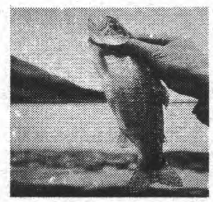
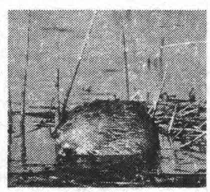
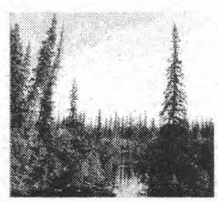
Canada Alberta Northwest Territories

Northern River Basins Study





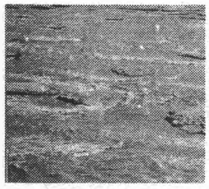




NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 63

EXECUTIVE SUMMARY OF A WORKSHOP ON THE IMPACTS OF LAND CLEARING

ON THE HYDROLOGIC AND AQUATIC RESOURCES OF BOREAL FORESTS IN ALBERTA

NOVEMBER 18 AND 19, 1994






Prepared for the
Northern River Basins Study
under Project 5203-C1

by

Elizabeth Alke
E. Alke Consulting

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PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of particular work conducted as part of the Northern River Basins Study. As such, the work was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

NORTHERN RIVER BASINS STUDY
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Whereas the above publication is the result of a project conducted under the Northern River Basins Study and the terms of reference for that project are deemed to be fulfilled,
IT IS THEREFORE REQUESTED BY THE STUDY OFFICE THAT;
this publication be subjected to proper and responsible review and be considered for release to the public.

F. J. Wrona ______ 18 Dec 95 ______
(Dr. Fred J. Wrona, Science Director) (Date)

Whereas it is an explicit term of reference of the Science Advisory Committee "to review, for scientific content, material for publication by the Board",
IT IS HERE ADVISED BY THE SCIENCE ADVISORY COMMITTEE THAT;
this publication has been reviewed for scientific content and that the scientific practices represented in the report are acceptable given the specific purposes of the project and subject to the field conditions encountered.
SUPPLEMENTAL COMMENTARY HAS BEEN ADDED TO THIS PUBLICATION: [ ] Yes [✓] No

P. A. Larkin ______ 2 Jan 95 ______
(Dr. P. A. Larkin, Ph.D., Chair) (Date)

Whereas the Study Board is satisfied that this publication has been reviewed for scientific content and for immediate health implications,
IT IS HERE APPROVED BY THE BOARD OF DIRECTORS THAT;
this publication be released to the public, and that this publication be designated for: **[✓] STANDARD AVAILABILITY [ ] EXPANDED AVAILABILITY**

Lucille Partington ______ January 11/96 ______
(Lucille Partington, Co-chair) (Date)

Robert McLeod ______ 11/01/96 ______
(Robert McLeod, Co-chair) (Date)

EXECUTIVE SUMMARY OF A WORKSHOP ON THE IMPACTS OF LAND CLEARING ON THE HYDROLOGIC AND AQUATIC RESOURCES OF BOREAL FORESTS IN ALBERTA, NOVEMBER 18 AND 19, 1994

STUDY PERSPECTIVE

A major goal of the Northern River Basins Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Peace, Athabasca and Slave rivers and their major tributaries. Through coordination with existing initiatives and initiating appropriate new technical studies the sponsoring governments of Canada, Alberta and the Northwest Territories hoped the Board would be able to make recommendations to better predict and assess the cumulative effects of development.

> ***Related Study Purpose***
>
> *2.2 The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the study area by coordinating with existing programs and undertaking appropriate new technical studies.*

Under the terms of the Study agreement and in subsequent correspondence between the Board and the sponsoring governments, the Board has been advised that the emphasis of the Study is to be on the water component of the Peace, Athabasca and Slave rivers. The Board, public and Science Advisory Committee expressed concern over the Study being limited to an examination of the mainstem Peace, Athabasca and Slave rivers and their major tributaries. As a consequence, the Study Board accepted a recommendation of its independent Science Advisory Committee to sponsor a workshop dealing with the effects of land-clearing within the boreal mixed wood forest on the aquatic environment. The Board also accepted the recommendation to contract the work to Dr. Bruce Dancik, University of Alberta, in light of Dr. Dancik's earlier work in the area of forestry practices and the environment.

The workshop was structured to bring together a broad cross-section of invited representation from the various disciplines involved with ecological research and management of land and water applicable to the boreal mixed wood forest. A combination of plenary and discussion group sessions provided the framework for the workshop to provide feedback on three areas of Board / Science Advisory Committee interest. Those areas included: expert assessment and consensus of the significance of land-clearing on preserving the ecological integrity of the Basins aquatic resources, consensus on the state of knowledge and research priorities, and consensus on what the Study and others should be doing on land-clearing.

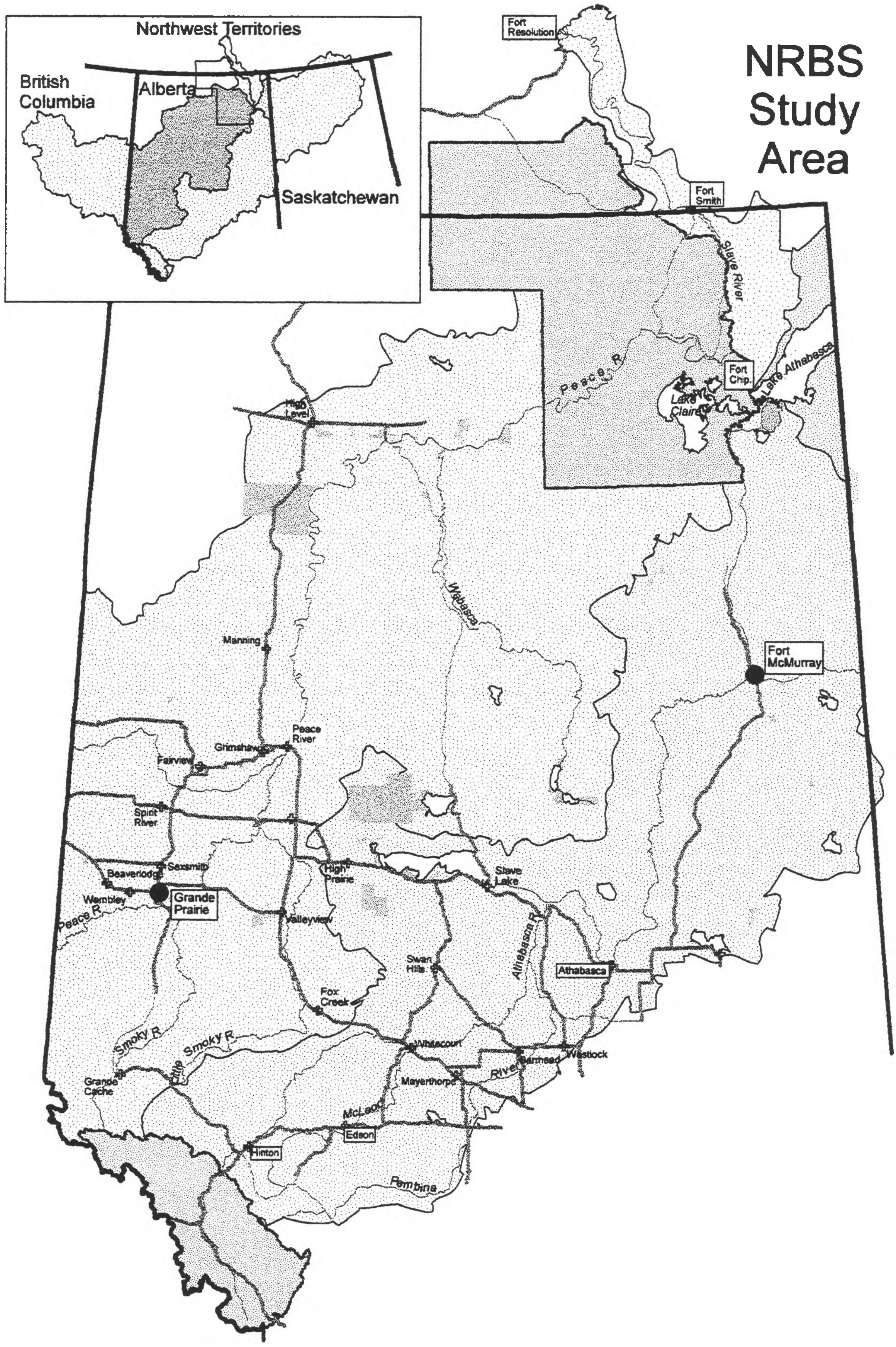
The proceedings of the workshop were taped and transcribed and are available through the Study Office. This report provides the text of the presentations by the keynote speakers and a synthesis of the workshop discussions, with recommendations. Much of the emphasis contained in the six key goals identified for immediate action and eight goals for further research, focus on strengthening the level of knowledge, building alliances for additional research, and improving the level of integrated land / water management and decision making. The findings of this workshop will be used by the Board in formulating recommendations that recognize the inalienable relationship of land and water.

REPORT SUMMARY

The Northern River Basins Study (NRBS) workshop on the impacts of large scale land clearing on the hydrologic and aquatic resources of the Northern River Basins was held November 18 and 19, 1994 in Edmonton, Alberta. Court reporters generated a transcript of over 548 pages, from which this executive summary was derived. This summary includes precis of expert presentations on the following topics: the history of land-use policies in Alberta, the hydrologic impacts of forest land clearing, forest impacts and the extent of harvesting in Northern Alberta, hydrologic impacts of agricultural production, impacts of land clearing activities on water quality, approaches to management at the watershed scale, food chains and large scale land clearing, and social and human issues associated with large scale land clearing and development of boreal ecosystems.

This report also includes a summary of the discussions of expert land managers, industry representatives, and scientific researchers who took part in breakaway and plenary sessions that were designed to answer a series of related questions. As a result, the body of this report reflects the expert knowledge and experience of participants relevant to 1) the unique geography, soils, climate, hydrology, water quality, vegetation and wildlife of the boreal forest, 2) the impacts of land clearing activities, agriculture, forestry, hydrology and roads on these natural processes and resources, 3) research needs in terms of agriculture, forestry, hydrology, water quality, biology and general land disturbance activities, 4) larger research issues such as goals, strategic planning, land-use decisions, regulations, approaches to science, models and the scale of research, and 5) the challenges and advantages of interdisciplinary studies.

The conclusion contains comments about points of general consensus that emerged from the workshop as well as very specific recommendations for further action by the Science Advisory Committee of the Northern River Basins Study.


NRBS
Study
Area
Northwest Territories
British
Columbia
Alberta
Saskatchewan
Fort
Resolution
Fort
Smith
Slave River
Peace R.
Fort
Chip.
Lake Athabasca
Lake
Claire
High
Level
Wabasca
Manning
Fort
McMurray
Peace
River
Grimshaw
Fairview
Spirit
River
Sexsmith
Beaverlodge
Wembley
Grande
Prairie
High
Prairie
Slave
Lake
Valleyview
Peace R.
Athabasca R.
Swan
Hills
Athabasca
Fox
Creek
Smoky R.
Little Smoky R.
Whitecourt
Barrhead
Westlock
Grande
Cache
Mayerthorpe
River
McLeod
Edson
Hinton
Pembina

FOREWORD

The Northern River Basins Study (NRBS) was established September 27, 1991 with the signing of a joint agreement between the governments of Canada, Alberta and the Northwest Territories. The main objective of this five-year study is to provide scientific information about the Peace, Athabasca and Slave river basins, both to establish how development has affected the aquatic environment and to develop a baseline for future comparisons. Public concern over the cumulative environmental effects of development within the Northern River Basins is a driving force behind this study.

Over the course of numerous hearings and public information meetings, it became apparent that both the general public and the NRBS Board had concerns over the NRBS being limited to examining the Peace, Athabasca and Slave rivers and their major tributaries. As a consequence, the NRBS accepted a recommendation of its independent Science Advisory Committee to sponsor a workshop dealing with the effects of land clearing within the boreal mixed wood forest on the aquatic environment. (The term *land clearing* was chosen to limit the scope of the workshop, so that it did not encompass the broader array of activities implied by the words *terrestrial activities*.)

The Board also accepted the recommendation to contract the work out to Bruce Dancik, the chair of the Department of Renewable Resources, Faculty of Agriculture, Forestry and Home Economics at the University of Alberta on the strength of his work in the area of forestry practices and the environment. Subsequently Bruce Dancik appointed an organizing committee to develop a workshop that would explore available information on land clearing activities affecting the aquatic ecosystems of the Northern River Basins. Workshop participants were recruited among experts on the biophysical resources and land clearing activities in the Northern River Basins, notably forestry and agriculture. The NRBS Board approved funding for a two-day workshop and consulted with the Science Advisory Committee to articulate the following terms of reference:

1) Compile an expert assessment and points of consensus on the impact of forestry and other land clearing operations on the ecological integrity of natural resources in the Northern River Basins,

2) Identify consensus on the state of knowledge relative to the impact of land clearing,

3) Compile a list of the critical priorities for scientific investigation, and

4) Identify the consensus of workshop participants regarding further research objectives or initiatives, so that the NRBS can include this information in a report to study sponsors.

ACKNOWLEDGMENTS

The organizing committee would like to recognize the efforts of the 50 participants who demonstrated their commitment and interest in the Northern River Basin Study (NRBS) by including this workshop in their schedules and participating vigorously in workshop discussions. Their enthusiasm and conscientious attention to concerns and issues relevant to conserving and sustaining the natural resources in the Northern River Basins was evident throughout the formal and informal discussions that took place over the course of this workshop. The members of the organizing committee sincerely hope that this report constitutes a satisfactory summary of their efforts.

Facilitators Tom Mill, Andre Plamondon, Bob Swanson, and Annette Trimbee deserve recognition for leading breakaway sessions that participants never wanted to leave, rendering the results for the plenary sessions, and rising to the challenge of doing all this again on day two of the workshop.

Thanks are also due to presenters and round table discussion panellists: Pat Chambers, Allan Chapman, Bruce Dancik, Trevor Dickinson, Milton Freeman, Daryll Hebert, Robert Naiman, Andre Plamondon, Ellie Prepas, Dave Rosenberg, and Robert Steedman. These individuals rose to the challenge of compiling relevant and provocative information, in some cases at short notice, and presenting it as background for breakaway discussions. Douglas Golding deserves thanks for listening carefully and neatly tying together the essential points that emerged from plenary session reports, discussions and presentations.

FROM THE AUTHOR

Bruce Dancik of the Department of Renewable Resources, Faculty of Agriculture, Forestry and Home Economics at the University of Alberta initiated early discussions, oversaw the project, recruited Richard Rothwell to administer the project, presented at the workshop, and reviewed and approved this report. Richard Rothwell, also of the Department of Renewable Resources at the University of Alberta, administered the project. Despite significant delays and challenges, he recruited research leaders who gave excellent presentations on topics relevant to workshop objectives. The slate of speakers, facilitators, and participants that Richard and the other members of the organizing committee selected set the tone for an efficient and candid exchange of information and a generally dynamic workshop. Richard Rothwell also reviewed the drafts of this report and wrote the conclusion.

NRBS Associate Science Director Ken Crutchfield helped keep everyone focused on workshop objectives and acted as a valuable resource during workshop planning and delivery. He also performed the important task of liaison between the NRBS Science Advisory Committee and workshop organizers and made suggestions that contributed significantly to the quality of this executive summary.

Graham Hillman of Natural Resources Canada, Canadian Forest Service in Edmonton made numerous contributions by raising important questions during the planning stage and ensuring that important details were not missed. His tenacity, promptness and careful scrutiny during the process of creating this executive summary were essential to its accuracy and comprehensiveness.

Early workshop planning sessions also included Bill MacKay of the Department of Biological Sciences at the University of Alberta and Ellie Prepas of the Environmental Research and Studies Centre also at the University of Alberta.

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1.0 INTRODUCTION

1.1 ABOUT THIS PUBLICATION

To ensure that a comprehensive and useful report on this workshop could eventually be generated, the firm of J.G. Moore Court Reporters was hired to record the workshop presentations, breakaway discussions, and plenary sessions. The resulting transcript consists of 548 pages of dialogue. From this typewritten record, Communications Consultant Elizabeth Alke made notes on participants' answers to the key questions, circulated the notes to organizing committee members for review and comments, wrote a draft including these comments and submitted it to Ken Crutchfield, Bruce Dancik, Graham Hillman and Richard Rothwell for revision and approval. The following report is the result of these efforts.

For the convenience of readers, common issues, questions, and recommendations that were raised, discussed, and agreed upon within the different breakaway sessions are summarized together under relevant headings. Most of the text is a paraphrase of what was recorded in the workshop transcript. In some cases, direct quotes are made. The content of this report, therefore, reflects the information that participants themselves emphasized as well as certain salient points that the organizing committee identified as crucial insights or perspectives on the workshop objectives.

1.2 WORKSHOP DESIGN

In response to the terms of reference set by the NRBS Science Advisory Committee, Bruce Dancik and Richard Rothwell of the Department of Renewable Resources in the Faculty of Agriculture, Forestry and Home Economics at the University of Alberta convened an organizing committee. The organizing committee consisted of Bruce Dancik, Richard Rothwell, Graham Hillman of the Natural Resources Canada, Canadian Forest Service, Ken Crutchfield, Associate Science Director of the Northern River Basin Study, Bill MacKay of the Department of Biological Sciences, Ellie Prepas of the Environmental Research and Study Centre at the University of Alberta and Elizabeth Alke, an independent Communications Consultant.

To fulfill the objectives of the workshop, the organizing committee invited participants from among professional land managers, academics, and consultants with expert knowledge in the areas of biology, hydrology, water quality, agriculture, and forestry. Then it recruited experts to present background and context information as well as points for discussion on a variety of relevant topics including:

- Issues and Concerns of Forestry Development in Northern Alberta,
- Hydrologic Impacts of Forest Land Clearing,
- Forest Practices and the Extent of Harvesting,
- Hydrologic Impacts of Agricultural Production,
- Impacts of Agriculture and Forestry on Water Quality,
- Land Management at the Watershed Scale,
- Food Chains and Aquatic Life, and
- Social and Human Issues Associated with Large Scale Land Clearing.

1.3 KEY QUESTIONS

Finally, all participants were assigned to breakaway discussion groups led by facilitators and set with the task of answering key questions (see Appendix B) and reporting back to plenary sessions. The key questions included:

- What makes the boreal forest different from other regions?
- What are the impacts of land clearing in the boreal forest? (Will these impacts be the same or different from other regions?)
- What do we know and what don't we know about the impacts of land clearing on the resources of the boreal forest?
- What research is needed?
- What can be done to remedy the gaps in knowledge and understanding of the impacts of large scale land clearing on the boreal forest?
- How can we integrate current knowledge and research into day-to-day land management decisions?
- What are the priorities for future research?
- Who should carry out needed research?

2.0 PRECIS OF PRESENTATIONS DELIVERED BY GUEST SPEAKERS

2.1 OPENING REMARKS ON THE BACKGROUND FOR THIS WORKSHOP

Dr. Bruce Dancik
Chair, Department of Renewable Resources, Faculty of Agriculture, Forestry, and Home Economics, University of Alberta, Edmonton, Alberta

Forests have been important to Albertans for a long time. That's not surprising since over 60 percent of the province is covered by forest. One of the first suggestions to the old Environment Conservation Authority (ECA) in 1970, was to hold hearings about activities in the province's forests. After a period of 10 years, a restructured ECA did conduct hearings and released reports on the environmental effects of forestry operations in Alberta. Some of the changes suggested by the writers of the report were implemented. Other suggestions were ignored.

In 1988, the provincial government predicted that future forestry development activity would result in 3.4 billion dollars of capital investments as well as 4,000 direct and 8,000 indirect jobs. The new area being allocated for forestry was 177,000 square kilometres, almost the size of the United Kingdom, about 27 percent of the provincial forests and 50 percent of the green area. In early 1989, just before a provincial election, a series of further announcements were made concerning forest industry developments. There was public concern about these announcements, but proposed developments were phased in slowly.

It was clear then, in the late 1980s, that the recommendation to include the public in land-use decisions had been ignored. Broadly-based public uproar resulted, and the Minister of Environment ordered some damage control operations. He ordered an expert review panel to review an earlier consultant's report, to bring any relevant new information forward and to make recommendations on the state of forest management and land use in the north. The panel's mandate did not include a consideration of the impacts of industrial operations themselves. Subsequently, the panel identified several areas of concern:

- the lack of public involvement in land-use decisions that were being made about Crown lands,
- the lack of planning and coordination in land-use allocation,
- the shortage of personnel to monitor and regulate forestry, fish and wildlife activities,
- the lack of information on how to handle and manage the basic biology of the boreal forest,
- the mandate, structure, and accountability of government agencies/personnel,
- the environmental consequences of various land management operations, such as harvesting methods, roads and stream crossings, and the global carbon balance,
- the relative effectiveness of reforestation, and
- the well-being of fish and wildlife resources across the province.

As an overall comment, the panel felt that techniques like impact assessments were not particularly appropriate and that we needed something more dynamic. So we were attracted to the principle of a ground rule system. Such a system would be more dynamic and evolutionary and require scientific information and appropriate management strategies to implement what we learned from science. That need for good scientific information and appropriate management strategies is partly why we are here today. We are here today to define a little more clearly where research should be concentrated and to make good educated guesses from the kinds of information we already have.

2.2 OVERVIEW OF THE HYDROLOGIC IMPACTS OF FOREST LAND CLEARING

Presented by Dr. Allan Chapman
Integrated Resources Section, British Columbia Ministry of Forests, Victoria, B.C.

In the boreal forest of Northern Alberta, the annual precipitation typically ranges between 400 and 600 millimetres. Typically, it is a low precipitation environment and there is low year-to-year variability in the annual precipitation. About a third of the annual precipitation occurs as snow during the winter, and about two-thirds as rain during the summer. In about nine years out of ten, the stream flow in the spring that results from the melting snow is typically the largest runoff event of the year. In one year out of ten, or fifteen, the largest peak event of the year is produced by a rain event associated with a summer cold front. Snowmelt peak flows are by far the most common peak events in the boreal watersheds, and the rain-caused peak flows are by far the largest events.

Of the 500 millimeters or so of annual precipitation that falls, only a portion reaches the ground. The amount of interception by the canopy varies widely from event to event, depending on the magnitude and duration of the rain and snow, the forest type, and the closure of the canopy. Hydrologically, the interception of snow by the coniferous forest is very important. So, one of the predominant impacts of land clearing in boreal forests with a coniferous element is the resultant increase in snow accumulation on the ground during the winter, then the availability of water on the ground to runoff during the spring snowmelt.

An increase in snow accumulation of 20 percent in the openings in a watershed that had about 30 percent of its timber volume removed through logging, would result in an increase of about 7 percent in the total water that reaches the ground on the annual basis. The amount of increased snow accumulation varies with the size of the openings. Small openings the size of one to three tree height diameters have the maximum area of snow relative to snow in adjacent forests. The next significant relationship between the forest land clearing and snow then deals with the rate and timing of the snowmelt. Snowmelt in spring occurs in response to the transfer of energy to the snow from a number of different sources: shortwave solar radiation, longwave radiation, and latent and sensible heat transfer. The biggest change that occurs with the removal of the forest is that latent and sensible heat transfer increases. In turn this creates snowmelt.

In cleared, snow-covered areas, shortwave radiation increases triggering fairly rapid snowmelt in the spring when the snow has a bit of colour. A typical result of forest clearing is an increase in snowmelt water of 10 to 30 percent above what occurs in the adjacent forest. Other impacts include: earlier snowmelt (ten days to two weeks), increased total water yield from the block and the watershed during spring snowmelt, and the potential for increases in the peak rate of runoff in creeks.

The latent and sensible heat transfer in small openings of one to two hectares is increased slightly after clearing, but not nearly as much as in larger openings. The same is true for shortwave radiation transfer.

Longwave re-radiation, the transfer of heat energy from the forest mass itself to the snow, decreases slightly in small openings, but the proximity of the forest to the opening still maintains some longwave radiation transfer.

Evapotranspiration typically accounts for about 65 to 80 percent of the annual precipitation input, taking water out of the soil and out of the watershed and returning it to the atmosphere. In the growing season, at least 90 percent of precipitation is evapotranspired and hence made unavailable for runoff. With the removal of the forest, transpiration losses decrease substantially. As a result, sub-soils are wetter and water tables are higher in the logged areas. This often occurs directly underneath the cutblocks, making more water available for runoff.

In conjunction with higher water tables, the soil surface can appear drier. The trees have been removed and the soil surface is exposed to turbulent energy transfer from the atmosphere. The soil surface seems drier, but the water table is higher and the soil below the surface layer is wetter. In addition, there are problems reestablishing second growth coniferous forests on sites where saturation has occurred. This has often led to the fairly widespread use of herbicides to control broad-leaf plants. It has also led to the use of considerable site scarification and mounding to produce dry sites in which to plant trees.

Due to the interaction of precipitation and transpiration, about 20 percent of precipitation moves through the terrestrial portion of the watershed and becomes part of the stream ecosystem. The soil surface and the soil act as a filter that determines the pathway by which water reaches streams. Where the rate of snowmelt or rainfall is greater than the infiltration capacity of the soil, water moves over the surface of the soil, on surface pathways, to streams.

The infiltration capacity of most forested soils typically far exceeds the rate of rainfall and snowfall. So most of the water that is available on the ground infiltrates the soil and moves through subsurface pathways into creeks and streams. Part of the infiltrated water percolates deeply down into the soil and becomes part of the groundwater system. Groundwater moves slowly (from weeks to years) to reach streams, then contributes to base flow in a river.

Part of the infiltrated water reaches streams quickly during storm peaks. Storm flow is created through subsurface storm flow and saturation overland flow. Saturation overland flow consists in part of return flow, where water has moved through the soil and returned to the surface of the soil. This type of flow usually occurs down at the base of slopes adjacent to creeks and wetlands. These areas of return flow are the dynamically expanding and contracting wet areas adjacent to streams and riparian areas. Saturation overland flow also consists of rain or snow that falls or melts on areas of return flow that are saturated, so water runs off directly. This process is called *direct precipitation onto saturated areas*.

When a watershed is logged, surface runoff increases dramatically. This increase occurs as a result of the construction of roads, trails and landings that are developed to access and remove timber. These areas have a very low rate of infiltration, and snowmelt typically runs off very quickly to reach the streams. With logging, the effective drainage density of surface pathways changes from one and a half kilometer per square kilometre in the un-logged watershed, to three and a half to four kilometers per square kilometer in the developed watershed. That's an increase of 100 to 200 percent.

A common associated problem is the potential for erosion of fine sediments from roads and ditches. Water quantity and water quality changes will be triggered by increased stream power. Increased sediment inputs have the potential to cause stream-channel bank and bed erosion as well as considerable impacts on the in-channel aquatic environment.

Two main groups of relationships exist between forest removal and the hydrology of the watershed. First, the removal of vegetation decreases rain and snow interception. This results in increased soil water content, increased water yield in all seasons, significantly increased flows in summer, and increased peak flows from spring snowmelt.

There has been a fair amount of research done on the relationships between forests and water, on the effects of forest removal, and on hydrologic changes to streams ranging from small to large boreal forest streams. But many important questions remain and these include the role of natural disturbances, such as fire, in the hydrologic cycle and whether or not forest practices produce impacts that are outside the range of natural disturbances.

2.3 OVERVIEW OF FOREST IMPACTS AND THE EXTENT OF HARVESTING IN NORTHERN ALBERTA

Presented by Dr. Daryll Hebert
Director, Environmental Resources, Alberta Pacific Forest Industries, Boyle, Alberta

The land clearing that has gone on for the last hundred years has dominated well over 50 percent of the province. Oil and gas exploration activities account for anywhere from three to 5 percent of the land manipulation in Northern Alberta, wild fires of the early 1900s account for about 2 percent of the land clearing or disturbance on the landscape, and timber harvesting accounts for disturbance of about .25 percent of the land base each year.

Over the past decades of harvesting, many large clear-cuts were scarified, burned or in the case of some cuts in British Columbia, exposed to mineral soils, so that Douglas fir could be planted beyond its normal range. In pine forests in northern Canada and central British Columbia, very small buffer strips were left adjacent to some streams that pass through clear-cuts. With traditional skidder logging and large-scale disturbance, there is very little material left on the ground.

Under normal operating ground rules, we would produce even-aged management, generally small cutblocks spaced through the landscape with 50 percent cut and 50 percent removal. Some material in the form of snags would be left, the cutblocks would be square or rectangular and a certain amount of access road construction would be evident.

Because of fire suppression activities, Alberta Pacific will now be harvesting in the 60 - to 80-year age class. Conversely, in a fire disturbance pattern that has a 30 - to 40-year interval, you see a multitude of block shapes, a wide variety of block sizes and a random dispersion of cutblocks through the landscape. We have been able to approximate this using satellite photography, phase III inventory maps and GIS technology to look at a random, dispersed system throughout the landscape.

While information about structure in stands has been available for almost two decades now, it's just reaching the implementation stage. So when we harvest now, we'll be looking at a fairly wide range of both vertical and horizontal components that are going to be built into those cutblocks. So there will be coarse and fine woody debris left on the ground, and the sites generally won't be burned or scarified.

We are also looking at retaining coniferous material, an incidental conifer that will provide a seed source, and keeping the mixed wood forest mixed. We are also looking at a wide variety of cutblock sizes and shapes, leaving older conifer and snags, then spatially partitioning that material in the form of live individual green trees or tree clumps. Every block will look different and have a different amount of standing and residual material on the ground.

In the boreal mixed wood forest, wetlands may change to upland over a change in elevation of less than two or three feet. The topography is undulating with varying forest soils, pH, and vegetative species composition. To approximate some of the components of natural disturbance, which generally leaves 80 percent of the material standing, we can start to leave material amounting to one to 5 percent up to 30 to 50 percent. As that material works through the system over the next 70 years, it will start to approximate the results of a fire.

What we see in the boreal mixed wood forest is a relatively simple forest in terms of tree species, but a relatively complex forest in terms of the juxtaposition of polygons and the adjacency effects that occur between some of the coniferous/deciduous polygons on the upland components. There are some areas that have wetted perimeters and wet components surrounding a stream. Or the forest grows right down to either the lake or the stream edge, which under the current operating ground rules are being buffered by 30- or 60-metre strips.

A large number of fires in the boreal forest begin in wetland areas among black spruce which have a lot of boreal lichen. The upper parts of these black spruce stands are generally more flammable. A lot of fires move across large areas of wetland crossing large numbers of streams into upland areas. This burning currently occurs along streams because we have produced huge fuel loads as a result of fire protection.

We have already started to change the composition of the forest from aspen to spruce, which is more flammable. Fires burn down to the edges of wet areas because of the spruce component within them. So, you get a variety of patterns along stream banks, and the heat of the fire, which is based on fuel loading and species composition, to some degree determines the rate of sedimentation, the changes in pH, or the removal of organic material. Based on current guidelines, the actual ecosystem will remain intact between the wetland system and the upland system that border streams.

Nevertheless, there are some primary questions that must be answered. What baseline should we be talking about? What is the level of perturbation that has occurred along these streams? What are these streams capable handling? and, What kind of program could approximate that natural system?

If you look at the data over the past 100 years, you can see the fairly wide range of variability of fire, from 700 hectares along the one stream up to almost 3,000 hectares along another stream. It wasn't a consistent fire regime. It was highly variable, with pulses of fires, nutrients and sediments that went into streams over a 100- to 150-year period. It is also evident that the entire length of the stream was affected by fire over the 100- or 150-year period. Very few areas were not affected by fire, though there are some areas along the north slope of the Athabasca River that probably have not burned for 50 to 100 or more years.

With the kind of landscape planning that we are doing, we are now developing a logging system that will be quite stochastic in nature, dispersed through the entire FMA. We will also be setting different criteria for selecting cutblocks, based on this kind of natural disturbance regime. We are just getting to the point with GIS systems, Alberta Vegetation Inventory (AVI), and satellite landscape patterns of addressing some of the more difficult questions about how these things change through longer periods of time. But this technology is giving us a completely new view of landscapes. It is also giving us a completely new view of baselines and what we should be looking at for baselines. Fortunately, we have been able to implement many of these insights in our logging operations.

2.4 OVERVIEW OF HYDROLOGIC IMPACTS OF AGRICULTURAL PRODUCTION

Presented by Dr. Trevor Dickinson,
Professor, School of Engineering, University of Guelph, Guelph, Ontario

Over the 25 years or so that I have been working in hydrology, I've worked on the impacts of forestry associated with the Marmot Basin here in Alberta. In Ontario, much of my work has been related to the impact of agricultural drainage and the long-term effects on watersheds. After reading the literature in preparation for this workshop, it struck me that researchers have tended to make lists of possible impacts, taken measurements on a watershed or sub-basins, then built computer models to try to describe and predict what's happening or going to happen.

In almost every case, researchers have been misled or allowed themselves to be misled with all three approaches. This has happened because we imply, when presenting information on impacts, that all the possible impacts happen everywhere, all the time. For example we say wetlands reduce flood peaks, sustain summer flows, recharge groundwater and wells, and on and on. Individual wetlands can do one or more of those things, but individual wetlands don't do all of those things. In fact, if a wetland performs one of these functions, there is no way it can do some of the others.

Another thing that happened when I was reading the literature on agricultural and forest hydrology was that I could find any result I was looking for. I read in some papers that deforestation significantly increases flood peaks, and I could turn around and find another article saying deforestation makes no difference to flood peaks. So, how do we ascertain which impacts are likely to occur? How far have we come to knowing even the right questions to ask?

When it comes to models, they are constrained by the sets of data they are based on plus the concepts that we chose to build into the model. The results we get are dependent on the validity of the concepts they are based on. Generally, models tend to work better on the hydraulic situations that are closest to the situations that the model was developed for. Subsequently, I have felt the need for a better kind of conceptual model or picture of hydrologic impacts themselves.

While sorting out hydrologic impacts, it seemed to me that land development activities do one of three things. They change either vegetation, the surface conditions (by paving), the topography (slope and drainage), or the inputs of contaminants. These changes set in motion some changes in the input end of hydrologic variables such as precipitation and radiation. Then I asked, what might happen on the surface to processes such as interception, depression storage, and infiltration? And that question suggested that there must be a number of the interactions that could be affected by land development.

It seemed helpful then to identify where a loss of vegetation or a dramatic change in vegetation might affect some of the input variables. I'm not sure a change in vegetation will change rain very much, so I just left a question mark by that variable; but changes to vegetation will certainly change the distribution of radiation. Such a checklist of impacts can be useful for looking at the impact picture of any kind of development for any area. Whenever I look at an impact study, this list of probable impacts can help me identify the possible cause of specific changes to input variables.

As an example, if something leads to a different distribution of snow or a different redistribution of snow, then that might lead to changes in the spatial and temporal distribution of snowmelt, and that might be manifested in terms of the change in the snowmelt hydrograph. Or, it might be manifested in a change in groundwater recharge. From there, I'd have a good reason to check this relationship by monitoring.

If I'm able to sort out what the possible linkages are in a given situation, how do I ascertain what's really going on? It seems to me that there are at least two or three kinds of issues to look at. If there are going to be some changes in the so-called input variables, what are they in time and space? For example, if I cut some trees and that leads to additional snow accumulation or a redistribution of snow, What do I know about the temporal and spatial patterns of such changes? A second question that follows is, How does the development activity influence the spatial distribution of the input variable? Over time? A third relevant question is, What are the dominant surface processes in a particular watershed?

Unless we can start measuring the right things that tell us what the dominant processes are at the different times of the year, I think we are really fooling ourselves with a lot of our generalizations. The actual impacts in any particular watershed come right down to being a function of the specific characteristics of that watershed. If my concept of how a particular watershed behaves is wrong in terms of what the significant processes are, I don't stand a chance of coming up with a good estimate. Since any mathematical model or computer model I develop is going to be based on my concept of what's going on in space and time, I better make sure that my concept of basic processes and their spatial and temporal significance is straight. I think that is really tough to do, and it is what is plaguing researchers.

I'd like to see us work harder in comparing notes about our conceptual models of what's going on in a watershed. [I'd also like to see us working harder to follow] the suggestion in the literature about computer models that it is important to spend a lot of time developing our conceptual models. Examine the concept you come up with, then spend 20 to 30 percent, not the usual four to 10 percent, of your time putting the mathematics to it and trying to calibrate and validate. Then we need to go back and ask, How do we see this thing? and, in the light of our concept, Where do we go from here?

2.5 IMPACTS OF LARGE SCALE LAND CLEARING ON WATER QUALITY

Presented by Dr. Andre Plamondon,
Centre de Recherche en Biologie Forestiere, Universite Laval, Quebec City, Quebec

In one relevant study, my colleagues and I compared 17 stations along a stream that is 2.4 kilometres long. One area that was cut and had a buffer strip of 10 metres showed that the concentration of suspended sediment in the stream increased from two to four parts per million. Elsewhere, the buffer strip and two intermittent streams were crossed by skid trails. Of course, these perturbations pushed up the amounts of inorganic suspended sediment.

From this sampling, we learned that where we don't protect the intermittent streams, buffer strips are not useful. Therefore, in Quebec, we decided to protect all intermittent streams with a buffer of undisturbed soil five metres wide on each side of the stream. Clear-cuts are allowed, but the soil must remain undisturbed.

Elsewhere, we set other standards. In an area called Haute-Mauricie, the topography could be described as gentle, rolling hills. In the Cote Nord, the topography is a bit more varied. The third location we included in this study is mountainous. From the data collected on sediment concentrations at these three sites, Quebec decided that there should be a minimum buffer strip of 20 metres on each side of the streams and along the lake to protect water quality for human use and aquatic organisms.

For roads, we adopted another approach based on various studies that include one by Trimble and Sartz in New Hampshire. We used 60 metres as a minimum distance between streams and road networks. Of course, the roads have to cross the streams and this is another matter. In general, we can say that careful logging on the Precambrian Shield maintains the concentration of suspended sediment below 25 milligrams per litre, 90 percent of the time.

Bedload is another element which might be important in relation to erosion. It is difficult to measure, has not been measured very often, and the relationship between bedload and suspended sediment or turbidity has not been shown. At Carnation Creek on the West Coast of Vancouver Island, Scrivener and Hartman say that bedload movement is very important in the stream dynamics on the West Coast. There have also been some bedload studies in Idaho and now Ontario. Some studies on bedload are planned in Ontario. Right now we don't know the importance of bedload in the boreal forest.

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In a literature review conducted by MacDonald et. al., for the Pacific Northwest, they suggested that we should measure turbidity and suspended sediment, make links between those values, and use turbidity for monitoring because it is an easier measurement to take. Other components of water quality, such as water temperature should also be looked at. Where there was no buffer, we noted an increase of about two degrees on 50 percent of the streams over a three-year period following logging activities. Elsewhere, increases of 3.5 to 5 degrees have been found.

Other changes in water quality after logging include the reduction of dissolved oxygen from zero to six milligrams per litre. This depends upon the type of logging, the amount of debris left in streams and the time of year. As soon as the stream flows with some turbulence, there are no problems with dissolved oxygen. Careful logging, so that there is little debris in the water, along with enough of a buffer strip to shade the stream removes problems with dissolved oxygen.

Studies have shown that deforestation tends to increase pH, and reforestation increases it. For dissolved solids, specific conductivity is used as the measuring stick. This factor does increase after clear-cutting, and there are higher increases where there is no buffer. The same result was found with phosphorus levels and levels of dissolved ions: potassium, calcium, magnesium and iron. They seem to be higher where there is no buffer and lower where there are buffers. The levels of each type vary with the location.

With nitrates, a Kenora Ontario study showed that a small increase of nitrate occurred after blowdown by wind, and an increase of nitrate nitrogen occurred after the blowdown area was burned by fires. A study of treated or clear-cut watersheds in Alberta didn't show any change. One study also indicated that forested buffer zones are important for agriculture. The buffer trapped 80 to 90 percent of sediments and the attached phosphates and nitrates.

Usually, when the water flows through the root zone, the filtering function is much higher; when the water flows through groundwater before entering a stream the filtering effect is very low. What we don't know are the short- or long term- effects of the small changes in water quality on aquatic organisms. So, can we manage the riparian area in a positive way to enhance the production of aquatic organisms or fish?

To connect with Dr. Dickinson's presentation, the results from the Hubbard Brook and Carnation Creek studies may give some insight into where changes to the hydrologic cycle are introduced and where measurements could be taken to help modify harvesting practices. It is important to note that, while changes in water chemistry may not be meaningful for human consumption they may be for aquatic biota. That is why in Quebec, we are now reviewing all the buffer strips and taking account of birds and wildlife in the riparian zone. Buffer strips may have to be increased in some places and generally be more site specific.

2.6 APPROACHES TO MANAGEMENT AT THE WATERSHED SCALE

Presented by Dr. Robert J. Naiman
Director, Centre for Stream Studies, University of Washington, Seattle

In my presentation today, I want to touch on four topics. First, I want to talk about disturbance regimes, essentially how we treat the landscape; second, the persistence and invasiveness of plants and animals on a changing landscape; third, the role that human culture and institutions play in shaping the landscape; and fourth, the concept of connectivity.

Disturbance Regimes

If you look at small streams, it's hard to imagine sometimes that they are subject to serious disturbances from time to time; but in natural systems, it is not uncommon for small streams to have things like debris flows. Every so often, however, a surge flow flood occurs that literally resets the entire system overnight. These severe disturbances on small streams occur only in the order of once every four to five centuries.

Medium-sized streams can have different kinds of disturbances. On these systems impacts that occur may have very long lag times and leave substantial biological and physical legacies in the channels. These impacts occur probably in the order of tens of years. As we move down through river networks, as we go from small streams into big rivers, the kinds and frequencies of disturbances change.

Another thing that we see, at least in natural watersheds, is that we have nonsynchronous disturbances in adjacent basins in response to the same kind of perturbations. After a 100-year storm or a 500-year storm, adjacent basins in natural watersheds do not have the same response. However, in highly managed systems, we are finding synchronous disturbances across basins. So, we have completely changed the disturbance regimes.

If we look within relatively large basins, of 1,000 to 5,000 hectares in size, disturbances are out of phase throughout the basin. Different kinds of disturbances occur from headwaters into the big rivers. This pattern creates a dynamic patch mosaic of disturbance regimes throughout the basins. Understanding these regimes and estimating natural disturbance regimes are exceedingly difficult.

The point here is that if you have an ecologically healthy watershed, it is largely determined by its disturbance regime. Its disturbance regime really imparts the legacy by which the biology develops later on. If you understand that regime, you'll find that it results in a dynamic equilibrium between the various resources that you find in that basin. If you are able to maintain a natural disturbance regime, it results in a resilient and productive system that is strongly regulated by feedback loops, biological integrity, and long-term social and ecological value.

In North America and throughout many parts of the world, I find management agencies trying to manage for stability in time and place instead of managing for variability over time and place. These two objectives show a very fundamental difference in how system management is approached. But, the natural systems are telling us that variation helps maintain their long-term integrity.

Persistence and Invasiveness of Species

As you change from a watershed that has had relatively little in the way of human intervention to one that has had a lot of human intervention, the habitat for various species is going to change. How you change that landscape in terms of its patch mosaic is going to benefit some species and some processes and decrease the benefits for others.

For example, on the Olympic Peninsula we know what it was like in 1940 and 1988, so we are making projections about species persistence. While the habitat for spotted owls and salmon populations as well as water quality is declining, we have created a landscape that's great for elk. Therefore, as you begin to change the mosaic of the landscape into the future, it becomes very important to have the ability to predict who the winners and losers are going to be. That requires that you have some sense of the theory of biodiversity as well as what maintains it.

Whenever you change the landscape you are going to begin to see the invasion of exotics. Not all parts of the modified watershed are going to be as susceptible to exotic invasions as other parts, and yet these exotic species can have long-term lasting effects on ecosystem processes at watershed and landscape scales. In the state of Washington, for example, we find a lot of exotics moving up the river valleys very, very quickly. They have invaded cobble bars and alder forests. Fewer are found in clear-cuts and where we start to get canopy closure; and a few species are able to persist into the young and mature forest. Nevertheless, understanding how exotic species actually move across the landscape and how they affect ecological processes is very important in predicting future outcomes.

Human Culture and Institutions

Our human culture and the institutions we set up may be the most important things out there really affecting how we manage watersheds and what they look like. Even though you may think your watershed is isolated, it is actually being influenced by market forces from around the world. The price of pulp, the price of lumber, the price of precious metals, and the beliefs of people in Ottawa, Toronto, or Vancouver are shaping what your land will look like.

To help integrate these factors, my colleagues and I are at the stage of putting together a land-use change analysis system. It allows us to actually link models of social and economic factors with landscape change models and response models. The result is a system that allows us to examine the long-term effects of various scenarios that you might foresee on the landscape.

For example, if your society makes a decision that you want to cut 20 percent of your forest annually for the next 10 years, this analysis will tell you what your landscape will look like as well as the ecological and socio-economic consequences of your decision. This and other models are available on the Internet from the Centre for Streamside Studies, so you can preview their relevance to your planning activities.

In terms of human institutions, resource management can learn something from business. Currently, we see a decline in the size of corporations and a decline in centralized and tradition-based operations. Newer successful businesses are very flexible in that they rely on partnerships to get the job done. Such smaller, knowledge-based groups that are highly flexible may be better for watershed management than centralized control at either national, or state, or provincial levels.

In trying to manage watersheds, whether with traditional management or with smaller partnerships, information flow and communications are very important. Some obstacles to avoid include 1)making false analogies (taking data or ideas and trying to apply them, wholesale, to other conditions), 2)insufficient detail (short observation series that don't give you enough data to make good decisions), 3)managerial detachment (physically living at a distance from the community surrounding the watershed management area, or remaining psychologically distant from the problems at hand), 4)subscribing to societal myths (like the one that says technology will save the human race from environmental disaster), and 5)failing to acknowledge and plan for the connectivity between ecosystem components.

Risk Management

Risk and decision making require three things. Whoever makes decisions should have a very broad social, economic, and environmental perspective and be trained enough to know how those areas are interconnected. The decision making process has to explicitly recognize that there are various spatial scales ranging from local sites to global economic and ecological processes that factor in the outcome of decisions. Finally, decision makers need to consider that their actions transfer risks to successive decision makers and future generations.

Risk assessment requires that scientists are explicit about the degree of confidence they have in cause and effect relationships. It would be better for scientists to say they are about 50 percent sure that what they propose is accurate. With this level of honesty as well as contingency plans for other outcomes, scientists, stakeholders and decision makers can develop, modify and respond to changing conditions.

How do we know when we are successful? You can pick a whole variety of endpoints to measure your results. From an ecological perspective, you can monitor riparian forests. Riparian forests are the first place you'd expect to see change. Water quality and the life history strategies of salmon and mollusks are other components that are key markers of change.

On a social level, there are a number of questions that can be asked to gauge progress. Do the people in your watershed have sufficient literacy and information to make informed decisions? Is your social system flexible enough to adapt to new situations? Do you have useful partnerships in place? What is the level of stewardship and responsibility among the people that live within the watershed? On the Willapa Bay project in Washington state, they have developed a socio-environmental index that helps them evaluate their annual progress. The challenge to all of us is, How do we develop watersheds and encourage economic strength along with environmental integrity and a good social system for the long term?

2.7 FOOD CHAINS AND LARGE SCALE CLEARING

Presented by Dr. Robert Steedman
Centre for the Study of the Ecology of Boreal Ecosystems, Lakehead University, Thunder Bay, Ontario

To me, two key questions seem to be: What kind of science has influenced human behaviour at the landscape level? and What kind of evidence do we have for that? One example of where science did influence decision making was in the Great Lakes Basin. Using a simple model with relatively few inputs, the study identified the impact of phosphorus and influenced decision makers enough to incorporate the findings into shoreline development policy. Another example is a study regarding the effect of large woody debris in Pacific Northwest streams on migratory salmon. Those findings have been incorporated into timber management practice, though not at as large a scale as we would like to see.

I'd like to emphasize a couple of points about land-use management. First, the duration of land clearing activities is important. Where timber harvesters follow existing guidelines, some relatively effective vegetation cover will be in place at the end of 10 years. With agriculture, there is very little reason to expect that much of the agricultural land will revert to forest. It is also important to note that the scale of agricultural land disturbances is far greater than forestry or urbanization, and includes frequent disturbance such as exposure of bare soil, which facilitates erosion. With urbanization, the disturbance is typically small in scale; but it is permanent, and usually results in 40 to 80 percent of the watershed becoming impervious with very efficient artificial drainage networks.

It is extremely important to think about why we want science. Are we after science for landscape planning? If you asked me to demonstrate or measure the effects of land use change on a catchment, I would pick the urban one every time, because that's where most of our understanding about intense effects has occurred.

When people are asking me to spend a million dollars a year on a quasi-military scale of watershed study to look at nutrient inputs or clear-cutting, I get the distinct impression that they are not really worried so much about nutrients as they are about the fact that the landscape is changing in a radical and highly visible way. Perhaps one of the driving motivations for such studies, particularly in northern boreal forests, is that wilderness is being lost and that we are losing something. We have no idea about the subtle consequences of that.

I don't expect to be able to show that the lakes are going to turn green after a timber management rotation. I may be able to detect subtle incremental or cumulative effects that suggest this activity needs to be done in a different way. The underlying concern may, however, be that cut-overs are ugly, they change our landscape, and we are losing something very valuable that has to be expressed somehow in water chemistry or fish. By this roundabout way, I'm suggesting that the kind of science directed at a catchment scale, looking at nutrient inputs or subtle geomorphic effects, may not be addressing some of the main issues that are driving people to be concerned. You need to be realistic about that.

Two very important issues are 1) How do we protect aquatic ecosystems in the face of land use? and 2)How do we adjust the mix of fibre extraction versus remote fly-in fishing versus wilderness recreation or even the perception of wilderness versus fish harvest in a wise and sustainable way? To be effective, science has to be designed at very, very different scales and different intensities. You are not going to be able to make management decisions based on a specific study of the effects of sediment on salmon.

An integrated catchment scale to look at what happens at the mouth of these big basins is one approach. If you want to answer questions about impacts on arctic estuaries as a result of land use in the Peace, Slave, or Athabasca basins, you need a very different study. In this case a retrospective or comparative analysis of land cover changes using LandSat technology might be most appropriate. Spatial nesting or hierarchical sensitivity in watershed analysis is also important.

We know a lot about food-web responses to large scale land clearing, but it is often difficult to translate what we know into credible land-use decisions. The quality of the information we have on many of these issues is not of a resolution or geographically broad enough scale to influence land-use culture or the culture of land-use planning, particularly in the boreal forest.

The take home message is that quantitative evidence regarding the effects of forestry is strong for hydrology, temperature effects on streams, certain aspects of geomorphology, the effects of solar radiation biology, water quality and other processes at the stream scale. There isn't much evidence on the effects of land disturbances on lakeshore morphology, but we soon expect to be looking at wind velocity on a small catchment and a regional scale. There's also good laboratory evidence to show that moving pulses of sediment exceed the physiological capacity of fish to adapt and thrive.

Lastly, we have enough information to say we are highly capable of simplifying, degrading and destroying aquatic communities, because we have some compelling anecdotal evidence from a large number of systems. There is very little we can say specifically about the boreal forest, except that you can expect these processes to be operable here.

2.8 SOCIAL AND HUMAN ISSUES ASSOCIATED WITH LARGE SCALE LAND CLEARING AND DEVELOPMENT OF BOREAL ECOSYSTEMS

Presented by Dr. Milton Freeman
Professor, Department of Anthropology, University of Alberta, Edmonton.

I will be talking about the socio-cultural dimensions of environmental impacts. Because of the complexity of the systems that we are talking about here, I would just like to make the observation that ecology is of course about relationships, and relationships are not only quantitative or measured in quantitative terms, but are also qualitatively assessed. Sometimes it's better to try and be generally right rather than precisely wrong.

Generally speaking, anthropologists are more concerned with conceptual models which are qualitative. This way we can gain an understanding of what's generally happening when systems change. To try and quantify cultural changes is difficult and sometimes misleading because cultural systems are very complex. If you think the biosphere and geosphere are complex, try and work with our system; the neurosphere, the whole mind concept. So our conceptual models are of a very general nature. They can be empirically tested quickly, in real time. Then we know whether we are on- or off-track. In terms of public policy, of course, you do need this very quick response. I think it is very important that the science we do be policy-relevant.

What I want to talk about today is the importance of rivers as sources or locations for people to gather food. Changes to these environments can, of course, affect food supply. The important goods in relation to rivers are fish and wild fowl as well as mammals. However, fish tend to be the most reliable source of food. They are, therefore, associated with a sense of security: environmental, social and nutritional. That's one reason why we would immediately believe that changes to rivers can have serious impacts on people who use the food from these environments.

There are costs associated with changes to a river or hydrologic regime which may affect the margins of lakes and rivers and the terrestrial habitat. These impacts are of a diverse nature. When a food source is lost, there is an economic impact because there is a cost associated with replacing the food. But there are psychological and socio-cultural impacts that are hard to discern and quantify. When we are speaking of resources that we value in many ways, social scientists describe them as being valued multidimensionally.

As anthropologists, we also recognize that a people tend to establish a hierarchy of values with respect to their existence. One of the values that people who live in a hunting, fishing and gathering mode place a high value on is subsistence. A subsistence culture is one where the process of obtaining food is the very basis of social relations. Generally, people are always faced with change. In adapting to these changes, a people will trade away various values. For First Nations people who choose to live in a food producing mode, one of the last values that would be traded away is usually subsistence.

In one study that we did for the International Whaling Commission, we looked at the frequency of traditional food use. We saw that fish are particularly important in the fall and winter. Of course, winter is a time when food can be scarce because of the migratory nature of the wildlife that leave the area. In spring, small mammals are an important food source. We can also quantify the number of people who are participating in food capture, preparation, distribution and consumption.

In the particular society we studied, the Alaskan Inupiat, or people of the whale, there is a tremendous amount of ritual and ceremony associated with whale hunting. They even have customary laws about sharing relationships and associations that are based on the fact that people belong to crews and clans.

The important thing in terms of where all this leads is identity. All these components relate to who the people feel they are, something they will cling to because identity is very important to mental and physical health. So in this case the source of food is not merely nutrition. The source of food contributes to a sense of self-worth in the Inupiat.

When we conducted this study, biologists at the time were recommending a zero quota on bowhead whales (the primary quarry of the Inupiat) because this species was endangered. Other cultures might be happy to substitute walrus, ringed or bearded seals or white whales, but the important species from this society's point of view is the bowhead whale. The issue was resolved through traditional knowledge and modern science which discovered that there were in fact a large number of these whales within the scope of Inupiat hunting parties.

You have to consider that these people had already been bombarded with and adapted to forces originating outside the community. First, there was the impact of Hudson Bay activities, company credits in return for pelts, the collapse of that system, then outside government, schools, training projects, disposable income, community councils, housing programs. These are very important qualitative changes that have occurred over the last 20 to 30 years.

Under these conditions individuals or households may show a low ability to respond and adapt. They will be susceptible to high stress and the social breakdown, substance abuse, family breakdown, violence and so on that frequently occur as a result of cultural dislocation. We found that the people who show high adaptation and low stress are the people who have maintained in varying ways some sort of contact with their traditional culture. For people showing who are on the high stress end, their changed circumstances will affect their identity, self-worth, purpose and sense of belonging.

A complete moratorium on whaling had the potential of destroying a food gathering tradition that was virtually the last straw holding a northern culture together. Thorough understanding of human cultural issues, empirical studies and dialogue with environmental researchers resulted in an agreement that the affected community could harvest one whale a year without affecting the intent of the moratorium.

2.9 SUMMARY OF THE ROUND TABLE DISCUSSION

Panellists for the round table discussion held on the second day of the workshop included Pat Chambers, Robert Naiman, Andre Plamondon, Ellie Prepas and David Rosenberg. The ensuing discussion between panel members and significant contributions from the audience of participants is summarized here.

David Rosenberg

I would like to start this discussion by reiterating the importance of scale, both spatial and temporal to addressing the questions of the effects of large-scale land clearing on water quality. Questions about non-point source types of disturbances generally need large-scale research, which is often a hard thing to do. My background is in hydro developments. While the details will differ on a site-to-site basis, we've developed enough knowledge from hydro studies worldwide to be able to predict the broad outlines of what will happen when a reservoir is created or a water diversion is done. In terms of the impacts of large-scale land clearing in the boreal forest, in this part of Canada, the impacts are really non-point sources, and I sense that we haven't yet achieved the kind of synthesis that we have for hydro development. Perhaps something like Robert Steedman's synthesis of data would be a useful start.

Another aspect of the impacts of large scale land clearing that intrigues me is the potential effects of land clearing on global carbon budgets. This is a very difficult question to address, both technically and from a research standpoint. Political and grant funding horizons don't match the spatial and temporal scales that are required to do this kind of carbon budget analysis.

Patricia Chambers

In terms of the impacts on the boreal forest, what we need to think about is the long-term effects. This has been alluded to by a number of speakers here. Things like in-filling by sediments on gravel spawning beds aren't going to be happening next month or next year. It's going take place over a period of decades.

Together with our deliberations on the impacts of forest clearing on water quality, we should consider the effects of a multitude of stressors that are acting on a system. We have a lot of activities that are occurring simultaneously; for example, the expansion of industries and the expansion of human habitation with their related effluents. So, we have to consider how the effects of the stresses from say forest clearing are going to interact with the stresses caused by other activities. Considering that we don't know how either of these stressors interact particularly well, the interactive effects are going to be extremely difficult to tease out.

Andre Plamondon

I strongly believe that to tackle the impact of large-scale clearing on water quality, we need an integrated approach from maybe two extremes. On the one hand we should use monitoring to inform and support short-term management decisions and to improve management policy from one year to another. We can't wait 20 years before we attempt to support management decisions with science.

At the same time, we need to improve our understanding of the natural process occurring in the Northern River Basins. Therefore, we have to have some long-term studies that are integrated with monitoring efforts. We don't for example, know how clear-cutting in uplands affect lowland areas or how clear-cutting or buffer strips in lowlands affect streams. We need some studies that are long-term, some short-term research objectives and a means of integrating the two

Robert Naiman

The thing I would urge you to think about is coupling perhaps some traditional approaches with some of the synergistic elements that you find in the environment such as light, light conditions, temperature conditions and so forth. Also, you should consider that nutrients often times don't bring about large changes unless these other environmental elements interact with them.

There is also a whole variety of things that are not really in our scientific arsenal at the moment in terms of being able to monitor systems. For example, in the boreal forest, changes in ice conditions can be of immense importance, especially in streams. The type of ice and changes in ice conditions are some of the greatest determinants of the productivity and community structure that we find in streams, yet very few people really monitor that on regular basis.

Another quite integrative approach is to look at suspended organic matter concentrations as an index of how well the system has recovered from discharges of sediments. You'll often find that the concentrations of sediments or organic matter will increase greatly at the beginning of the discharge increase; but as discharge continues to increase, the concentrations start to come down a bit, then recover to a precondition level. This recovery can occur some time before the storm or discharge event has ended or soon thereafter. Called *hysteresis*, this process can be a very powerful tool in looking at the responses of systems to subsequent disturbances.

Boreal research might also benefit from an adaptation of some of the new molecular techniques, like DNA probes. These probes might be able to help distinguish between microorganisms that are of terrestrial origin and those that are of aquatic origin. Looking at the ratios of terrestrial to aquatic microorganisms in the stream discharge could help as a measure of how efficient the terrestrial system is in terms of retaining organic matter after cutting. You might also look at the life-history strategies of fish. And, you could also try to identify the most sensitive components of a landscape to change. In my research we use the riparian zone and riparian vegetation as indicators of change, and it's something that we can do quite easily using remote sensing techniques.

In terms of how you actually analyze this data, you might want to look at Bayesian approaches which focus on probabilities rather than just frequencies. Another thing to consider in our analysis is the idea of classification. On one medium-sized watershed I'm faced with over 40 distinct types of streams that have very different disturbance regimes, communities, even histories. In these situation, we begin to classify the landscape into units where we can identify ecological attributes that allow us to make meaningful comparisons about what percentage of the landscape is in what classification and scale up from site-specific to landscape scale studies. It can take several years sometimes to actually develop appropriate classification systems that are defensible in both scientific and legal arenas.

Finally, just a couple of words about habitat. Perhaps you can learn from what happened over the U.S. Clean Water Act. If you took it to its logical conclusion, we would have seen distilled water moving from the mountain tops to the ocean. It ignored habitat. If something can be learned from such policies, then we probably shouldn't try to convert the naturally turbid waters of the Athabasca River into nice clean clear waters.

So, how do you monitor habitat, especially when you're faced with 40 different kinds of habitat. We use aerial photography, remote sensing and infrared scanners. We have to have the data points on the ground, arrayed in such a way that allows us to take the whole pulse of watershed and not just of specific sites at specific times. All this is expensive. It requires a long-term commitment from people to really carry this out: commitment from people as well as agencies.

Then you have the data management issues to deal with. If you are really going to do it right, you've got to analyze it, get good people, equipment and an infrastructure to back them up in order to make heads or tails out of all the information you've collected. The average costs to complete the circle in this way should be about 30 percent of your science budget. It's something you can't scrimp at.

Ellie Prepas

The first question that we know very little about is what the systems were like before there were various kinds of disturbances from European settlers. We are beginning to collect, I think, a very substantive database on the main stem rivers in the Northern River Basins. But there are only tiny pockets of work on areas other than the main stem rivers. Even so, our knowledge is very spotty when it comes to patterns.

Another important issue for research is how we deal with runoff and water movements in this area. This area is one of low relief. Virtually all of the impacts we are talking about are non-channelized, non-point and subsurface. Of the very few lakes where there has been some attempt at creating detailed water budgets, the estimate is that on average about 30 percent of the in-flow comes from groundwater flow as opposed to non-channelized runoff. In addition, few streams in the study area are amenable to traditional approaches. Most streams are ephemeral, with poorly defined channels.

A third area I wanted to mention is nutrients. There's a database of zero at the moment on the impact of disturbances on nutrients in the study area, be they phosphorus, nitrogen or carbon. Furthermore there are some features besides slope and the relatively nutrient-rich soils that make them particularly amenable to some unusual features. For example, the pH of soils in aspen-dominated areas is relatively high. In all probability, we can project that these same areas will tend to have a relatively high release of phosphorus relative to nitrogen. Therefore, we have situations where runoff is probably very much phosphorus dominated. Yet, none of this is characterized or quantified at the present time.

The final thing I wanted to raise was a point about food chains. In aquatic food chains, dissolved oxygen is fairly important. In the study area streams and lakes, dissolved oxygen is very low, and biota are likely adapted to low oxygen conditions. If water or nutrient levels change, we may see complete extirpation of some biota that are subjected to long durations of even lower oxygen. Perhaps we should look at the impact of various kinds of disturbances on the exchange of water and nutrients and sediments between land and surface waters. Then we could try to understand what impacts these exchanges have on biota.

Ken Crutchfield

I believe the time scales are just out of whack here a little bit. We've got a lot of frustrated people out there that appreciate the need for bigger investments in time and money. But the world is not stopping. How might you recommend us coming to grips with this a little bit better than we are at present?

Robert Naiman

I don't have a full answer, but one of the places to start is to form partnerships with forest products companies, those involved in other extraction activities, the scientific community as well as local residents. There is nothing wrong with thinking of this as an adaptive process whereby you try a number of things and see how they are working. You have real time data analysis and sufficient monitoring, but you use it as an iterative process to make changes as you go along.

Having a realistic and adaptive philosophy in place from the beginning becomes very, very important. And that is much more effective than starting off with one vision in mind that may not turn out to be entirely satisfactory. There are a number of ways to bring the public into this. One is modelling. Modelling enables people in a community to see, from computer generated pictures, what results we expect to see from different land-use activities. Show them some alternatives and involve them in the process right from the beginning rather than setting things in motion and trying to sell it to them afterwards. When you are ready to make decisions, bring the recommendations to all stakeholders, the community, industry, administrators and multidisciplinary team members at the same time. If you don't get involved in developing a common vision of the future, then you can get into so serious troubles down the road.

Trevor Dickinson

A good analogy that just came to my mind is the time when they were pouring the first large concrete dam on the Colorado River. They had never done a continuous pour that large, so they didn't know how to finish it. Their projections did suggest how to start, so they put monitors in the dam as they went. In this case they monitored temperatures. If their projections didn't fit, they changed the manner in which they poured.

Some questions arise from this analogy. How do you get the best vision possible at the outset? How do you set up the interaction amongst the scientists and others to make sure feedback is possible? and, What are the best monitors to put in place, traditional or otherwise?

Brian Taylor

We have this dichotomy of purpose. On one hand we feel we don't have enough information, but on the other hand we need to make decisions reasonably quickly. Couldn't we just cut to the heart of the matter by using accumulated general ecological knowledge and expert opinions to create computer or conceptual models, test them to see if the resulting projections are reasonable, then use the projections in a broad sense to guide the focus of research efforts?

Robert Naiman

I am a little bit afraid when you are starting to work in systems where you really don't have sufficient information to build a halfway decent model. Sometimes the models take a life of their own. Often, you need a bit of time to see whether or not you have false analogies or are on the right track. In one case, only one of my ten hypothesis was working out. We checked equipment and took about a whole field season that the system of streams was responding to different things. It turned out that beaver action had changed the streams I had expected to find. The message I'm trying to deliver is that we should remain open to learning from the surprises out there.

Ellie Prepas

I really agree with what Bob says. The database isn't there to develop certainly very sophisticated models. At the end of the very extensive Northern River Basins Study, there will be a modest modelling enterprise with the limited database that was collected.

Andre Plamondon

I don't agree 100 percent with Dr. Prepas. We are making management decisions every day and some type of monitoring would be useful to advise land-use decisions. I think we have enough information to do that. We have to start somewhere.

Dave Rosenberg

I've been in the business for about 25 years and one thing hasn't changed. Development plans are ten years in the making and biologists and scientists are brought in at year nine and a half to offer their comments and their information. Maybe there is something we can do about the agencies that require research and science that would compel them to get us involved a little earlier. Then we could properly employ the time scale the need to get the answers that are being asked of us. The lesson that science needs a certain amount of time to generate answers, never seems to get learned.

David McNabb

Yesterday we heard from Trevor Dickinson that we probably don't spend near enough time on conceptual models in terms of their development. It's certainly not a high-tech or high capital investment operation. How do you make use of conceptual models in terms of trying to integrate them with traditional scientific approaches to do a better job at getting our answers sooner?

Ellie Prepas

Your point about conceptual models is probably a good one in the sense of making a start. Then you could test your model. The questions need to be asked need to be within a framework, and that framework hopefully is based on the best information that's available. The conceptual models are the framework we should be proceeding under. I would be surprised if there were major disagreements in terms of how we think the land and water are interacting.

Robert Naiman

It's important that conceptual models evolve and are not perceived as reality. Don't blind your self to startling new findings by hanging on to your conceptual model. I did that and almost prevented a post doctoral student from getting credit for his discovery. He found that groundwater and surface water interactions are absolutely essential in determining the productivity and characteristics of small streams in Quebec's boreal forest. You've got to remain adaptive, and I guess I learned a very big lesson from that.

Ron Millson

Ellie mentioned that researchers can build conceptual models of systems and probably get reasonable agreement about the basis of how these systems work and that you can to some extent quantify them using educated guesswork. I'm a manager in the field, a generalist. I can't build the models you can, but I do have to make day-to-day decisions based on what I can generate from my knowledge. I know there's great hesitance on the part of the scientific community to go out on a limb and start to generate these models and distribute information on what can be learned from them. But management is going to be a lot further ahead if the scientific community can find the courage to be less scientific and more communicative. It's not that scientists are uncooperative. It's more that the systems are so far apart.

Robert Naiman

I agree 100 percent. Personally, I believe it is the responsibility of a scientist to become involved in the watershed being studied. Not long ago I learned that less than 10 percent of the specialists I was meeting with actually lived in the watersheds they were working on. That is a very, very low percentage. Yet scientists have an important role to play, not only as scientists, but also as citizens.

On a regular basis, the Centre for Streamside Studies at the University of Washington puts on symposia on various topics. The response in the Pacific Northwest has been absolutely overwhelming. We put on a watershed expo with the Environmental Protection Agency which was specifically designed to bring people in who are making the day-to-day decisions at the watershed scale. We had 1200 people show up.

We also put on a whole variety of workshops on very specific topics like hill/slope stability, stream restoration, and so on. They attracted practitioners to learn, over a three- or four-day period about the state of the art in each one of these topics. Again, every workshop was fully subscribed to. Such activities are one way universities can be in strong partnerships with people in communities at all different levels.

Bob Wynes

We (Daishowa-Marubeni International) are contributing to a research project through the University of Alberta right now, looking at water yield changes from timber harvesting. Very much we are focussed on preventing change. I think we are missing the point. We should be trying to maintain the long-term health of our ecosystems and take a low risk approach to development based on an understanding of natural processes.

3.0 <u>SUMMARY OF BREAKAWAY SESSION DISCUSSIONS</u>

3.1 UNIQUE FEATURES OF THE BOREAL FOREST

The first challenge addressed by participants at the NRBS workshop was to identify the unique features of the boreal forest. As the following description indicates, participants were, in some cases, more comfortable qualifying their answers by identifying biophysical features that are important, rather than unique, about the natural features and processes at work in the study area.

3.1.1 Geography

Geographically, the study area encompasses the Athabasca, Peace and Slave River watershed and includes alpine, subalpine, foothills physiographic regions as well as interior plains. The Peace and other rivers in the watershed have cut deeply, up to 274 metres, into the landscape of the boreal forest (R. Millson, Land Disturbances Transcript, p. 20, Nov. 18, 1994). By contrast, the greater proportion of the landscape and streams have low-gradients and are quite flat. Overall, the landscape can be described as having high spatial variability: a highly diverse range of soils and vegetation occurring over small changes in elevation. Figure 1 shows boundaries of the study area and its network of rivers.

3.1.2 Soils

In contrast to the areas of boreal forest that are located on the Canadian Shield, the boreal forest in Alberta and parts of the Northwest Territories occurs on sedimentary bedrock with calciferous-type rocks. Mineral soils predominate and include luvisols, solonetzic soils and chernozems that exhibit solonetzic properties. The interaction between climatic inputs and these soils make the area highly susceptible to soil erosion and stream sedimentation. A significant part of the region is flat and poorly drained, containing lakes and wetlands with soils derived from organic deposits of peat.

3.1.3 Climate

The Northern River Basins are classified as having a continental climate that is modified by the lakes and wetlands that cover significant portions of the landscape. Combined with the soil and hydrologic conditions, including a six-month freeze-up, the climate of the boreal forest supports a fairly slow maturation rate of 80 to 100 years for trees. The natural occurrence of two fire seasons, spring and fall, is unique to this boreal forest and has had a significant effect upon its structure and appearance.

The way that climate, geography and hydrology contribute to flooding regimes is one aspect of the boreal forest that can be classified as truly unique. To begin with, the headwaters of rivers in the boreal region flow north rather than south, which means that ice break-up starts earlier in the more southerly headwaters. Subsequently, increased volumes of water flow move downstream to ice-blocked channels, and major rivers in the area are very susceptible to ice jams, significant scouring of exiting channels, stream/river bank erosion from ice, and flooding.

Snowmelt patterns in the region also affect the timing of flows and the potential for flooding. Snowfall accounts for only 30 percent of annual precipitation, but determines the amount of spring runoff. The timing of spring runoff is affected by factors such as air temperature, rainfall, snow exposure, wind, and solar radiation. Spring runoff can also be highly variable from year to year. If the melt is fast, spring flows can be high and lead to flooding. Other years, if melt is slow and prolonged, spring flows are much lower. Due to the variability of spring temperatures, the spring thaw typically starts and stops, and some soils thaw only after snowmelt. In those cases, very little surface water infiltrates soils and most water flows into lakes and streams. Besides resulting in flooding, spring runoff from snow can cause a serious depression of pH. Such natural fluctuations in water conditions make even the natural environment inherently precarious for fish and aquatic organisms (R. Tallman, personal comment, Biology Transcript, p. 17).

3.1.4 Hydrology and Water Quality

Most of the rivers in the study area originate in the mountains and foothills. Spring and summer storm flows tend to carry high concentrations of suspended solids. Some of the highest suspended sediment concentrations in Canadian rivers occur in these headwater rivers and streams. Boreal rivers in the Northern River Basins tend to be more calcareous and alkaline than the boreal rivers found in other parts of Canada because of the sedimentary and calcareous geological formations they flow through. As boreal rivers progress in a northeasterly direction, the water gets softer (i.e., the concentrations of calcium and magnesium decrease) and generally carries a higher concentration of organic material (L. Noton, personal comment, Water Quality Transcript, p. 12). The higher organic contents are reflected by the brown colour of water in many of these northern streams.

3.1.5 Vegetation

The boreal forest of Alberta is characterized by pure to mixed wood stands of aspen, white spruce, balsam fir, lodgepole pine, jack pine, black spruce and tamarack. Large stands of pure aspen, often with understory spruce and mixed aspen-white spruce, are common on better drained sites. Aspen is considered by many as a sub-climax species because of the frequent occurrence of wild fires that interrupt natural succession to climax spruce-fir stands.

The vast network and complex mix of fens, bogs and swamps is one of the striking features of the boreal forest. These wetlands occur on poorly drained sites with fine mineral soils or soil profiles with impermeable B-horizons. Such conditions enable water to accumulate on the surface and prevent downward percolation of water. Many sites with these soil conditions support peatlands with a wide variety of mosses, mushrooms, flowering plants and stands of black spruce and tamarack. Much of this timber is classified as un-merchantable because of the small tree size caused by slow growth or unstable ground conditions that make harvesting difficult. Comprehensive information on forest stands is available through Phase III Forest Inventory maps published by the Land and Forest Services Branch of Alberta Environmental Protection in Edmonton (G. Hillman, written response to draft Report, p. 8, 8 May 1995).

3.1.6 Wildlife

The boreal forest contains a variety of large mammals such as moose, white-tailed and mule deer, black bear, and wolves; small mammals on which the larger animals feed; subarctic birds such as the sandhill crane and caspian tern; and a number of neotropical migratory species. The study area has a low diversity of fish, reptile and amphibian species. Little is known about some of these species. For example, the migratory routes of fish and how they adapt to the highly turbid waters of some northern streams are poorly understood. The importance of this adaptability and the potential impact of land use on wildlife are difficult to assess because of the lack of reliable population inventories of species in the boreal forest.

3.2 IMPACTS OF LAND CLEARING ACTIVITIES

Generally, workshop participants agreed that the causes and types of impacts from land clearing will be the same in the Northern River Basins as elsewhere. The consequences of land clearing activities in the study area will, however, manifest themselves in ways particular to the geography, soil, climate and hydrologic conditions that exist there. In most cases, breakaway session participants articulated what they expect is happening or will happen in the study area, based on their knowledge and experience with similar land clearing activities elsewhere. Everyone acknowledged that the impacts of forestry are better documented than impacts from agriculture, oil and gas extraction, mining activities, human settlement activities and urban development.

3.2.1 Agricultural Impacts

Agricultural land clearing activities, are a major agent of change. Fifteen million hectares of land within the study area are currently under cultivation compared with annual forest harvesting activities that affect a much smaller area. Besides affecting a larger area than forestry does, agriculture maintains the land in an un-treed state and introduces large amounts of pesticides into the environment. Furthermore, summer fallowing, a practice which makes the soil very susceptible to erosion, is used on about 10 percent of cultivated lands (C.F. Bentley, personal comment, Land Disturbances Transcript, p. 6).

The need for more sustainable agricultural practices and quantifiable evidence to support them becomes even clearer when pressure to expand agriculture northward is considered. Such pressure is likely to occur in response to declining soil productivity, decreased availability of land, and predicted climate changes in more southerly locations.

A change in the micro-climate is another anticipated consequence of agricultural land clearing activities. The accumulation of snow on the ground in larger, wide-open areas created through agriculture and forestry land clearing, can result in a net loss of available moisture when compared with the moisture retained where snow accumulates in the undisturbed forest. In large, open areas snow is more exposed to sun and wind and disappears at a faster rate during spring thaw than snow in the forest. In addition, winds have better access to snow on these open areas, so that sublimation and evaporation increase and the snow pack disappears into vaporous form. In general cleared lands usually become drier. Snow pack accumulation is maximized when the diameter of the cleared areas is about twice the height of surrounding trees.

Water quality is also likely to be affected by agriculture. Phosphorus and other nutrient loading in streams and rivers, for example, tend to be high in cultivated areas. Increased sediment in rivers also occurs as a result of agriculture, and the high organic content of waters in the boreal forest predisposes them to attachment of metals. While there is no evidence that this has happened to the extent of being toxic, this combination of elements might cause lower levels of dissolved oxygen, which can have significant detrimental effects on fish and aquatic biota.

In terms of pesticides, those that are very water soluble don't bind to the soil and are less of a problem. Herbicides like Atrazine and Simazine can cause problems (D. Grant, personal comment, Water Quality Transcript, p. 19). Even small concentrations of pesticides or other chemicals, dioxin for example, may endanger human or aquatic populations. Furthermore, the use of pesticides and fertilizers has increased phenomenally in the last 20 years and that has major implications for water quality. Agricultural land clearing or clearing on private land is not regulated in terms of environmental concerns (G. Hillman, written response to notes on Water Quality Transcript, p.5, 23 February 1995).

3.2.2 Forestry Impacts

The significant difference between forestry clearing and land clearing for agriculture is that lands cleared for forestry can potentially return to a more natural state (i.e., forest cover), whereas cultivated land remains in continual use. However, this assertion doesn't mean that forestry activities have a low impact. In most cases the impacts of forestry may not look the same as agricultural impacts, but they are felt. For example, while lauded by the timber industry and landowners, modern fire prevention programs have altered the age of the forest. More old-age classes of timber now exist than was the case with natural fire cycles. Subsequently, natural processes of hydrology, tree regeneration, runoff and evapotranspiration have been altered (M.T. Dick, personal comment, Hydrology Transcript, p. 15)

Given the poor hydraulic conductivity and poor drainage of soils in the boreal forest, removal of trees under certain conditions can exacerbate the existing high water tables and contribute to flooding. Sustainable forestry practices, such as regenerating spruce are often impossible where water tables are high because tree seedlings cannot compete with phreatophytic species such as grasses, willows and alders that take over these harvested sites (R. Rothwell, written response to draft report, p. 10, 23 May 1995).

In areas of the boreal forest presently conducive to peatland formation (paludification), large scale forest clearing will produce unfavourable conditions for this process (D. Klym, personal comment, Land Disturbances Transcript, p. 25). It is expected that land clearing will cause an increase in runoff and a decrease in groundwater which recharges these wetland areas. Complicating this process is the fact that impacts are location specific. After logging, some peatland areas have become marshy, other wetlands have dried up (I.G. Corns, personal comment, Land Disturbances Transcript, p. 24). It may take several hundred years for a site to reach its vegetation climax state. After harvesting, reseeding or replanting an area with the same tree species that were harvested may be appropriate. It may be necessary ecologically to ensure that the site go through the same natural successional stages before vegetation can reach the stage that existed when the area was harvested (N. Parker, personal comment, Land Disturbances Transcript, p.13).

Finding low-impact forest practices is a difficult and complex task. From a technical perspective, the trend toward larger clear-cuts offers potential savings in terms of reducing soil impacts; but increases the impacts on hydrology. Those impacts will likely be more severe because future harvesting activities may involve logging on relatively steep slopes and adjacent to major rivers (i.e., the Athabasca River Valley, Wapiti, Little Smoky, Clear River). It should be noted that the forestry industry is looking at alternative methods to clear-cutting when harvesting on problem sites. Furthermore, ground rules set out by Alberta Land and Forest Services do not allow harvesting on riparian areas or on slopes greater than 45 percent, with conventional wheeled skidders (G. Hillman, written response to draft report, p. 10, 8 May 1995).

Besides technical considerations, it is difficult to define and quantify sustainable use of forest and other natural resources. Economic conditions influence decisions made by the forestry and agriculture industries as well as local communities. With a greater understanding of technical and economic concerns among the general public, clearly defined social values, a commitment to holistic, flexible long-range planning and effective dialogue between representatives of commercial and public perspectives, it might be possible for interest groups to arrive at some satisfactory, achievable conservation goals. Over the course of the NRBS workshop, participants acknowledged and placed increasingly urgent emphasis on achieving such a state of affairs and identifying precedents where members of scientific, industrial and local communities have been able to learn from each other and plan cooperatively.

3.2.3 Impacts on Hydrology

Participants' views on the impacts of land clearing activities on the hydrology ranged from predictions of conservative changes in hydrology to warnings about catastrophic increases in water yield. Conservative estimates suggested that there will probably be no change or an increase in water yield, but that will be very scale dependent. At the other end of the continuum, some experts predict that flood events could occur for the next 30 to 50 years (C. Hunt, personal comment, Biology Transcript, p. 46). There was agreement, however, that land clearing will likely include some or all of the following hydrologic impacts:

- changes to water tables and water retention capacity of soil,
- slow recovery of evapotranspiration processes,
- changes in the capacity of peatlands to store water,
- reduction in the size and number of wetlands,
- potential for increased flow causing degradation (downcutting) of rivers and streams at some locations and aggradation of river and stream beds (accumulation of sediment) at other locations,
- decreased stream gradients,
- low nutrient soil environments, and
- changes to sediment levels, water yield, water temperature, and aquatic biota.

3.2.4 Impacts on Water Quality

Because agriculture, forestry and hydrology have significant impacts on water quality and biological organisms, many of the comments about impacts arising out of this discussion group have been included under those respective headings. The water quality group generated a considerable amount of information on how to encourage interdisciplinary studies and improve communication among stakeholders. These suggestions are contained in the *Larger Research Issues* section of this report.

Defining the term *water quality* quite rightly received some attention in this breakaway group. It was noted that water quality can vary depending upon one's perspective. Aquatic organisms are sensitive to abrupt changes in water chemistry and must have certain temperatures, pH and specific dissolved oxygen levels as well as other water conditions to survive. Standards for human consumption of drinking water are more stringent for factors like sediment than are standards of safe water for aquatic organisms. For other factors, standards for human use are less stringent.

3.2.5 Impacts on Wildlife

Participants agreed that land clearing will have qualitative impacts on biology, but that quantitative assessment of impacts will be difficult to do because there is little or no baseline information about animal populations in the boreal forest. They also acknowledged that the make-up of species groups is known to change after logging. Local observations support this prediction, reporting that some species like magpie have increased and others have disappeared. Dr. Robert Steedman added that the types of insects found near streams can be used as indicators of geomorphic characteristics and environmental changes (R. Steedman, personal comment, Biology Transcript, p. 79).

Habitat fragmentation, which affects wildlife migration among other behaviours, has resulted from all types of land clearing activities. For example, the larger trees grow where there's more moisture, along the rivers and valleys, so that's where harvesting is often done (except on Crown lands where buffer zones of undisturbed riparian vegetation are maintained). This is unfortunate because, riparian zones are very important in terms of local and migrating wildlife that depend on them for a variety of foods. Forests and the small openings that border on rivers and lakes are also important to wildlife because they offer protection from weather and predators. Besides directly reducing treed habitat, harvesting on rivers, creeks and islands affects the amount of water available to the vegetation on flood plains. Over the long term, changes in vegetation influence ungulate behaviour (B. Wynes, personal comment, Biology Transcript, p. 42).

3.2.6 Impact of Roads

Discussions about the impacts of roads became rather contentious at times. However, participants agreed that impacts of the removal of vegetation combined with roads, drainage ditches, culverts and stream crossings constructed for resource extraction have significant impacts on hydrology, more so than changes to vegetative cover alone (F. Davies/A. Plamondon, personal comments, Hydrology Transcript, p. 21-22).

Roads, for example, can interfere with hydrologic systems through a damming effect, and stream crossings are important sources of silt loading (G. Hillman, written response to notes on Hydrology Transcript, p. 6, 15 February 1995). With the network of peatlands that occur in the boreal forest, resource extraction activities are frequently limited to winter when the ground is frozen. The building of snow bridges and the impact of heavy equipment used for crossing streams at this time of year may also be significant. Generally, the cumulative effect of sediment released by road crossing and access activities, rather than individual road construction events, were considered to be continuing sources of sediment. As the sediment migrates downstream, it has different impacts at different levels (C. Hunt, personal comment, Biology Transcript, p. 64).

In the Pacific Northwest, 80 to 90 percent of sediment problems in streams are the result of roads. Solutions to the problem of impacts from road construction are quite complex due to the very strong cultural/social/economic values that various stakeholders attach to them. For example, roads give access to vacation homes, recreational activities such as fishing, and a spectrum of commercial activities (C.F. Bentley, personal comment, Land Disturbances Transcript, p. 42). Participants acknowledged that roads, drainage, culverts and stream crossings can have more impact on an ecosystem than changes in vegetative cover. They also agreed that progress toward lower impact road and drainage activities needs to be supported by better community liaison, education and government regulations rather than research.

3.2.7 Impact Summary

The impacts of forestry have received more attention, in terms of research and public awareness, than the impacts of agriculture, oil and gas extraction and mining activities. Similarly, impacts from human settlement such as road construction and sewage treatment are regulated to some extent, but have a low profile in terms of research and public awareness when compared to commercial activities.

There is a perception that the Northern River Basins are relatively untouched by human activities, but in fact the whole landscape is being managed either directly or indirectly (D. McNabb, personal comment, Water Quality Transcript, p. 37). Even if the north continues to open up at a rate slower than that of the prairies, the following current and predicted impacts are bound to increase:

- altered water chemistry,
- soil erosion and flooding,
- inhospitable habitats for indigenous wildlife and aquatic biota,
- increased water yield from cleared areas,
- decreased groundwater loading,
- changes in water table (lower or higher) dependent upon parent soil material,
- a dryer region due to increased snow sublimation and evaporation, and
- a higher water table.

Given the number of different land clearing and resource extraction activities being pursued in the Northern River Basins, participants shared a common perception that continued lack of cooperation among stakeholders could have as yet unknown cumulative impacts on the region and that these impacts will be felt downstream.

3.3 STUDIES NEEDED

Throughout the four breakaway discussion groups, a few general and specific areas for study received common emphasis. Some of the larger research needs that were mentioned included the need for research into the potential impacts of land use on global warming and climate change and the effects of climate change on the study area. Fortunately, these impacts are currently being studied as part of the Mackenzie River Basin Impact Study (G. Hillman, written response to Biology notes, p. 3). Researchers should, however, be giving some thought to the type of timber and vegetation that would thrive under an altered climate.

It was also noted that the amount of research in the western part of the boreal forest is limited when compared to what has been done in the eastern portion. Another general area for future research is palaeontology. The rationale for this suggestion is that climates of past ages could recur. Palaeontology could help predict the potential effect of climate change on the natural resources in the Northern River Basins (D. Klym, personal comment, Land Disturbances Transcript, p. 64).

Consensus also emerged from breakaway sessions, presenters, and plenary discussions about the proliferation of research questions, information needs, and the tendency for scientists to examine, re-examine and expand upon each other's work without directly addressing the land managers' urgent need for sustainable options.

In response to the implied question, "Do we need further research or a really good review of research?" (B. Swanson, personal comment, Biology Transcript, p. 51), participants suggested that a thorough literature search be compiled and reviewed by a multi-disciplinary panel. It was also suggested that some form of central bulletin board on the Internet, or even an existing agency should be used to centralize, update and distribute information on relevant studies. The Northwest Territories Science Act, which requires registration of relevant studies, was cited as a means of ensuring a central clearing house for research (K. Crutchfield, written response to draft report, p.1, 2 May 1995).

More specifically, the biology, hydrology, water quality and land disturbance breakaway sessions identified the need to better understand hydrologic processes, the sources and pathways of sediment, and the cumulative impacts of land clearing. Participants also felt strongly about the impact of roads, stream crossings, drainage and culvert construction on hydrology and suggested that these factors be looked at from a land management or regulatory standpoint rather than as topics for scientific research.

3.3.1 Research Needs - Agriculture

In terms of understanding the impact of agricultural land clearing, workshop participants pointed out that a clear conceptual model of how agricultural practices affect water quality and the hydrologic regime does not exist (B. Taylor, personal comment, Water Quality Transcript, p. 16). Better predictive capabilities about how certain agricultural uses will affect water quality (for human and other biological organisms) of rivers and quantified answers about other agricultural impacts such as increases in nutrients are needed. Keeping in mind that most of the remaining arable land in the NRBS area is, at best, of marginal agricultural value, such information should be in place as soon as possible. Then decision makers will be able to answer the imminent question of how much more agricultural development there should be in the Northern River Basins (C.F. Bentley, personal comment, Land Disturbance Transcript, p. 9).

3.3.2 Research Needs - Forestry

With forestry, it is acceleration of natural processes, rather than contaminants that need attention (R. Tallman, personal comment, Biology Transcript, p. 56). The outstanding research questions relevant to forestry that participants identified include:

- What are the chances of increasing drought conditions in harvested areas?
- How do the impacts from timber harvesting compare to impacts from fires?
- How should forest soils be interpreted and managed for silviculture purposes?
- How does the forest regeneration cycle function?
- How does the regeneration cycle function on sites that become wetter or drier after harvest?
- What are the most likely spatial impacts of land clearing activities?

In general, participants suggested that agriculture and oil and gas exploration activities are not receiving as much research attention as forestry activities.

3.3.3 Research Needs - Hydrology

The need for research into various aspects of hydrology emerged in every breakaway session. Changes in amounts of moisture available can be expected to have significant impacts on biology and vegetation. Unfortunately, assumptions about runoff and drainage from other locations cannot be easily applied to the Northern River Basins for two reasons. First, the contribution of individual sub-basins to watershed drainage can vary from 10 to 70 percent. Second, areas that contribute to runoff in the boreal forest are governed by the varying degree of saturation along stream channels, extended channels, and wetlands (S. Ahmed, personal comment, Water Quality Transcript, p. 16).

To monitor hydrologic processes in the Northern River Basins effectively, participants recommended the development of an integrated data collection system. Radar could be used to monitor the flux of water vapour effectively, and satellite images might be helpful to monitor other environmental changes. Ground measurements, field monitoring, and attention to hydrologic events should also be included in data collection efforts (M.T. Dick, personal comment, Hydrology Transcript, p. 81). To improve the efficiency of hydrologic studies in the Northern River Basins, participants would like to have enhanced methods for examining the moderating function of peatlands. Participants also discussed the advantages of comparing hydrologic responses on both an undisturbed landscape and one where significant land clearing had already taken place (B. Taylor, personal comment, Water Quality Transcript, p. 27).

Existing data, like that obtainable from Bob Swanson's work on evapotranspiration in Spring Creek, should be used to get an understanding of the relative rates of evapotranspiration and develop a fundamental hydrologic model of the area. A stream and river classification scheme that would include two to three different types would enhance the usefulness of the model (R. Rothwell, response to Water Quality Transcript notes, p. 3). The U.S. Forest Service study at Coweeta was cited as an example of optimal watershed development. The Coweeta Hydrologic Laboratory was established in 1934 to study forest hydrology in the humid mountain region of the southeastern United States. There, researchers were able to address a large study area and identify discrete watershed units to measure water flow. Twelve catchments were subjected to various cutting and cover conversion treatments since 1940 (G. Hillman, written response to draft report, p. 14, 8 May 1995).

For a number of reasons, participants identified flooding as a very important area of study. It affects the biological component of the boreal forest because it has an impact on the storage of water in estuaries, deltas, beaver ponds and muskegs (B. Swanson, personal comment, Biology Transcript, p. 40). Participants identified two practical applications of work on flooding. The first application would be to address public concerns about the connection between timber harvesting and water yield. The second application for research studies on the impact of land clearing on water storage and flooding would have two alternate goals: to specify a type of timber harvesting that would maintain an existing hydrologic regime, or to predict how the probable change in water yield would affect the hydrologic regime (R.J. Anderson, personal comment, Biology Transcript, p. 59).

While participants expressed confidence about current methods to measure runoff and evaporation, there was significant disagreement about the state of methods for studying snowmelt, snowmelt relationships, snow accumulation, and event-based precipitation.

More specific targets for study identified during the Hydrology breakaway session include

- hydrologic effects of fire frequency at a watershed scale,
- permafrost,
- the influence of weather conditions and snow pack on spring runoff,
- drainage,
- flooding,
- groundwater recharge areas,
- wetlands,
- the impact of beavers on boreal forest hydrology and water quality,
- groundwater recharge areas,
- water storage,
- base flows of streams,

- stream productivity,
- the land's ability to rebound from land clearing activities,
- evapotranspiration, precipitation, runoff and snow sublimation, and
- long-term site productivity.

3.3.4 Research Needs - Water Quality

Participants in the Water Quality breakaway session agreed that the development of quantified water quality guidelines within the range of natural variability would be a most appropriate goal for research (A. Trimbee, personal comment, Water Quality Transcript, p. 30). Strong support was also expressed for development of a comprehensive model of impacts of land clearing on basic hydrology, for an inventory of biological resources, and strong database networks as prerequisites for understanding the impacts of land clearing on water quality. Participants also felt that exploring the impacts of the natural fire regimes on water quality has some merit.

Additional research questions identified during discussions of water quality include:

- How much does land clearing contribute to increases in sediment?
- Where do those sediment increases occur?
- Which land clearing activities do what?
- What are the consequences for fish habitat and spatial/temporal migration patterns?
- What amounts of sediment occur?
- What levels of aquatic risk exist?
- What standards are acceptable or unacceptable for water quality in the boreal forest?
- Which impacts are natural, and which are manmade?
- How is water quality affected by agriculture (pesticides and nutrient loadings from fertilizers, feed lots, etc.)

3.3.5 Research Needs - Biology

Participants in the Biology breakaway session identified the need for baseline information on wildlife populations as top priority for future studies. Research into the role of pesticides and sediment in aquatic environments came a close second. Third, participants in the biology discussion group stated a preference for an ecosystem approach to studying the biological resources of the Northern River Basins.

Thorough inventories and maps of geographical land classifications and timber resources exist, but inventories for biological resources such as habitat, or wildlife are not yet in place. Until these inventories are brought up to the standard of forestry inventories, then management decisions will be made based merely on qualitative impacts on biology. Baseline research questions identified during the breakaway session on biology include:

- What are the natural limiting factors on fish populations?
- Where specifically are the fish spawning areas?

- What are the spawning times of whitefish, bull trout, and arctic grayling?
- How is winter survival of fish affected by winter flows?
- What controls fish migration?
- What is the relationship between physical variables, habitat and population dynamics? and,
- How severe are the effects of angling on fish populations?

It was proposed that research into the mechanism through which sediment might influence a specific fish community and species could be addressed in a very short-term study (G. Sterling, personal comment, Biology Transcript, p. 77).

In terms of the impact of sediments on biological resources of the boreal forests, some basic questions about the impact of timber harvesting on floods, bedload movements, fish, sediments, and where impacts are greatest (high- or low-gradient streams) are, apparently, still unanswered after 40 years of logging (C. Hunt, personal comment, Biology Transcript, p. 64). Research on the following topics would do a lot to fill some of the knowledge gaps relevant to the impact of sediments:

- tolerance of fish populations to sediment,
- tolerance of aquatic organisms to increased duration of exposure to sediments,
- the toxicity of nutrients bound to the sediments,
- the impact of sediment on light and heat penetration in river ecosystems,
- land-use decisions that support acceptable standards, and
- effects of sediment on fish reproduction (spawning beds).

The ecological approach to research suggested in the Biology discussion group assumes that land clearing activities have significant impacts. With more information about the ecology of wildlife, fish and other organisms in the study area, participants asserted that it might be possible to determine some realistic goals regarding acceptable impacts. For example, it might be acceptable to lose grayling habitat in a discrete area for a certain period, as long as enough diversity is maintained for grayling to repopulate at some other place or time (B. Wynes, personal comment, Biology Transcript, p. 73).

3.3.6 Research Needs - Land Disturbances (General)

Again, the topics for further research generated by the Land Disturbances discussion group reiterated what was said in other breakaway sessions. The following list, generated by C.F. Bentley (personal comment, Land Disturbances Transcript, p. 40), summarizes the group's specific suggestions for further study.

1) Determine the deposition sites of eroded soil materials and evaluate the positive or negative effects on crop yields, woody species growth, wildlife habitats, and aquatic species.

2) Determine the amounts, if any, of nutrients (nitrogen and phosphorus) from fertilizers or livestock operations, and pesticides in lakes, streams, rivers and groundwater.

3) Appraise the effects of increased runoff on crop yields, growth of woody species, and groundwater. (There is real concern about the contamination of the Shaftesbury aquifer, the largest single aquifer in the Peace River area.)

4) Include consideration of stressors like transportation, tourism, recreation, clear-cutting, urbanization, climate variability, and other developments in impact studies.

5) Estimate the economic implications of the findings from items one to four.

6) Propose mitigative programs for one to four.

7) Commission a multi-disciplinary compilation/synthesis/summary of existing relevant knowledge, with comments on issues and concerns where there is little information.

8) Have a broad multi-disciplinary group (management, industry personnel, users, researchers) compile an achievable list of priorities and set up a strategy to regularly review and revise these priorities.

3.4 LARGER RESEARCH ISSUES

3.4.1 Goals

In their search for answers about how science can help to conserve and manage resources in the north, participants communicated an urgent need for a clear, realistic vision of the environment and society that can be achieved through quantitative and qualitative goal setting. A number of pressures contribute to this sense of urgency about strategic planning.

Although tremendous progress has been made toward understanding the physical world, researchers no longer predict natural occurrences with absolute certainty. They acknowledge that thorough understanding of some complex natural processes comes only after decades of studies and numerous trials. Nevertheless, the pace with which human impacts are proceeding continues to surpass applied and theoretical research and the adoption of conservation practices. Adding to the pressure on natural resources is a changing economy. Current market conditions frequently mean lower profit margins for natural resource industries and fewer public dollars for regulation enforcement and research. In response to these circumstances, an increasingly aware public is becoming intolerant of social, economic and environmental initiatives that are not strategic. It is critical, therefore, for stakeholders to work together to set a vision and achieve cooperative sustainable goals.

To develop a shared vision and accountable management of the boreal forest, workshop participants raised some key questions for stakeholders to consider. These questions include:

- What does society desire of the boreal forest?
- What do the different sectors or interest groups in our society desire from the boreal forest?
- Given present day and projected conditions, are these benefits feasible?
- Given current land-use practices, what is the long-term site productivity of the boreal forest?
- What future activities and changes are planned for the boreal forest?
- How should research findings affect management decisions in the NRBS area?
- What are the social, scientific, legal, and economic values that should guide our research?
- What will NRBS recommendations look like from the view of Edmontonians? People in Fort Chipewyan? Fort Smith?
- Under whose jurisdiction is the land? and,
- What weight is given to global issues in regards to land clearing?

These important questions are value oriented and difficult to answer. Nevertheless, all stakeholders must be heard before their views and perspectives can be synthesized into an achievable vision with clear cooperative goals that society can commit to.

3.4.2 Communication

Understandably, participants agreed that an effective and cooperative effort to set goals and manage resources will depend upon communication and leadership at all levels. They went so far as to identify some critical supports for the communication aspect of strategic planning. For example, participants mentioned over and over again that industry, researchers and field people need to have better dialogue. Otherwise environmental research is not included in development plans, and land managers can get caught in the middle, trying to balance the commercial interests of their employers with conservation values. Possible solutions offered include an ongoing extension/consultation program for stakeholders with learning formats that encourage the sharing of information and the generation of valid questions for further research (E. Telfer, personal comment, Biology Transcript, p. 87).

Clear leadership and reporting mechanisms were favoured by participants. A strong preference also emerged for a project culture that encourages creative activities such as brainstorming and contributions from all members of the research or decision-making team. At all times, project leaders should avoid a *talk-down* situation between senior decision-makers or scientists and participants with an implied lower status (C.J. Traynor, personal comment, Hydrology Transcript, p. 84).

In stating these preferences, participants recognized that such adaptive management requires both skills and humility from all parties. Personal agendas should be avoided, initiative rewarded, and mistakes spoken about in an open and timely enough manner to mitigate the consequences. Conflict should be accepted as a creative and productive outcome of meaningful discussions; therefore, informal and formal protocols to deal with conflict should be established and maintained. Overall, project planners and team members should adopt the attitude of "How can we do better?" at all times (E. Telfer, personal comment, Biology Transcript, p. 86-87).

3.4.3 Strategic Planning

The mandate of this workshop did not include formulating a plan for realizing sustainable use of the boreal forest; however, participants agreed that the responsibility for articulating a vision for the Northern River Basins should rest with the broadest possible range of stakeholders (B. Wynes, personal comment, Biology Transcript, p. 66). Concurrently, project leaders and sponsors should adopt or design a planning process for research, management, land-use practices and regulations that would support the articulated vision. A strategic planning strategy as simple as the critical path method could be used to incorporate participants' numerous suggestions for optimal planning (E. Alke/G. Hillman, written response to Water Quality Transcript notes, 24 February 1995). These suggestions include:

- provide open channels of communication among stakeholders by involving them in designing the strategic plan, setting goals, and monitoring progress,
- incorporate social, cultural and economic issues in objectives,
- recruit a planning group that is representative and reasonably small,
- ensure that members of the planning group have excellent skills as communicators and team members,
- establish procedures for informal and formal conflict management,
- follow a team approach,
- assign a clearly accountable leader,
- use project objectives to guide and monitor decisions,
- revise goals and objectives when warranted by new information,
- dovetail information gathering and research tasks with time sensitive decisions,
- be flexible,
- solicit feedback from a larger stakeholder group,
- incorporate relevant feedback into the planing and decision making,
- use short- and long-term and ongoing objectives,
- have definite deadlines and overall timelines that are monitored and updated,
- determine objectives for communicating progress and results to stakeholders,
- determine objectives for education and technology transfer to field people, and
- evaluate the process and research products on a formative and summative basis.

Successfully Planned Studies

While articulating standards for strategic planning, participants identified a number of studies that incorporate these standards. ALPAC, for instance, has some initiatives wherein stakeholders participate in problem solving activities. Where education or information delivery is required, every effort is being made to facilitate two-way learning rather than resorting to a traditional teaching or lecturing format (R. Millson, personal comment, Land Disturbances Transcript, p. 51).

The Timber Fish and Wildlife (TFW) program in Washington offers another example of an integrated planning process. The sponsors consist of a coalition of industry, government, and First Nations. This coalition developed a process to look at a watershed, identified the existing relevant studies, and currently manage the system based on that information. In terms of its decision making process, the TFW is following *adaptive management*. Both the way it works and the tasks it achieves continually evolve as information becomes available. Such a process is called *iterative*. The framework of TFW also includes sample protocols that allow for a whole range of people to do the monitoring and training (C.J. Traynor, personal comment, Hydrology Transcript, p. 92).

A study on the effects of pollution, specifically the increase in algae formation on Lake Erie is an example of problem-based research that planners of future research in the Northern River Basins might consider. Municipalities hired scientists to look at the problem. They later determined the cause of the algae formation: phosphate. The process showed that field observations, management policy, and applied science can be linked to solve problems effectively (M. Dick, personal comment, Hydrology Transcript, p. 99). Additional references to model projects are contained in Appendix A.

Land-Use Decisions

Whether or not the recruitment of land managers for this workshop (along with research scientists) is responsible for the emphasis placed on the eventual end-use of scientific work isn't clear. However, research relevant to policies and field-level challenges received enough attention throughout discussions to be mentioned here. In the words of one participant "How do we get the products of scientific research used by decision makers?" (D. Rosenburg, personal comment, Round Table Discussion Transcript, p. 164).

Before proceeding with a strategic plan, it would aid the effectiveness of research and conservation activities to ask questions such as, What time of year is important to you fisheries people? What is the range of variability that is of concern to you? or, What does a fish in the boreal forest area need? What does the ecosystem need? Which times in species life cycles, or which times of year are biota most susceptible to the consequences of land use activities? (R. Harrison, personal comment, Hydrology Transcript, p. 85).

Naturally, there was some discussion of how field decisions are currently made. Apparently, field-level decisions are often based on what is known about more southerly locations and intuitive or subjective responses to a particular problem. Some of the concerns raised by land managers clearly indicate the need for science, resource policy, and land-use policies to be governed by relevant field-level experience.

For example, as part of a discussion on long-term studies, R. J. Anderson said "I may be making potentially damaging land-use decisions daily, so I can't wait for 20 years while researchers try to determine whether they are 80 percent sure of something "(R.J. Anderson, personal comment, Biology Transcript, p. 71). Other revealing questions include: "How do we manage the risk surrounding factors we are uncertain of?

Assuming that protecting every watershed the way it is now isn't realistic, what are acceptable impacts?" (R.J. Anderson, personal comment, Biology Transcript, p. 95-96).

Some of the larger policy decisions that will be made in the near future will address the size and management strategies for buffer zones, whether traditional or ecosystem-based management patterns will be used, and what guidelines should be used to ensure sustainable forestry practices. When these upcoming decisions were mentioned, the question of how to ensure that these decisions are based on research findings was raised.

Science, it was asserted, does not always form the basis of land-use decisions. Social and economic values and politics usually drive the system of how differences are settled in the field (K. Crutchfield, personal comment, Biology Transcript, p. 76). Sometimes science is used to support stakeholder agendas, rather than to actually inform the decision-making process (Crutchfield/Bourbonniere, personal comments, Water Quality Transcript, p. 36). Ideally, scientific research should be pursued to represent the perspectives of all interest groups. It should also be done on an ongoing basis, for the purpose of understanding and supporting the well-being of the environment, and pursued in a way that is accepted and integrated into stakeholder's knowledge.

Regulations

Because discussions turned frequently to the practicality of applying research to field-level decisions, some valuable comments and suggestions about regulations emerged. The size and growth stage of the vegetation cycle in buffer strips was cited as an immediate regulation concern. Leaving these strips in mature old forest (100-200 years) to sustain the large wooded debris in streams was stated as a preference (C. Hunt, personal comment, Biology Transcript, p. 81). The need for work on the enhancement and regulation of reforestation practices and activities affecting hydrology also arose (T. Prowse, personal comment, Hydrology Transcript, p. 47).

Some discussion took place about how regulations are developed and modified. Apparently management practices are in place that were designed to support soil conservation and reduce soil erosion. Whether they are working is another question. Alberta Timber Harvest Planning and Operating Ground Rules and Stream Crossing Guidelines - Operational Guidelines for Industry identify the rules that resource extraction companies are expected to follow when constructing roads, seismic lines, well sites, stream crossings, etc. (G. Hillman, written response to report draft, p. 31, 8 May, 1995).

Alberta Environmental Protection and the Alberta Agriculture, Food and Rural Development regulate agricultural practices. However, it was not known whether there is a mechanism in place to modify these guidelines to take new knowledge into account. Enforcement of regulations was also discussed, and doubts were raised about the enforcement and subsequent effectiveness of soil conservation and timber harvesting guidelines (T. Prowse, personal comment, Hydrology Transcript, p. 51, and L. Kemper, Water Quality Transcript, p. 57).

Participants favoured the use of impact assessments before land is developed or altered for human activities. The rationale for this suggestion is to prevent unnecessary and unproductive development. There are large areas within the Northern River Basins that are not particularly productive for forestry or agriculture and are best left as wildlife habitat. For Forest Management Areas (FMA's) it was suggested that impact assessments be required before land is allocated for use (G. Hopky, personal comment, Biology Transcript, p. 67).

Scientific Approaches

Besides being asked to identify what studies are needed, participants were asked to debate the best approaches to research challenges. Some of the more general issues that participants debated included the relative importance of qualitative studies; the need for long-term, ongoing quantitative research; and the urgent need for scientific information on which to base day-to-day land-use decisions. Process issues that arose during discussions include the need for more holistic, application-based planning of scientific research, resource policy and land-use practices. The issue of scale also arose frequently because the quantification, or measurement, of environmental impacts often brings quite varied results over time and space.

In terms of the length of research projects, the consensus was that planners should look at ongoing research and monitoring as a form of investment that allows for more informed decisions over time (Crutchfield, personal comment, Biology Transcript, p. 75). Short-term studies may be very suitable for small components of the study area, especially if they offer more sustainable options to land managers and are part of an overall strategy. In all cases, we should try to avoid the situation that developed at Tri Creeks " . . . where 30 percent of [one] Forestry Management Area [FMA] was logged before the results of the fifteen-year study were released" (B. Swanson, personal comment, Biology Transcript, p. 72). As mentioned elsewhere, improved dialogue is essential to strategic research planning.

Discussions also took a critical look at the motivation behind research activities. For example, the rationale for monitoring environmental changes was questioned. "Are environmental changes chronicled for information sake with no intent to intervene? Is monitoring done with the intent to take corrective action?" (K. Crutchfield, personal comment, Biology Transcript, p. 76). Some agreement was reached that monitoring can be useful for learning about natural variances. Because ecosystems are dynamic rather than static, natural cycles and variances become very important when it comes to applying research findings in the field.

Questions about traditional versus ecosystem approaches arose. "Are decision makers trying to keep the evolutionary and cyclic natural processes in a static state that is desired by one group or another? If so, is the value system driving this policy sustainable? Human values are as variable over time and space as ecosystems, so how can these changes be incorporated in strategic planning? Should we be trying to reclaim a disturbed area with vegetation similar to what existed before land-clearing? or, Is there a different part of the re-vegetation process we should try to emulate?" (K. Crutchfield, personal comment, Biology Transcript, p. 62).

Other suggestions regarding how research, policy and field activities are planned emerged in discussions. A need for better knowledge of natural variances as a basis for appraising manmade impacts was mentioned. It was also suggested that snapshots of boreal resources, including the demography of wildlife, be created before plans for large scale development are made (R. Tallman, personal comment, Biology Transcript, p. 55). With biophysical inventories and knowledge of proposed development options, it might be easier to list the stressors on each part of the ecosystem, look at each stressor individually and how it may vary, then plan for acceptable impacts (N. Parker, personal comment, Land Disturbances Transcript, p. 38-39).

Research Design

Research design could be improved in a number of ways. The end-use of impact studies should be clear at the start. Clear long-term objectives, some short-term studies, and research conducted in conditions similar to those where the findings will be applied would go a long way toward achieving another preferred scientific approach, that of including research activities as an integral part of land-use management. To save unnecessary duplication, a literature search of relevant studies should be compiled, data collected over the past 15 years amalgamated, and all such information sources made accessible (A. Chapman, personal comment, Hydrology Transcript, p. 48).

Other, more specific approaches to research were also tabled. It would enhance the communication and comparison of research results if common procedures and terminology for addressing and reporting issues of scale were established. Currently, the larger portion of research budgets go to data collection, so it would be helpful if a larger percentage, up to about 30 percent, of research budgets were devoted to skilled data analysis and interpretation (R. Naiman, personal comment, Round Table Discussion Transcript, p. 150).

Researchers would also do well to re-evaluate the way they look at data, attending to changes in the level of variance in the data as well as how data are summarized. Another tradition, installing extensive well networks to understand water flow was called into question as impractical for a large study area. To replace this costly approach, it was suggested that markers for measuring how water moves be developed. Inventory methods also need to be modified.

Participants generally endorsed the use of more automation and new technologies. They also supported the idea of spending time on identifying new variables that might be easily measured and are more relevant to specific interest groups. However, traditional methods will have to do until innovative methods have been proven. A traditional hypothesis approach to boreal research, for example, would be useful to focus specific studies.

If an iterative process was feasible within the project timeline, the central hypothesis could be modified as new information became available. Finally, it was agreed that basic field information will always be in demand and that land managers will always be in the position of having to do the best job possible given the information available. As a general rule for applied research and land-use decisions, emulating what happens naturally and using a common sense approach will probably help prevent pathological changes to ecological systems.

Models

Fairly lengthy discussions arose in response to the question of whether computer modelling and the calibre of current models are sufficient to address landscape-scale impacts. Participants agreed, with qualified enthusiasm, that modelling has potential for aiding the complex task of analyzing environmental impacts.

In terms of the strengths of current modelling technology, it was generally agreed that models are normally designed and used to focus on individual and specific problems (e.g., one for hydrology, streamflow, aquatic organisms). They are also useful to integrate information and do sensitivity analysis (relative orders of magnitude). In terms of communication, models facilitate general information transfer and assist interdisciplinary teams with problem solving and reaching agreement on priorities.

The limitations of current modelling technology include the lack of predictive accuracy when analyzing complex systems such as precipitation and watersheds. The data incorporated into models and the results generated are always incomplete and results have to be modified by extrapolations of what has been learned elsewhere (B. Swanson, personal comment, Biology Transcript, p. 84). Nevertheless, models are useful for monitoring rather than forecasting, as long as they are approached as a tool rather than allowed to become ends in themselves.

Most of the suggestions for improving models targeted project and model design. First, researchers need to determine the transferability of relevant conceptual models and, if necessary, modify them. To ensure modifications are relevant, researchers should identify the weakest links in the model and ask "What information is required by stakeholders? What kind of data is available? and, Which models can give us relevant answers?" (R. Harrison, personal comment, Hydrology Transcript, p. 93).

Tasks that models might effectively perform include

- integrating the perspectives of different disciplines on hydrologic events,
- enhancing scientific knowledge about the roles of trees, precipitation, evapotranspiration, sublimation, snow capture and snowmelt,
- comparing the natural variability of ecosystems to conditions resulting from land clearing,
- helping to determine important time and space scales,
- integrating land-water connections, and
- generating simultaneous data for conceptual model development.

Scale

While the research driven by the Northern River Basins Study has focused on the aquatic resources in main river stems, workshop consensus pointed to the need for studies of smaller watersheds and streams, major natural processes such as hydrology, and how the whole ecosystem interacts. As part of an ecosystem approach, a number of long-term experimental watersheds could be established. This might prove especially revealing if a comparison of disturbances by fire, human impacts, and undisturbed systems was included in the study. Then coordinated work could proceed to measure and analyze changes in soil chemistry, groundwater, hydrology, water chemistry in streams, wildlife and vegetation. The Hubbard Brook study in New Hampshire and the Coweeta study in South Carolina were offered as examples of large basin research projects that include the monitoring of selected sub-basins.

3.5 INTERDISCIPLINARY STUDIES

In response to the question of how to ensure that knowledge from different disciplines is integrated into problem solving and decision-making processes, participants tabled a number of obstacles and supports. It should be noted that there are many facets to this issue.

3.5.1 Obstacles

In terms of obstacles to interdisciplinary work, participants suggested that the difference between the conditions, values and rewards that land management people and research scientists face in their daily operations affects how efficiently they cooperate when working together. Universities could generally do more to reward or recognize their faculty for such cooperative activities (T. Veeman, personal comment, Land Disturbances Transcript, p. 53).

Another hurdle that must be overcome if interdisciplinary studies are to be encouraged may be one of perception. There is a false perception that applied research, which usually addresses particular industry problems, excludes pure research, or studies that are done for the sake of discovering how something in the physical world works (B. Swanson, personal comment, Biology Transcript, p. 88). Closely related to this obstacle is the fact that granting bodies and research organizations do not actively encourage collaboration between field people and researchers. For these reasons there are noticeable reluctance to engage fully in finding out how to do interdisciplinary studies (G. Hopky, personal comment, Biology Transcript, p. 88-89).

3.5.2 Supports

On the positive side of things, participants did identify a number of practical supports for encouraging interdisciplinary research and decision making. Emphasis was placed on the importance of how a research question is phrased. Interdisciplinary study processes will be enhanced if research questions are defined in an interdisciplinary manner. This question format would define the problem in its broadest sense and identify the different components for study (I.G. Corns, personal comment, Land Disturbances Transcript, p. 49). Prior to writing a proposal on an issue such as the prospect of increased flooding as a result of land clearing, researchers might ask, "What will we or can we do together to investigate this issue?" (T. Mill, personal comment, Land Disturbances Transcript, p. 48).

A high degree of openness regarding study design and implementation among scientists and other stakeholders was identified as another support for integrating knowledge from varied disciplines into decision-making. Whenever it is appropriate to include local citizens in study design or report to them on important events, teams in different or related disciplines should consult with each other about what will be covered or debated. Such opportunities for communication should have clear achievable objectives and be conducted systematically (B. Swanson, personal comment, Biology Transcript, p. 82).

Given appropriate regulation on publication and use, free access to databases is another way to promote interdisciplinary interest and cooperation. If information is available as soon as it is cleared for public release, and first rights to publish data resides with originators, researchers can benefit from current information months, rather than years, after it is generated (T. Mill, personal comment, Land Disturbances Transcript, p. 54). Another suggestion for sharing information was for all research centres conducting relevant research to be connected some way to the Northern River Basins Study headquarters, or some central agency (K. Crutchfield, written response to draft report, p.1, 2 May 1995).

Existing supports for interdisciplinary research include the TRI-Council project at the University of Alberta. Its funding requirements encourage interdisciplinary work. Also, at U of A, the centre of excellence initiative is exerting some pressure for faculty in different disciplines to work together. National Green Plan monies are also available for interdisciplinary initiatives (T. Veeman, personal comment, Land Disturbances Transcript, p. 49). In addition to these special initiatives, cooperation among researchers would be advanced if granting bodies and research organizations did more to acknowledge and support applied research. The Carnation Creek Study in British Columbia is one successful example of interdisciplinary work.

3.6 WHO SHOULD BE DOING THIS RESEARCH?

As mentioned earlier, participants were very clear that strategic planning should precede any initiatives to recruit a research team or organization. Then the selection of the right mix of expertise and capabilities should be based, even roughly, on the study requirements. Particular emphasis was placed on approaches to leadership.

A strategically planned study would need a leader to coordinate resources and monitor how well the direction and progress of the project fit the original objectives. Included in this coordinating role would be the task of ensuring that personal agenda's don't drive the research, or that they at least are contributing to the stated goals. Stakeholders, scientists and environmental groups should work together to frame the research questions before the study is begins, but the task of formally reviewing the process and goals at predetermined points within each phase should clearly fall to the project leader.

Such leadership might warrant a coordinating committee of accountable stakeholders to help gather information and complete these administrative tasks. An added advantage of involving stakeholders from the start of the planning process is that such an approach encourages local administrators and citizens to take psychological ownership of the project. Then it isn't left to the scientists to sell their research findings after the fact (D. Maynard, personal comment, Land Disturbances Transcript, p. 59).

Participants came up with a number of suggestions in answer to the question of who should proceed with the proposed studies. An interest in involving social scientists and traditional and local knowledge was expressed along with the idea that private consulting companies might be more flexible than large government agencies (R. Millson, personal comment, Land Disturbances Transcript, p. 61). On the other hand, staff in government agencies such as the Northern Forestry Centre, National Hydrology Research Institute, Freshwater Institute, Fisheries and Oceans Canada, or Canadian Wildlife Service would have their salaries covered, removing that cost from project budgets.

4.0 CONCLUSION

The recommendations made by participants during the November NRBS workshop on the impacts of large scale land clearing were wide and encompassing, including some very specific suggestions and very general recommendations. A fair range of different opinions also emerged regarding the significance of current scientific information, current knowledge of natural processes, the availability of information and how what is known should be used. These differences in opinion probably reflect the range of specialized knowledge and experience among workshop participants. It should also be noted that many of the ideas and suggestions were necessarily described in rather brief terms.

Even so it was difficult to identify which research initiatives should be top priority. Development activities and impacts are occurring at a pace that far exceeds the rate at which science is conducted and communicated to those making land-use decisions. Land managers have an immediate need for up-to-date research and effective policies or guidelines to reduce the impacts of their decisions; and researchers are continually looking for ways to either expand their current work or embark on new projects. Local populations, local industrial concerns, policy makers, land managers and scientists all have a vested interest in prompt and effective action toward understanding, managing and conserving the resources in the boreal forest.

A lengthy or complicated planning process that delays immediate action would be unattractive to all concerned. Yet, some strategic planning is essential to systematically resolve gaps in knowledge, inform policy decisions in an orderly and effective manner, and improve the sharing of knowledge between stakeholders. While the planning process should be iterative, it would probably be beneficial to develop a strategic plan with clear goals and objectives before shorter-term initiatives are pursued.

4.1 RATIONALE

Many of the issues and priorities, by their mention in discussions, reflect the lack of understanding of natural processes or the lack of availability of information in general. There was general agreement, however, that even in the short term, better information is especially needed regarding inventories and data bases describing terrestrial and aquatic fauna and water quality. At the same time, participants recognized that attention must also be given to the analysis and interpretation of data to ensure its use and value. Collection just for the sake of collection is unacceptable in these days of limited financial resources.

The development of conceptual models for the boreal ecosystem was mentioned by all the discussion groups as important. They also emphasized the importance of models as works in progress themselves, needing continual refinement and development. With these considerations, conceptual models can serve as a basis for understanding, help identify research priorities and assist with developing a research focus. Identifying existing relevant models or creating new ones would aid immediate strategic planning efforts because they are designed to enhance management decisions in the absence of hard data.

More specifically, efforts should be directed towards defining models for: the hydrology of northern systems, land-use impacts with regard to the generation of sediment and its fate in aquatic systems, the ecology of northern forests in particular with respect to fire and regeneration on difficult sites, the ecology and dynamics of riparian systems and how they can be managed (i.e. buffer management), and the impacts of agricultural systems on hydrology and water quality. Furthermore, optimal models should address the spatial and temporal impacts of land clearing/use at site-specific and landscape scales.

Another initiative that would be useful to pursue immediately would be a series of literature searches and literature reviews. By cataloguing and reviewing the relevant research that has been done and what is currently being done, these literature studies would serve to advise preliminary strategic planning. As part of this type of research, some consideration should also be given to a centralized inventory of relevant research, to an agreement between loosely associated researchers and research organizations to share information, and to a means of providing interest groups with progress reports.

The objectives mentioned above have the potential to evolve into long- term projects. Before this can happen, however, the development of some kind of structure to provide leadership and promote northern studies is necessary. To this end, participants identified the need for a forum, or means of ensuring ongoing communication between the various stakeholders in the resources within northern forests. All workshop participants were concerned or interested in the processes that lead to land-use decisions and to regulations that determine the allocation and conservation of resources. To insure such public needs are addressed, better communication at all levels of society was considered important. The public at large, local stakeholders, government agencies, scientists and land managers should be consulted as part of the research process.

While no specific approaches for better ways conduct scientific research were identified during the workshop, it was agreed that impending policy decisions should be identified and used to prioritize research projects. For example, are forests to be managed on a dynamic basis where change is the accepted norm? or Should forests be maintained in a static state that is desired by one interest group or another? At a more general level, workshop participants agreed that ongoing research and monitoring should be pursued and interpreted as a form of investment that allows for informed decisions over time.

Who should be responsible for further research? and How should research to advance knowledge of norther forest ecosystems? Leadership and the creation of the right organizational culture for participative decision making, or adaptive management, was viewed by participants as a basic requirement for further research. Such an organizational structure could be achieved through some kind of formal structure. Or, it could be an informal, loose coalition of agencies and institutions working singly and collectively to fulfill and agreed upon plan. Participants in such a structure would likely include scientists and land managers, working together to guide the inquiry process and secure the necessary human and financial resources.

Input from appropriate local representatives and governing agencies would help maintain the momentum of the project and ensure that findings become part of policy and land-use decisions.

Examples of organizational structures that might be examined and adopted include: establishment of long term watershed studies similar to Coweeta or Hubbard Brook, cooperative research programs such as the East Slopes Watershed Research Program, or the recent Centres of Excellence programs being established across the country. Well planned research studies can provide well thought out objectives and goals that are achievable in the short and long run. Cooperative programs or foundations can provide some of the leadership and infrastructure conducive to finding resources and sustaining goals and objectives.

To reiterate the discussions and suggestions of participants in the NRBS workshop on the impacts of large scale land clearing, workshop consensus and project administrators Bruce Dancik and Richard Rothwell recommend that the NRBS Science Advisory Committee should consider further research into the following objectives:

4.2 GOALS FOR IMMEDIATE ACTION

- Conduct thorough literature searches and reviews of research on land use impacts for boreal forest conditions, prior to embarking on further studies
- Identify the different administrative jurisdictions and interest groups within and outside the study area
- Adopt a strategic planning method that incorporates the strengths of critical path, social planning models, and the successful precedents in terms of dialogue and communication of local, multi-stakeholder interest groups such as the Willapa Alliance in the Pacific Northwest and the Haisla Nation's Kitlope watershed in Kitimaat, B.C.
- Identify potential researchers or research organizations to ensure a multidisciplinary approach
- Develop conceptual models of how agriculture, forestry and human land-use impacts affect the ecosystems in the Northern River Basin
- Develop, test, implement and monitor low-impact, site-specific road and drainage technology

4.3 SPECIFIC GOALS FOR RESEARCH

- Implement biophysical inventory projects to serve as a basis for describing the ecology of northern forests
- Identify relationships between the northern fire cycles and forest regeneration at both local and landscape levels
- Identify the ecology and dynamics of riparian systems to serve as a basis for developing buffer management systems
- Document the impacts of agriculture on northern hydrology and water quality
- Describe the pathways and magnitude of eroded soil in Northern Alberta and how it and affects on crop yields, woody species growth, wildlife habitats and aquatic habitats

- Describe the natural variabilities of water chemistry as a basis for establishing water quality criteria and standards for northern streams and rivers, with respect to both aquatic and terrestrial habitats
- Investigate the potential impacts of land use on local climate change and global warming, and
- Initiate paleontological studies as surrogates of climate change

The initiatives listed above under *goals for immediate action* appear to be the most logical start-up objectives. It would be up to planners to decide which specific goals for research should be pursued first or concurrently. In any case, careful consideration and input from multidisciplinary sources should be pursued prior to embarking on any of these objectives.

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HAISLA TRIBAL COUNCIL
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NORTHWEST INDIAN FISHERIES COMMISSION
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SOCIETY, ENVIRONMENT & ENERGY DEVELOPMENT STUDIES (SEEDS) FOUNDATION,
440-10169 -104th Street, Edmonton, Alberta T5J 1A5 Phone: (403) 424-0971 Fax: (403)-424-2444
(Has an infrastructure of stewards/environmental representatives among high school teachers across Alberta who participate in various biophysical inventory activities.)

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APPENDIX A
TERMS OF REFERENCE

NORTHERN RIVER BASINS STUDY

SCHEDULE A - TERMS OF REFERENCE

PROJECT 5203-C1: WORKSHOP "EFFECTS OF LAND CLEARING IN THE BOREAL FORESTS OF ALBERTA ON HYDROLOGIC AND AQUATIC RESOURCES"

Expectations include the organization and delivery of a workshop dealing with forestry and land clearing.

Purpose

1. Expert assessment and consensus of the significance of forestry and other land clearing operation relative to preserving the ecological integrity of the Basins aquatic resources.

2. Workshop consensus on the state of knowledge relative to this issue and what the critical priorities (questions to be answered) should be for scientific investigation.

3. Workshop consensus on what the NRBS should consider for inclusion in its investigations relative to the forestry and other land clearing issue or include as recommendations in its report to government as to what others should be doing.

Workshop Thematics

To obtain expert view (and assessment) of the significance of existing and proposed scales of forestry management on aquatic ecology (hydrology, biota, chemistry,....; surface and subsurface water) considering:

- basins hydrologic balance (water and sediment)
- regeneration of forests: species, canopy, time scales and life spans....
- soil type, erodability, climate, wet/dry cycles, land clearing practices: guidelines, methods, practices (eg. buffers)
- artificial controls of vegetation eg. herbicides
- agricultural use of pesticides
- clearing relationship to water bodies
- ecological alterations in aquatic ecosystems (physical, chemical and biological)
- Forestry Management Agreements and time scales

APPENDIX B
WORKSHOP PROGRAM

NORTHERN RIVER BASINS STUDY

WORKSHOP

The Impacts of Land Clearing on the Hydrologic and Aquatic Resources of Boreal Forests in Alberta: Current Knowledge and Areas for Study

November 18 - 19, 1994

Greys Nuns Regional Centre
9810 165th Street
Edmonton, Alberta

PRESENTERS

Dr. Bruce Dancik	Department of Renewable Resources, University of Alberta Edmonton, Alberta
Allan Chapman	B.C. Ministry of Forests, Victoria
Dr. Daryll Hebert	Alberta Pacific Forest Industries Inc. Boyle, Alberta
Dr. Trevor Dickinson	Department of Engineering University of Guelph, Guelph
Dr. Andre Plamondon	Centre de Recherche en Biologie Forestere Universite Lavel, Quebec
Dr. Robert J. Naiman	Centre for Stream Studies, University of Washington, Seattle
Dr. Robert Steedman	Centre for the Study of Ecology of Boreal Ecosystems, Lakehead University, Thunder Bay, Ontario
Dr. Milton Freeman	Department of Anthropology, University of Alberta

FACILITATORS

Room	Facilitator
100 B	Tom Mill, Alberta Environmental Protection
100 C	Dr. Andre Plamondon, Centre de Recherche en Biologie Forestere, Universite Laval
200 E	Dr. David Schindler, Department of Biological Sciences - University of Alberta
200 F	Dr. Annette Trimbee, Alberta Environmental Protection

REMEMBER

To assist the court reports in creating an accurate transcript of these proceedings please introduce each comment you make by stating your name. This convention is necessary in all sessions.

Thank You!

MORNING - DAY 1
November 18, 1994

0800-0815	Registration
	ROOM 100C (front section of 100 C-D) ALL MORNING
0815-0830	Introduction and Welcome
0830-0900	Dr. Bruce Dancik: *Issues and Concerns of Forestry Development in Northern Alberta*
0900-0930	All Chapman: *Overview of the Hydrologic Impacts of Forest Land Clearing.*
0930-1000	Dr. Daryll Hebert: *Overview of Forest Practices and*
the	*Extent of Harvesting in Northern Alberta*
1000-1030	***Coffee Break (100 D)***
1030-1100	Dr. Trevor Dickinson: *Overview of the Hydrologic Impacts of Agricultural Production*
1100-1300	Dr. Andre Plamondon: *Impacts of Large Scale Land Clearing on Water Quality*
1200-1300	Lunch

AFTERNOON - DAY 1
November 18, 1994

1300-1430 Breakaway Sessions:

Room #	Topic	Facilitator
100 B	Land Disturbances	Tom Mill
100 C	Hydrology	Dr. Andre Plamondon
200E	Biology	Dr. David Schindler
200 F	Water Quality	Dr. Annette Trimbee

1430-1500	***Coffee Break (100 D)***
1500-1630	Plenary Session: (100 C) Reports and discussion of breakaway sessions
1630-1800	*Hospitality (Wine and hors d'oeuvres) (100 D)*

MORNING - DAY 2
November 19, 1994

0800-0815 Registration

ROOM 100C (front section of 100 C-D)
ALL MORNING

0830-0900 Dr. Robert J. Naiman:
Approaches to Management at the Watershed Scale

0900-0930 Dr. Robert Steedman:
Foodchains and Large Scale Clearing

0930-1000 Coffee Break

1000-1100 Dr. David Rosenberg, Dr. R. Naiman, Dr. A. Plamondon, Dr. P. Changers, Dr. E. Prepas

Round table discussion on how to address the impacts of large scale land clearing on water quality

1100-1130 Dr. Milton Freeman:
Social and Human Issues Associated with Large Scale Land Clearing and Development of Boreal Ecosystems

1200-1300 Lunch

Grey Nuns Centre Cafeteria
(Downstairs)

AFTERNOON - DAY 2
November 19, 1994

1300-1430 Breakaway Sessions:

Room #	Facilitator
100 B	Tom Mill
100 C	Dr. Andre Plamondon
200E	Dr. David Schindler
200 F	Dr. Annette Trimbee

1430-1500 ***Coffee Break (100 D)***

1500-1630 Plenary Session: (100 C)

Reports and discussion of breakaway sessions

1630-1700 Summary by Dr. Douglas Golding

1700-1710 Close by Dr. Richard Rothwell

APPENDIX C
QUESTIONS FOR BREAKAWAY SESSIONS

N.R.B.S. WORKSHOP
IMPACT OF LAND CLEARING ON
HYDROLOGIC AND AQUATIC RESOURCES
OF BOREAL FORESTS IN ALBERTA

GENERAL INSTRUCTIONS TO FACILITATORS

Thank you for agreeing to act as a facilitator in the afternoon breakaway sessions.

We want to obtain as much as possible out of each breakaway session and the following plenary session. Each break away session will have a court recorder transcribing what is being discussed.

To make the recorder's job easier please ask each member of the session to identify themselves, and attempt to follow an orderly manner of discussion without too many ad hoc/ad lib statements. We do not expect Robert's Rules, but sessions should have an "even tempo."

Make sure that all persons in the group are wearing their name tags and that everyone is introduced. Also, please try to ensure that you encourage each participant to make a contribution and avoid personal agendas.

Plan on using the flip charts as a means of a) identifying the question you are discussing, and b) recording the main points, then the outcomes of your discussion. If possible, please keep the newsprint sheets as reference information for Day 2, when you will be advancing the discussion with the same people. The facilitator for each group should plan on reporting the group's discussions and suggestions in the plenary session. After reporting, please invite any of your members to make any additions or amendments to the report.

(Cont'd . . .)

PLENARY SESSIONS

The facilitator of each group will make a short report of the breakaway group's discussions to the following plenary session. To prepare for your breakaway group reports, identify major points discussed and record these on flip charts. This is especially important on Day 1 as we will want to assemble the main points identified by each group into a one-page handout for the Day 2 morning and afternoon sessions. Then this information will be available for further discussion and refinement by all the groups in Day 2 breakaway sessions. They will also help us identify areas of common concern, areas possibly missed by some groups, and help provide some degree of concensus at end of each day.

Plan on 10 minutes for reporting to the Plenary Session and 10 minutes for questions. The four breakaway group reports will take about 40 minutes, leaving about an equal amount of time for general discussion from the floor.

RAPPORTEUR (End of Day 2)

The Rapporteur will be expected to provide the audience with a summary and analysis of what we accomplished in the two days of the workshop. The primary focus of the Rapporteur will be to integrate what the breakaway sessions have come up with. He will also utilize the information provided in the morning presentations. It is hoped that the keynote presentations will provide information on the status quo as well as suggestions for new directions. We expect the Rapporteur to blend together morning and afternoon sessions as much as possible. We also want the Rapporteur to work with us to prepare a one page sheet summarizing the main points of Day 1. This will be handed out on the morning of Day 2.

N.R.B.S. STUDY BREAKAWAY SESSIONS
DAY 1
November 18, 1994

Most of the knowledge we have about land clearing is from studies of land clearing in grasslands and forest regions other than the boreal forest. Therefore the purpose of Day 1 of this NRBS workshop is to answer the following questions.

PART 1: QUESTIONS FOR DISCUSSION

1) What makes the boreal forest region different from other regions?

   a) biological and physical characteristics (the big picture and its components)
   b) specifically in terms of your breakaway topic (land disturbance, or hydrology, or biology, or water quality)

2) Given the characteristics and features of boreal forests, will the impacts of land clearing be the same as those impacts encountered in other areas (see below)? Answer yes or no for each of the following impacts.

Known Impacts of Land Clearing
(In regions other than the boreal forest)

a)	increased water yield from disturbed areas	Y	N
b)	higher peaks from disturbed areas	Y	N
c)	increased sediments	Y	N
d)	channel degradation	Y	N
e)	altered low flows	Y	N
f)	impacts of aquatic habitats	Y	N
g)	increased nutrient loading	Y	N
h)	increased water temperatures	Y	N
i)	altered richness and composition of aquatic habitats	Y	N
j)	increased erosion and sedimentation	Y	N
k)	other (list)	Y	N

3) If the impacts on the boreal forest are the same as for other areas, what studies or knowledge support these expectations? **(Answer for each impact.)**

4) If the impacts are different, why? **(List the differences and discuss them.)**

N.R.B.S. STUDY BREAKAWAY SESSIONS
DAY 1
November 18, 1994

PART II: INFORMATION TO BE REPORTED TO PLENARY SESSION

5) What do we know about the impacts of large scale land clearing on the resources (hydology/landscape/biology/water quality) of boreal forests?

6) What don't we know about the impacts of land clearing on the resources of boreal forest? (i.e., knowledge gaps)

7) What can be done in terms of research and/or data gathering to remedy the gaps in our knowledge and understanding of the impacts of large scale land clearing on the hydrologic and aquatic resources of boreal forests?

8) How we can identify and incorporate the impacts of large scale land clearing on the biological, physical and social values associated with the boreal forests of Alberta into day-to-day management decisions and activities?

N.R.B.S. STUDY BREAKAWAY SESSION
DAY 2
November 19, 1994

In Day 1 we more or less looked at what we know and don't know about the impacts of land clearing on boreal forest resources. On Day 2 we want to address how we can use that information on a landscape basis. The general question for Day 2 is: "How do we recognize, research, understand and incorporate the effects of large scale land clearing into management decisions and actions?"

PART 1: QUESTIONS FOR DISCUSSION

The goal for Day 2 is to answer the following questions and come up with a) a list specific recommendations for the kinds of research and data needed to further improve our understanding of the impacts of land clearing on boreal forest resources and b) a list of suggestions about who can or should do the research.

Some of the questions you might consider to get things started are:

1) What are the problems, knowledge gaps and impacts of concern?

2) Which of the above are most important?

3) Are these impacts cumulative?

4) How do we determine if they are significant?

5) Are they significant in biological, physical, and social terms?

6) If we can just barely measure them, and the impacts are cumulative over a long period, how do we address these issues?

7) How do we measure impacts at the landscape level?

N.R.B.S. STUDY BREAKAWAY SESSIONS
DAY 2
November 19, 1994

PART II: INFORMATION TO REPORT TO PLENARY SESSIONS

8) What kinds of research and/or research methods need to be used to address gaps in our knowledge?

9) Will traditional approaches and study designs be adequate to address some of these kinds of questions?

10) Is modelling a useful approach to addressing landscape scale impacts? Do these kinds of models exist?

11) How do we insure that the knowledge of different scientific disciplines is integrated into a problem solving, decision-making process?

12) Which individuals or institutions would be most appropriate to study these problems?

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