FRDA II
Program 3.0 – Research
B.C. Ministry of Forests Highlights and Accomplishments

FRDA Report 248
Canada - British Columbia Partnership Agreement on Forest Resource Development: FRDA II
FRDA II
Program 3.0 – Research

B.C. Ministry of Forests
Highlights and Accomplishments

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Rosalind Penty and Bill I'Anson researched, wrote, and edited the report.

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T.M. Communications designed and produced this publication.

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Preface

Forest management in British Columbia is constantly evolving as the search for more environmentally sound and sustainable forest practices continues at an unprecedented pace. This constant state of change presents forest resource managers with ever-increasing demands for new information and technologies. As a result, the requirement for extensive forest research has never been greater.

From 1991 to 1996, the Canada-British Columbia Partnership Agreement on Forest Resource Development: FRDA II provided $23 million for research into sustainable forest development, almost half of which was spent on provincially implemented projects. This funding allowed many long-term forest renewal projects initiated under FRDA I to continue. Many of these long-term research projects are now producing highly significant results as they enter their ninth or tenth year of operation. Tremendous strides have also been made in the areas of hardwood/mixedwood silviculture, vegetation management options, growth and yield, biodiversity, old-growth management, and environmental impact assessment.

FRDA II research contributed to a better understanding of forest ecosystems and their functions. This knowledge, in turn, facilitated the development of operational guidelines and more ecologically sensitive forest practices, which are now incorporated in the Forest Practices Code, providing better protection for our forest resources as well as greater certainty for the forest industry.

Research is the cornerstone of sustainable forest development. As new forest management issues arise in the years ahead, scientific investigations will continue to meet the challenge.

The following report highlights activities and accomplishments of FRDA II research projects conducted by the B.C. Ministry of Forests.

Larry Pedersen
Chief Forester
Co-Chair
FRDA II Management Committee
Contents

Acknowledgements ........................................................................ iii
Preface .......................................................................................... v

Introduction .................................................................................. 1

FRDA II Background ..................................................................... 1

Program 3.0: Research in Sustainable Forest Development .......... 2

Subprogram 3.1: Forest Renewal .................................................. 5

1. Conifer Plantation Establishment ............................................. 5

   Cold Weather Injuries to Interior White Spruce Seedlings ......... 6

   Soil Compaction and Seedling Root Development ................. 7

   Conifer Plantation Establishment Project List ....................... 8

2. Hardwood/Mixedwood Silviculture ......................................... 9

   Aspen .................................................................................. 10

   Paper Birch .......................................................................... 11

   Red Alder ............................................................................ 13

   Hardwood/Mixedwood Silviculture Project List ..................... 14

3. Vegetation Management .......................................................... 15

   Mechanical Site Preparation ................................................. 15

   Manual Methods of Vegetation Control ................................ 16

   Vegetation Management Project List ..................................... 17

Subprogram 3.2: Growth and Yield and Stand Tending ............... 21

1. Field Experiments .................................................................... 21

   Coast .................................................................................. 22

   Interior ............................................................................... 23

   Field Experiments Project List ............................................. 24

2. Stand Modelling ....................................................................... 24

   Dynamics of Mixed-species Stands ...................................... 25

   Modelling the Dynamics of Dead Trees .............................. 26

   Stand Modelling Project List ............................................... 27
Subprogram 3.3: Integrated Resource Management ........... 29

1. Biodiversity .................................................................. 29

   Maintaining Wildlife Diversity
   in Managed Coastal Forests ........................................ 29

   Conserving the Genetic Diversity of Conifers .............. 31

   Biodiversity Project List ............................................. 32

2. Old-growth Forests .......................................................... 33

   Invertebrate Diversity in Coastal Old Growth ............ 33

   Carbon Cycling in Coastal Old-growth Forests .......... 34

   Old-growth Forests Project List .................................. 35

3. Environmental Impacts .................................................... 35

   Stuart-Takla Experimental Watersheds .................... 36

   Long-term Soil Productivity .................................... 37

   Environmental Impacts Project List .......................... 39
Introduction

FRDA II Background

The Canada-British Columbia Partnership Agreement on Forest Resource Development: FRDA II was a five-year (1991–1996), $180-million, 50/50 cost-shared agreement between the federal and provincial governments designed to support the sustainable development and integrated management of British Columbia’s forest resources. It was the follow-up agreement to the highly successful 1985–1990 Forest Resource Development Agreement (FRDA I), which concentrated primarily on backlog reforestation and labour-intensive forest management.

The main objectives of FRDA II were to build on the successes of FRDA I, enhance the environmental health of British Columbia’s forests, stimulate the economic and social benefits of forestry, and promote the sustainable growth of the forest industry by:

- improving the value, quality, and health of regenerating forests through stand tending
- improving current forest management practices
- identifying new or value-added forest products and markets
- integrating the management of all forest resources (timber and non-timber).

FRDA II consisted of seven major programs:

1. Sustainable Forest Development
2. Communications and Extension
3. Research in Sustainable Forest Development
4. Small-Scale Forestry
5. Opportunity Identification
6. Economic and Social Analysis
7. Coordination, Implementation and Evaluation

The following report highlights some of the activities and accomplishments carried out by the B.C. Ministry of Forests under Program 3.0: Research in Sustainable Forest Development. For a comprehensive list of products generated from this research, refer to the appendices of this report under separate cover. Although several FRDA II projects carry on research initiated under FRDA I, these appendices only report products funded by FRDA II.
Program 3.0: Research in Sustainable Forest Development

The FRDA II Research Program was responsible for developing information and technology to support progressive forest resource management and strengthen the scientific basis of sustainable development. This goal was achieved by focusing research on high priority knowledge gaps in each of five subprograms: Subprogram 3.1 – Forest Renewal; Subprogram 3.2 – Growth and Yield and Stand Tending; Subprogram 3.3 – Integrated Resource Management; Subprogram 3.4 – Forest Protection; and Subprogram 3.5 – Advanced Forest Technologies.

The B.C. Ministry of Forests (MOF) carried out research in three subprograms: Forest Renewal, Growth and Yield and Stand Tending, and Integrated Resource Management. Research under the subprograms of Forest Protection and Advanced Forest Technologies was the sole responsibility of the Canadian Forest Service (with the exception of a minor contribution from the province to the Forest Protection Subprogram). The Canadian Forest Service also carried out research under the Forest Renewal, Growth and Yield and Stand Tending, and Integrated Resource Management subprograms; however, federal FRDA II projects are not reported here.

The annual budgets for the three MOF-sponsored subprograms are listed in Table 1.

Table 1. Funding for provincial projects under Program 3.0: Research in Sustainable Forest Development

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Joint federal/provincial research projects were conducted as much as possible and information was shared on an ongoing basis. Many FRDA II research projects were connected or coordinated with other ongoing federal or provincial research initiatives outside FRDA II, or with universities, forestry associations, the private sector, and other agencies. Within FRDA II, the Research Program was linked with all other program areas, particularly the Sustainable Forest Development Program and the Communications and Extension Program.
Some important highlights of provincially sponsored research projects include significant advancements in mechanical site preparation; reduced environmental impacts of forest practices; and a better understanding of managing for biodiversity.
Subprogram 3.1: Forest Renewal

Prior to FRDA II, the primary focus of forest renewal research in British Columbia was to support conifer plantation establishment following clearcut harvesting. While the contributions of past research (for example, FRDA I) and accumulated field experience significantly increased conifer seedling survival and improved plantation growth, many knowledge gaps still existed. For example, additional research was required for: planting sites with severe climate and/or biological stress; developing optimum planting regimes to achieve free-growing status; and designing effective stock production and site preparation systems.

In addition to the need for more research into conifer plantation establishment, demands increased for scientific investigations into alternative silvicultural systems, management approaches for hardwoods/mixedwoods, and vegetation management options. These new demands on forest management served to focus the priorities of the FRDA II Forest Renewal Subprogram.

Research under the provincial component of the Forest Renewal Subprogram focused on three main themes: conifer plantation establishment, hardwood/mixedwood silviculture, and vegetation management. (Canadian Forest Service and MOF Silviculture Practices Branch were responsible for silvicultural systems under Program 1.0).

A total of 64 provincial projects were funded under the Forest Renewal Subprogram over the term of the FRDA II agreement: 16 under the theme of conifer plantation establishment, 13 under hardwood/mixedwood silviculture, 29 under vegetation management, and 6 under administration. For a complete list of products from the Forest Renewal Subprogram, refer to the appendices of this report under separate cover.

1. Conifer Plantation Establishment

Under FRDA I, substantial investments were made in establishing long-term “benchmark” projects to evaluate forest renewal options. A major priority of the conifer plantation establishment component of the FRDA II Forest Renewal Subprogram was to assess these long-term research installations to determine the biological efficiency and cost-effectiveness of various treatments in establishing free-growing plantations. Other research priorities focused on demonstrating and quantifying technical advances in seed research, genetic improvement, nursery culture, stock quality assessment, and plantation establishment and maintenance.
Cold Weather Injuries to Interior White Spruce Seedlings

Two research projects investigated cold weather injuries to interior white spruce seedlings:

- BC-FR.02 – Assessment of treatment options for backlog hardwood stands in the BWBS – Overwinter injury to planted white spruce in BWBS.
- BC-FR.05 – Post-planting injury to white spruce seedlings on cold and dry sites (desiccation and water relation studies).

The project leader for both studies was Marek Krasowski (MOF Red Rock Research Station, Prince George).

The goal of BC-FR.02 was to determine the timing of winter injury and identify the damaging factors (environmental and silvicultural) related to the injury. BC-FR.05 focused primarily on studying the ability of planted white spruce seedlings to use soil moisture on cold sites during freeze-thaw cycles. Leaf properties as they relate to transpirational water loss were also studied, along with the influence of nursery growing regimes (dormancy induction treatments) on seedling morphology and physiology.

Both projects established that injuries to planted white spruce seedlings were predominantly caused by freeze desiccation, which occurred mainly in late winter and early spring. Newly planted seedlings were affected more than older established seedlings, while naturally regenerated seedlings were affected much less.

The injury occurred as chinook winds depleted unsheltered sites of snow cover and subsequent low temperatures froze the exposed soil to a deep level. The fine-textured soils common in the Peace River area thawed slowly and the ground often remained frozen below five centimetres (rooting zone) until late spring. As the days become warmer, increasing evaporative demands rapidly desiccated the seedlings. Subfreezing night temperatures further delayed soil thawing, restricting water uptake from the soil except from the thin upper layer.

Container-grown seedlings rarely developed extensive root systems in the upper soil horizon during the first post-planting season, but instead grew their roots deep into the soil. “This is the most striking characteristic that differentiates container-grown seedlings from naturally regenerated ones that don’t suffer much from desiccation problems,” observes Krasowski. He recommends using planting stock capable of growing new roots in the shallow as well as deeper parts of the soil horizon, and suggests using mechanical site preparation to break up the heavy soils and facilitate thawing as practical preventative measures for overwinter injury.

Although substantial seasonal changes were found in the foliage water content of interior white spruce seedlings, these changes could not be directly linked to desiccation injury. However, the method for determining foliage water
content may replace frost hardness testing in evaluating the readiness of nursery seedlings for lifting.

BC-FR.02 and BC-FR.05 have produced numerous publications on overwinter injury, morphological and physiological responses to various levels of photoperiodic dormancy induction treatments, and techniques for evaluating seedling growth. Additional publications on water relations are being prepared for future release.

**Soil Compaction and Seedling Root Development**

Another interesting project with wide applications under the conifer plantation establishment theme was **BC-FR36 – Root development in relation to moisture supply and mineral nutrition.** This project focused on studying the root architecture of several conifer species, and assessing the impacts of soil compaction on root development and seedling growth.

Baseline data collection on how compacted soils affect seedling development began in 1992/93 with growth chamber trials on Douglas-fir and lodgepole pine seedlings. Preliminary results from these trials showed that mid to higher levels of soil compaction resulted in a short-term boost to shoot development, but significantly restricted root development.

Field trials on the effects of soil compaction on soil moisture and gas levels are ongoing at sites in Dawson Creek, Prince George, Smithers, and Williams Lake. These trials are in conjunction with a major FRDA II research project under the Integrated Resource Management Subprogram: **BC-IR31 – Long-term soil productivity study.** In compacted soils, carbon dioxide levels tend to increase while oxygen levels decline; this change in soil atmosphere can dramatically affect plant growth. To study the impacts of changes in soil atmosphere, a reliable method of sampling soil gases in the field was needed.

"We were interested in collecting accurate measurements of soil gases and correlating these with the level of soil compaction," explains project leader Bob van den Driessche (MOF Glyn Road Research Station, Victoria). To accomplish this, project team member Timothy Conlin developed a simple brass tube with a sealed PVC capsule inside for taking repeated gas samples. The device has worked very well, and soil atmosphere and moisture
measurements will continue at the soil compaction test sites until 1997. Due to the successful research conducted under BC-FR.36, additional studies have been initiated to assess the effects of compacted soils on the regeneration of aspen stands in northeastern British Columbia.

**Conifer Plantation Establishment Project List**

**BC-FR.01** Site stress x stock type stress resistance interactions on SBS NSR backlog sites.
Contact: Marek Krasowski  Phone: 963-9651

**BC-FR.02** Assessment of treatment options for backlog hardwood stands in the BWBS – Overwinter injury to planted white spruce in BWBS.
Contact: Marek Krasowski  Phone: 963-9651

**BC-FR.03** Assessment of treatment options and effects in rehabilitating dense, suppressed lodgepole pine stands.
Contact: Marty Kranabett  Phone: 847-7435

**BC-FR.05** Post-planting injury to white spruce seedlings on cold and dry sites (desiccation and water relation studies).
Contact: Marek Krasowski  Phone: 963-9651

**BC-FR.08** Establishing germination temperature optima for nursery seedling production of white spruce (*Picea glauca*).
Contact: Carole Leadem  Phone: 952-4130

**BC-FR.20** Application of DNA probes to the analysis of spruce introgression.
Contact: Alvin Yanchuk  Phone: 387-3338

**BC-FR.34** The use of photoperiodic cultural treatments to induce dormancy and bud formation of spruce in northern nurseries.
Contact: Chris Hawkins  Phone: 963-9651

**BC-FR.35** Drought resistance of conifer nursery stock treated with triazoles and ABA analogs.
Contact: Bob van den Driessche  Phone: 952-4124

**BC-FR.36** Root development in relation to moisture supply and mineral nutrition.
Contact: Bob van den Driessche  Phone: 952-4124

**BC-FR.37a** Evaluation of SMP efficacy in Shuswap Adams Low Seed Orchard.
Contact: Michael Stoehr  Phone: 952-4120

**BC-FR.37b** Assessment of genetic diversity in natural stands and plantations using DNA-based genetic markers.
Contact: Michael Stoehr  Phone: 952-4120
BC-FR46  Relationship between productivity and internal nutrient retranslocation.
Contact: Bob van den Driessche  Phone: 952-4124

BC-FR51  Amabilis fir stock type trials (SX84103-V) Gold River.
Contact: Brian D’Anjou  Phone: 751-7116

BC-FR52  FRDA I projects finalization.
Contact: Chris Thompson  Phone: 354-6704

BC-FR64  DNA markers for terminal weevil resistance in spruce.
Contact: Alvin Yanchuk  Phone: 387-3338

BC-FR67  Identification of hypervariable regions in the chloroplast genome of lodgepole pine.
Contact: Michael Stoehr  Phone: 952-4120

2. Hardwood/Mixedwood Silviculture

Once viewed primarily as nuisance species, today many hardwoods are considered an important component of British Columbia’s forests. In addition to their valued wood products, hardwood species contribute to nutrient cycling, reduce the spread of root rot, increase site productivity, and promote biodiversity. Hardwood research in British Columbia has grown rapidly since the early 1990s. For example, the province now participates in a network of trial sites throughout the Pacific Northwest through the Hardwood Silviculture Cooperative based at Oregon State University.

FRDA II hardwood/mixedwood research helped to develop management strategies for hardwoods in pure and mixed stands, and provided support for diversifying and improving existing forest renewal options. Research focused on many issues including the impact of logging practices on stand health and regeneration, hardwood/mixedwood stocking standards, stand tending opportunities, pest management, and opportunities for integrated use. Selected hardwood species received priority in different regions of the province—aspen in boreal regions, birch in the Interior Cedar-Hemlock zone in southern regions, and red alder on the coast.
Aspen

Two research projects looked at management options for mixed aspen/conifer stands:

- **BC-FR54** – *Investigations of planting white spruce under a trembling aspen canopy* focused on aspen/white spruce stands in the boreal region of B.C.

- **BC-FR59** – *Effect of aspen density and stocking on the performance of coniferous stands in the Cariboo Region* focused on aspen/lodgepole pine stands in the sub-boreal region.

The BC-FR54 study consisted of three phases. The first phase collected baseline data from 28-year-old mixed stands of aspen and white spruce in Alberta. In northern Alberta and British Columbia, white spruce regenerates naturally under aspen canopies. This relationship offers several advantages to the spruce seedlings, including shelter from extreme winter temperatures and frost, increased soil nutrients and productivity from the accumulation of nutrient-rich aspen leaf litter, and reduced spread of conifer-related root diseases due to the presence of resistant aspen roots. In addition, the aspen cover reduces competition from invasive grasses and increases the overall biodiversity of the stand.

The second phase examined the suitability of the light environment and the availability of soil moisture for the growth of white spruce under 40- to 60-year-old aspen stands. Meso stands with low basal areas and densities were found to have the most suitable microenvironment.

The third phase of the project, initiated in 1992, established white spruce seedlings under aspen canopies and compared survival and growth with spruce seedlings established in clearcuts. Variables such as available light, soil moisture, soil temperature, and relative humidity are being evaluated. This phase of the study will continue for another seven years, when 10-year results of the outplantings will be assessed.

Project leader Craig Delong (MOF Prince George Forest Region) is confident that planting white spruce under maturing aspen canopies is a promising management option. “There’s no reason to expect that we can’t successfully establish spruce under aspen and maintain portions of the northern landscape in a more natural state. The benefits to be gained in biodiversity alone make it a worthwhile pursuit.”

BC-FR59, a long-term study, consisted of two distinct phases. The first phase, which began in 1992, took a retrospective look at established stands of aspen and lodgepole pine to determine the impact of aspen competition on lodgepole pine growth. The results were presented at the Northern Interior Vegetation Management Association’s Winter Workshop in 1995.
The second phase of BC-FR.59 began in 1994. Lodgepole pine was planted in an aspen area to monitor the growth of the pine with aspen competition from a state of initial establishment. Data on pine height, diameter, and condition; aspen density; and average height and percent cover of the aspen component are being collected.

Project leader Teresa Newsome (MOF Cariboo Forest Region) expects it will be five years before significant results can be obtained. The study is scheduled to continue for 20–25 years.

**Paper Birch**

Three research projects investigated interspecific relationships between paper birch and conifers in mixed stands in the Interior Cedar-Hemlock (ICH) zone:

- **BC-FR.42** — *Long-term effects of management practices on productivity of mixedwood stands in the ICH zone in the southern interior of B.C.*
- **BC-FR.47** — *Regeneration of paper birch/conifer mixtures in the ICH zone in the southern interior of B.C.*
- **BC-FR.47a** — *Belowground interactions between paper birch and Douglas-fir in the ICH zone of the southern interior of British Columbia.*

The project leader for all three studies was Suzanne Simard (MOF Kamloops Forest Region).

BC-FR.42 investigated the impacts of removing paper birch (for example, through weeding) on the long-term productivity of mixed paper birch/Douglas-fir stands. Beginning in 1991, UBC Ph.D. student Jian Wang collected above-ground biomass and nutrient data from three chronosequences (good, medium, and poor site classes) of pure paper birch stands in the ICHmw3 subzone. Forest ecology consultant Don Sachs used these data, along with juvenile tree growth data from the southern interior; decomposition data from paper birch/conifer mixture experiments (BC-FR.47, see following); physiological data from paper birch thinning trials in the southern interior (BC-B12); and Douglas-fir growth, biomass, and physiological data from the literature to calibrate the stand management model FORECAST.

A series of simulations were run to predict the impact of various management scenarios, including varying the proportions and densities of paper birch and Douglas-fir, whole tree harvesting, and broadcast burning, on long-term site productivity. Due to the nutrient cycling characteristics of paper birch, the model predicted higher stand and Douglas-fir productivity when Douglas-fir was mixed with a minimum of 200 paper birch stems per hectare than when Douglas-fir was grown alone.
The results of this study were presented at the Hardwood Workshop and the Free-Growing Workshop in Richmond, B.C., December 1993, and at the Mixedwood Workshop in Richmond, B.C., February 1995.

The long-term project BC-FR47 examined tree species interactions in mixed stands of paper birch/Douglas-fir, paper birch/western redcedar, and paper birch/western larch. Experimental sites were established in 1991, where the density and proportion of planted paper birch and conifer seedlings were systematically varied within the framework of an addition series design. The mechanisms of intra- and interspecific interactions are being investigated through detailed growth, physiology, and microenvironment measurements. The stands are also being evaluated with respect to long-term productivity, nutrient cycling, and mycorrhizae diversity and function. Jian Wang, in partial fulfilment of his Ph.D., established additional experiments to compare the effects of coastal and interior climates on competitive interactions between paper birch and Douglas-fir.

Under BC-FR47, project leader Suzanne Simard completed research for her Ph.D. thesis on carbon and nitrogen dynamics of ectomycorrhizal associates of paper birch and Douglas-fir seedlings. By tracing the movement of carbon isotopes, Simard showed bi-directional transfer of carbon between paper birch and Douglas-fir through interconnecting ectomycorrhizal fungi, with a 4 to 6 percent net carbon gain by Douglas-fir under shaded conditions. “This is a very important finding,” explains Simard. “We generally assume that different plant species simply compete with each other for resources, but this research shows that resources can be shared through mycorrhizal networks. As a result, it is poor practice to manage stands based on the assumption that competition is the only process shaping stand dynamics — it’s not quite as simple as that.”

In addition to Simard’s and Wang’s Ph.D. dissertations, several other publications, and oral and poster workshop presentations have been produced under BC-FR47.

BC-FR47a, an extension of BC-FR47, focused on below-ground ectomycorrhizal community dynamics in paper birch and Douglas-fir mixtures. Specifically, the project investigated the effects of density and proportion of paper birch and Douglas-fir on root infection rates and morphotype diversity of ectomycorrhizal fungi. Melanie Jones (Okanagan University College, Kelowna) conducted this work.
The diversity of ectomycorrhizal morphotypes associated with Douglas-fir and paper birch seedlings has been quantified annually since 1991, using greenhouse bioassays on soils collected from established field research plots in 1991, and using field bioassays of seedlings harvested from the field plots in 1992, 1993, and 1994. Study results showed that mixed stands with the highest density and highest proportion of paper birch tended to have the greatest total and Douglas-fir-specific ectomycorrhizal diversity and evenness.

Several poster and oral presentations have been delivered at workshops, and annual progress reports have been written. The project's final results will be published in 1996.

**Red Alder**

Numerous research projects focused on the management of red alder, a coastal hardwood with known nitrogen-fixing capabilities, resistance to laminated root rot (*Phellinus weirii*), and great potential for value-added wood products. *BC-FR38 – Adaptive variation and genetic architecture in red alder* (Alnus rubra), *black cottonwood* (*Populus trichocarpa*) and *balsam poplar* (*P. balsamifera*) populations looked at the adaptability and genetic characteristics of red alder and some other British Columbia hardwoods.

"When we first began this study, we knew very little about red alder," comments project leader Cheng Ying (MOF Research Branch). "We didn't know its distribution, geographic variation, preferred sites, genetic diversity, hardiness, or growth potential—basic information required for effective management."

The project began by collecting seeds from 69 locations throughout coastal British Columbia in 1990/91. The next step was a three-year nursery study on the genetic variation of growth, phenology, hardiness and biomass distribution, and ecophysiological traits. This portion of the study was completed between 1992 and 1994. Long-term field tests of nursery stock began in 1995 at Puckle Road, near Victoria; Bowser, north of Nanaimo; and Terrace. The final phase of the project, also initiated in 1995, surveyed an isozyme gene marker to correlate genetic growth and hardiness variations. Ying expects to determine the genetic potential of red alder within the next five years.

Two other hardwood research projects tied in closely with BC-FR38. One of these is *BC-FR53 – Effects of red alder density on conifer growth and nitrogen availability* (project leader: Phil Comeau, MOF Research Branch). This long-term study, which began in 1992, investigated the effects of red alder on conifer growth and nitrogen availability.

Red alder contributes to the nitrogen capital of a site and to long-term productivity on nutrient-deficient sites through symbiotic nitrogen fixation. However, alder also competes with conifers for light and water, and can significantly hinder crop trees. Beginning in 1992, several trial installations were planted to study the effects of different densities of red alder on the...
growth and survival of Douglas-fir and western redcedar seedlings, and on
site nitrogen capital. Information on BC-FR.53 has been written up in FRDA

Another long-term project (20–25 years) closely associated with BC-FR.38
was BC-FR15 – Use of red alder in managing Phellinus weirii root disease
(project leader: Rona Sturrock, Canadian Forest Service, Victoria). This
project, initiated in 1991, assessed the potential for red alder to control the
spread of Phellinus weirii in Douglas-fir stands. Test plots established in the
Greater Victoria Watershed and in the Chilliwack River Valley will be used
as demonstration sites as the research progresses.

Hardwood/Mixedwood Silviculture Project List

BC-FR.12 Membership in the Hardwood Silviculture Cooperative.
   Contact: Paul Courtin  Phone: 751-7120

BC-FR.13 Maintenance and updating of the COMB computerized
   bibliography on the ecology and management of several
   trees, shrubs, and herbs.
   Contact: Phil Comeau  Phone: 387-3299

BC-FR.14 Northern mixedwood forests, the carbon cycle, and
   sustainable production.
   Contact: Phil Comeau  Phone: 387-3299

BC-FR.15 Use of red alder in managing Phellinus weirii root disease.
   Contact: Rona Sturrock (CFS)  Phone: 363-0789

BC-FR.16 Analysis of quality and productivity of birch-dominated
   stands in the Prince George Forest Region.
   Contact: Les Herring  Phone: 565-6179

BC-FR.38 Adaptive variation and genetic architecture in red alder
   (Alnus rubra), black cottonwood (Populus trichocarpa) and
   balsam poplar (P balsamifera) populations.
   Contact: Cheng Ying  Phone: 387-3976

BC-FR.42 Long-term effects of management practices on productivity
   of mixedwood stands in the ICH zone in the southern
   interior of B.C.
   Contact: Suzanne Simard  Phone: 828-4175

BC-FR.47 Regeneration of paper birch/conifer mixtures in the ICH
   zone in the southern interior of B.C.
   Contact: Suzanne Simard  Phone: 828-4175

BC-FR.47a Belowground interactions between paper birch and
   Douglas-fir in the ICH zone of the southern interior of
   British Columbia.
   Contact: Suzanne Simard  Phone: 828-4175
3. Vegetation Management

Some $60 million is spent annually on vegetation management operational programs in British Columbia. FRDA II research in this area helped relate vegetation management options to the overall effectiveness of forest renewal systems. Research focused on the effects of competing vegetation on conifer seedlings; the costs and benefits of chemical and non-chemical vegetation management options; and the effectiveness of site preparation treatments on seedling development, physiology, and survival.

**Mechanical Site Preparation**

One of the most successful research projects conducted under the theme of vegetation management was BC-FR39—Appraisal and development of backlog reforestation mechanical site preparation systems. This project was originally established under FRDA I to test site preparation equipment and assess microsite characteristics, soil properties, and seedling growth and survival. Research continued under FRDA II where the biological and operational effectiveness of various site preparation machines and systems were assessed over the short and long term.

Prior to the initiation of this research, site preparation usually involved either broadcast burning or using heavy machinery (cats) to gather brush into slash piles for burning. As public attitudes turned against prescribed burning, alternative means of site preparation were required.

"Over the last 10 years we've basically changed the way we do business in site preparation, and BC-FR39 played an important role in that change," says project leader Lorne Bedford (MOF Silviculture Practices Branch). "We used to burn over 70 000 hectares per year in British Columbia and now we burn less than 25 000 hectares annually. Today, we treat over 100 000 hectares..."
per year with mechanical site preparation. Most of this work is done with specially equipped excavators, disc trenchers, or small cats: the method of site preparation is tailored to meet the specific needs of each site.”

Bedford attributes the success of the project to its long-term approach (over 10 years) and the high level of cooperation between practitioners and researchers to not only meet research standards but also accommodate operational requirements. He is also quick to point out the valuable contributions of Marvin Grismer, a project researcher who has maintained the field sites for over eight years.

BC-FR.39 has produced an exceptional number of high quality products, ranging from well-received scientific papers to instructional videos and training courses. Some trial results also contributed significantly to developing Forest Practices Code guidebooks on issues such as seedling performance, soil disturbance, and soil conservation.

Two demonstration sites, one at Inga Lake near Fort St. John and the other at Bednesti near Prince George, were established under BC-FR.39. Forest researchers, educators, ministry personnel, industry representatives, and contractors regularly tour both sites. Many tour participants have reported that trial demonstrations have significantly changed their operational silviculture prescriptions. For example, Tim Vinge (CanFor, Hines Creek, Alberta) notes that his company now uses mounding to provide their seedlings with raised microsites. In addition, the company is investing heavily in developing their own mounding equipment to support their large planting program.

**Manual Methods of Vegetation Control**

Another important area of research under the theme of vegetation management involved evaluating the effectiveness of manual methods of vegetation control. This kind of information is increasingly important as public opposition to the use of forest herbicides continues to escalate.

A good example of this type of research is BC-FR.33—Effectiveness of repeated manual cutting for release of Engelmann spruce from mixed-shrub communities in the Revelstoke District. In this study, located at Soards Creek near Mica, B.C., single and repeated manual cutting treatments are being compared with single herbicide treatments in releasing spruce seedlings from competing vegetation. This study, begun in 1992, is expected to continue for at least another seven years.
"We are looking to find ways of optimizing the return on investment for manual vegetation control," states project leader Phil Comeau (MOF Research Branch). The study will also document the effects of differing amounts of vegetation and vegetation control on seedling survival and growth.


Another study investigating the effectiveness of manual brushing is *BC-FR.57 - Effect of timing of manual release treatments on physiology and growth of spruce seedlings* (project leader: Chris Thompson, MOF Nelson Forest Region). This research is being conducted in the Nelson Forest Region where manual brushing has an annual budget of approximately $4.5 million. Now in its second year, BC-FR.57 will determine the effects of timing, opening size, and duration of manual brushing on crop seedlings and competing vegetation in a mixed shrub/fireweed community.

**Vegetation Management Project List**

<table>
<thead>
<tr>
<th>Project Code</th>
<th>Description</th>
<th>Contact</th>
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<tbody>
<tr>
<td>BC-FR.04</td>
<td>Treatment development for rehabilitation of ESSF backlog brushfields.</td>
<td>Teresa Newsome</td>
<td>398-4408</td>
</tr>
<tr>
<td>BC-FR.06</td>
<td>The conversion of multistoried brushfields to coniferous plantations - a benchmark evaluation of alternative silvicultural treatments.</td>
<td>Dave Coates</td>
<td>847-7436</td>
</tr>
<tr>
<td>BC-FR.07</td>
<td>Development of vegetation management techniques for sites prone to salal domination.</td>
<td>Brian D'Anjou</td>
<td>751-7116</td>
</tr>
<tr>
<td>BC-FR.09</td>
<td>Site preparation and planting procedures to minimize seedling water and temperature stress in backlog areas in the southern interior.</td>
<td>Graeme Hope</td>
<td>828-4127</td>
</tr>
<tr>
<td>BC-FR.10</td>
<td>Effects of competing vegetation on growth and survival of Engelmann spruce seedlings.</td>
<td>Phil Comeau</td>
<td>387-3299</td>
</tr>
</tbody>
</table>
BC-FR.11 Assessing the effects of fireweed and associated vegetation on planted conifer survival and growth in the southern interior. Contact: Suzanne Simard Phone: 828-4175

BC-FR.17 Development of a database system for entry and retrieval of vegetation management trial information. Contact: Phil Comeau Phone: 387-3299

BC-FR.18 Comparison of four brushing treatments for release of young, shrub-dominated spruce plantations in the ICH. Contact: Phil Comeau Phone: 387-3299

BC-FR.30 Effects of different rates/timing of glyphosate application on willow in moose winter range in SBS1. Contact: Phil Comeau Phone: 387-3299

BC-FR.31 Participation in the CRAFTS vegetation management cooperative. Contact: Phil Comeau Phone: 387-3299

BC-FR.32 Quantitative screening of the competitive effects of common coastal non-crop species. Contact: Phil Comeau Phone: 387-3299

BC-FR.33 Effectiveness of repeated manual cutting for release of Engelmann spruce from mixed-shrub communities in the Revelstoke District. Contact: Phil Comeau Phone: 387-3299

BC-FR.39 Appraisal and development of backlog reforestation mechanical site preparation systems. Contact: Lorne Bedford Phone: 387-8901

BC-FR.40 A comparison of seeding mixes applied to site prepared areas for vegetation control in the wet climatic zone of the Nelson Forest Region. Contact: Chris Thompson Phone: 354-6704

BC-FR.41 Controlling aspen regeneration in cutovers by the use of girdling and chemical treatments before harvesting. Contact: Suzanne Simard Phone: 828-4175

BC-FR.43 The effect of mechanical and chemical site preparation treatments on the growth and survival of planted PI and Se in rhododendron brushfields. Contact: Dennis Lloyd Phone: 828-4129

BC-FR.44 Comparison of site preparation treatments on a steep, dry grassy site in the IDF zone. Contact: Suzanne Simard Phone: 828-4175

BC-FR.45 Below ground factors limiting seedling productivity in recently clearcut salal-dominated sites on northern Vancouver Island. Contact: Phil Comeau Phone: 387-3299
BC-FR.48  Operational site preparation and planting stock trials on cool, dry IDFdk4 and SBSdw1 backlog sites in the Cariboo (Improving plantation performance of Douglas-fir).
Contact: Teresa Newsome  Phone: 398-4408

BC-FR.49  Herbicide rate and timing trial in a fireweed complex in the ICHe.
Contact: Teresa Newsome  Phone: 398-4408

BC-FR.50  Legume and grass seeding for brush control (knapsweed) on mechanically prepared backlog brush field sites (ICH and ESSF).
Contact: Ordell Steen  Phone: 398-4406

BC-FR.55  Effect of manual treatment timing and glyphosate on non-crop vegetation and conifer development.
Contact: Brian D’Anjou  Phone: 751-7116

BC-FR.56  Comparison of mulch mat and herbicide.
Contact: Phil Comeau  Phone: 387-3299

BC-FR.57  Effect of timing of manual release treatments on physiology and growth of spruce seedlings.
Contact: Chris Thompson  Phone: 354-6704

BC-FR.58  Effect of manual treatment timing on red alder regrowth/conifer response in Okeover Inlet.
Contact: Brian D’Anjou  Phone: 751-7116

BC-FR.60  Rehabilitation of Sitka alder/fireweed dominated backlog sites.
Contact: Dennis Lloyd  Phone: 828-4129

BC-FR.61  Effects of diffuse and spotted knapweed competition on the survival and growth of lodgepole pine and Douglas-fir seedlings.
Contact: Brian Wikeem  Phone: 376-3973

BC-FR.62  Evaluation of forest vegetation community dynamics, biodiversity and wildlife forage values eight years after herbicide and manual brushing treatments on the Bush River brushing trial site.
Contact: George Harper  Phone: 387-7794

BC-FR.66  Seedling survival and growth on LGP skidder trails.
Contact: Terry Rollerson  Phone: 751-7121
Subprogram 3.2: Growth and Yield and Stand Tending

Before FRDA II, most growth and yield installations were established in pure, even-aged stands consisting of the main commercial tree species. However, the models that were used to project growth and yield for these stands needed more accurate, reliable, and applicable information. In addition, new information was required for all commercial species for a range of treatments as well as for more complex forests—stands with several species, multiple ages, and more than one storey.

To collect such data, the Growth and Yield Research Program, with guidance from the Forest Productivity Councils of B.C., adopted two broad programs:

1. Field experiments, consisting of permanent sample plots established in biogeoclimatic zones, species, and silvicultural treatments where information "gaps" existed

2. Stand modelling, designed to better understand the biological processes that underlie stand development.

The province funded a total of 14 projects under this subprogram: 3 under the field experiments theme and 11 under stand modelling. For a complete list of products from the Growth and Yield and Stand Tending Subprogram, refer to the appendices of this report under separate cover.

1. Field Experiments

Obtaining reliable growth and yield information has long been identified as a high priority in British Columbia forest research. But from being a priority to generating data, much funding, planning, and hard work were needed.

In the late 1980s, the Forest Productivity Councils of B.C. developed a research priority matrix for field experiments, based on a range of biogeoclimatic zones, silvicultural treatments, and tree species. These field experiments focused on establishing and maintaining permanent sample plots. Data were collected and analyzed to (1) quantify tree and stand response to treatments, (2) identify optimum treatment combination and levels, and (3) validate site-index curves. This information is used to support decision-making at the highest level: it is applied in developing silviculture prescriptions and in determining allowable annual cuts.

The FRDA II-funded field experiments not only filled 40 percent of the gaps identified by the Councils, but also included experiments beyond the scope of the Councils' matrix. They helped to address the critical issue of how much wood of what type is available now and in years to come.
The field experiments program consisted of three separate projects:

- **BC-GY03** – *Provincial growth and yield experiments: coast.*
- **BC-GY04** – *Provincial growth and yield experiments: interior.*
- **BC-GY05** – *Provincial growth and yield experiments: nutrition.*

**Coast**

On the coast, project leader Louise de Montigny (MOF Research Branch) looked at the effects of various silvicultural treatments on growth and yield responses. Because the coast contained numerous older plots, a large portion of this work emphasized remeasuring these existing experiments. The data generated from fertilization remeasurement directly contributed to building a fertilization module in the Tree and Stand Simulator (TASS) model, while data from thinning experiments have been used to calibrate TASS.

“Remeasuring the older growth and yield plots—some dating back to 1929—generated valuable data for our models,” says de Montigny. She sees another practical benefit: “Our field installations are high quality demonstration areas useful for field tours.”

These field experiments required cooperation from critical players, including forest licensees such as MacMillan Bloedel, Pacific Forest Products, TimberWest, and Western Forest Products. In an experiment examining the effectiveness of sludge as a fertilizer, the Squamish Forest District, Municipality of Whistler, UBC, and MOF Research Branch joined forces.

In addition to the remeasurements, almost 200 new plots focusing on the effects of espacement, thinning, pruning, and fertilization were established. “The new coastal installations are statistically sound—they let us address specific hypotheses about the way silvicultural treatments can affect tree and forest growth,” explains de Montigny.

The coastal field experiments generated several FRDA reports and over a dozen journal articles and reports.
**Interior**

In contrast to the coast, few growth and yield trials established before the 1980s can be found in the interior. As this area became more important to the forest industry, more trials were established. During the past 15 years, growth and yield researchers from Research Branch have made concerted efforts to expand the experimental database for interior species. FRDA I and II have funded most of these new installations.

Two researchers from the MOF Kalamalka Forestry Centre led the interior growth and yield program. Wayne Johnstone headed the espacement and thinning research; Rob Brockley led the interior nutrition/fertilization work.

For Johnstone’s project, trials were set up in a range of treatments, species, and biogeoclimatic zones. Examples of such work include:

- espacement trials in lodgepole pine, interior spruce, western larch, spruce/pine, and hybrid poplar stands
- precommercial thinning trials in lodgepole pine and interior Douglas-fir
- commercial thinning trial in the Quesnel Forest District in cooperation with Weldwood of Canada Ltd.
- coastal and interior hybrid poplar studies involving MacMillan Bloedel (Vancouver Island), Scott Paper (Fraser Valley), and the Kalamalka Forestry Centre (Vernon).

In addition to setting up new trials, Johnstone and his colleagues remeasured those trials that date back more than five years. According to Johnstone, “FRDA II doubled the growth and yield efforts of FRDA I in the interior.”

As growth and yield studies continue in the British Columbia interior, more emphasis will be placed on species other than lodgepole pine. Also, focus areas have shifted over time. Because more and more foresters are interested in silvicultural systems other than clearcutting, the need for growth and yield information on stand management practices such as selection harvesting and commercial thinning is growing.

A great deal of effort was directed toward documenting the responsiveness of interior tree species to fertilization during FRDA II. Some 20 installations were established with FRDA II funding; another 50 trials were remeasured. According to Rob Brockley, “Nitrogen is certainly the major nutritional

**Fertilization research leads to improved operational fertilization guidelines.**
limitation to growth in the interior. However, other nutrient deficiencies—most notably sulphur and boron—are now known to limit the responsiveness of some interior forests to nitrogen additions." As such, emphasis during FRDA II shifted to evaluating the growth responses that can be achieved by applying blended fertilizers (for example, N+S) to a range of species and sites.

Research results are being incorporated into operational guidelines such as the Forest Fertilization Guidebook (1995), which offers stand selection guidelines for operational forest fertilization in the interior. Decision-making tools are being developed and fertilization response data will eventually be incorporated into growth models.

To study the effects of intensive, repeated fertilization on the growth and yield of major interior species, a few "maximum productivity" fertilization installations were established on benchmark sites throughout the interior. In Sweden, similar experiments have shown dramatic increases in the growth of intensively fertilized stands. "We hope that these trials will show to what extent intensive management can compensate for an ever-shrinking forest landbase in British Columbia," explains Brockley.

As with the coastal experiments, this long-term work in the interior serves to develop silviculture prescriptions and to validate and calibrate growth and yield models.

Products from the interior field experiments include a FRDA report, a FRDA memo, and several journal articles.

**Field Experiments Project List**

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<tr>
<th>Code</th>
<th>Description</th>
<th>Contact</th>
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<tbody>
<tr>
<td>BC-GY03</td>
<td>Provincial growth and yield experiments: coast.</td>
<td>Louise de Montigny</td>
<td>387-3295</td>
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<tr>
<td>BC-GY04</td>
<td>Provincial growth and yield experiments: interior.</td>
<td>Wayne Johnstone</td>
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<tr>
<td>BC-GY05</td>
<td>Provincial growth and yield experiments: nutrition.</td>
<td>Rob Brockley</td>
<td>549-5682</td>
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**2. Stand Modelling**

Historically, growth and yield modelling, as with field experiments, has focused on even-aged, pure species stands. Priorities are shifting to include mixed-species, multistoried, and multiaged stands. Research is also focusing on improving our understanding of the underlying biological processes of tree growth—to look beyond forests as contributors of wood fibre.
This research is aimed at acquiring knowledge and understanding of how trees, stands, and forests grow and respond to a range of stand treatments. Ultimately, this work supports allowable annual cut determinations and addresses important issues such as maintaining biodiversity and prescribing silvicultural treatments.

FRDA II funded several projects involving model development. We will highlight two projects that focus on newer areas of research: complex stands and non-traditional forest values such as coarse woody debris.

**Dynamics of Mixed-species Stands**

In the past, all growth and yield trials were established in conifer monocultures. As attention shifts to mixed-species stands, obtaining growth and yield information and an understanding of successional patterns are needed to explain and predict how mixed-species forests grow. To obtain data on mixed-species stands more quickly, project leader Ian Cameron (Research Branch) adopted a retrospective approach in project BC-GY01 – *Dynamics of mixed-species stands*.

By “reconstructing” stand development, Cameron, along with fellow MOF researchers Catherine Bealle Statland (Research Branch), and Phil LePage and Dave Coates (Prince Rupert Forest Region), backdated older plots and matched them with younger plots. All this number crunching provided information about changes in age structure, size distribution, and species composition over time. It also contributed to a better understanding of disturbance patterns and regeneration dynamics.

Determining how individual tree species interact with each other is essential to understanding how mixed-species stands grow. Graduate student Temesgen Hailemariam (UBC) modelled the distributions of foliage within tree crowns. At the same time, physiologists Mark Ashton and Graeme Berlyn (Yale University) investigated the variation in productivity within the crowns of individual trees and compared productivity between species.

So far this group has investigated mixtures in the Coastal Western Hemlock, Interior Cedar-Hemlock, and Interior Douglas-fir biogeoclimatic zones. Altogether, 600 plots have been established to measure the structure of mixed-species stands; 65 plots were reconstructed.

“We now have a better picture of how some mixed-species stands change over time,” explains Cameron. New ways of depicting stand structures, such as 3-D graphics imagery, helped foresters and modellers to visualize the changes.

As this work continues beyond FRDA II funding, plots will be established in other species mixtures.
Modelling the Dynamics of Dead Trees

Traditionally, growth and yield models have focused on the growth of trees for wood production. As priorities change, this information must also relate to non-traditional forest values. Dead trees, important ecological constituents of forests, are one such value.

Project BC-GY13 — Wildlife tree and woody debris module for an existing B.C. forest growth and yield model, led by Jeff Stone (MOF Research Branch), will allow forest and wildlife managers (1) to better understand the population dynamics of dead trees through time, and (2) to evaluate silviculture options in terms of wildlife tree and woody debris production.

The work of Ken Mitchell (MOF Research Branch) and colleagues in developing the Tree and Stand Simulator (TASS) was a critical background undertaking. TASS provided the necessary mortality input and flexibility to model many silvicultural options. Stone comments: "We can appreciate the value of individual tree growth models—such as TASS—that have some biological basis and can expand beyond their original use."

The MOF Research, Resources Inventory, and Silviculture Practices branches, and Nelson Forest Region staff jointly gathered information about dead tree dynamics with measurements from over 600 existing growth and yield permanent sample plots.

This information, combined with data from the scientific literature, was used to develop new modules within TASS and WinTIPSY. Most of the modelling concentrated on standing dead trees rather than on downed materials.

"The most valuable aspect of any model is to identify deficiencies in existing knowledge," observes Stone. This work identified the lack of information on dead tree falldown for many British Columbia tree species. Simply recording whether a dead tree is still standing during the remeasurement of MOF growth and yield permanent sample plots has started to address this deficiency.

The model does have its limitations. Currently, it reflects only the average falldown of a species from limited data sources. The model may be developed further to include changes related to mortality cause, or site and stand conditions. These directions will be pursued beyond FRDA II.

In addition to improved understanding about dead tree dynamics, some important side benefits were realized from this project. "We have learned the long-term value of permanent sample plots: they provide significant information on areas not considered important when the plots were established," notes Stone. An interesting project component in 1994 and 1995 saw over a dozen graduate students from Simon Fraser University update coarse woody debris information first collected in 1929 from the oldest thinning plots in British Columbia at the Cowichan Lake Research Station.

Ultimately, the wildlife tree users themselves—from small mammals and bats, to cavity-nesting birds—will benefit from this research.
**Stand Modelling Project List**

**BC-GY01** Dynamics of mixed-species stands.
Contact: Ian Cameron Phone: 828-3707

**BC-GY02** Construction of managed stand yield tables for root rot infested stands of coastal Douglas-fir, and interior Douglas-fir, white spruce, and lodgepole pine.
Contact: Ken Mitchell Phone: 387-6673

**BC-GY07** Comprehensive, value-based management of second-growth western hemlock forests.
Contact: Ken Mitchell Phone: 387-6673

**BC-GY08** Predicting overstorey and understorey floristics, structure, and grizzly bear habitat value following logging of the Khutzeymateen watershed.
Contact: Tony Hamilton (MELP) Phone: 387-9761

**BC-GY09** Fertilization and thinning effects on a Douglas-fir ecosystem at Shawnigan Lake: a synthesis of results.
Contact: Barrie Phillips Phone: 387-6642

**BC-GY10** Facilitate the process of determining the status of current research activities in B.C. and identifying client research needs.
Contact: Lynn Husted Phone: 356-8056

**BC-GY11** Construction, calibration, and validation of managed stand yield tables of root rot infected stands of coastal Douglas-fir.
Contact: Ken Mitchell Phone: 387-6673

**BC-GY12** PROGNOSIS management simulation experiments for interior Douglas-fir.
Contact: Catherine Bealle Statland Phone: 387-5447

**BC-GY13** Wildlife tree and woody debris module for an existing B.C. forest growth and yield model.
Contact: Jeff Stone Phone: 387-6672

**BC-GY14** The dynamics of regenerating lodgepole pine stands.
Contact: Gordon Nigh Phone: 387-3093

**BC-GY15** Structure and dynamics of mixed-species interior Douglas-fir stands.
Contact: Catherine Bealle Statland Phone: 387-5447
Subprogram 3.3: Integrated Resource Management

The Integrated Resource Management Subprogram of FRDA II addressed a wide range of issues in three broad areas or themes: biodiversity, old-growth forests, and environmental impacts.

Research focused on gathering information on the environmental requirements of key plant and animal species and ecosystems to develop strategies for maintaining biodiversity; defining and characterizing major old-growth forest types to develop appropriate management options for maintaining old-growth attributes in managed stands; and assessing the environmental impacts of forest practices to develop sustainable alternatives that minimize adverse effects.

A total of 44 integrated resource management projects were funded by the province over the term of FRDA II: 11 under the theme of biodiversity, 7 under old growth, 24 under environmental impacts, and 2 under administration. For a complete list of products from the Integrated Resource Management Subprogram, refer to the appendices of this report under separate cover.

1. Biodiversity

Research under the biodiversity theme focused on accumulating a knowledge base to support the development of viable options for maintaining or restoring biodiversity in forests of various ages. High priority was given to projects that documented the genetic resources, species, and ecosystems in coastal and interior forests; and evaluated the comparative biodiversity in managed and unmanaged forest stands.

Maintaining Wildlife Diversity in Managed Coastal Forests

Biodiversity: The term, now an integral part of the forest management lexicon, was virtually unheard of until the late 1980s. As this issue emerged, the need to quantify this diversity became apparent—no one knew how much diversity was “out there.”

For coastal vertebrate species, some inventory work had been carried out in the Pacific Northwest. However, no data had been gathered in British Columbia. Dale Seip (MOF, formerly Vancouver Forest Region, now Prince
George Forest Region) led project BC-IR13 — Maintaining wildlife diversity in managed coastal stands; a study focusing on vertebrate species in the Coastal Western Hemlock zone. To do so, he compared wildlife diversity between old-growth and managed forests.

The study consisted of two main components. The first, led by Seip and Jean-Pierre Savard (Canadian Wildlife Service), focused on determining the relative abundance and diversity of vertebrate species in old-growth forests compared to clearcuts and second-growth stands. André Arsenault (now MOF Kamloops Forest Region) conducted the second part: determining the relationships between habitat characteristics (such as snag abundance, woody debris, and shrub cover) and the abundance of vertebrate species. Sites were surveyed on the Lower Mainland, Queen Charlotte Islands, Sunshine Coast, and Vancouver Island.

The study found that many species of birds, mammals, and salamanders were abundant in clearcuts and second-growth forests. Other species, however, were strongly associated with old-growth forests and were uncommon or absent in young managed stands. Bird species that require snags for nesting and feeding had the strongest association with older forests.

These results suggest that although many vertebrate species can live in second-growth coastal forests, maintaining a component of old-growth forest and retaining features such as snags in second-growth stands are important for protecting diversity in coastal forests.

This work contributed greatly to the Coastal Biodiversity Guidelines, a document preceding the Biodiversity Guidebook of the Forest Practices Code.

Another study examining biodiversity in managed forests is project BC-IR44 — The role of riparian corridors in maintaining vertebrate diversity in coastal ecosystems. Leader Louise Waterhouse (MOF Vancouver Forest Region) focused on one bird species, the Winter Wren, as an indicator of forest health in riparian areas. By measuring variables such as habitat structure and ecosystem function, she will determine the impacts of different management regimes (such as reserve areas, wildlife tree reserves, and buffer strips) on the wren.
Conserving the Genetic Diversity of Conifers

Changes in the genetic composition of forests occur due to natural activities (such as wildfires and pest outbreaks) and human activities (such as harvesting). Although tree breeding programs in British Columbia use much of the genetic variation available for any species undergoing improvement, not all species or populations can be considered. Some wild populations are therefore at risk of losing important rare genes or gene complexes.

In 1993, this risk led Alvin Yanchuk (MOF Research Branch) and Don Lester (consultant) to undertake project BC-IR18—The development of a gene conservation strategy for the economically important conifers of B.C., a two-part gene conservation strategy for 23 native conifer tree species in British Columbia. The first part involved surveying the status of each species within the current reserves protected by legislation (for example, ecological reserves and provincial parks). This assessment assumed that genetic variation tracked geographic, climatic, and ecological variation.

In the second component, the researchers set priorities for additional gene conservation activities. Their approach, which examined individual species, used available information from (1) the survey of protected areas, (2) the status in provenance and breeding programs, and (3) the relative capabilities for natural regeneration.

Results indicated that, in general, the protected status of all the species in the current network of protected areas was adequate. Whereas some species were under little threat (for example, western hemlock), others, such as Pacific yew and whitebark pine, required more attention. However, special gene conservation collections and recent information about distribution and ecology may have reduced the perceived threat to Pacific yew, at least in the short term.

Implementing the recommendations in the strategy requires the cooperation of the Tree Improvement Councils (coast and interior), which include forest licensees and government agencies. Timely implementation of the strategy will produce two added benefits: conserving other forest species, and incurring low costs (relative to future costs as further pressures on the land base increase).

This strategy does have its limitations: a “made in British Columbia” analysis ignores tree populations elsewhere in North America. To date, only the provenance research programs accommodate this concern to some degree.

“The development of this strategy was useful—it allowed us to reshape our thinking about how we must manage the forest genetic resources of British Columbia. In short, both a system of natural protected areas and properly designed tree breeding programs for commercial species are necessary to ensure the long-term evolutionary potential of our forests,” explains Yanchuk.
Biodiversity Project List

BC-IR.06 Proposal for a biodiversity gap analysis of Vancouver Island.
   Contact: Marvin Eng Phone: 387-2710

BC-IR.07 Provincial gap analysis of protected areas and biodiversity.
   Contact: Andy MacKinnon Phone: 387-6536

BC-IR.12 Evaluating minimum patch sizes for viable populations of vertebrates living within the coastal western hemlock zone for Vancouver Island.
   Contact: Brian Nyberg Phone: 387-3144

BC-IR.13 Maintaining wildlife diversity in managed coastal stands.
   Contact: Dale Seip Phone: 565-6137

BC-IR.15 Biomass and carbon storage in the forest floor and woody debris of old-growth western redcedar and western hemlock forests on northern Vancouver Island.
   Contact: Phil Comeau Phone: 387-3299

BC-IR.18 The development of a gene conservation strategy for the economically important conifers of B.C.
   Contact: Alvin Yanchuk Phone: 387-3338

BC-IR.19 Management guidelines for biological diversity in the Prince Rupert Forest Region.
   Contact: Doug Steventon Phone: 847-7761

BC-IR.21 Assessing impacts on biological diversity of the distribution of forestry practices through time and space.
   Contact: Fred Bunnell (UBC) Phone: 822-5928

BC-IR.36 Development of grazing management programs to maintain avian diversity in B.C.
   Contact: Harold Armeled Phone: 398-4407

BC-IR.38 Evaluating the economic implications of managing forest land to maintain biological diversity.
   Contact: Fred Bunnell (UBC) Phone: 822-5928

BC-IR.44 The role of riparian corridors for maintaining vertebrate diversity in coastal ecosystems.
   Contact: Louise Waterhouse Phone: 751-7100
2. Old-growth Forests

Research on old-growth forests investigated the functional processes of old-growth ecosystems and related them to analogous processes in second-growth forests. High priority was given to projects that studied biological interactions, carbon cycling, and/or nutrient cycling in old-growth and managed stands; and projects that developed appropriate harvesting and silvicultural techniques for maintaining or restoring old-growth attributes in managed forests.

*Invertebrate Diversity in Coastal Old Growth*

Conserving the biodiversity of old-growth forests is recognized as an important key to successful forest management. Without some understanding of the nature of this diversity, predicting ecosystem responses to management practices is impossible.

Until the late 1980s, virtually nothing was known about the arthropod communities associated with coastal northern temperate old-growth forests. To find some answers, Neville Winchester (Ph.D. candidate, UVic) and Richard Ring (UVic) undertook a multi-year examination of the Coastal Western Hemlock zone forests in the Upper Carmanah Valley Watershed (Vancouver Island), Project BC-IR08 - Community ecology of the canopy-forest floor insect/arthropod fauna from an old-growth forest. By concentrating on species assemblages and community patterns, the researchers are identifying variations in community structure due to rapid changes in environmental gradients.

The initial focus of the project was to identify some 1.4 million arthropod specimens collected from the research site. To this end, over 80 taxonomists world-wide have collaborated on this identification process. To date, some 1500 species have been identified and 80 species (5% of identified species) are confirmed as new to science. All of the identified specimens are being stored at the Pacific Forestry Centre (Canadian Forest Service) in Victoria and are currently being catalogued.

Results indicate that this forest, dominated by Sitka spruce, supports a distinct community of arthropods. In addition, certain species within the canopy have evolved to form a distinct arboreal community.
This project will provide answers to some critical questions about (1) identifying species in the canopy and forest floor of old-growth forests; (2) recognizing changes in community structure between the forest canopy, forest floor, transition zone, and clearcut and second-growth areas; (3) determining how parasitoid predators change over time and space—from the old-growth stand to a clearcut; and (4) assessing the implications for forest management.

This project has received much publicity including an article in Discover magazine (November 1995), and a forthcoming article in National Geographic magazine. It was also included in an episode of The Secret Life of Plants, a television series with David Attenborough.

**Carbon Cycling in Coastal Old-growth Forests**

Forests serve as important storage sites for carbon, one of the major components of greenhouse gases. Scientists the world over are examining the ability of forests to absorb carbon released by burning fossil fuels. Project BC-IR14 — Carbon emissions from harvesting coastal old-growth forests is assessing carbon release resulting from the conversion of British Columbia’s old-growth forests to managed stands.

“This is a multifaceted, interagency project, bringing together expertise from the Canadian Forest Service, the MOF, and private forest consultants,” explains project leader Phil Comeau (MOF Research Branch). Collaborators include Mike Apps (Northern Forestry Centre, Edmonton, Alberta), Tony Trofymow (Pacific Forestry Centre, Victoria), and consultant Werner Kurz. The project is also closely linked with two other FRDA II research projects, BC-FR14 (Forest Renewal Subprogram) and the federally sponsored FC-IRM-010.

The major thrust of the study has been to conduct a retrospective analysis of provincial records and apply the Canadian Forest Service’s Carbon Budget Model (CBM-CFS2), developed by Mike Apps and Werner Kurz, to estimate historical carbon releases for British Columbia’s forests from 1920 to 1989. After recalibrating the model with data from British Columbia’s ecoregions, several simulations were run for the province as a whole, and for the coastal, interior, and northern regions. The results of this work were presented at a technical workshop to federal, provincial, and university participants on December 13–14, 1994. A final FRDA report is scheduled for release in 1996.

Another important component of BC-IR14 has been to provide professional and financial support to the federal project FC-IRM-010 — Modelling carbon emissions related to harvesting coastal old-growth forests (project leader: Tony Trofymow, Canadian Forest Service, Victoria). This closely related, long-term study will derive information on tree biomass and volume, understorey vegetation, soil organic matter, nutrient concentrations, and decomposition rates in coastal forests of different ages. The work is being conducted at 10
locations on Vancouver Island in established plots of four age classes at each location (regeneration 3--8 years, immature 25--45 years, mature 65--86 years, and old growth >200 years). This information will be used to evaluate the impacts of forest management activities on carbon emissions and to make recommendations for reducing impacts of forest practices on atmospheric carbon levels. To date, three file reports have been produced from this work.

**Old-growth Forests Project List**

**BC-IR.08** Community ecology of the canopy-forest floor insect/arthropod fauna from an old-growth forest.
Contact: Neville Winchester (UVic) Phone: 721-7099

**BC-IR.09** Macrofungi of old-growth forests: saprophytes and biotrophs and their correlation to biogeoclimatic zones and humus forms.
Contact: Shannon Berch Phone: 952-4122

**BC-IR.10** Old-growth lichens — status reports for rare species. Lichens of old-growth forests of the CWH and ICH.
Contact: Ted Lea (MELP) Phone: 387-9781

**BC-IR.11** Amphibian and forest bird associations in old-growth and second-growth communities.
Contact: Dale Seip Phone: 565-6137

**BC-IR.14** Carbon emissions from harvesting coastal old-growth forests.
Contact: Phil Comeau Phone: 387-3299

**BC-IR.16** A functional assessment of old-growth stand structures in some southern interior forest types.
Contact: Evelyn Hamilton Phone: 387-3650

**BC-IR.17** The role of large woody debris in old-growth forest streams: a spatial analysis of biogeoclimatic zones.
Contact: Steve Chatwin Phone: 387-5887

**3. Environmental Impacts**

Research under the theme of environmental impacts was directed towards documenting and comparing the effects of current and alternative forestry practices on the environment. The ultimate goal of this research is to develop forest management options that minimize adverse environmental impacts.

High priority was given to projects that evaluated the impacts of current and alternative harvesting, stand tending, and site preparation options on water quality and timing of flows in coastal watersheds; soil erosion and
stream sedimentation in community watersheds and streams with high fisheries value; wildlife habitat and livestock forage; and soil disturbance and associated long-term site productivity. Smoke management options for reducing emissions from prescribed burning were also investigated.

**Stuart-Takla Experimental Watersheds**

The effects of timber harvesting on fish populations and their habitats has been an important focus for research in British Columbia for nearly three decades now. The vast majority of this research has been conducted in coastal watersheds, the most well-known project being Carnation Creek on Vancouver Island. Now in its 25th year, the Carnation Creek project is internationally recognized as the longest running fisheries/forestry study conducted in an intact watershed anywhere in North America, if not the world.

Most of the provisions for aquatic resource protection outlined in British Columbia’s Forest Practices Code are based on information derived from the Carnation Creek project and studies from the Queen Charlotte Islands. However, results obtained from coastal watershed studies are not always applicable to the interior due to significant regional differences in climate, topography, hydrology, and soils. To address this gap in scientific knowledge, **BC-IR26 - Stuart-Takla fisheries/forestry interaction project** was initiated in 1991.

“The Stuart-Takla project is the interior equivalent of the Carnation Creek study,” explains project researcher Peter Tschaplinski (MOF Research Branch). “It’s the first long-term, multidisciplinary fish/forestry study of its kind ever conducted in the interior of British Columbia.”

In addition to FRDA II funding, several other agencies are involved in the Stuart-Takla research project, including the federal Department of Fisheries and Oceans, B.C. Ministry of Environment, Lands and Parks, Canadian Wildlife Service, the Tl’Azt’en Band (Tachie), Canadian Forest Products Ltd., University of Northern British Columbia, UBC, and Simon Fraser University.

The Stuart-Takla drainage is located within the Sub-Boreal Spruce and Engelmann Spruce-Subalpine Fir zones in the northernmost part of the Fraser River basin, about 130 kilometres northwest of Fort St. James. The area is known for its high value forestry, fisheries, and recreational resources. Its production of sockeye salmon is especially important. “On average, about 25 percent of the annual production of sockeye from the Fraser River originates in the Stuart-Takla,” adds Tschaplinski. “That’s why this research is so important.”

The project study site includes four small experimental watersheds draining into Takla Lake: Gluskie and O’Neel Creeks, which will be harvested to existing Forest Practices Code standards; Forfar Creek, which will act as an unharvested control with high fish abundance; and Bivouac Creek, which has been partially harvested and will act as a low-fish-abundance control.
Baseline data on channel morphology and hydrology, fish abundance and distribution, spawning and egg incubation, and fry rearing habitats were collected for four years prior to harvesting. Harvesting is scheduled to begin in the winter of 1995/96 in the Gluskie Creek watershed. These same parameters will be measured during harvesting operations and for an extended period of time after harvesting has been completed.

The data collected will be used to document interior watershed processes, including changes in snowmelt, groundwater, stream flow, sediment and thermal dynamics, channel morphology, fish populations, and stream channel habitats resulting from timber harvesting. This information will lead to increased understanding of the functioning of interior ecosystems and the biology of salmonid populations. It will also help to refine Forest Practices Code riparian guidelines to better protect interior aquatic systems.

Extension of the Stuart-Takla research to date includes field tours, a workshop, a poster display, and technical reports.

**Long-term Soil Productivity**

Maintaining long-term forest productivity is a high priority for forest managers in British Columbia. To address this important issue, a major research initiative, BC-IR31 – *Long-term soil productivity study*, was launched in 1991 to examine the impacts of mineral soil compaction and organic matter removal, the two most common types of soil disturbance that result from timber harvesting and site preparation.

The study was initiated on mesic sites in the Sub-Boreal Spruce zone where highly mechanized ground-based harvesting and site preparation systems are prevalent. Three study sites were established (staggered over a three-year period from 1991 to 1993), one in each of three participating forest regions — Prince George (regional contact: Paul Sanborn), Prince Rupert (regional contact: Marty Kranabbetter), and Cariboo (regional contact: Bill Chapman). In 1994, the project was expanded to include aspen sites in the Boreal White and Black Spruce zone.

Each study site contains nine core treatment plots consisting of combinations of three levels of organic matter retention and three levels of soil compaction. After the sites were selected, detailed ecological and soil descriptions (including soil fauna and mycorrhizae) were recorded, soil samples were taken, stem analyses were conducted to develop height over age curves and site index, and the area was then harvested. The next year, the organic matter and soil compaction treatments were applied, followed one year later by planting. The first productivity assessments will be made in the fifth year after the treatments were applied. The first site to be assessed will be Prince George in 1998/99.
"Understanding the long-term effects of forest practices on forest productivity and ecological processes requires long-term measurement and observation," explains Marty Osberg, project leader of British Columbia's Long-term Soil Productivity Study. "Retrospective studies, while having produced some valuable results, are generally limited by the lack of knowledge about initial site conditions, the lack of control over the level of impacts and the quality of regeneration, and the often limited availability of suitable replicate sites. Nevertheless, retrospective studies played a very important role in generating international interest in establishing long-term soil productivity installations on a wide range of forest ecosystems."

BC-IR31 is modelled after similar productivity studies being carried out in the United States. Both Canada and the United States are now collaborating to form a larger, more comprehensive North American long-term soil productivity study. Participating scientists from both countries meet every year to discuss new insights, problems and solutions, and management of the databases being created. The 1995 annual meeting was held in Prince George.

"An interesting aspect that British Columbia brought to the North American collaboration is that we're very interested in evaluating the treatment effects on the soil biological processes responsible for maintaining long-term soil productivity, whereas the Americans are concentrating primarily on the relationships between soil physical properties and forest productivity," adds Osberg. "British Columbia's research program is taking a more multidisciplinary approach — looking at microorganisms, mycorrhizal fungi, and overall soil biodiversity, as well as the more traditional chemical and physical characteristics of the soil. We are also looking to expand the British Columbia study to include sites in the warmer and drier ecosystems of the southern interior."

By conducting repeated baseline measurements of the original populations of soil organisms before any treatments were applied at the study sites, researchers from British Columbia have monitored changes in soil fauna and fungi resulting from compaction and organic horizon removal. This information will help to predict which soil organisms would be vulnerable to forest practices that remove all or part of the organic layer. It will also help scientists gain insight into the recovery of the soil community as they follow the reaccumulation of organic matter over time.
Shannon Berch is the lead researcher on soil fauna and mycorrhizae for BC-IR.31. "A fascinating subcomponent of this study is evaluating the impact that planting nursery plug stock may have on the original population of soil organisms at the site. Since we have already collected data on the soil fauna prior to planting, we will be able to monitor any changes that occur as a result of the introduced seedlings. This is the first time this kind of work has been done in the sub-boreal and boreal zones."

The sheer magnitude of the Long-term Soil Productivity Study provides an excellent setting for graduate students and specialized scientists to investigate forest soil ecology. Much of this work, particularly in the area of identifying soil microorganisms down to the species level, is being done for the first time ever.

The project’s long-term study sites will also provide valuable educational opportunities for universities and colleges, Forest Service staff, and industry personnel. But perhaps most importantly, the results of this research will be incorporated into the soil conservation component of the Forest Practices Code to provide practitioners with practical operational guidelines for protecting the soil resource.

Environmental Impacts Project List

BC-IR.01 Watershed sediment budget studies.
Contact: Steve Chatwin  Phone: 387-5887

BC-IR.02 Efficacy of biological control agents on diffuse and spotted knapweed.
Contact: Brian Wikeem  Phone: 376-3973

BC-IR.03a The response of planted spruce to slash-burn severity, initial seeding condition, and vegetation levels in the SBS zone.
Contact: Evelyn Hamilton  Phone: 387-3650

BC-IR.03b Vegetation development patterns after clearcutting and different slash-burn activities in the SBS and ESSF zones.
Contact: Evelyn Hamilton  Phone: 387-3650

BC-IR.04 Problem analysis of the impacts of site preparation on habitat utilization and availability for red-, blue-, and yellow-listed wildlife species in interior B.C.
Contact: Andy MacKinnon  Phone: 387-6536

BC-IR.05 The influence of vegetation management on the diversity of plants, small mammals, birds, and furbearers.
Contact: Tom Sullivan (UBC)  Phone: 822-3543

BC-IR.20 Adaptive management in forestry: a research proposal.
Contact: Chris Fletcher  Phone: 356-5959
BC-IR.22  Resource use conflicts problem analysis.  
Contact: Robin Hoffos (MELP) Phone: 398-4559

BC-IR.25  Effects of vegetation management for brush and alder on forest birds in the Adam and Eve watersheds.  
Contact: Rhonda Millikin (CWS) Phone: 946-8546

BC-IR.26  Stuart-Takla fisheries/forestry interaction project.  
Contact: Peter Tschaplinski Phone: 387-3025

BC-IR.30  Ecology of Pacific yew (Taxus brevifolia).  
Contact: Alison Nicholson Phone: 953-4107

BC-IR.31  Long-term soil productivity study.  
Contact: Marty Osberg Phone: 387-7795

BC-IR.32  Nutritional sustainability of timber harvesting.  
Contact: Tim Ballard (UBC) Phone: 822-2300

BC-IR.33  Machine impact on soil properties/demonstration of high impacts skid trail compaction.  
Contact: Marty Osberg Phone: 387-7795

BC-IR.34  Alternatives to broadcast burning following clearcutting on medium sites in the SBSmc and ESSFk subzones.  
Contact: Marty Kranabetter Phone: 847-7435

BC-IR.35  Carnation Creek - an experiment towards long-term integrated resource management.  
Contact: Dan Hogan Phone: 660-1812

BC-IR.37  The hydrological recovery of regenerating forests: snow accumulation and snow melt characteristics.  
Contact: Dave Toews Phone: 354-6284

BC-IR.39  The effects of cattle grazing, forage seeding rates, basal scarring, and shoot damage on forest regeneration.  
Contact: Brian Wikeem Phone: 376-3973

BC-IR.40  Upper Penticton Creek Experimental Watershed Study.  
Contact: Rita Winkler Phone: 828-4169

BC-IR.41  Hydrologic controls of landsliding in coastal British Columbia.  
Contact: Dan Hogan Phone: 660-1812

Contact: Graeme Hope Phone: 828-4127

BC-IR.45  Coarse woody debris dynamics in wet and dry ESSF forests.  
Contact: Cindy Prescott (UBC) Phone: 822-2507
BC-IR.46  Marbled murrelet nesting habitat on the Sunshine Coast.
Contact: Andrew Derocher    Phone: 751-7126

BC-IR.47  Relationship among grassland floral diversity, soil seed banks, and plant community stability.
Contact: Michael Pitt (UBC)    Phone: 822-3453