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# Planting Stock Improvement Research Update

## INTRODUCTION

The Canada-British Columbia Forest Resource Development Agreement (FRDA), 1985–1990, committed $300 million to reforestation of backlog NSR and intensive silviculture. The Extension, Demonstration, Research and Development (E,D,R&D) sub-program of FRDA identified the need for planting stock improvement studies, to meet the need for the high quality stock that is required for the severe conditions encountered in the reforesting of many backlog sites[1].

New opportunities in nursery-related E,D,R&D are considered annually, with guidance on priority areas being provided through the Nursery Technical Committee. Nursery projects are implemented and supported under the auspices of the FRDA Technical Advisory Committees (TAC) — CTAC-Coastal, NITAC-Northern Interior, and SITAC-Southern Interior — and the Federal Direct Delivery program (FDD - TAC).

Summaries of research projects follow. The first digit of the project numbers refers to the TAC under whose program these projects are being funded (1=NITAC, 2=CTAC, 3=SITAC). Project numbers beginning with "F" are being funded and directed by the FRDA Federal Direct Delivery program. Addresses for project leaders and agency contacts are listed at the end of this Memo.

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## PROPAGATION: SEED

**PROJECT 2.41:** *Improving seedling production and stock quality of* Abies lasiocarpa

**Project Leader:** C. Leadem

FRDA REPORT

**Status:** Completed/*FRDA Memo* 040, *FRDA Report* 095

**Results:**

FRDA Memo

Three seedlots of *Abies lasiocarpa* were stratified using the standard Ministry of Forests technique (48-h pre-soak, then 8 weeks of cold stratification at 2°C) and the stratification-redry method. With the redry method, seeds undergo 4 weeks of cold (2°C), and are then dried to a 35% moisture content (from 45%) before further chilling.

Germination in the dormant, good quality seedlots was increased by up to 61% when the stratification-redry treatment was used. In the non-dormant and poor quality lots, germination was not enhanced by the redry treatment, but the seeds were less subject to mould during chilling.

Three germination thermoperiods were used on the three stratified seedlots. These were (day/night) 15°C/10°C, 30°C/20°C, and 25°C/15°C. Germination for both stratification regimes was lowest at the coolest thermoperiod. The stratification-redry method enhanced germination for all three germination regimes, unlike the standard stratification method did.

[1] Five-Year Plan: Extension, Demonstration, Research and Development Sub-Program. Backlog Reforestation Program. May 1986.

**PROJECT 3.58:** *Survey of seedlots to which the IDS sorting method may apply*

**Project Leader:** G. Edwards

**BCFS Contact:** C. Leadem


**Status:** Completed/*FRDA Memo* 115

**Results:**

The project was completed in 1988/89. Ninety-six spruce (Sw, Se, and Sx) seedlots have been tested using the IDS (incubation, drying, separation) method of seed sorting. The method is based on the fact that water loss differs between weak (or dead) and vigorous seeds following incubation and drying. The technique involves three steps: 1) incubation of hydrated seeds at 15°C for 72 hours; 2) drying at 25°C for 8 hours; and 3) separation using a water sorting method that produces viable sinker and dead floater seeds. Results showed germination in many seedlots to be improved significantly. Increases in germination ranged from greater than 50% to as low as 10%, with an average increase of 17%.

**PROJECT 2.67:** *Operational testing of IDS-treated seeds*

**Project Leader:** G. Edwards

**Objectives:**

To refine the IDS (incubation, drying, separation) method of seed sorting for major British Columbia conifers, and to fill a portion of operational sowing requests with IDS-treated seeds.

**Progress to Date:**

The IDS method of sink/float sorting of tree seeds, to separate viable from non-viable seeds, has been thoroughly tested in the laboratory, and some specialized equipment has been built. Germination testing of treated and untreated seeds under operational nursery conditions has been completed.

**Expected Benefits:**

Improved seed quality will allow single seed sowing. This will eliminate nursery thinning and significantly reduce the cost of producing seedlings.

**PROJECT 2.69:** *Establishing germination temperature optima for nursery seedling production of British Columbia conifers*

**Project Leader:** C. Leadem

**Objectives:**

To construct a prototype temperature gradient testing system, and to use it to determine optimum germination temperature regimes for seeds of major British Columbia conifers.

**Progress to Date:**

The first module has been completed and is undergoing tests. Digital control boards for all four modules have been assembled. Two programs are being used in the initial testing of control software. The resident program can control as many as eight modules at one time. A view program can access the control program and allows the user to monitor the current status of the plates, modify control parameters, download accumulated data to external files, and present the historical data file graphically.

The outline for a user manual on the controlled temperature gradient system has been prepared, and includes a description of hardware, the theory of operation, and a user's guide to software features and options.

A Brinkmann Lauda recirculating chiller has been purchased for the base plate cooling system.

**Expected Benefits:**

Nursery managers will have information on the optimum temperature regimes for germinating major British Columbia coniferous species, and on the likely germination results when less than optimal conditions occur.

**PROJECT F52-41-014:** *Causes of cone and ovule abortion and case-hardening of cones*

**Project Leader:** J. Owens and A. Colangeli


**Status:** Completed/*FRDA Reports* 056, 057, 058

**Results:**

The three FRDA Reports completed are one each on western redcedar, Douglas-fir, and interior spruce.

**PROJECT F52-41-119:** *Guidelines for seed transfer of western white pine in British Columbia based on frost hardiness and seedling phenology*

**Project Leader:** D. Lester and J. Worrall

**Forestry Canada Contact:** M. Meagher and D. Haley

**Obectives:**

To determine whether western white pine seedlots are broadly or narrowly transferable for reforestation according to cold hardiness, and whether white pine seedling shoots can be used as an indirect but simple measure of cold hardiness; and to recommend how white pine seedlings can be safely distributed in the province according to frost tolerance.

**Progress to Date:**

Final report will be available in the Fall of 1991.

**Expected Benefits:**

Recommendations will be made to field foresters, silviculturists, seed orchard planners, and scientists on how white pine seedlings can be safely distributed throughout British Columbia according to frost tolerance.

## PROPAGATION: ROOTED CUTTINGS

**PROJECT 1.14:** *Development of a system for the mass propagation of rooted cuttings of genetically improved interior spruce*

**Project Leader:** J. Russell


**Status:** Completed/*FRDA Report* 110, *FRDA Memo* 014

**Results:**


Accelerated growth trials have been performed on 1500 cutting-donor plants of interior spruce from genetically superior open-pollinated and full-sib families. Several experiments have been initiated to test treatment effect on the speed, percentage, and quality of rooting, and on the subsequent growth and form of the rooted cutting. Early results show that 8-month-old accelerated-grown seedlings can produce 50 cuttings on average when combined with hedging. Cuttings from these donor-plants achieved 95% rooting.

Seedlings and rooted cuttings are being compared in two field trials established in the Prince George area. As well as these comparisons, 3000 rooted cuttings were outplanted in a demonstration trial in 1988 and 16 000 cuttings will be outplanted in 1989.

**PROJECT 2.40:** *Stock quality improvement of yellow-cedar*

**Project Leaders:** J. Russell and S. Grossnickle


**Status:** Completed/*FRDA Report* 148, *FRDA Memos* 083, 101

**Results:**


Rooting improvement trials under way at Cowichan Lake Research Station show that 5-year-old and 12-year-old yellow-cedar hedges provide the best cuttings. Fertilizer application should not begin immediately after setting, but should occur before cuttings begin to grow.

A demonstration site comparing yellow-cedar seedlings and rooted cuttings was established near Port McNeill, in conjunction with MacMillan Bloedel.

## PROPAGATION: TISSUE CULTURE

**PROJECT F52-41-110:** In vitro *clonal production and evaluation of coniferous propagules for reforestation*

**Project Leader:** P. Wooding and L. Clay

**Forestry Canada Contact:** E. White

**Objectives:**

To produce, in a pilot tissue culture project, clonal propagules of yellow-cedar (*Chamaecyparis nootkatensis*) suitable for operational planting; to evaluate the quality of yellow-cedar micropropagules; to establish demonstration plots of yellow-cedar micropropagules; and to continue research on micropropagation techniques of yellow-cedar, Douglas-fir, and white spruce.

**Progress to Date:**

A demonstration plot was established near Mission in October 1988. Fifty yellow-cedar micropropagules and 50 seedlings were planted. The survival as of July 1989 was excellent. Physiology of the outplanted seedlings is highly variable compared to that of the micropropagules, but overall growth is similar.

The technique for micropropagation of yellow-cedar was successfully developed. Techniques for acclimatization of micropropagules from sterile culture to soil mix were evaluated. In the future, micropropagules will be outplanted at Canfor's Harrison division, less demanding *in vitro* cultural conditions will be assessed, genetic effects on micropropagation rate will be evaluated, and research on micropropagation techniques for Douglas-fir, white spruce, and Sitka spruce will continue.

**Expected Benefits:**

The development of micropropagation by tissue culture for mass propagation of genetically superior conifer material is expected.

## NURSERY CULTURE

**PROJECT 1.36:** *The use of photoperiod to induce dormancy and terminal bud formation in spruce*

**Project Leader:** A. Eastham

**Objectives:**

To demonstrate the effectiveness of photoperiodic induction of budset in container-grown spruce, and to evaluate effects of treatment (photoperiod, treatment duration, spruce seed source) on various morphological and physiological characters in container seedlings and 1st-year farm-field outplantings.

**Progress to Date:**

Six seedlots of white spruce were sown in the spring of 1988 at Red Rock Research Station. Four blackout treatments (nominal/control 19-h, 17-h, 15-h, and 13-h photoperiods) were initiated on July 6 and applied for 2,4, and 6 weeks. The blackout treatments used were dynamic, and therefore changed with the natural daylength. At the end of each treatment, stock was returned to ambient photoperiod and grown until lifting and storage on October 26. Four seedlots of treated stock were outplanted at sites throughout the province, and all six seedlots were planted at Red Rock.

The best of the dynamic blackout treatments resulted in stock that has balanced shoot:root ratios, good root mass, early frost hardiness, and adequate time for dormancy induction. No effect on terminal shoot development (budflush and budset) was found between the blackout-treated or non-

treated outplanted seedlings at Red Rock or on regional planting sites. Terminal shoot growth on 1st-year outplantings was increased by nursery blackout treatment only for the Sxs. In the regional outplantings, terminal shoot growth in Sw and Se was reduced following the 13-h photoperiod blackout treatment. Three of the regional and all Red Rock outplantings were assessed again during 1990 (2nd year after planting).


*FRDA Memo* 082, "Energy Use Affected with Blackout in a High Latitude Nursery," is available, and *FRDA Report*, "Nursery and First Field Season Effects Following Blackout Treatment of Six Seedlots of Spruce at Red Rock Research Station," is currently under review.

During the 1989 nursery year, Sxs seedlot 3958 and the 15h-for-4-weeks blackout regime were used to compare the dynamic and static (fixed stop and start time) methods. Results show that the static method produced the shortest seedlings with the greatest root:shoot ratio and early frost hardiness. First-year field performance results confirmed previous results — no shift in shoot phenology and increased terminal shoot growth for blackout-treated Sxs. Results were presented at the 10th Annual Meeting of the Forest Nursery Association of British Columbia, Whistler, B.C., Sept. 24–27, 1990.

A successful Blackout Workshop in Kamloops, B.C., April 1990, was organized by research staff from Red Rock and Heffley Reforestation. It was attended by approximately 45 nurserymen, foresters, and researchers.

In the Red Rock Research facilities during the 1990 growing season, two experiments were conducted to further refine blackout treatments and adjunct cultural regimes for both summer-planted and fall-lifted spruce seedlings.

**Expected Benefits:**

The trial will demonstrate the operational usefulness of the tested treatments in producing seedlings better suited for growth in harsh northern and high elevation outplanting environments.

**PROJECT 1.41:** *Post-planting injury to seedlings on cold sites*

**Project Leader:** M.J. Krasowski and N. Livingston

**Objectives:**

To determine the influence of blackout treatments, used to control height in seedlings of spruce species, on bud phenology in relation to seedling susceptibility to frost damage; to determine if storage duration has any effect on seedling susceptibility to freezing injury; to evaluate various nursery treatments and stock characteristics in relation to the type and severity of freeze desiccation injury; and to evaluate the extent of seedling dehydration by studying leaf cuticular transpiration, leaf water status during winter, and quantity and configuration of epicuticular waxes.

**Progress to Date:**

Seedlings from various blackout treatments were removed from cold storage in February 1989, potted, and placed in a growth chamber. The blackout-treated seedlings broke buds sooner than the non-treated ones. A 10- to 12-day spread in timing of bud burst was noted between the various treatments. Seedlings that had undergone the same treatments were removed from cold storage and similarly assessed in May 1989; this time seedlings from all treatments broke buds simultaneously (the 2- to 3-day differences observed are negligible).

In 1990, bud phenology was investigated in different treatments of photoperiodic dormancy induction to determine the influence of these treatments on bud development and the onset of bud dormancy. To evaluate seedling dormancy status, the mitotic index (number of actively dividing cells/total number of cells in a terminal bud x 100%) was compared to freezing test results (assessing seedling hardiness status) and to days to bud break trials (assessing dormancy status) performed at lifting. The stock is currently in cold storage and will be outplanted in spring for further investigations.

A new component was added to the project in 1990. It investigates the influence of nursery culture on the deposition of epicuticular wax, subsequent seedling water status throughout winter, and susceptibility to frost desiccation. Seedlings of two stocktypes — 1+0 and 2+0 white spruce — were outplanted at three locations: one at Red Rock and two at Bear Mountain near Dawson Creek. Some of these sites were open and others were sheltered by aspen brush. Seedlings have been collected from these sites and the following characteristics are being evaluated: amount of epicuticular wax per unit of leaf surface area, osmotic potentials of needles from lower and upper seedling portions, cuticular conductance, thickness of cuticular membrane, and wax surface features. A limited number of spring-planted 2+0 seedlings have also been investigated in the same manner for comparison.

**Expected Benefits:**

The project will produce information on the phenological consequences of using blackout in production of white spruce seedlings. It will evaluate the usefulness of the mitotic index as a tool for assessments of seedling status, and may result in recommendations for stock selection and nursery practices to produce seedlings best suited for planting in frost-susceptible areas. A problem analysis on cold hardiness testing was published in 1990.

**PROJECT 1.43:** *Cultural regimes for* Abies lasiocarpa *in northern latitudes*

**Project Leader:** A. Eastham

**Objectives:**

To develop growing regimes for 1+0 and 2+0 container stock of *Abies lasiocarpa.*

**Progress to Date:**

*Abies lasiocarpa* was sown in spring 1988 at the Forest Research Lab in Victoria. The treatments used on these seedlings were reduction of light intensity and application of growth hormones (a gibberellin [GA 4/7] and a cytokinin [BA]). The gibberellin treatment improved height growth of the seedlings. Reduced light intensity had no effect. Results were presented at the 9th Annual Meeting of the Forest Nursery Association of British Columbia in 1989.

*Abies* seed, stratified with the redry technique detailed in *FRDA Memo* 040, was grown and studied in a growth chamber experiment in 1989. This study separated temperature, light, and applied growth hormones to determine the importance of each in limiting *Abies* growth. It appears that low temperature and high humidity favour growth, and low to high light intensity is tolerated. A report on the 2-year results is being prepared.

**Expected Benefits:**

This study addresses the current difficulty in producing acceptable *A. lasiocarpa* seedlings, and is expected to improve the method for growing plantable 1+0 plug stock. If a plantable 1+0 stock cannot be achieved, optimized production regimes for 2+0 plug stock will be developed.

**PROJECT 1.45:** *Development of alternative growing media for forest nursery seedlings*

**Project Leader:** R. Scagel

**BCFS Contact:** T. Willingdon

**Status:** Completed

**Results:**

Experimental media and irrigation regimes undertaken by private forest nurseries were monitored during 1988. The seedlings from this survey have been outplanted at Surrey Nursery.

A selection of experimental media that had not been used in forest nurseries was loaded into styroblocks, and physical and chemical properties of the media were tested.

An operational trial was initiated to examine select media and tree species under operational conditions. Results of this study were demonstrated during a winter 1989/90 tour of northern Interior forest nurseries. The two most important qualities that growing media should have are good aeration and good water-holding capacity. The type of cultural regime used must also be considered when growing media are selected, since the same media can react very differently under different watering regimes.

**PROJECT 2.38:** *Evaluation of winterization regimes to improve culture, storability, and performance of western redcedar*

**Project Leaders:** C. Hawkins and J. Owens

**BCFS Contact:** R. van den Driessche

**Objectives:**

To determine the type and timing of darkout/drought regimes needed to shift seedling development from height growth to caliper and root development; to study the effect of darkout/drought regimes and subsequent temperature regimes on shoot apical mitotic activity, leaf initiation, and shoot and root development; and to determine if selected winterization regimes and preconditioning alternatives can improve redcedar storability and resistance to winter condition stresses.

**Progress to Date:**

Drought and/or short days were used in 14 treatments for dormancy induction of western redcedar container nursery stock. The stock was lifted mid-December and either planted in wet or dry raised beds, or placed in cold storage for 1 month and then planted.

The best height control at the end of the nursery phase was observed in seedlings from drought/short day treatments, while the least height control was observed in no drought/short day treatments. However, good height control was also accompanied by smaller root collar diameters.

No clear pattern emerged of the effect of nursery treatments after 1 year in raised beds. The seedlings grown in wet beds were larger than those in the dry beds. Stock that had been stored 1 month and then planted in wet or dry beds were larger than non-stored stock. This may have been a result of the stored stock being protected from poor environmental conditions, or of greater stress resistance in the cold-stored stock.

**Expected Benefits:**

Results will enable operational nurseries to validate regimes and decide whether changes in cultural practice are justified. *FRDA Report* 155 is available.

**PROJECT 2.63:** *Colour publication of mineral nutrient deficiencies in container-grown Douglas-fir and white spruce.*

**Project Leader:** R. van den Driessche

**Status:** Completed/*FRDA Report* 100

**Results:**

The publication aids diagnosis of mineral deficiencies in container-grown Douglas-fir and white spruce. It contains colour photos showing mineral nutrient deficiency symptoms and information on adequate concentrations.

**PROJECT 3.17:** *Optimal seedling espacement for container-grown conifer seedlings*

**Project Leader:** D. Simpson

**Objectives:**

To determine the effects of nursery growing density (seedlings per square metre), container volume, and container dimension (diameter:depth) on the growth, both in the nursery and after field planting, of interior spruce, Douglas-fir, and lodgepole pine seedlings.

**Progress to Date:**

Interior spruce, Douglas-fir, and lodgepole pine seedlings have been grown in containers of various size to examine the effects of seedling growing density, container volume, and container shape. Field outplantings have been established at four sites for interior spruce and two sites for Douglas-fir. Two lodgepole pine plantations were established in May 1991, two more are to be established in May 1992.

A paper reporting the nursery and field results for interior spruce has been submitted for publication. The principal conclusions are:

1. Seedlings grown at higher densities showed decreased shoot and root weights, decreased stem diameters, and, in some cases, greater shoot heights.
2. Seedlings grown in larger volume containers were larger, although container volume and growing density interacted such that the effect of container volume was only evident at growing densities less than 568 seedlings per square metre.
3. On forest planting sites, larger seedlings had greater absolute growth. However, mean relative growth rates of seedlings were unaffected by nursery growing density or container shape.
4. The time required for planted seedlings to reach a free-growing size (1.5 m height) is shortened by approximately 1–2 years when larger planting stock is used.

**Expected Benefits:**

Results of this work is expected to give nurserymen a better understanding of how seedling size is affected by container size, and silviculturists a better understanding of how seedling size affects the growth of planted seedlings.

**PROJECT 3.18:** *Day length and drought effects on shoot and root growth of container-grown interior Douglas-fir, lodgepole pine, and western larch*

**Project Leader:** D. Simpson

**Objectives:**

To determine the effects of night length extension and drought on seedling morphology and physiology in interior Douglas-fir, lodgepole pine and western larch.

**Progress to Date:**

Experiments were undertaken to examine the effects of drought and night length extension on Douglas-fir seedling growth, dormancy, and cold hardiness.

The results of the Douglas-fir experiments have been reported in *FRDA Report* 151. Long-nights and moisture stress affect Douglas-fir seedling growth, cold hardiness, dormancy and root growth potential. The main findings were: 1) long-night treatment (16 h for 4 weeks) reduced height growth by causing the formation of resting terminal buds and moisture stress caused a slight reduction of stem diameter growth; 2) long-night treated seedlings were more cold hardy than controls and moisture stress had no effect on cold hardiness; and 3) long-night treated seedlings were less dormant and had higher root growth potentials following overwinter cold storage.

These results indicate that long-night treatments were clearly effective in preparing seedlings for overwinter storage. Experiments are under way to determine the effects of extended night length on the growth, dormancy, and cold hardiness of lodgepole pine and western larch.

**Expected Benefits:**

The use of long-night regimes to induce budset and terminate shoot growth is expected to benefit root growth potential and seedling quality in general.

**PROJECT 3.43:** *Use of fog misting to improve root quality in container-grown Douglas-fir and Engelmann spruce*

**Project Leader:** G. Hunt

**BCFS Contact:** D. Simpson

FRDA REPORT

**Status:** Completed/*FRDA Report* 111

**Results:**

The project, completed in 1989, was aimed at determining whether misting can be used to decrease the frequency of saturation watering, thereby improving growing medium aeration. Short-duration, fine-droplet water mists were applied to container-grown Engelmann spruce and interior Douglas-fir at intervals of 20 or 30 minutes, for 17 days when daily air temperatures exceeded 30°C. Seedling growth, water loss from styroblocks, and mycorrhizal colonization were assessed. A misting frequency of 20 minutes resulted in up to 36% reduced water loss from containers. Misting may indirectly alter growth of spruce by affecting mycorrhizal colonization; growth of Douglas-fir was not affected. When applied properly, misting does not increase the risk of foliar disease.

**PROJECT F52-31-004:** *Bud and shoot development in different seedling types of western hemlock during nursery growth*

**Project Leader:** J. Owens

FRDA REPORT

**Status:** Completed/*FRDA Report* 053

**Results:**

Three papers have been submitted to journals for publication. Short day (8-h) treatments in July/August of western hemlock container-grown seedlings were much more effective in controlling shoot growth and stimulating terminal bud development than were moisture stress treatments. A sequel (F52-41-016) to this project followed the growth of these seedlings on two Vancouver Island sites to determine which morphological and anatomical seedling characteristics best correlated with 1st-year field performance.

**PROJECT F52-41-005:** *Dieback of container-grown Douglas-fir seedlings: Phase 1*

**Project Leader:** S. Barnes

FRDA REPORT

**Status:** Completed/*FRDA Report* 142 (See Project F52-41-104)

**Results:**

Investigations into the factors causing dieback in con-

tainer-grown Douglas-fir seedlings revealed that peat source, perlite, vermiculite, and slow release fertilizer had no significant effect on its incidence. Dieback appeared to increase with hot sunny weather. Temperature alone, however, could not explain the high block-to-block variability that was evident in dieback incidence. Dieback's major initial impact was on root, not needle, growth. Nutrient concentrations did not indicate ammonium or aluminium toxicities, anaerobic growing medium conditions, or insufficient transport of calcium or boron to needle tips. A complex of *Pythium* species was consistently isolated from the roots of dieback seedlings.

Dieback was significantly reduced by sterilization of the growing medium, although the effectiveness of sterilization decreased at high growing medium temperatures. The study results suggest that the presence of *Pythium*, coinciding with unfavourable cultural regimes such as high medium temperatures and imbalanced ammonium-to-nitrate ratio, causes dieback.

**PROJECT F52-41-007:** *Dieback of container-grown Douglas-fir seedlings: associated microclimate*

**Project Leader:** M. Peterson


**Status:** Completed/*FRDA Report* 035 and *FRDA Memo* 046

**Results:**


This study evaluated the role of growing medium temperature on Douglas-fir needle tip dieback. Results indicate that high media temperatures may significantly contribute to phenomena such as Douglas-fir needle tip dieback. Recommendations for reducing the risk of high media temperature damage to conifer seedlings include:

- using peat with good water absorption and retention characteristics;
- maintaining sufficient moisture levels in containers to reduce the risk of extreme soil temperatures, while still minimizing the risk of damping-off fungi;
- avoiding the use of a dark-coloured grit cover (lighter granite-type grit will reflect more incoming solar radiation, thus promoting a lower soil temperature); and
- using the equation, soil temperature = 1.4 x ambient (°C) - 5.8°C, to provide an estimate of the soil temperature likely to be reached within 15 minutes. The rule-of-thumb — soil temperature = 1.25 ambient temperature — may also be used within the 30–40°C air temperature range. If excessively high temperatures are predicted, compensating measures such as watering or using shade cloth should be implemented immediately where possible.

**PROJECT F52-41-016:** *Bud and shoot development in different seedling types of western hemlock during the 1st year of field establishment*

**Project Leader:** J. Owens


**Status:** Completed/*FRDA Report* 091

**Results:**

Western hemlock seedlings were subjected to different nursery regimes during the 1st year of growth on a coastal wet and a dry site. Subsequent field performance was then monitored. Seedlings treated to short days (8 h) in the nursery did not grow as well in the field as those that had been grown under long (natural) day lengths. Use of moisture stress alone to control shoot growth in the nursery had no negative effect on 1st-year growth of western hemlock in the field.

**PROJECT F52-41-104:** *Dieback of container-grown Douglas-fir seedlings: Phase 2*

**Project Leaders:** S. Barnes and L. Husted


**Status:** Completed/*FRDA Report* 142 (See Project F52-41-005)

**Results:**

Investigations revealed that *Pythium* oospores, obtained from cleared dieback roots, invaded root tissue of Douglas-fir germinants *in vitro* and *in vivo* and caused dieback symptoms. Oospores isolated from inoculated dieback seedlings were similar to oospores of the original inoculum cultures. Toxins and chemical or physical properties of the medium are not major contributors to dieback. If contamination of the growing medium has occurred, dieback develops under a variety of growing conditions. Possible sources of *Pythium* inoculum in a nursery include peat, water, air-borne spores, and used styroblocks. Other coniferous species inoculated with *Pythium* did not develop dieback symptoms. This may have reflected the poor growing conditions of this experiment.

**PROJECT F52-41-108:** *Effects of low soil temperatures and styroblock design upon the root growth and seedling vigour of white spruce and lodgepole pine*

**Project Leader:** D. Lavender

**Forestry Canada Contact:** J. Arnott

**Objectives:**

To determine the effects of a range of soil temperatures (3, 10, and 17°C) on root growth of white spruce and lodgepole pine; to determine whether alternative container design will promote increased root growth in the upper portion of the root plug after outplanting; to determine the effect of rough handling (simulated by dropping seedlings 15 times from a height of 3 m) on the root growth of seedlings;

and to determine the effect of daily photoperiod during cold storage on the ability of white spruce and lodgepole pine seedlings to grow roots when planted in soils at the above temperatures.

**Progress to Date:**

First-year results for the objectives showed that root growth was greatest at the highest temperature. Root growth of lodgepole pine increased linearly with temperature, but for white spruce the increase was greater from 10 to 17°C than from 3 to 10°C. The majority of root growth occurred at the lower end of the root systems, regardless of the modifications to the design of the styroblock cavity.

Rough handling of boxed seedlings did not affect subsequent growth of seedlings right out of cold storage. However, the same type of rough handling did decrease growth of seedlings hot-lifted, such as those lifted for summer planting.

The use of a daily photoperiod during cold storage affected the timing of bud flush once the seedlings were taken out of storage and put into growing conditions. Seedlings treated with light during storage had more rapid budbreak than those with no light treatment.

A final report will be available in Fall/Winter 1991.

**Expected Benefits:**

Through this work, the effects of nursery factors that influence root growth after outplanting are expected to be clarified.

**PROJECT F52-41-124:** *Improvement of western redcedar seedling fall planting through nursery cultural manipulation*

**Project Leader:** S. Grossnickle

**Forestry Canada Contact:** J. Arnott

**Objectives:**

To increase the drought resistance and frost hardiness of western redcedar seedlings through modification of nursery cultural regimes; and to enhance fall establishment of western redcedar in the field, to improve seedling growth in the spring.

**Progress to Date:**

Western redcedar container stock was grown at the Pacific Forestry Centre under standard cultural nursery regimes and dormancy induction regimes that used shortened daylength and/or drought stress from mid-July to September 1, 1989. A series of stock quality assessment tests was performed before this stock was outplanted in the fall of 1989 and spring of 1990.

Seedlings treated with short days in the nursery had a greater level of frost hardiness throughout the subsequent fall, winter and spring. Those seedlings grown under standard cultural nursery regimes had the poorest drought avoidance characteristics. Fall-planted seedlings that had been subjected to shortened days in the nursery also grew more than seedlings that had received the standard cultural nursery regime.

This project has continued through 1990/91 with funding from the Coastal Regeneration Industrial Cooperative (CRIC).

**Expected Benefits:**

Nursery practices that provide western redcedar stock with an improved drought resistance and frost hardiness are expected, and these will improve fall planting success.

## DROUGHT

**PROJECT 2.20:** *Testing planting stock for drought resistance*

**Project Leader:** R. van den Driessche

**Objectives:**

To examine the relative importance of drought resistance to seedling survival following planting, and to devise ways of increasing drought resistance by modifying nursery regimes.

**Progress to Date:**

Effects of container nursery temperature and of stock drought stressing during summer have been investigated. Lower temperature and drought stress in July and August were both shown to increase drought resistance in Douglas-fir, lodgepole pine, and white spruce. The stock produced in these treatments was planted into sand beds under controlled moisture conditions, and survival of all three species was influenced by nursery conditioning treatment. Two papers on the results are to be published in *Canadian Journal of Forest Research.*

One-year-old container seedlings of Douglas-fir and lodgepole pine, representing wet site and dry site provenances, have been grown in 1 m tall containers so that root development can be examined. Preliminary evidence suggests that dry site provenances have greater total root length than wet site provenances. To improve our understanding of what controls new root growth within the seedling at time of planting, $CO_2$ uptake was studied with infra-red gas analysis equipment. New root growth of 1+0 container Douglas-fir is reduced 70–80% by lack of $CO_2$, in the presence of light. This work shows that active photosynthesis is essential for rapid establishment, and that carbohydrate reserves do not play a major part in new root growth over the short term. A paper on the results is to be published in *Tree Physiology.*

Measurements of water use efficiency, a factor that determines the ability of seedlings to continue to grow under droughty conditions, is in the process of examination, and the infra-red gas analysis system is being modified to improve measurement of water vapour exchange.

**Expected Benefits:**

This study provides information on how container nursery regimes may be modified to improve drought resistance of planting stock. It will also provide information on what characteristics are important in stock to be planted on dry sites. *FRDA Memo* 148 is available.

**PROJECT 2.21:** *Seasonal course of water loss from conifer leaves*

**Project Leader:** J. Worrall

**Status:** Completed in 1988

**Results:**

In spruce, the period from budburst to completion of shoot growth does not appear to be prone to excessive water loss, despite the incompletely developed cuticles of growing leaves and the large quantity of water consumed from soil held at field capacity.

An experiment to investigate environmental factors important in stomatal behaviour compared the morphological and physiological differences between natural and container interior spruce stock grown in soil held at field capacity. Both the morphology and physiology were significantly different between the two stock types, with the result that container stock used water at twice the rate of natural stock. These findings suggest that the stomata on the container stock tend to be open more often than is prudent.

**PROJECT 3.15:** *Effect of Agro-bacterium rhizogenes on root development and drought avoidance in interior Douglas-fir bareroot planting stock*

**Project Leader:** D. Lavender

**BCFS Contact:** D. Simpson


**Status:** Completed/*FRDA Memo* 168

**Results:**

The project was completed in 1988. Douglas-fir seedlings whose roots have been exposed for varying periods of time to cultures of the bacterium were outplanted in the UBC forest nursery and near Savona. The plantations were monitored for mortality and growth for two growing seasons. There was no evidence that the bacterium was able to colonize seedling root systems. Seedlings treated with the cultures, with or without bacterium present, showed poorer growth and had lower survival than the control populations.

**PROJECT 3.16:** *Hydrophylic polymers: their use with interior Douglas-fir and lodgepole pine*

**Project Leader:** D. Lavender

**BCFS Contact:** D. Simpson


**Status:** Completed/*FRDA Memo* 169

**Results:**

Hydrophylic gels were added to the rooting medium of container-grown Douglas-fir and lodgepole pine seedlings to determine if effectiveness of dormancy enduring drought treatments and outplanting success would be affected.

Applications of any of three hydrophylic gels failed to increase the survival or growth of seedlings of either species when planted in nursery or field conditions. Rodent and overwinter damage greatly affected survival of the seedlings planted in the field. The hydrophylic gels increased the water-holding capacity of the rooting medium, but did not increase the time between irrigations.

## SEEDLING QUALITY

**PROJECT 1.30:** *An investigation of the effect of non-refrigerated handling on stock quality of post cold-stored containerized white spruce seedlings*

**Project Leader:** W. Binder and P. Fielder


**Status:** Completed/*FRDA Memo* 149

**Results:**

The intensity and duration of temperature during pre-planting treatment modified seedling growth and survival measured one season later. The effect of pre-planting heat treatments on seedlings increased shortly after planting, with the greatest changes occurring within the first 63 days. Seedling damage and decreases in growth and survival at the higher temperatures are considered to be the result of whole or partial impairment of physiological processes. Exposure of seedlings to 40°C for 48 and 72 h before planting resulted in 50 and 100% mortality, respectively, at harvest time the following February. Exposure to 30°C for 72 and 96 h resulted in 25 and 40% mortality, respectively, at harvest time. Mortality was less than 8% after pre-planting exposures of up to 96 h at 5, 10, and 20°C. Shoot extension, stem diameter, and total seedling dry weight at harvest time were significantly affected after pre-planting exposure times longer than 24 h at 40°C and 48 h at 30°C. However, no significant effect on growth was seen in seedlings exposed to pre-planting treatments of up to 96 h at 5, 10, and 20°C.

Furthermore, no visible symptoms of injury were expressed at harvest time in planted seedlings exposed to pre-planting treatments of 5, 10, and 20°C up to 96 h and for 30°C for up to 48 h. Physiological changes were, however, detected in seedlings exposed to these treatments, notably their response to freezing temperatures ($I_{50}$) and the cell division that occurred in terminal apices (mitotic index). Despite observations of no injury at 10 and 20°C for the maximum 4-day treatment, exposure of boxed seedlings to temperatures above 10°C, for any duration, is not recommended.

Tissue electrolyte leakage, hydrolase-class enzyme activity, and root growth potential were found to be useful for detecting heat damage of white spruce seedlings before field planting. Bud respiration and mitotic index were not useful.

**PROJECT 1.31:** *Correlation of physiological and morphological assessments in white spruce seedlings to RGC and chlorophyll fluorescence*

**Project Leader:** C. Hawkins

**BCFS Contact:** D. Draper


**Status:** Completed/*FRDA Report* 064, *FRDA Memos* 018, 022

**Results:**


Three germination temperature regimes using underbench and overbench heating were used to grow an interior spruce seedlot at Red Rock Research Station in 1987. The crop was lifted and placed in freezer storage in November 1987. Two of the treatments were summer-planted in 1987 south of Prince George (FRDA 1.01 site) and a matching spring plant was done in 1988. All treatments were spring-outplanted in 1988 at Red Rock.

The results from the nursery trial led to modifications in white spruce cultural regimes at Red Rock. To speed up germination, 20°C for 24 h per day is being used for the first 5 days of the germination period. To encourage early control of crop growth and minimize heating costs, 20/11°C for the 12/12 h day/night regime is being used for the remaining 23 days of the germination period.

**Expected Benefits:**

Information about the effect of operational nursery procedures on seedling storability, growth, and survival will allow nursery staff to refine stock production, handling, and planting techniques.

**PROJECT 2.02:** *Determination of minimum root growth capacity (RGC) and stress resistance requirement for coastal Douglas-fir*

**Project Leader:** R. Scagel and G. Krumlik


**Status:** Completed/*FRDA Memo* 172

**Results:**

The study found that the RGC test did not live up to its reputation as an accurate predictor of outplanting survival and growth for coastal Douglas-fir. In operational plantations, planting quality, planting microsite, and microsite preparation were stronger determinants of survival and growth. Physiological and developmental explanations for the apparent lack of relation between RGC and outplanting survival are being investigated. In the interim, RGC should be used cautiously and in conjunction with other indicators of seedling performance.

Results of this research were published in the proceedings of the combined meeting of the B.C. and U.S. Intermountain Forest Nursery Associations held in Vernon in August 1988, and in *Solutions*, Vol. 2, No. 2, 1988. A paper has been submitted to a research journal.

**PROJECT 2.19:** *Variable chlorophyll fluorescence induction analysis as an indicator of tree seedling stock quality*

**Project Leader:** W. Vidaver

**BCFS Contact:** W. Binder

**Objectives:**

To test whether variable chlorophyll fluorescence emission ($F_{var}$) can predict the quality of seedlings following their handling and storage in the nursery; and to develop a method for its use in the nursery, greenhouse, laboratory, and field.

**Progress to Date:**

Physiological data on the performance of nursery-grown seedlings before lifting show that $F_{var}$ is a reliable indicator of seedling response to drought, short daylength, and low temperature. As well, results have demonstrated the effectiveness of $F_{var}$ assessment in determining seedling status in relation to stress-induced damage. Operational testing of a commercial prototype variable chlorophyll fluorometer started in May 1989 in three nurseries. Several journal articles describing $F_{var}$ assessment and the underlying physiology were accepted and a number of related papers and posters were presented at scientific meetings. A comprehensive handbook entitled "A Manual for the Use of Variable Chlorophyll Fluorescence in the Assessment of the Ecophysiology of Tree Seedlings" will be produced.

**Expected Benefits:**

The manual will provide nursery personnel, nursery managers, and researchers with information on variable chlorophyll fluorescence for the assessment of seedling physiological quality. It describes the fluorometer system, instructs in its use, gives protocols for the acquisition of data, and provides assistance in the interpretation of data. The manual will also explain the physiological basis of $F_{var}$ assessment and provide seasonal base-line examples for this physiological assessment.

**PROJECT 3.09:** *Interpretation of stock quality monitoring data: root growth capacity standards for the Southern Interior — Kamloops, Cariboo, Nelson*

**Project Leader:** D. Simpson

**Objectives:**

To determine the relationships between pre-planting root growth capacity (RGC) and field performance for interior spruce, lodgepole pine, and interior Douglas-fir.

**Progress to Date:**

Between 1985 and 1987, 18 plantations were established on a range of forest sites in the southern Interior. Before planting, seedlings were tested for RGC. The number of new roots 10 mm or longer after 7 days in a growth chamber was recorded. Findings reported in the proceeding of the Western Forest Nurserymen Association meeting in Vernon, 1988, indicate that selecting planting stock that has RGC levels greater than an average of 10 roots per plant results in

higher survival and less variation in performance for pine and spruce. There seemed to be no relationship between RGC and survival in interior Douglas-fir. Further measurements have been taken and will be reported in 1991.

**Expected Benefits:**


This research will provide us with a greater understanding of the relationship between RGC and field performance. *FRDA Memo* 147 is available.

**PROJECT 3.14:** *Cold hardiness of conifer roots*

**Project Leader:** D. Simpson

**Objectives:**

To evaluate several existing methods and develop new methods of measuring root mortality caused by low temperatures; to examine the seasonal development and environmental control of root hardiness; and to investigate the effect of temperature on the repair of non-lethal damage caused by low temperatures.

**Progress to Date:**

Procedures to freeze roots of container-grown conifer seedlings have been developed and tested. Techniques evaluated for measuring root damage caused by freezing include: 1) polarographic measurement of oxygen consumption, 2) TTC reduction, 3) freeze-induced electrolyte leakage, and 4) plant water loss. The latter two methods, both measures of membrane damage, were found to be better measures of root mortality than the first two methods, which measure tissue respiration.

Cold acclimation by conifer seedling roots requires cold temperature exposure. This contrasts to cold acclimation of shoots which requires only long-night exposure. Current research is examining relationships between bud dormancy and root cold acclimation, de-acclimation of roots, and relationships between root cold hardiness and storability.

**Expected Benefits:**

The study is expected to improve our understanding of root hardiness and the appropriate techniques for measuring root hardiness. This will help in the development of nursery practices that minimize or avoid the severe overwintering damage experienced in the past. *FRDA Memo* 014 is available.


**PROJECT F52-41-008:** *Analytical techniques for assessing stress/injury*

**Project Leader:** C. Hawkins

**Forestry Canada Contact:** J. Arnott

**Objectives:**

To assess and calibrate the stress-induced volatile emission (SIVE) analysis system using three stresses: drought, freezing and rough handling; to develop a series of fingerprint traces for Douglas-fir; and to determine whether these fingerprints change as trees come out of dormancy or because they have been in cold storage.

**Progress to Date:**

The SIVE technique uses gas chromatography to measure the levels of certain gases (such as acetaldehyde, ethane, ethanol, or ethylene) which are released in response to a given stress by plant tissues. *FRDA Report* 084 outlines the techniques used. The SIVE technique can give results within a day, making it one of the quicker means of seedling assessment. However, the number of samples processed will be limited as long as a gas chromatograph (GC) is being used as a multi-gas screening instrument. Non-destructive screening protocols must be developed which are based on a single gas. The best candidate appears to be ethanol, which correlated well with freeze/stress events and other more conventional seedling quality assessment protocols.


The data presented in the final project report (to be published in the fall of 1991) indicate that the SIVE technique is going to be a powerful seedling assessment tool in forest regeneration.

**Expected Benefits:**

A routine stress test, employing the SIVE system, is expected to be developed for operational stock testing.

**PROJECT F52-41-010:** *Ecophysiological assessment of operational and improved seedling stock types in coastal forest regeneration programs in coastal British Columbia*

**Project Leader:** S. Grossnickle

**Forestry Canada Contacts:** J. Arnott and R. Whitehead

**Objectives:**

To examine the physiological and morphological attributes of operational and improved stocktypes during and just after the nursery development phase; to examine the physiological and morphological attributes of various stocktypes of coastal conifer seedlings, and to make an assessment of their performance under controlled environmental conditions; to examine the physiological and morphological response of various stocktypes to field microclimatic conditions during the three phases of seedling establishment; and to link the performance of various stocktypes to nursery assessments and controlled environment conditions under field site conditions.

**Progress to Date:**

In 1987, western redcedar and western hemlock seedlings were treated with a variety of nursery cultural regimes for dormancy induction. A testing regime was used on this stock, including such tests as needle and root surface area, root growth capacity, frost hardiness, osmotic potential, needle resistance, and morphological assessment.


Results from these tests showed that short-day dormancy induction treatments as used in this experiment produced the best overall stock performance for western hemlock and that moisture stress was best for western redcedar. Results are presented in *FRDA Report* 069.

The western hemlock seedlings from these dormancy induction treatments were outplanted and seedling photosynthetic and water relation patterns were monitored in the first growing season. As also indicated from the nursery trials, the western hemlock seedlings from the short-day treatments appeared to have the best potential physiological response to the field site environmental conditions following two growing seasons on the field test sites. The testing procedures used provided a good overall picture of how the seedlings treated with different nursery cultural regimes responded to field conditions. The final report will be available in the Fall of 1991.

**Expected Benefits:**

The project will improve our understanding of the physiological response of various operational and improved stocktypes of western redcedar and western hemlock to field environmental conditions.

## NURSERY PEST MANAGEMENT

**PROJECT 1.06:** *Assessment of phytotoxicity and efficacy of fungicides for control of* Botrytis *gray mould on seedlings of white spruce and other conifers*

**Project Leader:** J. Sutherland


**Status:** Completed/*FRDA Report* 012 and *FRDA Memo* 039

**Results:**


This project tested six fungicides for control of *Botrytis* on five species of 1+0 container-grown conifers. The fungicides, listed in overall ranked order from greatest to least control, were iprodione, thiram, folpet, analzine, cichloran, and captan. This control ranking varied slightly between species. Some levels of phytotoxicity and *Botrytis* tolerance were noted with most fungicides.

**PROJECT 1.47:** *Trials with herbicides oxyfluorfen (Goal®) and napropamide (Devrinol®) and the fungicide benomyl (Benlate®) on container-grown conifer seedlings in British Columbia forest nurseries*

**Project Leader:** G. Shrimpton


**Status:** Completed/*FRDA Memos* 123 and 128

**Results:**

The fungicide benomyl applied as a drench did not control *Fusarium*- or *Cylindrocarpon*-caused root rot of container-grown conifer seedlings.

Oxyfluorfen at rates of 0.25 and 0.50 kg/ha appears to cause no injury to the conifer species tested, while offering good weed control before weeds become too large. Napropamide does not damage seedlings, but does not appear to provide effective weed control.

**PROJECT 2.29:** *Oxyfluorfen (Goal®) trials in British Columbia forest nurseries*

**Project Leader:** G. Shrimpton


**Status:** Completed/*FRDA Report* 092

**Results:**

At Surrey Nursery, oxyfluorfen was applied at 0.25, 0.50, and 1.00 kg a.i./ha before emergence or budbreak to 1+0 and 2+0 Douglas-fir and lodgepole pine bareroot seedlings; or at 3 and 6 weeks after emergence or budbreak. The 6-week post-emergence treatments gave minimal weed control since the weeds had grown to a size too large to control. The best treatments were pre-emergence or pre-budbreak applications of 0.25 kg. a.i./ha of oxyfluorfen, which were effective in controlling weeds but were not detrimental to any of the seedling types grown. Three-week post-emergence treatments had detrimental effects on growth and seedling densities in both conifer species.

Results have been submitted to Agriculture Canada and registration of Goal® is expected in 1–2 years.

**PROJECT 2.48:** *An update of the nursery pest manual*

**Project Leaders:** J. Sutherland, R. Sturrock, and G. Shrimpton


**Status:** Completed/*FRDA Report* 065

**Results:**

The 1980 manual has been revised to include life cycle diagrams and more pests. It will aid nursery staff in identifying and controlling disease and insect problems. Copies may be purchased from Crown Publications (386-4636).

**PROJECT 2.62:** *Styroblock sanitation trials*

**Project Leader:** M. Peterson

**BCFS Contact:** D. Brazier


**Status:** Completed/*FRDA Report* 140

**Results:**

Experiments were conducted in three trials where compounds or methods were examined for their sanitizing efficacy. The most effective methods for reducing fungal and algal propagules on used containers were: steam (95°C for 1 minute); heated soaps (Safer's *DeMoss* and Ivory soap, 10-second dip in a 5% solution at 80°C); bleach (10-second dip in a 0.5% solution buffered to pH 7.0); hydrogen peroxide (10-second dip in a 10% solution); sodium metabisulphite (10-second dip in a 5% solution); and sulphur dioxide fumigation. None of these treatments affected lettuce germination or growth.

**PROJECT F52-31-104:** *Gray mould control: seedling canopy humidity reduction through under-bench heating and styroblock aeration*

**Project Leader:** M. Peterson

FRDA REPORT

**Status:** Completed/*FRDA Report* 077

**Results:**

Coastal Douglas-fir seedlings were grown in Beaver Plastic Econoblock 160's at Canadian Pacific Forest Products Ltd. Three ventilated treatments plus a control (no ventilation) were used on these seedlings. For ventilation, holes were drilled through the styroblock at each four-cavity intersection. The ventilation treatments used were: 1) under-bench forced heated air; 2) under-bench forced unheated air; and 3) unforced air.

There was no difference in seedling size between treatments, but there was a large difference in amount of gray mould present: 75% of the control seedlings showed evidence of the infection, but only 25% of the seedlings in ventilated treatments did. Canopy-drying following watering in the ventilated treatments was about three times quicker than in the unventilated control.

**PROJECT F52-32-102:** *Additional analysis and extension and demonstration of gray mould control: seedling canopy humidity reduction through under-bench heating and styroblock aeration*

**Project Leader:** M. Peterson

**Forestry Canada Contact:** J. Sutherland

**Objectives:**

To provide further statistical analysis of the data set from project F52-31-104; and to prepare a slide show based on results from project F52-31-104.

**Progress to Date:**

Statistical analysis has been completed and a slide show has been prepared.

**Expected Benefits:**

Improved extension and demonstration of results from the gray mould project are expected.

**PROJECT F52-41-100:** *Monitoring the greenhouse environment to predict the need for or timing of fungicide applications for control of gray mould* (Botrytis cinerea) *on container-grown seedlings*

**Project Leader:** M. Peterson

FRDA REPORT

**Status:** Completed/*FRDA Report* 051

**Results:**

A curative fungicide program with sprays of captan (Captan®), chlorothalonil (Bravo 500®), and benomyl (Benlate®) was tried to combat *Botrytis*. The sprays were applied after conditions had been suitable for infection but before symptoms developed. This system was tried as an alternative to the protectant fungicide program which uses five or more spray applications and promotes strains of *B. cinerea* that show tolerance to fungicides.

Disease control was as good or better than that achieved under fixed schedule protection regimes. The best post-infective control was obtained with Captan® and Bravo 500® applied 24 or 36 h after an infection period.

Prediction of gray mould infection periods requires accurate estimation of times when relative humidity is high or there is free water on leaf surfaces.

## MYCORRHIZAE

**PROJECT F52-41-006:** *The effects of mycorrhizae fungi in coniferous nursery stock and reforestation success in Interior British Columbia*

**Project Leader:** G. Hunt

**Forestry Canada Contact:** J. Sutherland

**Objectives:**

To determine the effects of fertilization on mycorrhizae formation and growth of interior spruce, interior Douglas-fir, and lodgepole pine; to compare the effects of three genera of mycorrhizal fungi on seedlings of three species in a container nursery; and to evaluate the effects of three genera of mycorrhizal fungi on plantation performance of container seedlings of three species.

**Progress to Date:**

The establishment of mycorrhizal fungi in container seedlings has been enhanced by the use of a better quality peat, which allows good aeration of the growing medium, and less fertilizer. These changes have created conditions favourable for fungal inoculation.

Mycorrhizal stock has been outplanted at several sites in the Kamloops area and some seedlings have now had three growing seasons. *FRDA Memo* 029 presents initial results for outplantings near Kamloops and Merritt (Project 3.35-8). Further results will be published in the *Western Journal of Applied Forestry*. A FRDA report will be published late Fall 1991.

FRDA Memo

**Expected Benefits:**

FRDA Handbook

It is expected that the project may lead to development of inoculation regimes for mycorrhizal fungi that will enhance plantation performance in the southern Interior of British Columbia. FRDA Handbook 009 is available.

**PROJECT F52-41-109:** *Influence of soil temperature on the effectiveness of mycorrhizae in promoting white spruce seedling growth*

**Project Leader:** L. Husted

**Forestry Canada Contacts:** T. Trofymow

**Objectives:**

To examine the effects of soil temperature on the growth, physiology, and root development of mycorrhizal and non-mycorrhizal seedlings of white spruce by: 1) determining how soil temperatures affect white spruce seedling root growth and root colonization by northern and southern isolates of mycorrhizal fungi; and 2) comparing the tolerance of established northern and southern isolates of mycorrhizal fungi to different soil temperatures.

**Progress to Date:**

All experiments have now been completed. Growth and physiology assessments have been taken and the final data on mycorrhizal typing are being collected. The physiological experiments tested whether mycorrhizal inoculation affects early water uptake in outplanted seedlings. Other experiments tested the longer-term effects of mycorrhizae on nutrient uptake and seedling physiology when seedlings are grown in cold soils through droughty conditions.

FRDA REPORT

*FRDA Report* 144 is available.

**Expected Benefits:**

It is expected that the studies will improve our understanding of the relationship between soil temperatures and mycorrhizal establishment, and ultimately, to the growth of white spruce.

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