

FRDA Research Memo

CGJE
634909711
BCMI
RES
FRM
NO. 208

June 1992

Miscellaneous

No. 208

Integrated Resource Management Research Update

The FRDA II Integrated Resource Management Research Program focusses on four main areas:

- **Biological Diversity** In forested ecosystems, biological diversity has not been widely studied to date. As a result, the impacts of forest management decisions on biodiversity are unclear. Baseline information from the genetic, species and landscape levels will help in developing guidelines for forest managers.
- **Old-growth Ecosystems** These will be studied to identify the processes that have formed them. This information will then be used to modify forestry practices to recreate old-growth attributes in the managed forest where possible.
- **Environmental Impacts of Current and Alternative Silvicultural Systems** The impacts of these on a variety of environmental factors will be compared. Topics will include watershed hydrology, water quality, soil disturbance, soil erosion, site productivity, wildlife habitat, livestock forage and smoke management.
- **Resource Use Conflicts** Conflicts over forest management decisions are becoming more frequent, and the information required to resolve them is not always adequate. A problem analysis will identify knowledge gaps and recommend research priorities for next year.

This memo provides brief summaries and progress to December 31, 1991. Further information is available from researchers and project contacts listed on page 14.

TABLE OF CONTENTS

Biological Diversity	1
Old Growth	6
Environmental Impacts	9
Addresses of Project Leaders	15

BIOLOGICAL DIVERSITY

Project BC-IR-06 *A biodiversity gap analysis of Vancouver Island*

Project Leader: Marvin Eng

Objectives:

To provide a regional scale overview of the status of, and threats to, biodiversity for Vancouver Island, in a form that can be used and updated efficiently.

Proposed Approach

Threats to biodiversity resulting from forestry activities normally occur at the site-specific level, through activities such as harvesting individual trees or applying herbicides. However, assessment of the significance of any individual threat, and formulation of policies to deal with it, require a broader perspective. Gap analysis is a method of summarizing and presenting the nature, magnitude, and extent of threats to biodiversity at the landscape level.

Co-operation between the Ministry of Forests and other B.C. government agencies will be required to produce the digital maps for the project. Base maps of watersheds will be prepared as planning units, and land tenure maps will be prepared and used to identify protected areas and threats to biodiversity. The assembled information will be used to model animal and plant species richness and produce a "gap analysis."

Mention of trade names or products does not constitute endorsement by the authors, the B.C. Ministry of Forests, or Forestry Canada.

Expected Benefits

The end product of this project will be a digital atlas of biodiversity. The information gathered will enable planners to assess site-specific land use proposals in a regional context, and will aid in proactive land use planning.

Project BC-IR-07 *Provincial gap analysis of protected areas and biodiversity*

Project Leader: Rick Page

Objectives:

- 1) To analyze protected ecosystems by ecological unit;
- 2) to identify ecological units that have ecosystems not represented in protected areas; and
- 3) to make recommendations for appropriate additions to fill identified gaps.

Proposed Approach

This project will provide digitized mapping of the province on a scale of 1:250 000. Ecoregion and biogeoclimatic unit boundaries will also be mapped at the same scale. Maps of ecosystems in protected areas will be produced at a scale of 1:20 000. Protected ecosystems will be analyzed by ecological unit to identify gaps.

Expected Benefits

The results of this study will be used to produce a report and maps detailing ecosystems not represented in protected areas. From this information, recommendations can be made for additions to fill these gaps.

Project BC-IR-12 *Evaluating minimum patch sizes for viable populations of vertebrates living within the Coastal Western Hemlock zone of Vancouver Island*

Project Leader: Jim Schieck

Agency Contact: Brian Nyberg

Objectives:

- 1) To evaluate isolated patches of mature forest for the presence of viable populations of small, non-flying vertebrates; and
- 2) to determine the minimum patch size necessary to maintain viable populations, by evaluating relationships between patch size and species density, and patch size and population reproductive success.

Proposed Approach

To evaluate the effect of harvesting patterns on wildlife, we need to know the minimum patch size that will sustain viable populations. This information is not available for many old-growth dependent species.

In this study, 10 isolated patches of mature forest will be selected within the Coastal Western Hemlock zone on north-

central Vancouver Island. Patches will have similar shape, aspect, elevation, vegetation composition, and habitat structure and will have been isolated between 5 and 20 years ago. Patch size will vary from 2 to 10 000 ha. A 2-ha plot will be established in each patch. In all but the smallest patches there will be a buffer strip of at least 200 m between the plot and the adjacent logged area. Species will be sampled using visual reconnaissance, traps and listening stations. In each plot, abundance, age structure and reproductive success will be determined for each species and used to evaluate whether viable populations are present.

Expected Benefits

The results of this study will help us to evaluate which species of small non-flying vertebrates depend on mature forest to live and breed, and to set guidelines for the minimum patch size needed to maintain viable populations. Access to such information will allow managers to make more informed decisions when managing for integrated resource use and forest biodiversity.

Project BC-IR-13 *Maintaining wildlife diversity in managed coastal forests*

Project Leader: Dale Seip

Objectives:

- 1) To determine the relative abundance and diversity of vertebrate species living in old-growth forests compared to that abundance and diversity in clearcuts and second-growth stands; and
- 2) to determine relationships between habitat characteristics (e.g., snag abundance, woody debris, shrub cover, and elevation) and the abundance of various vertebrate species.

Proposed Approach

This study addresses increasing public concern that harvesting of coastal old-growth forests is reducing wildlife diversity. It focusses on determining the level of wildlife diversity in old-growth forests compared to that in managed forest stands, and on how much old growth must be retained to protect wildlife diversity.

Study areas will include coastal western hemlock forests on the Queen Charlotte Islands, Vancouver Island, and the Lower Mainland. The relative abundance of vertebrate species will be determined in old-growth stands (>250 years), 40- to 80-year-old second-growth stands and clearcuts. Sampling techniques will include census points and spot-mapping for forest birds, owl surveys, small mammal trapping, amphibian sampling, winter bird counts and track transects. Habitat characteristics, such as diameter distribution of live trees and snags, quantity and size distribution of coarse woody debris, shrub cover, and ecosystem association, will be determined for each stand. Relationships between the abundance of various wildlife species and habitat characteristics will also be analyzed.

Biological Diversity — Continued

Expected Benefits

The results of this study will aid in the development of guidelines to maintain wildlife diversity in managed stands.

Project BC-IR-18 *The development of a gene conservation strategy for the economically important conifers of B.C.*

Project Leader: Alvin Yanchuk

Objectives:

- 1) To create an inventory of important conifer species to determine their distribution and representation in current and planned forest reserves within the species range;
- 2) to determine the gene material currently represented in tree improvement installations;
- 3) to formulate strategies to ensure that an adequate number of populations is represented in some type of "conservation vehicle"; and
- 4) to identify important areas, populations, and gene conservation "gaps" that may require special conservation approaches.

Proposed Approach

Valuable gene pools of forest trees can be lost before they are recognized. Urban development, the rate of timber harvest, and the need for large scale planting programs threaten these pools. A strategy for ensuring the long-term maintenance of gene diversity for selected tree species will begin with this project.

Distribution maps of the species of interest will be constructed using inventory information compiled by the Old Growth Strategy committee, data from the biogeoclimatic base, Inventory Branch information from type maps, and current harvesting patterns. These maps will form the base for examining which populations are currently in some "protective status." Genetic variation information from the tree improvement programs will help us identify areas that may require additional or special conservation approaches.

Expected Benefits

The results of this study will provide important information on the genetic status of important conifer species in B.C. This information will allow the formulation of a gene conservation plan to address problem areas, as well as guidelines on what conservation vehicle would be most appropriate to "fill the gaps" in the conservation network. Implementation of these recommendations will ensure an increased level of protection for the forest gene resource of British Columbia.

Project BC-IR-19 *Management guidelines for biological diversity in the Prince Rupert Forest Region*

Project Leader: Jim Pojar

Objectives:

- 1) To identify the components of terrestrial biological diversity that are most threatened, or of greatest management concern, in the Prince Rupert Forest Region (PRFR); and
- 2) to develop preliminary guidelines for maintaining biodiversity in each forested subzone of the PRFR, with emphasis on the threatened/significant components.

Proposed Approach

Conservation of biological diversity has become a major resource management issue in the PRFR, with implications at all levels of forest management. This project will focus on the components that are most threatened or of greatest management concern, and on developing guidelines for management based on that information.

Expected Benefits

This project will provide guidelines to manage for biological diversity, tailored specifically to the PRFR. These guidelines will allow managers to make more informed decisions in all aspects of forest management for the region.

Project BC-IR-20 *Adaptive management in forestry*

Project Leader: Chris Fletcher

Agency Contact: Andy MacKinnon

Objectives:

- 1) To examine the principles of adaptive management, such as the nature of uncertainty, basics of experimental design, and passive versus active adaptive management; and
- 2) to develop experimental management approaches for some key forestry problems in B.C.

Proposed Approach

Forests are complex ecosystems with continual interactions among climate, topography, soils, vegetation, water, wildlife, insects and disease. The complexity of these relationships, added to public demands on the resource, guarantees that some uncertainty will always surround the outcome of management activities. The concept of adaptive management can help forest managers in coping with change and uncertainty in forest management. This project will consist of a review and analysis of the literature relevant to adaptive management. The final paper will be submitted to a refereed journal.

Biological Diversity — Continued

Expected Benefits

The completed paper will consolidate current knowledge on adaptive management, and provide suggestions for potential management strategies to use on current forestry problems.

Project BC-IR-21 *Assessing impacts on biological diversity of the distribution of forestry practices through time and space*

Project Leaders: Fred Bunnell
John Nelson

Agency Contact: Brian Nyberg

Objectives:

To develop ways of evaluating the probable impacts on biological diversity of the distribution of forest practices over landscapes through time.

Proposed Approach

One of the least understood aspects of maintaining biological diversity is the impact of habitat changes as they are distributed through time and space. This study will develop a system of grouping wildlife and plant species by attributes, so that their response to habitat changes in time and space can be predicted. A computer bookkeeping system will be created to relate habitat resources (e.g., snags, woody debris, space) to wildlife demands. Simulation and Geographic Information Systems (GIS)-based algorithms will be used for assessing the effects on biodiversity of: continuous vs. discontinuous corridors; the amount and spatial distribution of old-growth deferrals and extended rotations within working forests; the number and distribution of "New Forestry" practices among more traditional practices; and different specified green-up periods. As well, GIS will be used to develop routines for effectively displaying the probable impacts of different forestry practices. An appropriate experimental design will be defined for adaptive management approaches to evaluate the accuracy of predictions.

Expected Benefits

This study will combine biological expertise with expertise in GIS and simple simulation to produce a tool for assessing the impacts of the landscape distribution of forestry practices on biodiversity, as projected through time. The study will also identify knowledge gaps and define which further tools are needed to fill those gaps.

Project BC-IR-24 *Monitoring changes in biodiversity during research trials funded by FRDA II*

Project Leader: Tony Hamilton

Agency Contact: Brian Nyberg

Objectives:

- 1) To assess the impacts of FRDA II operational research on wildlife and biodiversity;
- 2) to develop and implement a monitoring program; and
- 3) to translate the results of the monitoring effort into interagency guidelines for maintaining biodiversity.

Proposed Approach

The list of projects funded under FRDA II will be examined for potential study sites. In consultation with operational and research staff of the Ministry of Forests and Ministry of Environment, Lands and Parks, projects will be ranked according to potential impact on wildlife and biodiversity. Sampling priority will be assigned on the basis of perceived impacts. A working plan for a monitoring program to cover the highest ranking topics will be prepared. This plan will include: 1) biodiversity and wildlife sampling design; 2) data collection methods to monitor changes in habitat characteristics; and 3) links to the existing sampling on the site.

The monitoring program will be implemented, with pretreatment data being collected wherever possible. Toward the end of the 5-year program, a technical summary of the monitoring program will be prepared with recommendations for maintaining biodiversity in managed stands.

Expected Benefits

This project will provide information which can be incorporated into the interagency guidelines for the maintenance of biodiversity. The final report will contain chapters specific to each research installation, and will summarize impacts of the various silvicultural practices in an ecological framework.

Project FC-IRM-01 *Ex-situ conservation of forest biodiversity in B.C.*

Project Leader: Yousry El-Kassaby

Agency Contact: George Edwards

Objectives:

- 1) To determine if commonly used forest seed storage practices result in biochemical changes, especially in protein complexes, that could reduce genetic diversity;
- 2) to relate any changes to specific genotypes; and
- 3) to provide an impact assessment of current seed storage procedures on the genetic composition of future plantation forests in British Columbia.

Proposed Approach

Forest tree seed is often stored for many years, yet the potential impact of storage on future genetic diversity has

Biological Diversity — Continued

never been investigated. This study intends to evaluate the effects of current storage methods on the genetic diversity of future forests. The study will include both conifer and broadleaved species. Techniques used include 2-D electrophoresis to monitor changes in protein complexes, and isozyme analytical methodology to determine gene frequencies and measure changes with duration of storage. The use of accelerated aging will allow simulation of long-term storage of seed materials. The main species to be investigated include white spruce, lodgepole pine, Douglas-fir, Sitka spruce, grand fir, western white pine and red alder. Garry oak, western madrone (arbutus) and big-leaf maple will also be included as examples of threatened species.

Expected Benefits

Maintaining genetic and species diversity is currently of great concern to both forest managers and the interested public. The results of this study will help us to evaluate the impact of current methods of storing seed on genetic diversity, and to determine whether changes in current methodologies are needed.

Project FC-IRM-02 *Soil nematode diversity and distribution in different forest soil habitats*

Project Leader: Valin Marshall

Objectives:

To provide qualitative and quantitative information on soil nematodes in various forest-soil habitats as a prerequisite to the conservation of biodiversity.

Proposed Approach

Initial sampling will be conducted to develop efficient survey methods for determining biodiversity in major forest soil habitats. Further sampling will be modified according to these results, but it is expected to be a form of stratified random sampling. Soil samples, including rotting wood, mosses and litter at tree bases, will be extracted and nematodes counted and identified. Permanent mounts will be made of representative species. Slide-mounted specimens will provide a collection for future ecological studies and the description of new species. Data will be analyzed by various multivariate analyses and similarity indices.

Expected Benefits

This study will complement on-going Forestry Canada research in forest biodiversity and will aid in the development of management options for conserving biodiversity in forest ecosystems. Results will be presented in lectures, scientific publications, and guides for developing preservation strategies.

Project FC-IRM-04 *Incentives for maintaining biodiversity*

Project Leader: Tim McDaniels

Agency Contact: Douglas Pollard

Objectives:

- 1) To investigate the underlying incentives for conserving biodiversity in Canada; and
- 2) to investigate how maintaining biodiversity can help manage environmental risks.

Proposed Approach

Increasingly, forest managers are required to make decisions affecting biodiversity. The potential importance of economic incentives in shaping these decisions cannot be overemphasized. Maintaining biodiversity is an investment in conserving a wealth of biological information that has evolved over time. There is a tendency to underinvest in maintaining this biological information because there are no clear ways that the benefits can be captured by the groups making the investment.

This project will investigate two aspects of management decisions regarding biodiversity: the incentives for maintaining biodiversity and the contribution of biodiversity toward managing environmental risk.

In Phase I, the nature of incentives for maintaining biodiversity will be reviewed and alternative institutional structures will be covered briefly. There will also be a discussion of the hypothesis that a stronger incentive for maintaining biodiversity exists in Canada than elsewhere because of public ownership of the resource base, which allows Canadians to benefit more widely from conserving biodiversity.

In Phase II, the potential contribution of biodiversity as a tool for managing environmental risk will be reviewed.

Expected Benefits

The two phases of the project will result in separate discussion papers. These papers will contribute to a better conceptual understanding of why the maintenance of biodiversity is important for regional, provincial and national resource policy objectives.

Old Growth

OLD GROWTH

Project BC-IR-08 *Developing methodologies to study community ecology of the canopy-forest floor insect/arthropod fauna from an old-growth forest*

Project Leaders: Richard Ring
Neville Winchester

Agency Contact: Andy MacKinnon

Objectives:

- 1) To develop and test a variety of sampling methods for obtaining information about the composition of insect/arthropod communities in the coastal, old-growth forest habitat;
- 2) to correlate information with biogeoclimatic zone and compare the old-growth community with adjacent second-growth and clearcut areas; and
- 3) to examine population dynamics and differential rates of occurrence among four study areas.

Proposed Approach

Present forest practices have unknown consequences on important components of the insect/arthropod community. More detailed information on this community is needed to ensure proper management of the resource.

The sample area will include four sites: old-growth canopy, old-growth forest floor, transition zone and clearcut. Two sampling methodologies will be used to gather field data. First, a branch clipping program will be conducted in the canopy site. Second, modified Malaise and Sticky traps will be run at all four sites in two experimental designs. Other sampling methodologies will be developed and tested. Sampling methods will be applicable to a variety of old-growth forest types.

Expected Benefits

This study will develop new sampling methodologies, and provide previously unavailable baseline information that can be incorporated into forest harvest policies for better integrated resource management. In addition, collected specimens will be deposited in the Royal British Columbia Museum and the Canadian National Collection. This collection of insects/arthropods from an old-growth forest will be the first of its kind, and will provide important biogeographical information as well as type specimens and a number of new species, genera, and possibly families.

Project BC-IR-09 *Macrofungi of old-growth forests: saphrophytes and biotrophs and their correlation to biogeoclimatic zones and humus forms*

Project Leader: Shannon Berch

Agency Contact: Andy MacKinnon

Objectives:

- 1) To predict from extensive literature and herbarium searches, macrofungi (saphrophytic, mycorrhizal, and pathogenic) of old-growth forests in coastal British Columbia;
- 2) to carry out limited on-site collections to establish protocols for more extensive studies to follow; and
- 3) to compare findings to predictions.

Proposed Approach

Macrofungi are an important part of the pre-harvest ecosystem, playing a significant role in making nutrients available for absorption and transport to tree roots. When harvesting occurs, a new balance must be established and more investigation is needed to determine whether the right fungi will be present after harvest to meet the needs of the post-harvest forest.

In the first year of this study, sites will be selected to determine biodiversity of organisms in old-growth forests. In subsequent years, new sites will be added of different age, composition, and geographic location. Selected sites will be classified and humus forms determined.

The prediction of macrofungi likely to be found on selected sites will be based on appropriate literature and lists of fungal species collections from the U.S. Pacific Northwest and Alaska. Throughout the year, fungi will be collected from the site. Specimens will be photographed in the field, described when fresh, collected, subjected to microchemical tests, returned to the lab for microscopy, dried and preserved. As information becomes available, collections will be mapped and correlated with biogeoclimatic zones and humus forms. Field findings will be compared to predictions.

Expected Benefits

This study will provide a knowledge base of macrofungi distribution, identity and function, which will aid the investigation of macrofungi biodiversity in old-growth forests of British Columbia.

Old Growth — Continued

Project BC-IR-10 *Old-growth lichens: status report for rare species. Lichens of old-growth forests of the CWH and ICH*

Project Leader: Ted Lea

Agency Contact: Del Meidinger

Objectives:

- 1) To determine the endangerment status of five rare lichen species confined to Coastal and Interior Wet Belt old-growth forests; and
- 2) to assess possible effects of harvesting on these species.

Proposed Approach

Little knowledge exists on rare species of non-vascular plants in old-growth forests. There are no species of lichens currently listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) because the status reports required for listing have not been written to date. A more complete knowledge of non-vascular species is necessary to determine what effect logging and silviculture may have on lichens.

In this study, five species of rare lichens believed to be old-growth dependent have been chosen for study and status reports. All potential habitats, including second-growth areas, will be surveyed for these species. Status reports will be written for each species, following both the format used for COSEWIC status reports and status reports written for the Ministry of Environment, Lands and Parks Wildlife Branch. The lichen species chosen for study are Pacific Northwest endemics, two of which occur only in British Columbia. Work will include both field and herbarium studies.

Expected Benefits

These results will give us a better understanding of the occurrence and habitat requirements of non-vascular plants in old-growth forests. The completion of status reports for each species will provide the information necessary for listing by COSEWIC and the Ministry of Environment, Lands and Parks Endangered Species legislation, should any of the species qualify.

Project BC-IR-11 *Amphibian and forest bird associations in old-growth and second-growth communities*

Project Leaders: Jean-Pierre Savard
Ron McLaughlin

Agency Contact: Dale Seip

Objectives:

- 1) To examine bird species composition in relation to forest succession, and determine the post-harvest stage at which forest birds recolonize;
- 2) to examine the distribution, relative abundance, and habitat requirements of amphibians in forests of different age classes; and

- 3) to determine which bird and amphibian species are old-growth dependent.

Proposed Approach

In recent years, the management of public lands for multiple use has placed greater emphasis on non-game species. At present, however, no attempt has been made to determine when and how forest birds re-establish following tree harvest. Information on amphibians and their habitat associations is also lacking, as they have only recently been included in inventories for the preservation of wildlife habitat.

Funding has been allocated to three on-going biodiversity studies on Vancouver Island. Two studies focus on bird and amphibian species diversity in various aged stands located in TFL's 39 and 44. The third study is a more detailed investigation of salamanders and stand age in the Nahmint Valley.

Bird surveys will include roadside point counts in five stand ages replicated in the Eve River, Kennedy Lake, Franklin River and Sproat Lake Divisions. Amphibians will be surveyed with the use of pitfall traps and selected stations on all roadside bird transects. Vegetation will also be surveyed along the above transects.

Expected Benefits

The project will provide information that will allow resource managers to:

- better understand habitat selection and community dynamics for the studied species;
- consider bird and amphibian habitat needs in future forest management plans;
- identify and compare the impact of various management regimes on the studied species; and
- maintain and enhance biological diversity on a local, regional and provincial scale.

Project BC-IR-14/ *Carbon emissions from harvesting*
FC-IRM-10a *coastal old-growth forests*

Project Leaders: Phil Comeau
Dave Spittlehouse
Tony Trofymow
Hugh Barclay

Objectives:

- 1) To provide models for assessing carbon emissions resulting from harvesting old-growth CWH (Coastal Western Hemlock) zone forest ecosystems; and
- 2) to provide a sound analysis of carbon emissions resulting from such harvesting.

Proposed Approach

In recent years there has been concern that harvesting British Columbia's coastal forests may release CO₂ to the atmosphere and contribute to the "greenhouse effect." This study will provide needed analyses to explore possible impacts of harvesting old-growth CWH zone forests on the global carbon budget.

Old Growth — Continued

Published and unpublished data are being consolidated and summarized for modelling carbon (CO₂, CO, and CH₄) emissions. During 1990/91, information on the quantity and turnover of soil organic material and coarse woody debris was assembled from a variety of sources. This information will be used in 1991/92, together with information on tree biomass accumulation, to model carbon accumulation in coastal forests. Carbon emissions resulting from harvesting will be estimated using model results and information on the fate and turnover of harvested materials.

Expected Benefits

In addition to addressing public and professional concerns about the "greenhouse effect," this research will also provide useful information on carbon and nutrient cycling in coastal old-growth and young-growth forests. Final results will be summarized and used to prepare estimates of carbon budgets for coastal old growth.

Project 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*

Project Leaders: Hamish Kimmins
Rod Keenan
Cindy Prescott

Agency Contact: Andy MacKinnon

Objectives:

To obtain an estimate of total biomass and carbon content of woody debris and forest floor material in old-growth cedar/hemlock forests.

Proposed Approach

The per-hectare volume of coarse woody debris (>15 cm and <1 m diameter) will be estimated at three locations in the Port McNeill area using the line intersect method. A full inventory of logs >1 m, dead standing trees, and stumps will be taken in four 25-m² quadrants at each location. Subsamples taken from downed logs and stumps will be dried and weighed to determine density. These values will be used to convert volume estimates to mass estimates. Woody debris <15 cm and >1 cm diameter will also be collected, sorted, dried and weighed. A portion of each subsample will be ground and analyzed for carbon content.

At each of the same three locations, 16 samples of forest floor will be collected and sorted into components for lab analysis.

Expected Benefits

This study is part of a larger project aimed at improving the understanding of stand dynamics, nutrient cycling and productivity in old-growth forests of the very wet, submontane Coastal Western Hemlock biogeoclimatic zone. It will provide an estimate of the carbon content of one component of unmanaged forest in this ecological zone.

Project BC-IR-16 *A functional assessment of old-growth tree population structures in some selected forest types*

Project Leaders: Philip Burton
Dan Kneeshaw

Agency Contact: Evelyn Hamilton

Objectives:

- 1) To test whether there are specific stand dynamic attributes and an identifiable stand structure associated with a particular population-based definition of "old growth" (i.e., old growth is the state which exists after more than half the basal area of a stand is composed of post-invasion cohort stems);
- 2) to identify other suitable stand criteria that are associated with qualitative differences in stand regeneration and dynamics; and
- 3) to improve understanding of the shifts in composition and structure of selected forest types as they change from "mature" to "overmature" or "old-growth" status.

Proposed Approach

Selected mature and old-growth stands will be sampled from within the Sub-Boreal Spruce biogeoclimatic zone. These stands will be inventoried for snags, downed logs, live trees, saplings, seedlings and understory vegetation. All living vegetation will be identified according to species and dead stems will be identified when possible. All stems will be measured for diameter and height, and standing trees will be cored for age and increment analysis. Standing and downed dead trees will be assigned a decay class. Mapping will include plotting the position of all stems and the horizontal projection of the canopy.

With the collected data we will be able to summarize the structural attributes of the selected old-growth stands, such as: the number of large trees, snags and downed logs; tree spacing; stratification of the canopy; abundance and size of gaps; recruitment of seedlings; and composition of the understory vegetation. This structural information will be compared with the functional definition of "old growth," determined from an analysis of age class distributions, and with radial increment changes.

Expected Benefits

The results of this study will give us a better understanding of the stand attributes and dynamics of old-growth sub-boreal spruce stands.

The data will allow the formulation of a more functional, quantifiable definition of old growth which incorporates concepts of stand dynamics, mortality and regeneration. This study will also provide information about successional pathways and the importance of small scale and large scale disturbances within sub-boreal landscapes.

Old Growth — Continued

Project FC-IRM-03 *Diversity of mycorrhizal fungi in old-growth and second-growth stands of Douglas-fir on Vancouver Island*

Project Leader: Douglas Goodman

Scientific Advisor: M.C.R. Edgell

Agency Contact: Tony Trofymow

Objectives:

- 1) To compare the diversity and community structure of mycorrhizae in an old-growth stand and an adjacent managed second-growth stand; and
- 2) to relate mycorrhizal distribution to spatial variation of soil characteristics and vegetation.

Proposed Approach

Mycorrhizae form important interfaces between trees and soil systems, with most soil nutrients passing through mycorrhizal fungi before entering the root and vascular systems of the tree. Researchers are attempting to explain the distribution of species of mycorrhizal fungi in forest soils in terms of specialization of habitat and ability to decompose specific substrates. There is evidence that stand aging is accompanied by a succession of mycorrhizal fungi, hence old-growth stands may be essential for the survival and dispersal of fungi adapted to soil conditions found in older stands.

Under the direction of University of Victoria staff, this study will evaluate the practical implications of changes in mycorrhizal communities caused by forest management. Sampling will be designed to include a wide range of micro-habitats to allow comparisons within and among cover types. Experiments will be conducted to determine whether variation in soil characteristics is related to the distribution of mycorrhizal fungi.

Expected Benefits

This research will produce documentation of mycorrhizal diversity in relation to soil and vegetation, allowing the development of management options to conserve the diversity of Douglas-fir mycorrhizae in a stand. Results will be transferred via reports and seminars, and site tours will be conducted periodically.

Project FC-IRM-05 *Utilization of residual patches of old-growth timber by forest birds*

Project Leader: Rhonda Millikin

Agency Contact: George Edwards

Objectives:

- 1) To map residual patches of old-growth timber in two watersheds of coastal western hemlock on Vancouver Island, noting their proximity to continuous stands; and
- 2) to determine whether these patches are large enough to contain the habitat components required by old-growth dependent bird species.

Proposed Approach

The need to maintain old-growth forests as reservoirs for genetic diversity and wildlife habitat is well recognized. However, suitability of these reservoirs for birds will depend on the size and configuration of residual patches. Data are required to document patterns of bird use in these patches, as well as their location, size and proximity to continuous stands of either old-growth or second-growth trees.

This project includes eight residual patches of old-growth Douglas-fir, ranging in size from 3 to 900 ha, with a 10-ha plot in each patch for mapping bird territories and vegetation. Habitat variables (number and type of wildlife trees, canopy height, diversity and closure, vegetation density at various layers and percent canopy cover) were measured for each patch and within selected bird territories. Breeding birds were counted using a territory mapping technique and behavioural observations were conducted to determine the use of the patch by all birds encountered. The presence of predators was determined from observation points above each patch. In addition, distances to continuous old-growth and second-growth forests were calculated.

Preliminary results of the past field season indicate that other factors, such as proximity to water and vegetation structure, were as important to species diversity as patch size. Many species were present across the entire range of patch sizes. Observations will continue in the next field season.

Expected Benefits

This study will provide needed information on how size, location and configuration of residual patches of old growth affect their suitability for old-growth dependent bird species. A report will be completed with maps and documentation of results.

ENVIRONMENTAL IMPACTS

Project BC-IR-01 *Watershed sediment budget studies*

Project Leaders: Steve Chatwin
Dan Hogan
Dave Toews
Jim Schwab

Objectives:

- 1) To construct sediment budgets for watersheds in three typical basins — coastal, transition, and interior; and
- 2) to develop field and airphoto methods which will allow easy transfer of experimental results to other watersheds.

Proposed Approach

Suspended sediment is a key determinant of water quality and a serious concern for community watersheds, fisheries habitat and sport fishing. A watershed sediment budget would help foresters identify natural and operations-induced sources of sediment production, and allow for rehabilitation work and testing of the effectiveness of sediment control techniques. Formulation of these budgets for three typical

Environmental Impacts — Continued

basins will require the following experiments within each watershed:

- inventory of all sediment sources;
- monitoring of sediment yield at two to four locations in each basin;
- measurement of all sediment yields from specific source types; and
- sediment tracer experiments for sediment delivery ratios.

Monitoring will take place during storms of different size, as well as during at least three snowmelt periods.

Expected Benefits

This study will provide us with a more thorough understanding of which forestry practices affect water quality, and will aid us in developing sediment control techniques to mitigate water quality problems. Results derived from three typical basins (coastal, transition, and interior) will be applicable to other watersheds.

Project BC-IR-02 *Efficacy of biological control agents on diffuse and spotted knapweed*

Project Leaders: Brian Wikeem
Allen Sturko
Jacob Boateng

Objectives:

- 1) To determine the relative impacts of *Agapeta zoegana*, *Sphenoptera jugoslavica* and *Cyphocleonus achates* on the growth and survival of spotted and diffuse knapweed; and
- 2) to determine the threshold density of each agent that results in reduced growth and survival for diffuse and spotted knapweed.

Proposed Approach

The most effective control of knapweed is through the use of Tordon 22K herbicide. However, due to increasing public concern, an alternative to herbicide use may become necessary. Biological control agents are a logical choice, but little is known about the impacts of these agents on growth and survival of knapweed. Through this study, information will be gathered on the timing and success of individual biocontrol agents for controlling knapweed.

Diffuse and spotted knapweed will be seeded in plots simulating field densities. *Agapeta*, *Sphenoptera* and *Cyphocleonus* will be introduced to three replicated plots at 5, 10, 25 and 50 female agents per plot. Three control plots will also be established. Knapweed survival will be assessed by measuring plant height, number of flower stalks, and number of flowers produced. Difference in above-ground biomass among plots will also be determined.

Expected Benefits

This project will contribute valuable information on the efficacy of biocontrol agents for knapweed. The results will be used to produce preliminary guidelines for planning propagation and distribution of biological agents to control knapweed.

Project BC-IR-03 *Development of predictive models of understory development in early forest succession*

Project Leader: Evelyn Hamilton

Objectives:

- 1) To collect, compile and analyze information on forest and vegetation succession in the Sub-Boreal Spruce zone;
- 2) to determine concurrent tree seedling performance;
- 3) to evaluate the utility of existing forest succession models for predicting the types of vegetation complexes and rates of succession that will develop from forestry practices; and
- 4) to formulate a working plan for co-ordinating future development of forest understory succession models.

Proposed Approach

There is a scarcity of information on successional patterns of understory vegetation in British Columbia forest ecosystems. In addition, little information exists on the effects of slashburning on successional patterns. Public concern about forestry practices makes acquisition of this type of information imperative.

This study will collect data on forest succession in the Sub-Boreal Spruce zone, following slashburns of differing severity performed in previous studies. Collected data on vegetation dynamics and seedling response will be analyzed. These data will be used to evaluate both the effectiveness of existing forest succession models in predicting the type of information needed by vegetation managers, and their ability to predict the actual observed response. A workshop with forest succession modelling experts will provide additional input on the utility of existing models. Future research needs will be identified and a working plan developed for co-ordinating the formulation of new forest understory succession models.

Expected Benefits

This project will provide valuable information on the efficacy of existing forest succession models and direction for development of future models. Results will be applicable to vegetation management, wildlife habitat enhancement, and the maintenance of biological diversity.

Environmental Impacts — Continued

Project BC-IR-04 *Impacts of site preparation on habitat utilization and availability for red-, blue- and selected yellow-listed wildlife species in the interior of B.C.*

Project Leader: Katherine Enns

Agency Contact: Brian Nyberg

Objectives:

- 1) To complete a problem analysis on the current and past use of site preparation in coastal and interior ecosystems and the projected extent of site preparation in the future;
- 2) to examine the known impacts of site preparation on red-, blue- and yellow-listed wildlife species in terms of habitat availability and utilization patterns;
- 3) to identify data gaps and research needs on the above; and
- 4) to suggest the design for a field program to evaluate the impact of selected site preparation methods on habitat utilization and availability.

Proposed Approach

Mechanical site preparation techniques are used in many managed forests in British Columbia. The impacts of those techniques on wildlife habitat availability and utilization are poorly understood. Site preparation techniques are likely to increase with increasing intensive silviculture, yet forest managers have little information with which to anticipate the impacts of these techniques on wildlife populations and habitats. This project will provide a thorough analysis of the current understanding of impacts and the applications of present research. It will also identify data gaps and research needs with respect to wildlife habitat management.

A literature review and review of current field knowledge relevant to the use of site preparation in British Columbia and wildlife use of prepared areas will be conducted. Personal communications with operations personnel and Ministry staff are expected to take place throughout the review process. The resulting information will be incorporated into a problem analysis. In addition, a synopsis will be written of physical and biological characteristics associated with each category of treatment, which may be important to wildlife (e.g., vegetation recovery schedules and forage enhancement).

A draft report will be submitted, covering: documentation of the prevalence and scope of site preparation in interior and coastal forests; known impacts of site preparation on red-, blue- and selected yellow-listed wildlife species; associated data gaps and research needs; recommendations on modification of site preparation treatments to maximize both wildlife habitat values and conifer establishment by subzone/variant; and a design for a field program to examine further the impact of selected site preparation methods on habitat utilization and availability. A final report will be submitted following the review process.

Expected Benefits

The results of this study will give us a better understanding of the effects of site preparation techniques on wildlife, as well as of how potential negative impacts can be mitigated.

Information from the study will contribute to more effective integrated forest resource management.

Project BC-IR-05 *Influence of vegetation management on diversity of plants, small mammals, birds, and furbearers in the ICH biogeoclimatic zone*

Project Leaders: Tom Sullivan
Fred Bunnell
Alton Harestad

Agency Contact: Brian Nyberg

Objectives:

To measure the impact of manual habitat alteration on species richness and diversity of plants, small mammals, birds and furbearers.

Proposed Approach

The impacts of forestry practices on small mammals, birds, furbearers and plant diversity are poorly understood. Since practices such as manual and herbicide-induced habitat alteration can be expected to continue, a better understanding is required for effective management.

This 5-year study will be located in replicated blocks (20–40 ha) in the Salmon Arm District of the Kamloops Forest Region. Nine plantations (three control, three herbicide-treated, and three with manual removal of vegetation), 5–10 years of age, have been selected within the ICH biogeoclimatic zone. Various intensive sampling techniques will be used for plant species, small mammals, birds and furbearers. Data will be analyzed for species richness (number of species) and diversity (heterogeneity).

Expected Benefits

Results of this study will give vegetation managers direction for minimizing negative impacts of forestry practices on the biological diversity of plantations.

Project BC-IR-25 *Effects of vegetation management for brush and alder on forest birds in the CWH zone within the Adam and Eve watersheds*

Project Leader: Rhonda Millikin

Agency Contact: Brian Nyberg

Objectives:

- 1) To define changes in vegetation structure brought about by management for brush on alluvial sites of the Coastal Western Hemlock (CWH) zone;
- 2) to characterize territories of selected bird species that are most common in unmanaged sites and show the greatest response to vegetation removal; and

Environmental Impacts — Continued

- 3) to determine how target vegetation is used by the selected species through observations of feeding and nesting behaviours.

Proposed Approach

Data on the use of brush by forest birds are needed to assist forest managers in assessing the risk of vegetation management to birds. Former studies of brush removal with herbicides have documented changes in diversity and abundance of birds, but have not examined habitat quality in relation to reproductive success.

This study will compare, in the Adam and Eve watersheds, three sites requiring brush treatment and three comparable sites that have already been treated. Plots will be site-typed to ensure uniform opportunity has existed for vegetation growth. A census for bird species will be done at each site pair, taking special note of absence or reduced abundance on managed sites. Special attention will be given to the band-tailed pigeon and the orange-crowned warbler, which are common in unmanaged sites and appear to show a significant response to vegetation removal. To determine utilization of brush, territories of selected species will be defined and nesting and feeding behaviours observed. Food brought to nestlings will be sampled and compared to insect samples taken from target vegetation. Vegetation on treated and untreated sites will be sampled to quantify differences in habitat components. Differences in plant abundance (availability) will be related to observations of habitat use by birds (feeding and nesting requirements), as well as abundance and diversity of bird populations.

Expected Benefits

The results of this project will provide information on the risk of vegetation management to forest birds.

Project BC-IR-26 *Takla Fish/Forestry Interaction Program*

Project Leader: Steve Chatwin

Objectives:

To establish three comparable experimental watersheds in the northern Interior (SBS zone) where the effects of forest practices on Interior fish stocks and habitat can be tested.

Proposed Approach

Fish/forestry guidelines are being developed for the interior of British Columbia to parallel those formulated for coastal regions. A major contributor to development of the coastal guidelines was the watershed level forestry impact study carried out at the Carnation Creek experimental watershed. Establishment of a similar experimental watershed for the Interior would facilitate development and testing of the interior guidelines.

This project will establish three long-term experimental watersheds on creeks tributary to Takla Lake. The Gluskie Creek site will be conventionally logged, the Forfar Creek site will be an old-growth control, and the O'Neil Creek site will be the focus of "New Forestry" methods. The study will evaluate

impacts from forest activities such as sedimentation, stream hydrology, temperature changes, stream nutrient changes and habitat changes. Cumulative impacts that might result in changes to fish ecology will also be evaluated. Baseline data will be collected before and during logging, and post-logging information will be collected for at least 3 years, to determine the impacts of harvesting on fish stocks and habitat.

Expected Benefits

The information collected in this study will be a valuable contribution to the new fish/forestry guidelines being formulated for the Interior. The results will include reports outlining the impacts of various forestry practices on Interior fish stocks, and the success of alternative practices in mitigating impacts.

Project FC-IRM-06 *Prescribed fire impact and smoke emissions models*

Project Leader: Stephen Taylor

Agency Contact: Peter Fuglem

Objectives:

To develop a model of fuel consumption, energy release and smoke emissions from broadcast prescribed burns in British Columbia.

Proposed Approach

Public concern with smoke is currently restricting the use of prescribed fire as a tool for regeneration, hazard abatement and wildlife management in many areas of British Columbia. Restriction of burning is occurring when smoke is "perceived" to have reached maximum tolerable levels, but no system exists to predict daily smoke emissions and dispersion quantitatively. This lack of information makes it difficult for managers to make effective decisions.

This study proposes to formulate a prediction system incorporating linked models of fuel consumption, smoke emissions, and smoke column development and dispersion. In addition, this project will develop models of fuel consumption and energy release by combustion phase, which are fuel-type specific. In this study, the spruce-subalpine fir fuel type will be targeted because many hectares of this fuel type are burned in the current silviculture program.

Smoke emissions will be predicted by combining predictions of fuel consumption in the flaming and smouldering phases of combustion, with emission factors for various smoke constituents in the respective combustion phases. A preliminary, generalized model will be developed from existing models. This model will be coupled with models of smoke column development and smoke plume dispersion being developed by other co-operators in the Smoke Plume Evaluation and Modelling Project (SPEM). The fuel-type specific model for spruce-subalpine fir slash will be developed using an empirical, regression modelling approach.

Data were collected from four prescribed burns in the 1991 field season. Work in 1992 will involve analysis and interpretation of these fuel consumption and infrared imaging data, and development of a prototype model.

Expected Benefits

The smoke emissions models will allow land managers to design burning prescriptions that reduce smoke emissions or increase smoke dispersion. They will also allow quantitative predictions of daily emissions on a regional scale for use in a smoke management system.

Project FC-IRM-07 *Evaluation of logging impacts on Carnation Creek streamflow*

Project Leader: Eugene Hetherington

Agency Contact: Steve Chatwin

Objectives:

- 1) To determine the magnitude and duration of stormflow runoff changes following logging in the Carnation Creek Experimental Watershed; and
- 2) to determine whether harvesting has affected rain-on-snow runoff peak flows.

Proposed Approach

The 20-year-old Carnation Creek Experimental Watershed Project was initiated to evaluate the impacts of clearcut logging on a coastal stream system. Preliminary analyses of the initial impacts on peak flows have been done. With re-establishment of logging in the upper part of the watershed, it is timely to update and extend the analyses.

The study will begin with updating and completing the streamflow data sets to 1991. Statistical procedures will be used to compare treated versus control data before and after logging for each parameter, as a basis for evaluating possible changes. Additional calculations and evaluation will be required to interpret rain-on-snow events.

The impacts on both peak flows and storm runoff volumes, and the possibility of harvesting impacts on rain-on-snow runoff will be evaluated. It would also be beneficial to determine whether vegetation regrowth has produced a trend toward pre-logging flow conditions. Assessing the impacts on stream channel morphology and planning for integrated resource management will depend upon gathering the above information.

Expected Benefits

In the past, rate-of-cut harvesting restrictions have been imposed on coastal watersheds according to "assumed" impacts on peak flows, with particular concern about rain-on-snow events. Peak flow changes are important because of their potential to increase erosion and stream channel damage, thus affecting fisheries resources. This study will provide quantitative data to guide critical decision-making on rate-of-cut harvesting in relation to hydrological impacts.

Project FC-IRM-08 *Development of data set for calibration and extension of the HSPF hydrologic simulation model using Carnation Creek data*

Project Leader: Eugene Hetherington

Agency Contact: Steve Chatwin

Objectives:

- 1) To develop an 18-year data set from the Carnation Creek data in a form suitable for calibrating the Hydrologic Simulation Program Fortran (HSPF) model on an hourly time step; and
- 2) to develop a prototype data set from the Carnation Creek data for application to other west coast watersheds.

Proposed Approach

Forest management practices can impose major changes on the hydrologic regime of watersheds, particularly on streamflow. Knowledge of streamflow and runoff regimes allows better design of road drainage structures and minimizes erosion and stream sedimentation. Unfortunately, in most watersheds on the coast the streams are ungauged. Methods are needed to provide realistic estimates of runoff in such situations.

The Carnation Creek Experimental Watershed Project is a unique source of long-term hydrological data that can be used to develop a prototype data set, and to calibrate a hydrologic simulation model. The HSPF model has been identified as suitable for extrapolating Carnation Creek data to ungauged coastal watersheds.

The first step leading to model calibration is preparation of the data that presently exist as processed computer files, charts, and unprocessed datalogger files. The existing and newly created computer files will be screened for completeness and gaps will be filled by estimation, using procedures such as regressions with data from other stations. Computer programs will be created for digitizing charts, formatting datalogger outputs, and creating hourly values. Existing programs will put data into the HSPF format.

Expected Benefits

The results of this study will allow valuable information on hydrological management gathered in the Carnation Creek area to be applied to other coastal watersheds through the use of a prototype data set. Having this information about individual watersheds will contribute to better integrated forest resource management and protection of water and fisheries resources. Completed Carnation Creek data sets up to 18 years in length for the selected variables will be available at the end of the study in both sequential and HSPF formats.

Environmental Impacts — Continued

Project FC-IRM-09 *Effects of habitat modification, through partial harvesting options, on wildlife species diversity and abundance in the ICH, Nelson Forest Region*

Project Leaders: John Senyk
Ron Kowall

Objectives:

- 1) To identify pre- and post-harvest wildlife species occurrence and relative abundance; and
- 2) to document wildlife responses to habitat modification resulting from various partial harvesting systems.

Proposed Approach

Partial removal of standing timber is considered compatible with current landscape and integrated resource management concepts. The habitat modification effects of partial cutting and its accompanying impacts on wildlife species are largely unknown. These effects need to be documented to aid forest and wildlife managers in making informed, site-specific recommendations.

Both the Ministry of Forests and the forest industry in the Nelson Region have made commitments to investigate and/or carry out partial harvesting in their areas. A variety of partial cutting techniques, block sizes, and seasons of operations are being planned. Choice of systems depends on a number of different factors, including visual concerns, maintenance or improvement of wildlife habitat, control/sanitation, site productivity, water quality and successful regeneration.

This study will examine a number of partial cuts and areas planned for partial cutting during the summer of 1991. The assessment will determine the areas and types of systems to be included in the study. Established methodologies for sampling wildlife populations and assessing vegetation response will be used in the selected study areas.

Expected Benefits

The results from this project will allow managers to make informed decisions on choice and placement of operational partial harvesting techniques, to benefit wildlife populations and satisfy integrated resource management objectives. The study will go on for 5 years, with a final report to be completed in 1995.

NAMES, AFFILIATIONS AND ADDRESSES OF PROJECT LEADERS

<p>Barclay, Hugh Pacific Forestry Centre 506 West Burnside Road Victoria, B.C. V8Z 1M5</p>	<p>363-0604</p>	<p>Goodman, Douglas M. University of Victoria Department of Biological Sciences Box 1700 Victoria, B.C. V8W 2Y2</p>	<p>721-7114</p>
<p>Berch, Shannon University of British Columbia Department of Soil Science 139-2357 Main Mall Vancouver, B.C. V6T 2A2</p>	<p>822-3716</p>	<p>Hamilton, Evelyn B.C. Ministry of Forests Research Branch 31 Bastion Square Victoria, B.C. V8W 3E7</p>	<p>387-3650</p>
<p>Boateng, Jacob B.C. Ministry of Forests Silviculture Branch 31 Bastion Square Victoria, B.C. V8W 3E7</p>	<p>387-8905</p>	<p>Hamilton, Tony B.C. Ministry of Environment, Lands and Parks Wildlife Branch 780 Blanshard Street Victoria, B.C. V8V 1X5</p>	<p>387-9761</p>
<p>Bunnell, Fred University of British Columbia Forest Sciences Department 270-2357 Main Mall Vancouver, B.C. V6T 1Z4</p>	<p>822-2727</p>	<p>Harestad, Alton Simon Fraser University Biological Sciences Department Burnaby, B.C. V5A 1S6</p>	<p>291-4475</p>
<p>Burton, Phil University of British Columbia Forest Sciences Department 270-2357 Main Mall Vancouver, B.C. V6T 1Z4</p>	<p>822-6018</p>	<p>Hetherington, Eugene Pacific Forestry Centre 506 West Burnside Road Victoria, B.C. V8Z 1M5</p>	<p>363-0658</p>
<p>Chatwin, Steve B.C. Ministry of Forests Research Branch 31 Bastion Square Victoria, B.C. V8W 3E7</p>	<p>387-5887</p>	<p>Hogan, Dan B.C. Ministry of Forests 4595 Canada Way Burnaby, B.C. V5G 4L9</p>	<p>660-7500</p>
<p>Comeau, Phil B.C. Ministry of Forests Research Branch 31 Bastion Square Victoria, B.C. V8W 3E7</p>	<p>387-3019</p>	<p>Keenan, Rod University of British Columbia Forest Sciences Department 270-2357 Main Mall Vancouver, B.C. V6T 1Z4</p>	<p>822-6018</p>
<p>El-Kassaby, Yousry Canadian Pacific Forest Products Ltd. Saanich Forestry Centre Saanichton, B.C. V0S 1M0</p>	<p>652-4023</p>	<p>Kimmins, Hamish University of British Columbia Forest Sciences Department 270-2357 Main Mall Vancouver, B.C. V6T 1Z4</p>	<p>822-6018</p>
<p>Eng, Marvin B.C. Ministry of Forests Research Branch 31 Bastion Square Victoria, B.C. V8W 3E7</p>	<p>387-2710</p>	<p>Kneeshaw, Dan University of British Columbia Forest Sciences Department 270-2357 Main Mall Vancouver, B.C. V6T 1Z4</p>	<p>822-6018</p>
<p>Enns, Katherine Larkspur Biological Consultants 966 Snowdrop Avenue Victoria, B.C. V8Z 2N4</p>	<p>479-6210</p>	<p>Kowall, Ron B.C. Ministry of Environment, Lands and Parks Wildlife Branch 780 Blanshard Street Victoria, B.C. V8V 1X5</p>	<p>387-1188</p>
<p>Fletcher, Chris Simon Fraser University Natural Resource Management Program Burnaby, B.C. V5A 1S6</p>	<p>291-3068</p>	<p>Lea, Ted B.C. Ministry of Environment, Lands and Parks Wildlife Branch 780 Blanshard Street Victoria, B.C. V8V 1X5</p>	<p>387-9781</p>

McDaniels, Tim McDaniels Research Limited 3819 West 21st Avenue Vancouver, B.C. V6S 1H5	228-9615	Seip, Dale B.C. Ministry of Forests 4595 Canada Way Burnaby, B.C. V5G 4L9	660-7530
McLaughlin, Ron T. MacMillan Bloedel Limited 65 Front Street Nanaimo, B.C. V9R 5H9	755-3404	Senyk, John Pacific Forestry Centre 506 West Burnside Road Victoria, B.C. V8Z 1M5	363-0688
Marshall, Valin G. Pacific Forestry Centre 506 West Burnside Road Victoria, B.C. V8Z 1M5	363-0663	Spittlehouse, Dave B.C. Ministry of Forests Research Branch 31 Bastion Square Victoria, B.C. V8W 3E7	387-3453
Millikin, Rhonda Canadian Wildlife Service P. O. Box 340 Delta, B.C. V4K 3Y3	946-8546	Sturko, Allen Agriculture Canada Research Station 3015 Ord Road Kamloops, B.C. V2B 8A9	376-1331
Nelson, John University of British Columbia Forest Sciences Department 270-2357 Main Mall Vancouver, B.C. V6T 1Z4	822-6018	Sullivan, Tom P. University of British Columbia Forest Sciences Department 2357 Main Mall Vancouver, B.C. V6T 1Z4	822-2727
Page, Rick B.C. Ministry of Forests Research Branch 31 Bastion Square Victoria, B.C. V8W 3E7	387-6710	Taylor, Steven Pacific Forestry Centre 506 West Burnside Road Victoria, B.C. V8Z 1M5	363-0758
Pojar, Jim B.C. Ministry of Forests Bag 5000, 3726 Alfred Avenue Smithers, B.C. V0J 2N0	847-7430	Toews, Dave B.C. Ministry of Forests Nelson Region 518 Lake Street Nelson, B.C. V1L 4C6	354-6284
Prescott, Cindy University of British Columbia Forest Sciences Department 270-2357 Main Mall Vancouver, B.C. V6T 1Z4	822-6018	Trofymow, Tony Pacific Forestry Centre 506 West Burnside Road Victoria, B.C. V8Z 1M5	388-0677
Ring, Richard University of Victoria Department of Biology Box 1700 Victoria, B.C. V8W 2Y2	721-7102	Wikeem, Brian Agriculture Canada Research Station 3015 Ord Road Kamloops, B.C. V2B 8A9	376-1331
Savard, Jean-Pierre Canadian Wildlife Service P. O. Box 340 Delta, B.C. V4K 3Y3	946-8546	Winchester, Neville University of Victoria Department of Biology Box 1700 Victoria, B.C. V8W 2Y2	721-7099
Schieck, Jim 425-1020 Pembroke Street Victoria, B.C. V8T 4Z6	381-1692	Yanchuk, Alvin B.C. Ministry of Forests Research Branch 31 Bastion Square Victoria, B.C. V8W 3E7	387-3338
Schwab, Jim B.C. Ministry of Forests Bag 5000, 3726 Alfred Avenue Smithers, B.C. V0J 2N0	847-7435		