

FRDA Research Memo

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Miscellaneous

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A Summary of Growth and Yield Research

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INTRODUCTION

The \$200 million Canada–British Columbia Partnership Agreement on Forest Resource Development (1991–1996)—FRDA II—is jointly funded by the governments of Canada and British Columbia. The focus of this agreement is sustainable forest development through intensive forest management and integrated resource management. Also addressed are new initiatives in hardwood utilization, silviculture systems, and identification of product and market opportunities.

A key topic area in the research program supporting the agreement is growth and yield and stand tending. Nearly all growth and yield installations in British Columbia are in pure even-aged stands of the five or six major commercial species. As a result, significant gaps exist in our understanding of growth and yield, and we need additional data to be able to predict more accurately the yields of all commercial species for the range of silvicultural treatments. As well, we need data on stands that have several species, multiple ages, and more than one story. The focus of the Growth and Yield Research Program is to fill gaps in the province's matrix of long-term field

experiments (permanent sample plots) and to increase our basic understanding of biological processes through modelling.

Thirty-one projects have been implemented since the beginning of FRDA II in 1991. The B.C. Ministry of Forests (MoF) has implemented 15 of these projects; Forestry Canada has implemented 15. One project was jointly implemented.

Brief project summaries incorporating progress to September 30, 1993 are presented in this memo. Project details are available from project leaders (whose addresses are included at the end of this memo) or from Elizabeth Easton, Growth and Yield Program Administrator, Ministry of Forests, Research Branch, 31 Bastion Square, Victoria, B.C. V8W 3E7 (604) 387-8115 or Chris Hyde, Forestry Research Administrator, Canadian Forest Service, Pacific Forestry Centre, 506 Burnside Road West, Victoria, B.C. V8Z 1M5 (604) 363-0600.

Mention of trade names or products does not constitute endorsement by the authors, the B.C. Ministry of Forests, or the Canadian Forest Service.

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MIXED-SPECIES STANDS

BC-GY01 Dynamics of mixed-species stands

Project leader: Ian Cameron, MoF, Kamloops
Forest Region

Objectives:

To describe and quantify the patterns of stand development in mixed-species stand types in the ICHmc, ICHmv and IDF zones and subzones; to make appropriate recommendations about silvicultural treatments for these stands; and to collect data essential to the development of growth models for mixed-species stands.

Progress:

In the ICH, six large reconstruction plots have been measured and destructively sampled. Compilation of earlier reconnaissance data and reconstruction data has been completed. Techniques were developed to identify missing rings and to obtain true ages in birch samples.

In the IDF, 74 stand structure plots were measured in two 130 hectare areas. In all, approximately 1800 cores were collected for measuring tree age and/or diameter increment. In addition, measures of tree spatial distribution were made on 158 point samples.

Benefits and end products:

Results in the form of written reports will improve our understanding of stand dynamics in mixed-species stand types, and contribute to the development of growth and yield models for ICH and IDF mixed-species stands.

FC-GY12 Creating a database for modelling the growth of aspen and aspen-conifer stands.

Project leader: Mike Bonnor, Canadian Forest
Service, Pacific Forestry Centre

Objectives:

To assemble all permanent sample plot data relevant to modelling of growth and yield in aspen and aspen-conifer stands in British Columbia, and to create a clean and complete database.

Progress:

This 1 year project was completed in 1993.

Benefits and end products:

The database for aspen and aspen-conifer stands is available at the Pacific Forestry Centre for authorized modellers. It will be used to develop a mixedwood modelling system.

FC-GY13 Mixedwood growth and yield

Project leader: Kerry Deschamps, Canadian
Forest Service, Prince George

Objectives:

To develop a preliminary set of variable-density aspen yield tables and to measure and access the competitive effects of aspen on spruce height and diameter growth in the BWBS and SBS zones. To employ destructive sampling and stem mapping in data-deficient areas to meet short-term objectives and to develop permanent sample plot procedures and install permanent sample plots to meet longer-term objectives.

Progress:

The problem analysis has been completed and a working plan developed. A matrix for reconnaissance field sampling is still to be developed and permanent plot installations are to be established.

Benefits and end products:

A problem analysis and several scientific publications, along with first approximation variable-density yield predictions (either model or tables) for aspen and mixedwood aspen-spruce stands, will result from this research.

ROOT ROT IMPACTS

BC-GY02 Construction of managed stand yield tables for root rot infected stands of coastal Douglas-fir, & interior Douglas-fir, white spruce & lodgepole pine

Project leader: Ken Mitchell, MoF, Research Branch

Objectives:

To provide forest managers with managed stand yield tables covering a broad range of root rot infection levels, site classes, and silvicultural regimes.

Progress:

A computer model (ROTSIM) that simulates the spread, occurrence, and impact of laminated root rot has been linked to TASS, a computer model for the development of second-growth stands of coastal Douglas-fir. Data from permanent sample plots and plot summaries have been searched and organized to create a database of root rot information, which is located at the Ministry of Forests. TASS and ROTSIM have been upgraded to simulate plots of up to 10 hectares where plot simulations were previously limited to one hectare. A change in the operating system now allows the simulations to be performed more quickly. Trial yield tables for coastal Douglas-fir infected with *Phellinus* have been generated that combine mortality and growth losses from laminated root rot with initial stocking density, thinnings, stump removal, bridge tree removal, and planting of naturally resistant seedlings.

Benefits and end products:

The managed stand yield tables produced will quantify the yield loss or recovery associated with the intensity of infection, silvicultural regime, and site productivity. This will aid forest managers of root rot infected stands in assessing the cost of remedial silviculture treatments against the benefits of potential timber recovery.

BC-GY11 Construction, calibration, and validation of managed stand yield tables of root rot infected stands of coastal Douglas-fir

Project leader: Ken Mitchell, MoF, Research Branch

Objectives:

To provide forest managers with yield tables for pre-commercial plus commercially thinned infected stand conditions, across a range of site indices, espacement densities, stand infection conditions, treatment ages/heights, treatment densities, and host-tree symptomatic recognition classes. To provide an updated summary of laminated root rot monitoring plots used in the calibration and validation of the TASS-ROTSIM root rot model.

Progress:

This project was transferred to FRDA Project BC-GY02 in April 1992.

Benefits and end products:

The construction, calibration, and validation of managed stand yield tables for infected stands of coastal Douglas-fir help forest managers and silviculturists determine the impact of root rot on productivity in order to define and document the benefits of silvicultural treatments.

FC-GY06 Commercial thinning in stands infected with *Phellinus* root disease

Project leaders: Rona Sturrock, Canadian Forest Service, Pacific Forestry Centre
Gerry Fraser, Pacific Forest Products Ltd.

Objectives:

To determine the effect of commercial thinning on the incidence of *Phellinus* root disease in crop trees and the subsequent growth response of crop trees.

Progress:

A draft report on the commercial thinning trial has been prepared and reviewed. The report is now being prepared for publication as a FRDA report and will be available in 1994.

Benefits and end products:

Guidelines for commercial thinning in *Phellinus*-affected stands will be distributed in 1994/95. Disease spread and effects on crop trees will be monitored for at least the next 10 years.

SPACING AND SILVICULTURE SYSTEMS

BC-GY03 Provincial growth & yield experiments—coast

Project leader: Louise deMontigny, MoF,
Research Branch

Objectives:

To maintain and report on 20 coastal growth and yield field experiments (115 installations, 1500 plots), which study the effects of various silvicultural treatments (fertilization, thinning, espacement, and pruning) on tree and stand growth, and to establish new installations on the basis of the proposed B.C. Forest Productivity Council matrix, including pruning, mixed plantations at different espacements, and silvicultural systems trials.

Progress:

Three new pruning installations for western hemlock, western redcedar and Sitka spruce have been established as well as a mixed-species espacement trial for Douglas-fir and western redcedar. Remeasurement of select EPs and SMC plots is complete and the data for all the older EPs have been rechecked and corrected for anomalies. A file report, *Douglas-fir Fertilizer Decision Making for Industrial Use—6 Yr. Remeasurement*, summarizing data relating to Douglas-fir fertilization, has been produced by Reid Carter of REMTECH.

Benefits and end products:

The data will be summarized and analyzed to quantify tree and stand growth responses to treatments, to identify the best treatment levels, to calibrate and validate growth models, and to validate site index curves.

BC-GY04 Provincial growth & yield experiments—interior

Project leader: Wayne Johnstone, MoF,
Kalamalka Research Station

Objectives:

To establish stand management experiments, including pre-commercial thinning, espacement,

and silvicultural systems trials in the British Columbia interior.

Progress:

From 1991 to 1993, four pre-commercial thinning trials were established. A post-spacing ingress study in lodgepole pine was also established in the Nelson Forest Region. During this period, six espacement trials were established, and three trials were laid out for planting in 1994/95. In addition, a silvicultural systems trial for selection logging of dry-belt interior Douglas-fir was established in the Kamloops Region. Previously established plots have been maintained and measurements were completed as scheduled throughout this period. Reconnaissance for new study sites is ongoing, and several potential sites have been identified for use in 1994/95 and beyond.

Benefits and end products:

The established permanent sample plots will help foresters quantify tree and stand response to spacing treatments and different silvicultural systems, identify optimum treatments levels, validate site index curves, and calibrate growth models.

FC-GY09 Growth and yield of coastal montane forests under alternative silvicultural systems

Project leader: Nick Smith, MacMillan Bloedel
Ltd.

Objectives:

To establish Permanent Sample Plots within the Montane Alternative Silvicultural Systems (MASS) Research Project (FC-FR01).

Progress:

This portion of the larger project is expected to be completed in 1994.

Benefits and end products:

A permanent sample plot location and establishment data report will be completed at the end of the 1993/94 fiscal year.

FC-GY14 Response of uneven-aged interior Douglas-fir to alternative spacing regimes

Project leader: Peter Marshall, University of British Columbia

Objectives:

To characterize the impact of various spacing regimes on stand structure and form of residual trees and to provide an indication of response of dense pockets of uneven-aged Douglas-fir to various spacing regimes.

Progress:

Tagging and remeasurement of residual trees on each of the established installations is completed. Data entry and preliminary analysis will be completed by the end of the 1993/94 fiscal year.

Benefits and end products:

A report documenting the impact of various spacing regimes on the structure and form of the residual Douglas-fir trees and on the growth, stem form, crown form, and stand structure response to the various spacing regimes will be published upon completion of the project in 1995.

FC-GY15 Evaluation of growth response to silvicultural treatments in coastal Douglas-fir.

Project leader: Holger Brix

Objectives:

To complete the Shawnigan Lake study of 18 year effects of thinning and fertilization on tree biomass production and nutrient content.

Progress:

The literature review and the chemical analysis of biomass samples have been completed.

Benefits and end products:

A file report analyzing and summarizing the collected data will be available at the end of the project in March 1994. A formal publication will be prepared in 1994.

NUTRITION AND FERTILIZATION EFFECTS

BC-GY05 Provincial growth & yield experiments—nutrition

Project leader: Rob Brockley, MoF, Kalamalka Research Station

Objectives:

To examine the nutrient status of forests in the British Columbia interior and to document the effects of various fertilization treatments on the nutrition, growth, and yield of major interior tree species. Three types of research trials are being established to achieve these objectives: 1) screening trials; 2) standard, fixed-area plot trials; and 3) "maximum productivity" fixed-area plot trials. The latter trial type involves repeated fertilization throughout the rotation in order to explore the upper limits to the productivity of forest sites in the British Columbia interior.

Progress:

After extensive site reconnaissance in 1991, five standard fixed-area plot trials (2 Pl, 3 Sx) and one maximum productivity trial were established in the 1992 field season. A further four standard, fixed-area plot trials (1 Sx, 1 Pl, 2 Fdi) and one maximum productivity trial were established in 1993. Over the past 3 years, scheduled remeasurements have been conducted in 34 previously established fertilizer screening trials and fixed-area trials. In addition, fundamental research has been conducted to examine the processes controlling sulphur availability and uptake in lodgepole pine stands in the B.C. interior.

Benefits and end products:

The established fertilizer research trials will be used to quantify tree and stand response to fertilization treatments, develop operational fertilization prescriptions, and improve our understanding of forest nutrition in Interior stands. In addition, FRDA Report No. 184, *Response of thinned, immature lodgepole pine to nitrogen fertilization: six-year growth response*, was published in the spring of 1992. Another manuscript was published in the Canadian Journal of Forest Research in 1992, and two others have been accepted for publication in 1994. In 1992, two manuscripts were published in the

symposium proceedings, *Forest fertilization: sustaining and improving nutrition and growth of western forests*.

BC-GY09 Fertilization and thinning effects on a Douglas-fir ecosystem at Shawnigan Lake: a synthesis of results

Project leader: Holger Brix

Agency Contact: Louise deMontigny, MoF,
Research Branch

Objectives:

To summarize and integrate results of the Shawnigan Lake project with regard to the effects of stand thinning (three levels) and nitrogen fertilization (rate, source, and refertilization) on growth, wood quality, biomass, growth partitioning, soil chemistry, fate of nutrients, nutrient cycling, soil and tree water relations, and growth processes as affected by internal and external conditions. This will aid in identifying critical factors for possible inclusion in growth models for managed stands.

Progress:

The review and summary of results from approximately 70 project reports was completed in March 1992.

Benefits and end products:

FRDA Report No. 196, *Fertilization and thinning effect on a Douglas-fir ecosystem at Shawnigan Lake: a synthesis of project results*, was produced in May 1993. This report will assist foresters in identifying critical factors for growth prediction and operational forest management.

FC-GY10 The fate and efficacy of nitrogenous fertilizer applied in a Douglas-fir plantation.

Project leader: Caroline Preston, Canadian
Forest Service, Pacific Forestry
Centre

Objectives:

To ascertain the amount and distribution of a defined application of ¹⁵N-labelled urea fertilizer in trees, understory, litter, and soil, 10 years after

application at operational levels. These findings will then be combined with results from two other long-term studies.

Progress:

All samples from the field have been collected and processed. A pot trial is in progress using Douglas-fir seedlings in the greenhouse. This will assess the availability of residual fertilizer ¹⁵N in LFH and mineral soil. All analyses are expected to be completed by the end of the 1995 fiscal year.

Benefits and end products:

A FRDA report and several scientific papers will provide the first comprehensive picture of what happens to fertilizer applied in a Douglas-fir ecosystem. The results will also be presented at various workshops, conferences, and tours.

FC-GY11 Studies in Forest Fertilization

Project leader: Holger Brix,

Objectives:

To propose experiments with fertilization of western hemlock that will assist in developing better fertilizer prescriptions for this species.

Progress:

This was a 1 year project for 1992/93 only. The western hemlock fertilization review and research proposal was completed by July 15, 1992.

Benefits and end products:

This project was published as FRDA Report No. 201, *Review of western hemlock growth response to forest fertilization and proposals for new studies*, in January 1993.

FC-GY16 Douglas-fir fertilization decision-making for industrial use: six year response

Project leader: Eleanor R.G. MacWilliams,
Forest Biometrics Consultant

Agency contact: Mike Bonnor, Canadian Forest
Service, Pacific Forestry
Centre

Objectives:

To determine individual Douglas-fir responses to the application of N, based on basal area, height, and volume growth over time and to interpret the results and make recommendations on the Douglas-fir site and stand types suitable for fertilization.

Progress:

This is a one year project taking place in 1993/94. As of September 30, 1993, the database containing information collected from an extensive fertilization experiment established by Reid Carter and Karel Klinka had been prepared for analyses.

Benefits and end products:

A FRDA research memo summarizing results and stating recommendations will be published in 1994. A scientific journal article is also expected to be published.

WESTERN HEMLOCK STANDS

BC-GY07/FC-GY03 Comprehensive, value-based management of second-growth western hemlock forests

Project leaders: Bob Kellogg
Bob Kennedy, University of
British Columbia

Agency contact: Ken Mitchell, MoF, Research
Branch

Objectives:

To develop a detailed working plan and budget for a comprehensive research proposal for growth and yield modelling of second-growth western hemlock, founded on a value-based methodology and analysis.

Progress:

The detailed working plan was completed in January 1992.

Benefits and end products:

The final program proposal was completed and submitted to the Ministry of Forests and Forestry Canada in February 1992.

MODELLING NONTIMBER IMPACTS

BC-GY08 Predicting overstory and understory floristics, structure, and grizzly bear habitat value following logging of the Khutzeymateen watershed

Project leader: Tony Hamilton, Ministry of
Environment, Lands and Parks,
Wildlife Branch

Objectives:

To link timber growth and yield predictions in the Khutzeymateen watershed with a computer-based succession model for predicting future grizzly bear habitat and stand conditions for these scenarios by means of GIS. This model will aid in assessing the impacts of various logging and silvicultural scenarios across the Khutzeymateen landscape over time.

Progress:

The project was completed in March 1992.

Benefits and end products:

From the assessment of impacts, recommendations about future land uses in the Khutzeymateen were made to the provincial government. The model and link with GIS provide a template design that can be adapted to other integrated land use planning situations requiring growth and yield information. Technical reports are also available.

BC-GY13 Wildlife tree and woody debris module for an existing B.C. forest growth & yield model

Project leader: Jeff Stone, MoF, Research
Branch

Objectives:

To provide forest and wildlife managers with a decision tool for comparing silviculture options in terms of wildlife tree and woody debris production. The tool must be compatible with an existing growth and yield model for British Columbia.

Progress:

A summary of existing snag dynamics models from Oregon and Washington has been completed, and the mortality output of TASS (a growth and yield model) has been revised to provide snag recruitment information for existing snag dynamics models. A draft version of a transition matrix-type model of Douglas-fir snag dynamics (based on existing models in Oregon and Washington) has been created.

Benefits and end products:

This model will allow forest managers to incorporate compatible nontraditional value information into existing growth and yield models for British Columbia.

INTERIOR DOUGLAS-FIR STANDS

BC-GY12 PROGNOSIS management simulation experiments for Douglas-fir

Project leader: Catherine Bealle, MoF,
Research Branch

Objectives:

To evaluate PROGNOSIS Version 6.0 as a stand-development prediction tool for IDF conditions.

Progress:

As of September 1993, three study sites had been located, and the collection of stand structure and site data is approximately 75% complete.

Benefits and end products:

The results of the experiments will be reported in ministry publications, including site-specific recommendations on the application of PROGNOSIS for stand-development prediction. This research will also assist in the continued development of short-term guidelines and tools in support of stand-level silviculture in uneven-aged interior Douglas-fir stands.

FC-GY08 Uneven-aged interior Douglas-fir stand development and factors influencing tree and stand growth

Project leader: Paul Boudewyn, Canadian
Forest Service, Pacific Forestry
Centre

Objectives:

To improve our knowledge and understanding of tree and stand development of uneven-aged interior Douglas-fir stands and the factors influencing their growth, particularly crown characteristics and efficiency.

Progress:

Research on this project was originally implemented under the number FC-GY02 in 1991/92. FC-GY08 was implemented in 1992/93 and is intended to continue through 1994/95. Detailed crown, stem, and biomass data have been collected and added to a current University of British Columbia database. As of September 30, 1993 the foliar nutrient analyses of all the sample trees had been completed and the leaf area index measurements had been completed on a subset of the sample trees. In addition, a framework for analyzing the dataset collected for this study was developed.

Benefits and end products:

A detailed chronological database for the six PSPs and selected sample trees, along with clear, descriptive, and informative summaries of this database, will be available by mid-1994. At the end of the project in 1995, a scientific report will be available providing new knowledge about the growth characteristics of interior Douglas-fir and the factors that influence them.

LODGEPOLE PINE STANDS

BC-GY14 The dynamics of regenerating lodgepole pine stands

Project leader: Gordon Nigh, MoF, Research
Branch

Objectives:

To understand and model the spatial dynamics of regeneration and to relate these dynamics of

regeneration to the future development of stands of lodgepole pine.

Progress:

A working plan outlining the research methodology has been developed and appropriate sites have been selected. Data collection for the first year has been completed and the data are stored electronically. Data analysis is under way.

Benefits and end products:

Spatial-distribution models of regeneration will be developed and linked to existing growth models. This will aid in understanding their relationship to stand development and yield. A report and computer-simulation program will be made available and will be supported by workshops.

GROWTH MODELLING

FC-GY01 Growth Modelling of Important Commercial Species.

Project leader: Mike Bonnor, Canadian Forest Service, Pacific Forestry Centre

Objectives:

To develop a growth model compatible with the provincial inventory that will predict tree and stand growth at any stage of stand development for natural and treated stands, and to implement this model for western hemlock.

Progress:

Work to improve and demonstrate the Stand and Tree Integrated Model (STIM) for western hemlock continues. The improvements to STIM fall into two categories: 1) to improve prediction equations to yield satisfactory projections; and 2) to track and eliminate errors in the user interface and inconsistencies between the user interface and the core of STIM. Development of the mixed spruce–aspen model has been initiated.

Benefits and end products:

Operational growth models and documentation for western hemlock, aspen, spruce, and mixed aspen–spruce will be developed. These products will provide professional foresters in industry and

government with data and information for management planning and inventory updates.

SITE-GROWTH RELATIONSHIPS

FC-GY07 Relationships between site index, basal area increment, and ecological site quality for lodgepole pine and white spruce in the SBS zone

Project leaders: Reid Carter
Karel Klinka, University of British Columbia

Objectives:

To develop and test regression models to estimate immature lodgepole pine and white spruce site index and annual basal area increment in specific subzones and to examine the variation in leaf area in relation to these measurements.

Progress:

The duration of the project was from November 1991 to March 31, 1992.

Benefits and end products:

A report discussing the relationships among site index, basal area increment, and ecological site quality for lodgepole pine and white spruce in the SBS zone is on file with the Canadian Forest Service.

ADDRESSES OF PROJECT LEADERS AND CONTACTS

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