry technologists and others interested in vegetation, including agroforesters.

The aim of the conference is to bring together current research knowledge and practical know-how and also to identify new areas for research and development. The conference will include a field day for inspection of large projects in South Australia, plus demonstrations of the latest direct seeding techniques and equipment. For more information and registration forms, contact: The Secretariat, Greening Australia Sowing the Seeds Conference, P.O. Box 232, Kensington Park 5068, South Australia.

21st Southern Forest Tree Improvement Conference June 17-20, 1991

Organized by the University of Tennessee and Tennessee Division of Forestry at the Hyatt Regency, Knoxville, Tennessee, contributed papers and posters are being solicited by the Program Committee for the 21st Southern Forest Tree Improvement Conference. Session topics include the following:

Tree Improvement Strategies and Environmental Change
Seed Orchard Management
Growth and Yield of Improved Plantations
Breeding and Propagation
Genetic Testing and Selection

Papers on basic and applied research areas will be integrated in the above sessions. Authors submitting papers on basic research topics should select the session most pertinent to the eventual use of their results. Submitted papers should not exceed 10 typed pages. Contributed presentations will be restricted to 20 minutes including 5 minutes for discussion. Contact: Dr. Scott E. Schlarbaum, The University of Tennessee, Department of Forestry, Wildlife & Fisheries, Knoxville, TN 37901-1071

Early Selection of Forest Tree Species Combining Morphophysiological Traits and Molecular Markers Workshop (Oak Ridge, Tennessee - June 13-14, 1991)

This workshop is designed to bring tree breeders and molecular geneticists together to determine where marker-aided selection fits in tree improvement programs.

If interested in attending, contact Dr. Jerry Tuskan, Oak Ridge National Laboratory, P.O. Box 2008 MS 6352, Oak Ridge, TN 37831-6352

Canadian Tree Improvement Association 1991 Meeting

Over the last decade our biennial meetings have focussed our attention on tree improvement, breeding, progeny testing, orchards, clonal forestry, and biotechnology. These meetings have intentionally often been quite technical with emphasis on "how to". Now that our breeding programmes are mostly well underway it may be worthwhile to think about the genetic variation that we have excluded from our breeding populations and the broader consequences of our activities on diversity and genetics. With this in mind the topic of our

next CTIA meeting is going to be: Maintaining Biodiversity - Should you be concerned? The meeting will take place at the Delta Inn in Ottawa (August 19-23, 1991). We are now in the process of putting together an exciting programme for you. At the present time we have confirmation from several distinctive speakers (G. Namkoong [U.S. For. Serv.], C. Millar [U.S. For. Serv.], and T. Williams [FAO]) who promise to make this meeting very stimulating for everyone involved with managing natural resources.

Please inform your colleagues about our meeting. Contact Steen Magnussen, Editor CTIA, Forestry Canada, Petawawa National Forestry Institute, Chalk River, Ontario, K0J 1J0, Fax. 613-589-2275.

Seed Dormancy and Barriers to Germination

The International Union of Forest Research Organizations (IUFRO) Project Group P2.04-00 (Seed Problems) will hold a Symposium "Seed dormancy and barriers to germination" in Victoria, British Columbia, during the week of April 22-26, 1991. The program, which is open to all individuals interested in forest tree seeds, will include:

A pre-Symposium reception, invited papers, volunteer papers, poster session, a banquet, field trips to the provincial seed centre, seed orchards, and the Pacific Forestry Centre (Forestry Canada), and post-Symposium tours to southern Washington/Oregon, and the Rocky Mountain region (Idaho/Montana) if sufficient interest is shown.

The local organizer is: Dr. D.G. Edwards, Pacific Forestry Centre, 506 West Burnside Road, Victoria, BC, Canada, V8Z 1M5.

International Symposium on Application of Biotechnology to Tree Culture, Protection and Utilization

Worthington, Ohio, USA, Aug. 5-8, 1991 contact Carol Cowles, Northeastern Forest Experiment Station, 359 Main Rd. Deleware, Ohio, 43015, USA, Phone 1-614-369-44767.

Symposium and Workshop on Seed Radiography for Quality Control

Nanjing Forestry University, China, Oct. 9-22, 1991, Contact, Mr. Gao Handong, Secretariat, Southern Tree Seed Inspection Centre, Nanjing Forestry University, Longpan Rd., Nanjing, 210037, China.

First National Silviculture Conference

Vancouver, B.C., Nov. 18-20, 1991. Contact Tony Hugh, Directorate of Development Forestry Canada, 351 St. Joseph Blvd., Hull, P.Q., K1A 1G5

International Symposium on Angiosperm Pollen and Ovules

Vila Olmo, Como Italy, June 23-27, 1991. Topic to be covered

- Genetics of male and female gametophytes
- Molecular biology of gametophytes
- Biotechnical methods
- Developmental selection in natural populations
- Gametophytic selection as a breeding tool

Contact D.L. Mulcahy, Dept. of Botany, University of Massachusetts, Amherst, M.A. 01003, USA.

23rd ISTA Congress 1992

Mar del Plata, Argentina. Theme Quality Seed for the Present and the Future. Keynote speakers to cover Synthetic seed, seed banks, seed technology training - their influence and importance for continuing development of seed technology around the world.

Symposium topics:

1. Producing quality seed
2. Seed lot potential performance
3. Seed hygiene
4. Seed testing for tropical and sub-tropical species
5. Seed programs for developing regions

Centennial Meeting of IUFRO, 1992

This meeting will be held in Berlin, September 1992. The proposed presentation by Entomology and Pathology consists of three different sessions, concerning temperate countries: Development of Forest Protection in Europe; Development of Forest Protection in North America; Protection Strategies and Tactics for the Future. A Pilgrimage to Eberswalde, the birthplace of IUFRO, is also planned.

Cone and Seed Insects

An IUFRO Working Party, S2-07-01, Cone and Seed Insects, Conference being planned for 1991 in Hasbin, China has been postponed (due to a poor attendance forecast). It is now being suggested that the meeting be held in 1992 in conjunction with the 19th International Congress of Entomology to be held in Beijing, China June 28-July 4. Note this is a suggestion and not definitely arranged. Organizers will welcome suggestions to make the meeting a success and also indications of papers that may be offered. Contact: Gary L. DeBarr, Southeastern Forest Experiment Station, Carlton St., Athens, Georgia USA 30602.

RECENT PUBLICATIONS

Arnold, R.J. 1990. Controlled pollinated radiata pine seed - a comparison of seedling and cutting options for large-scale deployment. New Zealand Forestry 35(3):12-16.

Askew, G.R.; Blush, T.O. 1990. An index of phenological overlap in flowering for clonal seed orchards - short note. Silvae Genetica 39(3-4):168-171.

Attree, S.M.; Tautorus, T.E.; Dunstan, D.I.; Fowke, L.C. 1990. Somatic embryo maturation, germination, and soil establishment of plants of black and white spruce (*Picea mariana* and *P. glauca*) Can. J. Bot. 68(12):2590-2594.

Bagchi, S.K.; Joshi, D.N.; Rawat, D.S. 1990. Variation in seed size of *Acacia* spp. Silvae Genetica. 39(3-4):107-109.

Blanche, C.A.; Elam, W.W.; Hodges, J.D. 1990. Accelerated aging of *Quercus nigra* seed: biochemical changes and

applicability as a vigor test. Can. J. Forest. Res. 20(10):1611-1615.

Campbell, S.J.; Landis, T.D. 1990. Managing seedborne diseases in western forest nurseries. Tree Plantter' Notes. 41(4):3-7.

Carter, K.K.; Adams, G.W.; Geenwood, M.S.; Nitschke, P. 1990. Early family selection in jack pine. Can. J. For. Res. 20:285-291.

Cordell, C.E.; Gramling, C.; Lowman, B.; Brown, D. 1990. A precision seed sower for longleaf pine bareroot nursery seedlings. Tree Planters' Notes. 41(4):33-38.

Crawford, R.M.M.; Balfour, J. 1990. Female-biased sex ratios and differential growth in Artic willows. Flora. 184(4):291-302.

Crook, G. 1990. Four decades of forestry, Canadian Pacific Forest Products, Harrington Forestry Centre. Silviculture. 5(4):15-18.

Davidson, C.G.; Remphrey, W.R. 1990. An analysis of architectural parameters of male and female *Fraxinus pennsylvanica* in relation to crown shape and crown location. Can. J. Bot. 68(9):2035-2043.

de Groot, P.; Ennis, T.J. 1990. Cytotaxonomy of *Conophthorus* (Coleoptera: Scolytidae) in eastern North America. Can. Ent. 122(11/12):1131-1135.

Dick, J.McP.; Jarvis, P.G.; Barton, C.V.M. 1990. Influence of male and female cones on assimilate production of *Pinus contorta* trees within a forest stand. *In*: Isebrands, J.G.; Ceulemans, L.; Dickson, R.E.; (eds.). Dynamics of ecophysiological processes in tree crowns and forest canopies. Heron, Victoria.

Dick, J.McP.; Smith, R.; Jarvis, P.G. 1990. Respiration rate of male and female cones of *Pinus contorta* trees. 4:142-149.

El-Kassaby, Y.A.; Park, Y.S. 1990. Harvest index and wood density in a Douglas-fir early progeny test. Joint Meet. West. For. Gen. Assoc. and IUFRO Work. Part S2.04-.05,.06,.12,.14, Olympia, Washington, Aug. 20-24, 1990, 11 p.

Erickson, V.J.; Adams, W.T. 1990. Mating system variation among individual ramets in a Douglas-fir seed orchard. Can. J. Forest. Res. 20(10):1672-1674.

Ernst, W.H.O.; Decelle, J.E.; Tolsma, D.J. 1990. Lifecycle of the bruchid beetle *Bruchidius uberatus* and its predation of *Acacia nilotia* seeds in a tree savanna in Botswana. Entom. Experimentalis et Applicata. 57(2): 177-190.

Etheridge, P.G.; Adams, G.W. 1990. Vegetative propagation: its role in applied tree improvement. Joint Meet. West. For. Gen. Assoc. and IUFRO Work. Part. S2.04-.05,.06,.12,.14, Olympia, Washington, Aug. 20-24, 1990, 16 p.

Feret, P.P.; Diebel, K.E.; Sharik, T.L. 1990. Effect of simulated acid rain on reproductive attributes of red spruce (*Picea rubens* Sarg.). Environ. and Experi. Bot. 30(3):309-312.

Fleming, R.A.; DeGroot, P.; Obarymskyi, A.; Burns, T. 1990. Devising sampling methods for inventory of receptive seed cones of jack pine. Can. J. Forest Res. 20(11):1704-1713.

Fritz, V.A.; Cloud, H.A.; Deef, R.F.; Borowski, A.M. 1990. A versatile heat pump seed dryer. Hort. Sci. 25(8):977-978.

Gosling, P.G. 1991. Beechnut storage: A review and practical interpretation of scientific literature. Forestry. 64(1);51-60.

Haines, R.J.; Woolston, R.R. 1991. The influence of reproductive traits on the capture of genetic gains. Can. J. Forest. Res. 21(2);272-275.

Hong, T.D.; Ellis, R.H. 1990. A comparison of maturation drying, germination and dessication tolerance between developing seeds of *Acer pseudoplatanus* L. and *Acer plantanoides* L. New Phytologist 116(4):589-598.

Innes, D.J.; Ringius, G.G. 1990. Mating system and genetic structure of 2 populations of white spruce (*Picea glauca*) in eastern Newfoundland. Can. J. Bot. 68(8):1661-1666.

Jones, S.K.; Gosling, P.G. 1990. The successful redrying of imbibed, or imbibed plus prechilled Sitka spruce seeds. Seed Sci. and Tech. 18(3):541-548.

Kamra, S.K. 1990. Improving the forest seed situation in some African Countries. Pages 126-133 *in* J.W. Turnbull, ed. Tropical Tree Seed Research, Proc. Internat. Workshop, Gympie, Qld, Australia, Aug. 1989.

Kamra, S.K. 1990. Studies on seed of some tropical pines by X-ray contrast method. Pages 101-108 *in* Diaz, T.T.; Jara, L.F. Memorias. Seminario-Taller Sobre Investigaciones En Semilles Forestales Tropicales. Bogota, Colombia, Oct. 1988. Corporacion Nacional de Investagacion y Formento Forestal Doc. No. 18.

Koul, K. 1990. Factors influencing *in vitro* micropropagation of *Pinus strobus* L. Biologia Plantarum. 32(4):266-272.

Krug, E. 1990. Pollen germination of *Picea abies* Karst and *Pinus sylvestris* L. influenced by electromagnetic fields and waves (in German). European J. Forest Path. 20(4):251-255.

Kuchler, L.; Braun, H. 1990. Storage of European aspen pollen in liquid nitrogen. Beitrage fur die Forstwirtschaft. 24(3):124-125.

Manders, P.T. 1990. Soil seed banks and post-fire seed deposition across a forest-Fynbos ecotone in the Cape-Province. J. Vegetative Sci. 1(4):491-498.

Mladenoff, D.J. 1990. The relationship of the soil seed bank and understory vegetation in old-growth northern hardwood-hemlock treefall gaps. Can. J. Bot. 68(12):2714-2721.

Morgenstern, E.K.; Hall, J.P. 1990. Genetic aspects of black spruce silviculture. Pages 107-111 in Titus, B.D.; Lavigne, M.V.; Nuwton, P.S.; Mades, W.J. (eds.) Proc. IUFRO Work,. Part S1.05-12 Silvics and Ecology of Boreal Black Spruce, St. Johns, Nfld., Aug. 12-17, 1989, For. Can., Newfoundland For. Cen., Inform Rept. N-X-271.

Morgenstern, E.K.; Mullin, T.J. 1990. Growth and survival of black spruce in the range-wide provenance study. Can. J. For. Res. 20:130-143.

Morgenstern, E.K.; Steeves, D.G. 1990. Correlation of traits in (*Larix laricina* (Du Roi) K. Koch) (Abstract) Page 450 *in* Proc. XIX IUFRO World Congress, Section 5, Montreal, Que., Aug. 5-11, 1990.

Philipson, J.J.; Owens, J.N.; O'Donnell, M.A. 1990. Production and development of seed and pollen in grafts of *Picea sitchensis* (Bong.) Carr. treated with jibberellin $A_{4/7}$ to induce coning and the effect of forcing treatments. New Phytologist. 116(4):695-706.

Raymond, C.A.; Lindgren, D. 1990. Genic flexibility - A model for determining the range of suitable environments for a seed source. Silvae Genetica 39(3-4):112-120.

Sheng, Chuxing; Wang, Shasheng. 1990. Effects of applied growth regulators and cultural treatments on flowering and shoot growth of *Pinus tabulaeformis*. Can. J. Forest. Res. 20(6):679-685.

Sherwood, D. 1990. Federal forests pickin seed. American Forests. 96(11+12):28-32.

Snow, G.A.; Matthews, F.R.; Nance, W.L.; Foster, G.S. 1990. Effect of pollen source on loblolly pine resistance to *Cronartium quercum* f. sp. *fusiforme*. Forest Sci. 36(2):304-312.

Sub, R.; Ewald, D.; Matschke, J. 1990. Production of somatic embryos from seeds of the common spruce. Beitrage fur die Forstwirtschaft. 24(3);126-129.

Takass, T.; Tomlinson, P.B. 1990. Cone and ovule ontogeny in *Taxodium* and *Glyptostrobus* (Taxodiaceae, Coniferales). Am. J. Bot. 77(9):1209-1221.

Tauer, C.G.; Loo-Dinkins, J.A. 1990. Seed source variation in specific gravity in loblolly pine growth in a common environment. Forest Science. 36(4);1133-1145.

Thomson, J.; Matthessears, U.; Peterson, R.L. 1990. Effects of seed provenance and mycorrhizal fungus on early seedling growth in *Picea mariana* seedlings. Can. J. Forest Res. 20(11):1746-1752.

Valenti, M.A.; Abrahamson, L.P.; Maynard, C.A. 1990. Control of white pine cone beetle (Coleoptera: Scolytidae) with Carbofuran granuals in a New York State white pine seed orchard. J. Econ. Ent. 83(6);2349-2351.

Webster, F.B.; Roberts, D.R.; McInnis, S.M.; Sutton, B.C.S. 1990. Propagation of interior spruce by somatic embryogenesis. Can. J. Forest. Res. 20(11):1759-1765.

Ying, L.; Morgenstern, E.K. 1990. Inheritance and linkage relationships of *Larix laricina* in New Brunswick, Canada. Silvae Genet. 39:245-251.

We thank Petawawa National Forestry Institute for their assistance in the preparation of this Newsletter.