1996

Forest - Fish Conference 1996

Land Management Practices Affecting Aquatic Ecosystems

May 1 - 4, 1996
Calgary, Alberta
Coast Plaza Hotel

Forest Fish Conference 1996
c/o Trout Unlimited Canada
Box 6270, Station D
Calgary, Alberta T2P 2C8

printed on environmentally sound paper

Sustainable Forestry

Golder Associates has been providing services to the forest industry since 1962. With a worldwide staff of over 1700, Golder Associates has the resources to service the rapidly growing requirements of the forest industry, including:

Geotechnical

- Natural hazard and terrain stability assessments
- Road design and route selection
- Rock and soil engineering
- Groundwater/surface hydrology assessments and monitoring
- Foundation investigations and design for bridges and buildings
- Blast design and monitoring
- Debris flows
- Investigation, design and construction services

Environmental

- Classification of streams, wetlands, lakes
- Soil characterization and remediation
- Fisheries, wildlife and vegetation inventory and assessments
- Classification of recreation and scenic areas
- Cultural heritage resource assessment
- Mitigation plans for habitat maintenance and enhancement
- Automated data collection systems, GIS, remote sensing
- Fisheries / wildlife input to preparation of stand management and silviculture plans
- Public consultation
- Watershed assessments
- Environmental audits
- Environmental management systems (ISO 14000)

Geotechnical, Environmental & Mining Solutions

1 800 414-8314

1011 - Sixth Avenue S.W.
Calgary, Alberta T2O 0W1
Tel: (403) 299-5600
Fax: (403) 299-5606

243-1889 Springfield Road
Kelowna, B.C. V1Y 5V5
Tel: (250) 860-8424
Fax: (250) 860-9874

760 Seymour Street
Kamloops, B.C. V2C 2H3
Tel: (250) 828-6116
Fax: (250) 828-1215

500 - 4260 Still Creek Drive
Burnaby, B.C. V5C 6C6
Tel: (604) 298-6623
Fax: (604) 298-5253

Offices throughout Canada, the United States, Europe, Asia & Australia.

Forest - Fish Conference:

Land Management Practices Affecting Aquatic Ecosystems
c/o Trout Unlimited Canada, P.O. Box 6270, Station D
Calgary, Alberta, Canada, T2P 2C8
Ph.: (403)-221-8369 Fax.: (403)-221-8368

Welcome to the Forest - Fish Conference:
Land Management Practices Affecting Aquatic Ecosystems

As are many of our other natural resources, pure, clean water is often taken for granted, particularly in western North America. However, the general public's concern about the potential impacts that various land-use practices have on aquatic resources is increasing. This growing concern is driving the need for a greater technical understanding of how forest management practices affect such things as stream flow regimes, water quantity and quality, and fishery habitat. Of equal, if not more, importance is the development and implementation of workable management solutions.

The recognition of these needs, and frustrations among technical staff with their decreasing ability to keep up with the current literature, led to a series of discussions between stakeholder groups in Alberta. These discussions cumulated in the creation of a multi-stakeholder Steering Committee to host a scientific conference focussing on the relationships between forest land use activities and aquatic resources. The multi-agency Steering Committee included representation from conservation organizations, government agencies, academia, the forest industry, and the oil and gas industry. There was unanimous agreement among the Steering Committee that the conference should not just focus on what the problems are, but should also concentrate on identifying potential management solutions. The ***"Forest - Fish Conference: Land Management Practices Affecting Aquatic Ecosystems"*** was organized with the following objectives:

- to facilitate the exchange of information concerning relationships between forest land-use activities and aquatic resources among an international assemblage of technical experts;
- to increase awareness of management solutions that improve watershed protection and minimize the impacts of forest land-use activities on aquatic environments;
- to increase opportunities for stakeholders to work together to find cooperative solutions to potential forestry related problems;
- to identify benefits, or ways and means of providing benefits, of forest management practices affecting aquatic resources; and
- to publish the proceedings from the conference.

The Steering Commitee also recognized that to be successful the Conference could have to attract some out-of-province expertise. To accomplish this, the Steering Committee developed an international mailing list and sent out a Invitation and First

Call for Papers last August. We also bought advertising space in several major scientific journals dealing with fisheries and forestry management announcing our Call for Papers and that the ***"Forest-Fish Conference: Land Management Practices Affecting Aquatic Ecosystems"*** would be hosted in Calgary during May 1-4, 1996.

We were astounded by interest from potential presenters. We received replies from more than 125 potential presenters from eight provinces, 14 states, Sweden, Finland and Australia. Although, some of these potential presenters did not submit an abstract for us to review, we believe we have been able to assemble an impressive list of oral and poster presentations. We expect over sixty oral presentations, fifteen poster presentations and two keynote speakers. We are also pleased the Honourable Ty Lund, Minister of Alberta Environmental Protection, will be attending the conference and speaking at one of the luncheons.

The Steering Committee realizes the large number of presentations during the next three days will provide a busy, and often tiring, schedule for delegates. With cutbacks to government budgets it was apparent that many out-of-province people who wanted to attend could only do so if they gave a presentation. Consequently, we have tried to accomodate as many presentations as possible into the program.

The Steering Committee is very pleased that so many people have decided to attend the conference. We hope that your participation, and the exchange of technical information and subsequent networking that results, will help us in our attempts to identify innovative and effective management solutions that will carry us forward into the next century.

We welcome you and hope you enjoy the conference.

Thank you.

Kerry Brewin
Conference Chairman

FOREST-FISH CONFERENCE:
LAND MANAGEMENT PRACTICES
AFFECTING AQUATIC ECOSYSTEMS

CONFERENCE HEADQUARTERS:
COAST PLAZA HOTEL
(formally the Marlborough Inn)
1316 - 33rd Street N.E.
Calgary, Alberta, Canada
T2A 6B6

Phone: 403/248-8888
Fax: 403/248-0749
Toll free: 1-800-661-1464

A free shuttle service is available from the Coast Plaza Hotel. For more information call the Coast Plaza Hotel.

The Forest-Fish Conference Steering Committee is grateful for the financial support and contributions committed to date that help us to host the "Forest-Fish Conference.

These contributions help us to facilitate the exchange of technical information concerning land management practises affecting aquatic ecosystems.

We thank the following who have committed financial support or a donation:

Fisheries Management Enhancement Program
Sunpine Forest Products Ltd.
Weyerhaeuser Canada Ltd.

Alberta Newsprint Company
Canadian Forest Products Ltd.
Golder Associates Ltd.
Canadian Energy Pipeline Association

Daishowa-Marubeni International Ltd.
R L & L Environmental Services Ltd.
Spray Lakes Sawmills (1980) Ltd.
Manning Diversified Forest Products Ltd.

FOREST-FISH CONFERENCE
MAY 1, 2 3 AND 4TH, 1996
COAST PLAZA HOTEL, CALGARY, ALBERTA

WEDNESDAY, MAY 1, 1996

5:00 - 7:00 PM:	Poster & Display Set-up in *Garden Court Rooms 1 & 2 or Lobby Area*
7:00 - 9:00 PM:	Early Registration/Social *(Marlborough Room 5)*
	Sponsored by Canadian Forest Products Ltd.
7:00 - 9:00 PM:	Poster and Displays Open

THURSDAY, MAY 2, 1995

7:15-8:15 **EARLY MORNING REGISTRATION (COFFEE)**
(Lobby Area in front of Marlborough 3, 4, 5) Sponsored by: Spray Lakes Sawmills Ltd.

MORNING INTRODUCTORY AND PLENARY SESSION: *(Marlborough Room 3,4 and 5)*

8:15-8:30	**Introductions**
8:30-9:20	**KEYNOTE SPEAKER** *Sponsored by: Sunpine Forest Products Ltd.*
	Dr. Stanley Gregory *Title: Ecological principles and natural disturbance processes in stream ecosystem protection*
9:20-9:40	**Vadas** *Assemblage structure of stream fishes and mega-invertebrates along environmental gradients in British Columbia*
9:40-10:10	**COFFEE BREAK**
	Sponsored by: Golder Associates Ltd.
10:10-10:30	**Benda and Miller** *Dynamic properties of climate and topography: the basis of natural disturbance*
10:30-10:50	**Mackereth and Marshall** *A synoptic survey program to assess the impacts of timber harvest on aquatic habitat in Northwestern Ontario Boreal Forest Ecosystems*
10:50-11:10	**Shaw et al.** *An ecosystem diagnostic tool for adaptive management of fisheries resources*
11:10-11:30	**Toth** *Watershed analysis as a tool for landscape management, monitoring and restoration*
11:30-11:50	**Gilmore** *Forest ecosystem management and public involvement: A case study in progress in west-central Alberta*
11:50-12:10	**Ahvonen and Jutila** *Environmental changes affecting the population density of brown trout in the River Isojoki Basin, western Finland*
12:00	**All Poster and booth displays should be set-up**
12:10-1:30	**LUNCHEON SPEAKER** *Sponsored by: Sunpine Forest Products Ltd.*
	(Marlborough Room 2) **Honourable Ty Lund: We can only do it together**

PLENARY AFTERNOON SESSION: *(Marlborough Rooms 3, 4 and 5)*

1:40-2:00 **Hebert** *Integrating timber harvest with aquatic management*

2:00-2:20 **Branton** *The Upper Little Smoky River: Integrating timber harvesting with Fisheries and Recreation Management - A Case Study*

2:20-2:40 **Homberg and Brewin** *Comparisons of protective stream buffer requirements between jurisdictions*

2:40-3:00 **Reynolds and Kennard** *Beyond the ordinary high-water mark: Designing riparian buffers in anticipation of channelized landslides*

3:00-3:20 **Curry** *Assessing riparian zone buffer strips as protection for brook trout spawning and incubation habitat*

3:20-3:50 COFFEE BREAK *Sponsored by: Daishowa-Marubeni International Ltd.*

3:50-4:10 **McKinnon** *Riparian ecosystem protection in B.C.: Past, present and future*

4:10-4:30 **Barrett et al.** *Regional variation in the response of stream channels to timber harvest related impacts*

4:30-4:50 **Swanson** *Estimating the cumulative long-term effects of annual forest harvests on streamflow in Alberta*

4:50-5:10 **Fitch et al.** *Can instream structures effectively restore fisheries habitat?*

FRIDAY, MAY 3, 1996

MORNING PLENARY SESSION: *(Marlborough Rooms 3, 4 and 5)*

8:20-8:30 ANNOUNCEMENTS

8:25-9:20 KEYNOTE SPEAKER
Mr. Don Oman *The recovery of degraded riparian systems with improved livestock management*

9:20-9:40 **Harvie** *Fisheries Act Prosecutions: Implications to the forest industries*

9:40-10:10 COFFEE BREAK *Sponsored by: Golder Associates Ltd.*

MORNING CONCURRENT SESSION A: *Marlborough Room 3*

10:10-10:30 **Steedman et al.** *The coldwater lakes experimental watersheds: mid-term perspectives on a 10-year catchment-scale experiment to measure the effects of forest management on Boreal Lake ecosystems*

10:30-10:50 **McCullough** *The contribution of forest litterfall to phosphorous inputs into Lake 239, Experimental Lakes Area, Northwestern Ontario*

10:50-11:10 **Merkowsky** *Predicting the importance of boreal forest streams as fish habitat*

11:10-11:30 **France** *Stable carbon and nitrogen isotopic evidence for ecotonal coupling between boreal forests and fishes*

11:30-11:50 **Headley et al.** *Hydrology and temporal distribution of organic carbon from an upper boreal wetland ecosystem*

MORNING CONCURRENT SESSION A: *Marlborough Room 3*

11:50-12:10 **Wiskel** ***Placement of shelterbelt trees around man made trout ponds***

MORNING CONCURRENT SESSION B: *Marlborough Rooms 4 & 5*

10:10-10:30 **Macdonald** ***Takla Fish/Forestry Interaction Project: Introduction***

10:30-10:50 **Hogan** ***Forest management channel morphology of small coastall watersheads.: Resulks from Carnation Creek and the Queen Charlotte Islands***

10:50-11:10 **Heinonen** ***Selected hydrology and geomorphology study projects in the Takla experimental watersheds***

11:10-11:30 **Beaudry** ***Suspended sediment regimes of three experimental watersheds in the Takla area of north central British Columbia***

11:30-11:50 **Petticrew** ***The influence of aggregation on settling dynamics of fine grained particles in salmon bearing streams***

11:50-12:10 **Gottesfeld** ***Bedload transport by sockeye salmon, Takla Experimental Watersheds, British Columbia***

12:10-1:30 **LUNCHEON** ***(Jimmy Dean's)***

AFTERNOON CONCURRENT SESSION A: *Marlborough Room 3*

1:30-1:50 **Jones** ***A forest activist's thoughts on protecting and preserving forest fish habitat***

1:50-2:10 **Bergdahl** ***Wild Pacific salmon streams as biological indicators of the conservation value of wilderness areas on the central British Columbia coast***

2:10-2:30 **Mitchell** ***Windthrow hazard assessment and management in riparian management areas in coastal British Columbia***

2:30-2:50 **Smiley et al.** ***Biology and mercury content of bull trout in the Oldman River Reservoir and tributaries***

2:50-3:10 **McDade** ***Protecting British Columbia's streams: A Sierra Legal Defense Fund perspective on fisheries and forestry lawsuits***

AFTERNOON CONCURRENT SESSION B: *Marlborough Rooms 4 and 5*

1:30-1:50 **Scrivener and MacDonald** ***Analysis of spawning gravels, bedload transport and their relationships with sockeye salmon in Stuart-Takla watersheds***

1:50-2:10 **Cope and MacDonald** ***Responses of sockeye salmon embryos to intragravel incubation environments in selected streams within the Stuart/Takla watershed***

2:10-2:30 **Tschaplinski** ***Abundance & distribution of adult sockeye salmon relative to physical habitat characteristics in streams tributary to Takla Lake & the Middle River of central BC***

2:30-2:50 **Macdonald and Scrivener** ***Stream temperature regimes, possible logging effects, and the implications for salmonids in the Takla Lake area***

2:50-3:10 **Whitehouse** ***Assessment of sockeye salmon spawner abundance and characteristics in selected streams within the Stuart/Takla watershed***

3:10-3:40 **COFFEE BREAK** ***Sponsored by: Daishowa-Marubeni International Ltd.***

AFTERNOON CONCURRENT SESSION B: *Marlborough Rooms 4 and 5*

3:40-5:00 **PLENARY PANEL DISCUSSION** *(Ground Rules: Are they working?)*
Moderator: Norm Rodseth, President, Yellowhead Chapter, Trout Unlimited Canada.
A panel discussion has been organized to encourage disucssion among, and between, panel members and the audience. The panel will include representation from:
*1) government/management: **George Robertson** (Chief Forester, Lands & Forest Service Alberta Environmental Protection) and **Carl Hunt** (Regional Head, Fisheries Management Division, Natural Resources Service, Alberta Environmental Protection)*
*2) industry: **Jim McCamon** (Woodlands Manager, Alberta Newsprint Company) and **Don Carr** (Forest Care Co-ordinator, Weyerhaeuser Canada Ltd.)*

7:00-9:00 **BANQUET: BANQUET SPEAKER TO BE ANNOUNCED**

SATURDAY, MAY 4, 1996

MORNING CONCURRENT SESSION A: *Marlborough Room 3*

8:20-8:30 **ANNOUNCEMENTS**

8:30-8:50 **Scruton et al.** ***Water temperature dynamics in small headwater streams in boreal forests of Newfoundland., Canada: Quantification of 'thermal' brook trout habitat to address effects of forest harvesting***

8:50-9:10 **Clark et al.** ***Large woody debris dynamics of four small boreal streams with an initial analysis of relationship to brook trout density***

9:10-9:30 **McCarthy et al.** ***The effect of logging and road construction on brook trout movement & habitat use in the Copper Lake watershed, Newfoundland, Canada***

9:30-9:50 **Clark et al.** ***The effects of logging and road construction on fine sediment yield in streams of the Copper Lake watershed, Newfoundland, Canada: Initial observations***

9:50-10:10 **Spencer** ***Impact of timber harvest on sedimentation deposition in surface waters in Northwestern Montana over the last 150 years: a paleolimnological study***

MORNING CONCURRENT SESSION B: *Marlborough Rooms 4 and 5*

8:20-8:30 **ANNOUNCEMENTS**

8:30-8:50 **Antoniuk** ***Access effects and management in northeast British Columbia***

8:50-9:10 **Huntington** ***Streams and salmonid assemblages within managed and unroaded landscapes in the Clearwater Basin, Idaho***

9:10-9:30 **Sawyer** ***Cumulative effects analysis of land-use activities in the Carbondale River catchment: Implications for fish management***

9:30-9:50 **Bank** ***A private land inventory for southern Alberta and some possible uses***

9:50-10:10 **Koning et al.** ***Stream fertilization as a fisheries mitigation technique for purturbated oligotrophic trout streams in British Columbia***

10:10-10:30 **COFFEE BREAK** *Sponsored by: Golder Associates Ltd*

MORNING CONCURRENT SESSION A: *Marlborough Room 3*

10:30-10:50 **Johannes et al.** ***Impacts of forest harvest practices on salmonids and their habitats in the Kennedy Watershed, Clayoquot Sound.***

10:50-11:10 **Tschaplinski** ***The effects of logging, climate variation, and ocean conditions on salmonid populations of Carnation Creek, Vancouver Island, British Columbia***

11:10-11:30 **Richardson and Neill** ***Associations between forest harvest and stream-dwelling amphibians in coastal British Columbia***

11:30-11:50 **Hogan** ***Forest management and channel morphology in small coastal watersheds: Results from Carnation Creek and the Queen Charolette Islands***

MORNING CONCURRENT SESSION B: *Marlborough Rooms 4 and 5*

10:30-10:50 **Anderson** ***Sediment generation from forestry operations and associated effects on aquatic ecosystems***

10:50-11:10 **Van Lear et al.** ***Sources of sediment in the Chatooga River watershed***

11:10-11:30 **Spillios and Rothwell** ***Freeze-core sampling for sediment intrusion from road-crossings in small Alberta foothills streams***

11:30-11:50 **Purser and Rhodes** ***Overwinter sedimentation of clean gravels in simulated redds in the Grande Ronde River, Oregon, USA: Implications for the survial of endangered spring chinook salmon***

11:50-1:00 LUNCHEON *Jimmy Dean's*

PLENARY WRAP-UP SESSION: *Marlborough Rooms 3,4 and5*

1:10-1:30 **Gill et al.** ***Sediment delivery following road construction and timber harvest in the Blue Mountains, Oregon***

1:30-1:50 **Van Lear et al.** ***Sedimentation impacts on benthic macroinvertebrates and rainbow trout in a southern Appalachian stream***

1:50-2:10 **Dunnigan et al.** ***Effects of forest practices on westslope cutthroat trout distribution and abundance in the Coeur D' Alene River system, Idaho***

2:10-2:30 **Sullivan** ***How buffer strips cause stability and destroy ecosystems***

2:30-2:50 **Kennard et al.** ***Riparian-in-a-box: A manager's tool to predict the impacts of of riparian management on fish habitat***

2:50-3:10 **WRAP-UP/THANK YOU'S**

5:00 **ALL POSTERS AND DISPLAYS SHOULD BE REMOVED**

ABSTRACTS FOR ORAL PRESENTATIONS
LISTED IN ORDER OF PRESENTATION

THURSDAY, MAY 2, 1996

May 2, Introductory Session **8:30 - 9:20 AM** Keynote speaker Sponsored by: Sunpine Forest Products Ltd.

Dr. Stanley Gregory (Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR)

Ecological Principles and Natural Disturbance Processes in Stream Ecosystem Restoration

North America has experienced an explosion in stream and watershed restoration projects over the last decade. Riparian restoration commonly rushes to specific engineering approaches, often erecting *"permanent structures"* in streams. Static structures are often imposed on dynamic ecological systems. Sound restoration of aquatic ecosystems requires a solid foundation on ecological principles and a clear recognition of the dynamic nature of streams, river, wetlands, lakes, and their adjacent forests. The fundamental goal of restoration is to reestablish the ability of the ecological system to maintain its function and organization without continued human intervention.

Natural disurbances, such as floods, fire, windthrow, disease, and pest outbreaks, are the major agents of ecological restoration in in river basins or forest landscapes. Dynamic portions of river networks, such as tributary junctions and meanders, inherently have rapid rates of recovery if key ecosystem elements are available or provided. "After-the-disturbance" policies are needed to protect beneficial changes caused by natural disturbances.

Resource evaluation begins at least at the scale of river basins, focussing down to specific watersheds, and finally addressing local reach characteristics. Regional networks of key watersheds are fundamental components of regional ecosystem management policies such as the Northwest Forest Plan. Restoration provides materials or organisms to reestablish natural physical and ecological processes. Environmental and biological uncertainty are inherent in ecosystems, and actions should be reversible either by natural processes or by human correction, if possible. Restoration of habitat that is only slightly degraded may be a more effective use of limited resources, but the risks associated with threatened species or fragile habitats may require *"heroic"* efforts on severely degraded systems. Evaluation of the effectiveness of restoration should be based on the ability of the system to effectively use the changes or materials provided by the project to re-establish ecological functions. Permanence of structures or plantings should not be equated with ecological function.

Most ecological restoration practices have not been rigorously tested through experimentation or detailed evaluation with comparisons with reference systems. Examples of restoration experiements in the Pacific Northwest and consequences of recent major floods will be described to illustrate potential approaches. Without rigorous measurement systems, we run the risk of building future restoration on a regional folklore rather than professional application of environmental sciences.

May 2, Introductory Session **9:20 - 9:40 AM**

Robert L. Vadas, Jr. (CWS/SFU Program for Wildlife Ecology, Pacific Wildlife Research Centre, BC)

Assemblage Structure of Stream Fishes and Megainvertebrates Along Environmental Gradients in British Columbia

Research was undertaken on the Salmon and Nicola rivers in the southern interior of British Columbia (Fraser-Thompson River system) during the fall of 1994. The goal was to assess effects of agricultural deforestation on aquatic habitat and ecological structure, the latter including species diversity, species composition, and patterns in habitat-use guilds. In both rivers, the middle and lower mainstems were sampled at three sites with different riparian conditions, namely forested, semi-forested, shrubby, and/or grassy. Biological sampling was conducted with seine nets and a streamside electroshocker in different mesohabitat types, e.g., shallow pools and fast riffles.

There were three major habitat-use guilds: pool-cover and open-pool limnophiles and rheophiles. Limnophiles inhabited moderately deep water with variable substrata. Pool-cover species included juvenile salmon (Oncorhynchus spp.), which were most abundant near organic cover. Open-pool species included non-salmonid fishes and dragonfly nymphs (Anisoptera), which were prominent over fine (sandy or muddy) substrata. Rheophiles inhabited moderately shallow water with coarse (especially cobble) substrata, and included trout (Oncorhynchus mykiss), non-salmonid fishes, and stonefly nymphs (Plecoptera).

The three guilds apparently differed in their sensitivity to agricultural deforestation. The pool-cover guild appeared particularly sensitive, via its dependence on coarser substrata and organic cover. These habitat features and juvenile salmon were more common at treed sites. Rheophiles were moderately sensitive, since cobble and boulder substrata would probably only get smothered with fine sediments after severe bank erosion or instream-flow reductions. The guild was common at both treed and unforested sites. The open-pool appeared most tolerant of siltation, since they were often found over fine sediments. These habitat features and the guild were common at treed sites and abundant at unforested sites. The results reinforce the importance of maintaining riparian buffer strips along inland streams, for protecting water and habitat quality for salmonid fishes and other aquatic fauna.

May 2, Introductory Session **10:10 - 10:30 AM**

L. Benda (Department of Geological Sciences, University of Washington, Seattle, WA) and I.D. Miller (10,000 Years Institute, Seattle, WA)

Dynamic Properties of Climate and Topography: the Basis of Natural Disturbance

Aquatic ecosystems exist within a framework of natural disturbance governed by dynamic inputs of water, sediment, and organic debris. The impact of a single event such as a fire or storm can be dramatic; integrated over time the effects of dynamic processes strongly influence forest structure and channel morphology. To define natural disturbance requires characterization of the frequency and magnitude of water, sediment, and organic-debris inputs to the channel system, and of subsequent routing and storage. This is hindered by a lack of theory coupling the supply and routing of channel inputs to climate, topography and drainage structure. Such theory can be constructed on the basis of four universal landscape properties: 1) the episodic nature of climatic perturbations, such as fires and storms, that concentrate the flux of sediment and woody debris in time; 2) the spatially discontinuous supply of sediment and wood to channel networks; 3) the hierarchical nature of the channel network, which juxtaposes different sediment transport regimes; and 4) the history of past disturbance, which effects 1 through 3 above. Within this framework, interactions of climate, topography, and drainage structure can be analyzed to explicitly account for the frequency, magnitude, and timing of stochastic events such as fires, floods and landslides and their effects on channel and floodplain morphology. We illustrate these relationships for field sites in the central Coast Range of Oregon and the southern Cascade Mountains of Washington. Interpreting channel and floodplain characteristics in the context of the dynamic properties of climate and topography (1-4) allows us to better understand natural disturbance and therefore to better identify how landuse may be altering disturbance regimes.

May 2, Introductory Session **10:30 - 10:50 AM**

Robert W. Mackereth and Terry R. Marshall (Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Lakehead University, Thunder Bay, ON)

A Synoptic Survey Program to Assess the Impacts of Timber Harvest on Aquatic Habitat in Northwestern Ontario Boreal Forest Ecosystems

Forestry is a major component of the economy of northwestern Ontario and, along with ensuring that forests are managed in a sustainable way, the mandate of the OMNR includes monitoring the effects of timber harvest on aquatic habitat. Part of this mandate is being addressed by the experimental watersheds program. However, given the wide diversity of aquatic habitat types over a broad geographic area, it was determined that a synoptic survey program should be conducted to compliment the experimental study. The goal of the synoptic survey program is to assess the effects of watershed timber harvest on aquatic habitat and to determine if buffer strips required under Ontario's Guidelines for the Protection of Fish Habitat are effective at mitigating negative effects. By measuring key habitat variables in aquatic systems with different disturbance histories (e.g. undisturbed, recent harvest, regenerating or burned), we plan to quantify natural variability in these systems and determine the extent and persistence of timber harvest effects. In the first year of the program we have started field research to identify key habitat variables in aquatic systems in this area. We have also begun developing a GIS data base to summarize information including aquatic system types, watershed size, forest type, surficial geology and disturbance history. This data base will be used for site selection and to summarize information collected. The purpose of this presentation is to describe the goals of the project, outline the development of the study design and report some preliminary results from both lake and stream aquatic systems.

May 2, Introductory Session **10:50 - 11:10 AM**

Mark Shaw (Bonneville Power Administration, Portland, OR), Lars Mobrand and Larry Lestelle (Mobrand Biometrics, Vashion Island, WA)

An Ecosystem Diagnostic Tool For Adaptive Management of Fisheries Resources

This work was performed in the Grande Ronde Watershed, State of Oregon, U.S.A, in September 1994 through June 1995. The project was performed to address the complex question of how to develop, prioritize, and implement salmon habitat restoration projects for Pacific anadromous salmon that recognizes the importance of an ecosystem perspective. Important ecosystem concepts such as habitat complexity and self-organizing capacity of the stock are reviewed. An ecosystem diagnostic tool and six-step restoration planning process are described. The approach includes a comparison of historic and current habitat complexity and connectivity and intrapopulation life-history diversity. Uncertainties are incorporated into the planning process through assumptions which are clearly identified. Risk of project failure is determined through a qualitative or quantitative weighing of the critical uncertainties. We emphasize the concept that restoration planning is an iterative process that must be continued during and after implementation. Results included: 1) A science based conceptual framework for linking restoration actions to resulting benefits, 2) A set of tools to translate existing data, information and knowledge into the language of the framework including a data base system for capturing information, models and analytical tools for analyzing information and graphic reports for displaying information, and 3) A planning process in which to use concepts, frameworks and tools. The final reports illustrated a comparison of the historical and present habitat conditions by reach, and their relative effects upon the in-basin productivity by life cycle stage of the Snake River Spring Chinook, Oncorhynchus tshawytscha. Fourteen environmental attributes were analyzed, and a composite productivity index was developed for each of four life history trajectories. The analysis showed that present conditions offer a very narrow window for successful completion of the full in-basin life cycle. In the Upper Grande Ronde, present productivity would have to increase by 3.6 to 20.0 times to increase smolts/spawners to 100. In Catherine Creek, productivity would have to increase by 2.3 to 2.7 times to achieve the same results.

***May 2, Introductory Session* 11:10 - 11:30 AM**

Steven Toth (Plum Creek Timber Company, Seattle, WA)

Watershed Analysis As A Tool for Landscape Management, Monitoring and Restoration

Watershed analysis in Washington State was developed by constituents of the Timber Fish and Wildlife (TFW) agreement (Native tribes, state agencies, environmental groups, and timber industry). The methodology addresses the cumulative effects of forest practices on fish and water resources in the context of natural ecological processes. While other watershed analysis methodologies have been developed recently (e.g. Federal Guide, Idaho, British Columbia), TFW watershed analysis is unique in its scientific rigor and ability to affect land management/restoration decisions. Close interaction between scientists and policy makers allowed development of a method that is repeatable, defensible, and accountable to constituents.

The watershed analysis process consists of three components: resource assessment, prescriptions, and monitoring. An interdisciplinary team of scientists with expertise in geology, hydrology, fish biology, soils, and forest ecology assesses the physical and biological components of the watershed. Natural disturbance processes (e.g., floods, fire) and human-related disturbance (e.g., timber harvest, grazing) are evaluated in the context of present land management activities. The evaluation relies primarily on aerial photographs, monitoring data, landform maps and geographic information systems, with some additional field work. The team delineates specific areas on the landscape that are sensitive to management practices and have the potential to impact public resources. The resource assessment and synthesis of information for watersheds ranging in size from 20,000 to 50,000 acres takes approximately 2 to 3 months.

In the prescriptions phase, land managers work with scientists to develop options for operating in sensitive areas. Potential restoration actions are also identified and prioritized to improve or restore aquatic habitat conditions. The entire watershed is addressed regardless of administrative boundaries. The direct connection between the scientists and land mangers ensures that information generated by the assessment team is at a scale appropriate for guiding management decisions in the field.

Finally, a monitoring program is developed to evaluate the implementation of the prescriptions, test assumptions about watershed process, and assess recovery of aquatic resources. Monitoring priorities are developed jointly with stakeholders in the watershed.

The results of watershed analyses conducted in the central Cascade Range of Washington State will be used to illustrate the assessment of a watershed, implementation of prescriptions, and monitoring of watershed conditions. Preservation and restoration of ecological processes are evaluated and prioritized using the information generated from the watershed analysis.

***May 2, Introdutory Session* 11:30 - 11:50 AM**

Daniel W. Gilmore (Canadian Forest Products Ltd., Grande Prairie, AB)

Forest Ecosystem Management and Public Involvement: A Case Study in West-Central Alberta

The Grande Prairie Division of Canadian Forest Products, Ltd. is in the process of simultaneously renewing its Forest Management Agreement with the Province of Alberta, and writing a twenty year Forest Management Plan for the 655,485 hectares of Crown lands included in its Forest Management Agreement. Fifty-one percent of the land base under Canfor's tenure is considered productive forest from which an annual allowable harvest of 730,000 cubic meters is extracted to produce 173 million board feet of spruce/pine/fir lumber with pulpwood or chips as by-products. We have formed a Forest Management Advisory Committee comprised of representatives of community stake holders, which includes representatives from local government, sporting groups, aboriginal peoples, the oil and gas industry, and Alberta Environment to review our Forest Management Plan during its development to allow us to address concerns from the public at large. We have also formed a Forest Ecosystem Management Task Force comprised of experts in the fields of ecology, forestry, and wildlife employed by academia, resource management consultants, and the Alberta Provincial Government to assist us in establishing principals of sustainable ecosystem management that will be used as the foundation of our Forest Management Plan. Concurrent to this, we are in the process of identifying our research priorities pertaining to forest growth and yield, reforestation practices, landscape ecology, harvesting practices, wildlife habitats, and fisheries management to enable us to effectively interact with academic, industrial, and government-sponsored research groups to initiate projects that will contribute to our understanding of the forest ecosystem. We anticipate the development of a Forest Management Plan that will have the flexibility to incorporate advances in our understanding of the forest ecosystem.

May 2, Introductory Session 11:50 - 12:10 AM

Anssi Ahvonen and Eero Jutila (Finnish Game and Fisheries Research Institute, Helsinki, Finland)

Environmental Changes Affecting the Population Density of Brown Trout in the River Isojoki Basin, Western Finland

Population density of brown trout over 1-year old were examined on the basis of habitat and catchment factors in the brooks of the River Isojoki, Western Finland. Forestry is the main activity that has affected on those environmental factors. The distribution and abundance of brown trout was surveyed in the whole catchment area by electric fishing. Trout was found in 30 brooks. The analysis method implemented was multivariate regression. A significant regression model was achieve, where single significant ($p<0.5$) independent variables were number of pools, number of undercut banks. pH value of water and relative amount of drains in the catchment area (negatively correlated). These four factors explained 42% of the variation. The population densities of brown trout in the dredged brooks were compared with those of natural ones. The mean population density in the dredged sites was 4.7 fish in 100 square metres, and 11.0 in the natural sites correspondingly. The transformed means differed significantly from each other. Multivariate regression model explained 90% of variation in trout density of natural sites. In dredged sites the regression power of independent variables was low, 28%.

The factors representing physical diversity of the brook channel had the most pronounced influence on the population density of brown trout in the forest brooks. A direct demonstration of this is the lower population density of trout in the dredged sites as compared with the natural ones. Acidity (pH value) influences on the distribution of fish especially as a limiting factor for the reproduction. The lowest values in this data were below pH 5. The negative influence of the drainage on the population density of brown trout may be caused by permanent changes in water quality, by changes caused by increased sediment load or by the changes in the composition of the bottom material in the brook channel. Also hydrological changes may have such effects. None of these factors can be excluded on the basis of these results.

***May 2, Plenary Afternoon Session* 1:40 - 2:00 PM**

Daryll Hebert (Alberta-Pacific Forest Industries Inc., Boyle, AB)

Integrating Timber Harvest with Aquatic Management

Aquatic systems, riparian vegetation and especially stream systems have been protected and managed using buffer strips, for several decades. This evolved largely as a constraint management tool, driven by intensive fibre extraction under sustained yield forest management.

A variety of buffer strip techniques; protection of understory vegetation, selection logging, directional falling, etc., were practiced on the coast for decades and gradually proliferated to other regions of BC and Canada.

Stream protection using buffer strips was an attempt to reduce sedimentation, reduce instream debris, protect stream banks, reduce or stabilize peaks in flow, modify overland and subsurface hydrology, regulate stream temperature, provide a variety of food and nutrients and supply a host of other requirements.

Although management by constraint techniques served a useful purpose during intensive fibre extraction, protection by regulation, using buffer strips, appears to have reduced a broader understanding and exploration of watershed management options. A recent summary (Idaho) of over 300 research documents on stream protection, dealt almost solely with buffer strips.

Alberta-Pacific has begun to shift the emphasis from standardized buffer strips to rate of extraction in a watershed including spatial distribution of the extraction.

***May 2, Plenary Afternoon Session* 2:00 - 2:20 PM**

Greg Branton (Alberta Newsprint Company, Whitecourt, AB)

The Upper Little Smoky River: Integrating Timber Harvesting with Fisheries and Recreation Management - A Case Study

The upper Little Smoky River has long been considered a popular sport fishing and wilderness recreation area. Alberta Newsprint Company is proposing an integrated approach to allow timber harvesting to occur without compromising the integrity of the fisheries or the capacity of the area to provide an outdoor recreation experience.

The paper presented would provide an opportunity to review ANC's plan and will hopefully generate thought and discussion on the potential for integrating industrial activity, recreation use, and fisheries habitat. ANC's intention is to integrate stakeholder concerns into the plan as much as possible with the plan having a firm basis in scientific principles. It is expected that the plan will include a variety of management scenarios ranging from special logging techniques to special access management considerations. The plan will also include an assessment program to determine if these special practises are having the affect that was intended.

***May 2, Plenary Afternoon Session* 2:20 - 2:40 PM**

Nikolaus Homberg and Kerry Brewin (Trout Unlimited Canada, Calgary, AB)

Comparison of Protective Stream Buffer Requirements Between Jurisdictions

Protective buffer strips along streams are important to maintaining a stream's sensitive aquatic and riparian environments. Buffers provide a number of important functions such as: shade to maintain consistent stream temperatures; protection from bank erosion; filtering ability to reduce potential of sediment inputs from upland areas; large organic debris inputs, and control of flooding and run-off.

Guidelines fro protective buffers strips vary greatly between jurisdictions in North America. In order to examine and make comparisons between jurisdictions, we wrote the senior burecrat(s) responsible for fisheries and forestry management in each province and state in Canada and the U.S.A. and requested a copy of the current protective buffer requirements for private and public lands within their jurisdictions. We also sent a similar request to the federal agencies responsible for fisheries and forestry management. Upon receipt of the regulations, we focused our efforts on examining buffer requirements among jurisdictions that contain cold water habitats with self-sustaining salmonid populations.

***May 2, Plenary Afternoon Session* 2:40 - 3:00 PM**

Patrick H. Reynolds (Muckleshoot Indian Tribe Fisheries Department, Auburn, WA) and Paul Kennard (The Tulalip Tribes Natural Resources Department, Marysville, WA)

Beyond the Ordinary High-water Mark: Designing Riparian Buffers in Anticipation of Channelized Landslides

At least two types of channelized landslides periodically disturb montane drainages of western Washington, Oregon, and British Columbia, namely, debris flows and dam-break floods. These processes dramatically alter the architecture of their host channel by displacing stored sediment and redistributing meta-stable roughness elements such as wood. Channelized landslides also disturb streamside vegetation, locally reducing or eliminating intended functions of riparian buffers such as channel stocking, bank stabilization, and shading.

Total width as measured from the ordinary high-water mark is a convenient measure of riparian buffers, but in the event of disturbance it will not reflect a buffer's functional width through time. Basin analysts who overlook the potential for landslide-induced modification of streamside settings will overestimate the post-disturbance volume of wood supplied to streams from riparian buffers diminished in the wake of landslide runout. Riparian buffers incapable of retaining material volumtes of timber at their exterior margins may prolong impacts to aquatic resources by impeding rates of channel recovery following distrubance.

Landslide hazards within 130 km^2 of the Green River basin, King County, Washington, were evaluated in 1994 to guide development of basin-specific regulations for timberland management in accordance with state forest practice codes. During the mid-1970's, dam-break floods in this area canvassed valley floors in five montane drainages, althogether affecting more than 15 km of stream. Their runout paths correlate well with emprically derived routing criteria reported by others, which predict termination of dam-break floods where channel slope falls to two degrees, or confinement surpasses ten channel widths.

Using landslide-hazard maps to locate reaches downstream of potential initiation sites, basin analysts can apply routing criteria for dam-break floods (or analogous criteria for derbis flows) to determine a channel segment's vulnerability to runout from channelized landslides. This information canl assist basin amangers in efforts to design riparian buffers capable of yielding their full range of intended long-term benefits, which periodic disturbance of channelized landslides may otherwise preclude.

***May 2, Plenary Afternoon Session* 3:00 - 3:20 PM**

R. Allen Curry (New Brunswick Cooperative Fish and Wildlife Research Union, University of New Brunwsick, Fredricton, NB)

Assessing Riparian Zone Buffer Strips As Protection For Brook Trout Spawning And Incubation Habitat

A study of two lakes and one stream in central Ontario, Canada from 1990-92 assessed the value of riparian zone buffer strips for the protection of brook trout (Salvelinus fontinalis) spawning and incubation habitats in the nearshore zone. Groundwater was observed to be a critical component of these habitats. Trout used discharging groundwater to locate spawning areas. The groundwater then provided protection from freezing for incubating embryos. The groundwater originated from local sources in the terrestrial catchment associated with the nearshore habitats. Measures of annual discharge in the habitats and estimates of groundwater recharge in the catchment suggested that 90m wide buffer zones (maximum width in Ontario's managed ~~forests~~), protected only 9 to 55% of the terrestrial catchment necessary to sustain the groundwater discharge required by brook trout. These results indicated the need for an integrated approach to managing forest and fish resources.

***May 2, Plenary Afternoon Session* 3:50 - 4:10 PM**

G.S. McKinnon (BC Ministry of Environment, Lands and Parks, Victoria, BC)

Riparian Ecosystem Protection in BC - Past, Present and Future

British Columbia's Forest Practices Code, which became law in June of 1995, provides a framework for riparian ecosystem protection including both aquatic and terrestrial components. The presentation will show how this present framework has evolved from past practices in BC, will outline current constraints on forest practices in and adjacent to riparian areas, and will provide an overview of future needs for research and adaptive management aimed at refining best management practices in these areas.

***May 2, Plenary Afternoon Session* 4:10 - 4:30 PM**

Jeffrey C. Barrett, Edward J. Connor and Dudley W. Reiser (R2 Resource Consultants, Redmond, WA)

Regional Variation in the Response Of Stream Channels to Timber Harvest Related Impacts

Watershed analysis efforts are currently being conducted throughout the Pacific Northwest. Most of these analyses attempt to identify how road construction and timber harvest affect the condition of stream channels and fish habitat. These studies report similar types of impacts: increases in sediment loading and transport, habitat simplification, modifications in discharge, and changes in channel morphology. However, the magnitude of these changes, and their resultant effects on anadromous fishes, vary widely in magnitude.

We present several case studies from our work in Alaska, British Columbia, Washington, Oregon, and California, to demonstrate the importance of local and regional factors in determining the impact of timber harvest activities on streams. We argue that parent geology is the most important factor to consider because of its influence on slope stability, soil particle erodibility, and, frequently, bank and stream bed stability. Other factors of importance include logging history, precipitation type/patterns, and the assemblage of fish species occupying the watershed.

Our conclusions, if correct, have implications for land management. Current forest practice codes in the Pacific Northwest frequently lack specific area or regional guidelines for road construction or log yarding techniques. Although we support giving landowners and timber companies operational flexibility, it is clear that some watersheds require more stringent road construction and harvest procedures than are currently embodied in many regulatory codes.

***May 2, Plenary Afternoon Session* 4:30 - 4:50 PM**

Robert H. Swanson, (RH Swanson & Associates Canmore, AB), Robert D. Wynes (Daishowa-Marubeni International Ltd., Peace River, AB) and Richard L. Rothwell, (Department of Renewable Resources, University of Alberta, Edmonton, AB)

Estimating the Cumulative Long-Term Effects of Annual Forest Harvests on Streamflow in Alberta

Forest harvesting interacts with fisheries in two important ways; by modifying the flow regime of a stream and by altering the input of sediments. The solution to the latter is primarily one of applying good and reasonably well-known engineering practices during the harvesting phase. The 'solution' to the first is more difficult to determine, as the effects on flow regime may be insignificant, beneficial or detrimental, depending upon how and when they occur.

Our purpose in this paper is to demonstrate the capability of one presently available hydrologic procedure to estimate the cumulative magnitude and duration of water yield changes resulting from forest harvesting as it occurs in normal practice in Alberta. We use Forestry Canada's WRNSHYD program (the hydrology portion of the U.S. Environmental Protection Agency's WRENSS procedure), coupled with the results of experiments and studies done on forest management agreement (FMA) areas in Alberta over the past 25 years on the rate of change of water yield in the years following harvest, to estimate the cumulative effect of several harvesting sequences on the magnitude and duration of increased stream flows.

The effect of sequential annual harvests in coniferous forests is a prolonged increase in water yield that results in elevated streamflow levels, particularly during the spring snowmelt period. The change in streamflow regime should be expected to be permanent because of the slow regrowth of conifers, the intensity of harvest in any given watershed, and the relatively short rotation periods (80 to 100 years) desired (relative to the rate of hydrologic recovery which is estimated at 80 to 120 years). Those managing aquatic resources within and downstream of the several coniferous FMA areas in Alberta should be aware of this gradual shifting of flow towards a general increase over the entire area.

The effect of sequential annual harvests in deciduous forests is a relatively short-term increase in water yield that is less concentrated in the spring runoff period than that in coniferous forests. Because of the much faster regrowth, hydrologic recovery in deciduous forests is estimated to occur within about 15 to 30 years. Given that current rotations in deciduous forests are about 60 years, harvesting can probably be scheduled to minimize the impact in any given watershed by appropriate spatial and temporal sequencing of the harvests.

***May 2, Plenary Aftrnoon Session* 4:50 - 5:10**

Lorne Fitch (Natural Resources Service, Alberta Environmental Protection, Lethbridge), Rick Pattenden, Jim O'Neil (R L & L Environmental Services Ltd., Edmonton, AB), Gordon Hartman (G F Hartman Fisheries Research & Education Services, Nanaimo, BC), Rolf Kellerhals (P. Eng, Consulting Engineer, Harriot Bay, BC), and Mike Miles (M. Miles and Associates)

Can Instream Structures Effectively Restore Fisheries Habitat?

The effects of various land use practices on stream hydrology, channel morphology, and the associated aquatic ecosystems have been extensively studied during the past three decades. The negative effects of some land use practices are no longer in doubt. For example, clear-cut logging significantly increased flood magnitude and accelerates rates of sediment production. Removal of riparain vegetation causes banks to be less erosion resistant, channels to become wider, water temperatures to increase, a long term loss in woody debris availability, and possible, smaller minimum flows. Urbanization results in larger flood flows and changes in water quality. Clear-cut logging of floodplains can destabilize some channels. Unrestricted grazing results in a loss of bank vegetation, a decrease in bank stability and degraded water quality. The problem facing fisheries managers is how to rectify the effects of historic land use practices and how to minimize the effects of future development.

Instream structures are commonly used to mitigate impacts on fish habitat in degraded streams and enhance habitat in natural, relatively pristine streams. Both mitigation and enhancement efforts are based on the perception that some type of habitat is limiting fish production (e.g., deep-water refuge during low flows). Our research suggest that instream structures tend to be ephemeral and they do not necessarily provide useful fish habitat over the long term.

During 1991 and 1992, the short-term performance of 350 instream structures was investigated in SW Alberta. The majority of these structures were between two and seven years of age (90% of sample) and none had been subjected to greater than a 1 in 6 year flood event. Under these conditions 53% of these structures were found to have maintained their physical stability or had minor faults. In addition, only 61% of the surveyed structures provided the desired deep-water adult habitat. The performance of 177 of these structures was re-assessed following a sizable flood in June 1995 (>1 in 100 year flood). Seventy-seven percent had been destroyed or were severely damaged due to processes of general and local scour, sediment deposition and channel shifting. Many of the intact structures were also found to provide only low quality fisheries habitat. These results indicate that many instream structures built in Alberta were substantially damaged by small floods and most did not survive a major flood. Similar results are now being reported from other locations in western North America.

Our experience indicates that instream structures can have a short-term benefit in providing habitat during the period immediately following a localized stream disturbance (e.g., a pipeline or highway crossing). Structures must be appropriately located and designed if they are to withstand flood discharges and regular maintenance will be required if they are to remain effective. However, instream structures alone cannot provide the variety of channel processes that result in a healthy stream channel. This implies that the long term solution is to preserve or re-establish these processes. At a minimum, this would involve watershed level restoration activities where required, limiting the amount of develoment in sensitive watersheds and the establishment of appropriately sized riparian corridors. These kinds of restoration activities require community cooperation, integrated planning and the ability to compensate landowners for required changes in land-use. This is much more complicated than merely placing a few logs or rocks in a stream channel. The challenge is to find ways to undertake this work over the extensive areas that require restoration.

Friday, May 3, 1996

May 3, Morning Plenary Session **8:25 - 9:20 AM, Keynote Speaker**

Don G. Oman (Twin Falls Ranger District, Sawtooth National Forest, Twin City Falls, ID)

The Recovery of Degraded Riparian Systems with Improved Livestock Management

The Twin Falls Ranger District is one of five subdivisions of the Sawtooth National Forest in south central Idaho. It is a gentle, isolated mountain range adjacent to the Nevada border. It is a primary recreation area for many of the 100,000 people who reside in the Snake River Valley, near the city of Twin Falls. This area has been grazed by livestock since the first cattle were brought to the country in 1871 and the first sheep in 1890.

The impacts of heavy livestock grazing during the late 1800's and early 1990's had devastating effects upon the basic building-block resources of soil and water. This is true of much of the millions of acres of public land across the western United States. The impacts of grazing continue to this day on the Twin River Ranger District and across the West. Riparian areas especially continue to be degraded as they water livestock which graze the vast uplands. Grazing has negatively impacted all of the other resources to some extent, including fish, wildlife, and dispersed recreation.

The good news is that the impacts of grazing can be turned around and - in most areas - allow grazing to continue. The Twin Falls Ranger District in the past nine years has made significant gains in putting the other resources on the road to recovery. This has been accomplished by insisting on improved livestock management practices, numerous riparian demonstration projects, and through cooperative efforts with other agencies, livestock permittees, the news media, and the public. It is also recognized that a lot of good work has been done in the past by some of the managers in place at the time.

This paper describes the present condition of the resources, some history of grazing on the District, problems encountered in making the needed changes and strategies used to gain improvement. It also describes a number of riparian improvement projects the District has initiated, with some rather astounding results. Improved management on the District has resulted in much improved riparian condition and trout habitat in virtually all of the streams. These results are well documented with photos and permanent studies. This information is being disseminated through numerous talks, slide shows, tours and papers, and is helping to promote good livestock managementon public lands across the Nation.

We are not doing our job as public land managers if we are not leaving the resources in better conditions than we found them, for the generations to come.

***May 3, Morning Plenary Session* 9:20 - 9:40 AM**

Alan Harvie (MacKimmie Matthews, Calgary, AB)

Fisheries Act Prosecutions: Implications to Forest Industries

This paper will provide a general overview of the *Fisheries Act* (Canada) and the regulations promulgated thereunder, with a specific focus on sections dealing with fish habitat protection and pollution prevention in Canada. A review of the offences and punishment sections will be included, as will references to various forest-industry specific regulations and guidelines. The majority of the paper will summarize the facts, issues and findings from recent prosecutions of forest industry participants under the *Fisheries Act*. The paper and the oral presentation will be designed for an audience of non-lawyers.

***May 3, Morning Concurrent Session A* 10:10 - 10:30 AM**

R. J. Steedman, M.A. Bozek, M.H. Johnston, R.S. Kushneriuk (Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Thunder Bay, ON), K.G. Beaty, R.E. Hecky, G.K. McCullough (Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, MB), R.L. France (Department of Biology, McGill University, Montreal, PQ) and C.J. Allan (Department of Geography and Earth Sciences, University of North Carolina, Charlotte, NC)

The Coldwater Lakes Experimental Watersheds: Mid-Term Perspectives on a 10-Year Catchment-Scale Experiment to Measure the Effects of Forest Management on Boreal Lake Ecosystems

Initiated in 1989 during an environmental assessment of timber management on Ontario's crown lands, this study is one element of an integrated program to characterize the effects of timber management on boreal aquatic ecosystems, and to measure the effectiveness of Ontario's guidelines (buffer strips, BMPs) for the protection of fish habitat during timber management. The study is centred on five headwater catchments (approx. 1km^2 each) in boreal/Great Lakes transition forest 250 km west of Thunder Bay, an area of bedrock outcrops, shallow soils, and jack pine, spruce, and aspen forest cover. Most of the study lakes support native lake trout populations plus white sucker and 3-5 species of small fish. Starting in 1991, a comprehensive program of ecosystem monitoring has been phased in; it includes regular measurement of meteorology (upland and lake surface); upland and outflow hydrology, water chemistry, profundal and littoral sedimentation, oxygen, light and temperature profiles, phytoplankton, zooplankton, and fish population characteristics. Other projects have addressed regional paleoecology and mappable catchment features including soil depth and nutrient capital, vegetation biomass, and lake bathymetry. Flexible partnerships with government agencies and university researchers have been key to the establishment and operation of several key monitoring networks, particularly hydrology, upland biogeochemistry, water chemistry, and taxonomy of phytoplankton and zooplankton. In 1996, the catchments of three of the lakes will be clearcut by commercial operators; two lakes will be cut to the shoreline; one lake will retain a shoreline buffer strip designed according to Ontario's Timber Management Guidelines for the Protection of Fish Habitat. Ecosystem monitoring will continue for an undetermined period of time after the experimental timber harvests. We expect that three years of post-harvest monitoring would be a reasonable minimum to characterize short-term hydrologic and chemical responses, while 5-7 years would be minimal for detection of early recovery behaviour and long-term ecosystem responses to timber management. The oral presentation will include a discussion of variability in the pre-cut data series, and analytical strategies for detection of experimental response.

May 3, Morning Concurrent Session A **10:30 - 10:50 AM**

G. K. McCullough (Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, MB)

The Contribution of Forest Litterfall to Phosphorous Inputs into Lake 239, Experimental Lakes Area, Northwestern Ontario

In conjunction with a catchment scale study of the effectiveness of current Ontario buffer strip guidelines on fish habitat, P, N, and C inputs to lakes via litterfall from the forest edge is being measured at the Coldwater Lakes Experimental Watersheds and the Experimental Lakes Area, in northwestern Ontario. P inputs from 100 y old and fire regeneration jackpine stands along the shores of Lake 239, a headwater lake at the E.L.A., are the subject of this paper. In the summer of 1995, pans containing distilled water were set out in two pairs of transects from the water's edge to the centre of the lake, at distances of 0,1,3,9,30,90 and 250 m from shore. Samples were collected at two day intervals from mid-May to mid-October and filtered through 1.2 um filters. After identification of large particles, filters and filtrate were analysed for total P, N and organic C. Pans collected various vegetative material (including pollen, conifer needles and flowers, leaves, seeds and bits of bark and lichen), spiders, and insects (plus their faecal material and sometimes eggs). Jackpine pollen disersal in late June-early July was responsible for the largest single input; it was also the most evenly distributed over the whole lake. Leaffall in autumn was important, but almost entirely restricted to within 3 m of shore. Insects comprised a major part of the litter and were found in samples throughout the summer, and widely distributed across the lake. They are problematic in that some had presumably emerged from the lake and thus did not constitute a gross addition to the lake nutrient load. Numerically, however, the majority of insects collected in pans were of terrestrial origin. Most insects found in pans were also caught in occasional net sweeps of the lake surface. P analysis of a small subset of litter pans sampled over the open-water season on Lake 239 has been completed. P inputs into pans within 10 m of shore averaged 459 $ug \cdot m^{-2} \cdot d^{-1}$; further offshore P inputs were 118 $ug \cdot m^{-2} \cdot d^{-1}$. Total P input by litterfall over the open-water season was calculated to be 0.3 $kg \cdot ha^{-1}$ (of lake surface area); this can be compared to traditional measured P inputs in precipitation and runoff ranging from 0.3 $kg \cdot ha^{-1} \cdot y^{-1}$ in dry years to 0.9 $kg \cdot ha^{-1} \cdot y^{-1}$ (22 y period of record). Litterfall collection began this summer at the Coldwater Lakes Experimental Watershed, and will be continued through the forest cutting experiment to determine whether nutrient inputs via litterfall are affected by clearcutting to the lake's edge.

May 3, Morning Concurrent Session A **10:50 - 11:10 AM**

Alan Merkowsky (Terrestrial & Aquatic Managers Ltd, Saskatoon, SK)

Predicting the Importance of Boreal Forest Streams as Fish Habitat

One of the problems that managers of Forestry Operations and government Fisheries Biologists face is predicting the importance of small streams as fish habitat. In Saskatchewan, Fisheries Branch of the Department of Environment and Resource Management in conjunction with Forestry Canada of the Federal Department of Natural Resources conducted a three year (1992 - 1994) study of fish habitat in streams of the boreal forest. The major objective was to develop regression models for predicting the size of the streams and the number of species of fish that could be expected to be found in them.

A total of 51 stream reaches were sampled over the three years. A number of physical parameters were determined for each stream. These parameters were divided into two types: basin parameters which were determined from 1:50,000 topographical maps and channel morphology parameters which were measured in the field. The basin parameters were watershed area, stream order number and stream segment linkage number. The channel morphometry parameters were: mean bankful width; mean wet width; mean depth; and mean volume. In addition to the channel morphology parameters, each stream was sampled with a Coffelt Mark 10 electro fisher to determine what species of fish (if any) were present.

Multiple regression analyses were employed to determine which of the drainage basin parameters were the best at predicting bankful width as an indicator of stream size. Then all of the drainage basin and channel morphology parameters were used in a multiple regression analyses to determine the best model for predicting species richness.

Results of the analyses for predicting stream size indicated that the log of the watershed area of a stream had the highest coefficient of determination ($r^2 = 0.827$; t =0.001) for predicting the log of the bankful width of a stream. The regression model for predicting the log of bankful width was: Log Bankful Width = -0.047 + 0.478(Log Watershed Area).

The regression model with the highest coefficient of determination ($r^2 = 0.539$; t = 0.001) for predicting species richness had the log of the wet width of the stream as the only independent variable. The equation for the regression model was: Species richness = -0.157 + 3.618 (Log Wet Width).

Electro fishing results indicated that the brook stickleback, Culaea inconstans, was usually the most common species captured in streams with only one or two species present.

***May 3, Morning Concurrent Session A* 11:10 - 11:30 AM**

Robert France (Department of Biology, McGill University, Montreal, PQ)

Stable Carbon and Nitrogen Isotopic Evidence for Ecotonal Coupling Between Boreal Forests and Fishes

As a result of water turbulence effects on carbon isotopic discrimination, the $o^{13}C$ values (ratios of ^{13}C:^{12}C) of attached algae may often overlap those of terrestrial plants, thereby making it impossible to distinguish between the relative importance of these two potential food sources for aquatic animals. The present study uses a dual isotopic approach ($o^{13}C$ and $o^{15}N$) to refine measurements of the incorporation of allochthonous organic matter into freshwater fishes. The dependence of 5 species of littoral fishes on terrestrial detritus for part of their energy sustenance is demonstrated. the littoral zones of Canadian Shield lakes are, therefore, not isolated from their surrounding riparian forests in terms of carbon flow as present day timber management guidelines erroneously assume, but instead exhibit a measurable degree of ecotonal land-water coupling. As a result, clearcut logging of riparian forests to the lakeshore edge, permissible by law in most Canadian provinces containing boreal forests, may have to be reassessed as a forest harvesting strategy.

***May 3, Morning Concurrent Session A* 11:30 - 11:50 AM**

John F. Headley (National Hydrology Research Centre, Saskatoon,SK), Tom Sneddon , Maria Neuwirth (MT Environmental Systems Inc., Calgary, AB) and Merle Korchinski (Kaizen Environmental Sampling Inc., Calgary, AB)

Hydrology and Temporal Distribution of Organic Carbon Frorm An Upper Boreal Wetland Ecosystem

Dissolved Organic Carbon (DOC) is an index parameter used primarily to assess the trophic state of natural water bodies. Field studies have shown that most of the DOC observed in undisturbed water bodies is contributed by groundwater. The primary source of DOC is interflow and shallow groundwater(surface to -10m) and the chemical species it represents are refractory to soil organisms. Peatlands, which are groundwater outcrop features, are also significant sources of DOC.

The chemical character of DOC is site specific. In general, the humic and fulvic acids are the most abundant species, followed by tannins and lignans; carbohydrates and the amino acids. In general, hydrocarbons are not present under a state of nature although in petroliferous regions they may be present in trace quantities in the water column.

Both seasonal and diurnal cyclic variations in DOC are well documented. The biochemical processing of groundwater derived carbon compounds by wetlands, bottom and sub-bottom dwelling heterotrophs at night to produce pre-dawn minima. Algae derived organic exudates are known to produce afternoon maxima. Seasonal variations in surface waters are thought to be produced by the life cycles of aquatic organisms and by leaf fall in the autumn.

Basins which have been subjected to intensive agriculture show much large DOC discharges than undisturbed basins, although the relative abundance of carbon species is similar. Humic colloids have been associated with the presence of sorbed pesticides and pesticide residues. These chemicals nay be carried through the soil column and transported to surface water by groundwater, where they once again become biologically available. the association between humus and trivalent metals is also well known, which suggests that carbon-rich groundwaters may provide a transport medium for metals released through man's activities in upland areas.

This paper presents DOC data from three forested watersheds from the Boreal Zone of west central Alberta which include wetland areas and compared results from similar montane regions both in a natural state and in a disturbed state produced by forest harvesting and silvicultural activities. Results reported from basins disturbed by agriculture are also compared and conclusions drawn with respect to predicting the fate of pesticides applied to both forested and agricultural areas.

***May 3, Morning Concurrent Session A* 11:50 - 12:10 AM**

Bruno Wiskel (Evergreen Environmental)

Placement of Shelterbelt Trees Around Man-made Trout Ponds

The destruction, degradation and over fishing of North American trout habitat has encouraged many fishermen and conservationists to dig their own ponds for the purpose of creating a small, private, trout fishery.

Succcessful trout propagation in these ponds is not simply the result of digging a hole, filling it with water and stocking fish. Correct pond placement, orientation, and the planting of trees grass and shrubs around the pond margins is important for vigorous trout growth.

Shelterbelt tress can be used for securing an adequate water supply, protecting the pond walls from erosion and for reducing water temperature. Certain tree species and shelterbelt locations however, can actually decrease water quality and reduce pond productivity.

This oral presentation briefly describes the optimum conditions for pond propagation of trout and how the correct pond design, construction and shelterbelt planting can assist in maintaining conditions to maximize trout growth and survival.

***May 3, Morning Concurrent Session B* 10:10 - 10:30 AM**

J.S. MacDonald (Dept. of Fisheries & Oceans, West Vancouver, BC)

Takla Fishery/Forestry Interaction Program: Introduction

While coastal based fisheries/forestry interaction research has been conducted since the early 1960's, the relationship between forest harvesting and the productive capabilities of aquatic habitats in the interior of B.C. are poorly understood. In order to assist with the development of interior fish/forestry/wildlife guidelines, and to test the efficacy of B.C.'s new Forest Practices Code, a new research project was initiated in 1990 on five tributaries of the Stuart/Takla watershed. The watershed basins are in the Hogem Range of the Omineca Mountains at the northern end of Sub-boreal Spruce biogeoclimatic zone (Engelmann Spruce Subalpine Fir zone at high elevations). The Stuart-Takla watershed supports both early and late run sockeye salmon, a distinct race of kokanee and many other species of salmonids (e.g., rainbow and bull trout) and non-salmonids (burbot, squawfish and shiners).

This is a long-term multidisciplinary project that is spatially (5 creeks) and temporally (before and after a variety of forestry treatments) controlled. Forestry activities will begin in two of the watersheds during the winter of 1996. Project components are designed to develop an understanding of the ecosystem processes that effect stream production and forest outputs. Participants from a number of agencies are involved including the B.C. Ministry of Forests (MoF), Fisheries and Oceans Canada (DFO), Tl'Azt'En Nation, B.C. Ministry of Environment, Lands and Parks (MELP) and several of B.C.'s universities.

***May 3, Morning Concurrent Session B* 10:30 - 10:50 AM**

Dan Hogan (Research Branch, British Columbia Ministry of Forests, c/o Fisheries Centre, U.B.C., Victoria, BC)

Forest Management and Channel Morphology in Small Coastal Watersheds: Results from Carnation Creek and the Queen Charlotte Islands

Sixteen watersheds have been studied on the Queen Charlotte Islands (QCI) to determine the temporal and spatial response of stream channels to landslide impacts. Detailed stream surveys covered over 60 km of channels. The watersheds have had a wide range of logging histories and the channels have experienced natural landslide disturbance which span more than a century. This study has been in progress for over 10 years (starting in 1982) and uses a synoptic approach (extensive post-treatment design) to compare logged and forested watershed streams over space and time. Annual channel surveys in Carnation Creek (CC) on Vancouver Island began in 1971 and are on-going. The intensive before-after treatment design used in the CC study provides much finer temporal resolution of channel change than the studies in the Queen Charlotte Islands. The CC results are used to confirm those from the QCI.

There is a direct link between landslide occurrence and channel morphology. Landslide incidence invariably lead to the formation of large woody debris jams in the streams. Specific morphological and sedimentological changes occur upstream and downstream of the jams; these changes have impacts on fish spawning, incubation and rearing environments. The influence of debris jams on stream morphology changes over time as the jams deteriorate. Channel morphology is radically altered during the first decade following landslide inputs but the channel begins to resemble undisturbed conditions after approximately 35 years. Extremely complex and diverse channels are typical after 50 years. The evolution of channel features is clearly evident over these time spans.

If logging on steep hillslopes accelerates landslide frequency, there will be a corresponding increase in the number of recently formed woody debris jams. Stream sections associated with these young jams are characterized by altered channel patterns, less variable sediment texture, channel width and depth, less stable sediment storage zones, deep scour and fill, as well as increased frequency, extent and duration of de-watered channel. Log jams are considered to be the fundamental factor controlling the physical condition of these streams, therefore, management of steep, unstable hillslopes must ensure that any shift in landslide frequency, and log jam age, be minimized to maintain channel integrity.

***May 3, Morning Concurrent Session B* 10:50 - 11:10 AM**

John Heinonen (Dept. of Fisheries & Oceans, Vancouver, BC)

Selected Hydrology and Geomorphology Study Projects in the Takla Experimental Watersheds

The hydrologic and geomorphic impacts of northern interior logging activities on fish-bearing streams are being monitored and assessed as part of the Takla Research Project. The study watersheds are hydrologically dominated by snow so detailed studies are underway to evaluate differences in snow accumulation and melt between the forested and clearcut areas. A paired sub-basin study is being used to isolate the effects of clearcuts on hydrologic response in streams. Sediment generation from road surfaces is being studied using detailed surface measurements. Floodplain hydrology relationships are being evaluated prior to and after logging so that impacts to the spawning environment can be assessed. The ultimate goal is to integrate physical studies using GIS based hydrologic models, and testing and validating the models to enable extension of derived relationships to other fisheries watersheds.

***May 3, Morning Concurrent Session B* 11:10 - 11:30 AM**

Pierre Beaudry (Ministry of Forests, Prince George, BC)

Suspended Sediment Regimes of Three Experimental Watersheds in the Takla Area of North Central British Columbia

The objective of this study is to characterize the natural annual suspended sediment regimes of three watersheds with high fisheries values, and to identify any forestry related changes to the natural sediment budget. Large increases in suspended sediment loads can have negative impacts to fish and fish habitats by affecting feeding, spawning and rearing activities. Terrain and sediment source maps of the experimental watersheds identify and describe terrain types and erosion hazards, and in combination with hydrological information, will assist in understanding the annual and spatial variability in the amount of suspended sediment generated and transported.

Suspended sediment regimes have been monitored annually near the mouth of three of the experimental watersheds since 1992 using both manual and automated techniques. In each stream the majority of the suspended sediment is transported during a one to three day period during spring peak flows. Occasional very short pulses occur during summer and fall storms. Kynoch Creek carries a much greater annual suspended sediment load than other nearby watersheds. This is explained by terrain and sediment source information which clearly indicates Kynoch Creek as having large deposits of lacustrine soils in the lower reaches and therefore has a much higher erosion potential. Three small headwater tributaries are also being investigated to better understand their role in the generation and delivery of fine sediment to the main channels, before and after forest harvesting activities.

***May 3, Morning Concurrent Session B* 11:30 - 11:50 AM**

Ellen L. Petticrew (UNBC Faculty of Natural Resources & Environmental Studies, Prince George, BC)

The Influence of Aggregation on Settling Dynamics of Fine Grained Particles in Salmon Bearing Streams

As part of the larger in-stream processes component of the Stuart-Takla fisheries/forestry research programme a study on the role of aggregation of fine grained sediments has been undertaken. Fine grained sediment (<63 microns) which is transported in suspension moves not only as single grained particles but also as aggregates of fines which are held together by bacterial exudates. These aggregates have different settling properties than clay and silt sized materials and so are likely to be stored in the channels on the bed surface and within the gravel matrix. The hydrodynamic models which predict sediment transport in gravel bed streams do not account for these altered sizes and mistakenly predict quicker flushing of fine material following extreme loading events (debris flows, bank slumping, roadside erosion). Two seasons of *in situ* particle sizing using underwater photography and image analysis techniques has been completed and aggregates in excess of 800 micron diameters have been noted. Field settling experiments on sediment disturbed by redd building was undertaken in August 1995. Results of these experiments will be presented in the context of channel storage and transport of sediments.

***May 3, Morning Concurrent Session B* 11:50 - 12:10 AM**

Allen S. Gottesfeld (University of Northern BC, Prince George, BC)

Bedload Transport by Sockeye Salmon, Takla Experimental Watersheds, British Columbia

Movement of 1379 bedload clasts were recorded from 1992 to 1995 in Forfar and O'Ne-eil (Kynoch) creek, important sockeye salmon spawning streams of the Upper Fraser River. Clasts were uniquely numbered and marked for relocation with a magnetometer, with embedded magnets. Movement was monitored 3 or 4 times per year. Over 8000 recoveries were made during the relocation surveys. Overall, at the five stations monitored, sockeye salmon spawning activities resulted in 11% of the annual bedload transport. Spawning related transport contributes 4% of the total transport on the higher gradient upstream stations, and 48% on the lower gradient downstream stations. Nearly all of the remainder of the bedload transport is by nival flood transport. Fall storms and winter ice movement account for only 0.7% of the total movement.

In normal spawning years sockeye salmon spawning reworks nearly the whole streambed in the lower 3 - 4 km. of each experimental stream, to a depth of approximately 30 cm. In general flood transport is more selective than spawning transport, with a smaller portion of the bedload mobilized, but with longer transport distances. Sockeye salmon spawning changes the pool-riffle configuration of the streams. It results in the filling in of pools and widening of the effective channel. The intense bioturbation by sockeye salmon may be expected to result in selective winnowing of fine sediments, increased bedload permeability and improved egg survival.

***May 3, Afternoon Concurrent Session A* 1:30 - 1:50 PM**

Gray Jones (Western Canada Wilderness Committee, Edmonton, AB)

A Forest Activist's Thoughts on Protecting and Preserving Forest Fish Habitat

Approximately 40 per cent of Alberta's forests include water ways, water bodies and wetland habitats. Water systems are interconnected with and part of the forest environments which surround them. This water web is the mother of the forests, nourishing the plants and animals.

There is a great degree of chaos in the forest/aquatic environment in Alberta, despite the system's integrity and the symbiotic relationships of all living things sheltered and nurtured therein. This chaos is caused by the interface of mankind. All of the elements of our forest/aquatic environment form a gestalt – mankind's heavy-handedness tends to fragment it.

Alberta's forest/ aquatic environment is divided into various jurisdictions and administer the regulations and laws often do not speak to each other or plan together.

Foresters take care of the trees, fisheries officers take care of the fish, wildlife officers take care of the deer and moose while loggers, miners, oilmen, hunters and fishermen harvest the various elements.

This lack of communication between the people who oversee the forest-aquatic environment and the users often leads to degradation of the streams and water bodies and the destruction of fish habitats over time.

Communication between people and organizations, wholistic planning and comprehensive laws and regulations to protect, would do much to maintain and honour the forest/aquatic environment for future generations of humans and non-humans. The natural mosaic, from the bugs and algae in the water, to nesting, old-growth-dependent wood warblers in the spruce trees sheltering the stream would be protected through space and time.

We must realize that mankind is part of and not apart from the forest/aquatic environment.

***May 3, Afternoon Concurrent Session A* 1:50 - 2:10 PM**

James C. Bergdahl (The Valhalla Wilderness Society & Northwest Biodiversity Center, Seattle, WA)

Wild Pacific Salmon as Biological Indicators of the Conservation Value of Wilderness Areas on the Central British Columbia Coast

Pacific salmon (Oncorhychus spp.) runs are seldom used to evaluate wilderness areas for protected status (Provincial Park, etc.) in British Columbia despite the fact that many key wildlife species (such as black and grizzly bears) depend on healthy runs.

Size of salmon runs is not necessarily the best indicator of salmon resource-value to salmon dependent wildlife since fish may be nearly impossible to catch in large rivers. Spatial and temporal aspects of salmon runs across wilderness landscapes must be considered.

Using a simple biodiversity rating scheme, a comparison of wild Pacific salmon resource-values and terrestrial habitat diversity in nine large wilderness areas on the central British Columbia coast indicates that the greater Spirit Bear park proposal (265,000 hectares) clearly has the highest conservation value. Fifty-four percent of all federally classified salmon streams across all study areas, and 33% of the average annual salmon escapement, occur in the greater Spirit Bear park. Salmon will be discussed as "keystone" food resources for the long-term survival of bear, wolves and many other wildlife species in coastal forest ecosystems, including the white Spirit Bear, a unique subspecies of the North American Black Bear (*Ursus americanus kermodei*). Establishment of a 265,000 hectare Spirit Bear park would greatly contribute to the conservation of important biodiversity components of British Columbia, whereas a 25,000 hectare park (the area currently being studied by British Columbia government agencies) would be of little consequence. Clearcut logging and its unavoidable, cumulative, negative impacts to salmon spawning and rearing habitats is a major threat to wild salmon along the coast of British Columbia and the complex forest food webs which depend on them. Western Forest Products owns a tree farm license within the proposed Spirit Bear park and plans to begin clearcutting there in the near future despite the fact that the thin, waterlogged, and steep forest soils on the remote outer coast are extremely unstable, and ecologically and economically unfeasible to sustainably log using clearcut techniques.

***May 3, Afternoon Concurrent Session A* 2:10 - 2:30 PM**

Stephen J. Mitchell (U.B.C. Forest Sciences, Vancouver, BC)

Windthrow Hazard Assessment and Management in Riparian Management Areas in Coastal British Columbia

Windthrow damage to riparian management areas is a concern in many areas of coastal and interior British Columbia. Under the recently enacted Forest Practices Code of BC Act, lakes and streams must be classified and management areas of specific widths are required. For example, fish bearing creeks wider than 1.5 meters require 20 meter wide riparian reserves plus 20 meter wide management zones to buffer the reserve. In response to these new requirements a variety of management options are being developed in coastal BC. The "Windthrow Handbook of BC Forests' outlines procedures for pre-harvest assessments of windthrow hazard. Feathering of management zones is being used in multi-story stands with low or moderate windthrow hazard. In areas determined to have high windthrow hazard, topping, and pruning techniques are being tested. A recent innovation is the use of a helicopter suspended shearing bar to remove the top branches from trees. This is a safe, inexpensive technique for directly treating reserve zone trees and has won support from licensee and agency representatives in the locations where it has been applied. Research into the long term effectiveness of topping and feathering treatments is underway.

***May 3, Afternoon Concurrent Session A* 2:30 - 2:50 PM**

K.L. Smiley, K. Schwalme, L.Z. Florence and S. Wu (Alberta Environmental Centre, Vegreville, AB)

Biology and Mercury Content of Bull Trout in the Oldman River Reservoir and Tributaries

In 1991, the Alberta Environmental Centre (AEC) initiated a five year research study project on mercury in fish inhabiting the newly formed Oldman River Reservoir and tributaries within the upper Oldman River drainage basin. Over 100 bull trout (Salvelinus malma) have been collected from sites located upstream, downstream and from the reservoir, between 1991 - 1995.

Bull trout, once abundant throughout many of Alberta's rivers, have in recent years had it's range and distribution reduced, due to a number of changes in it's environment. Bull trout spawning and overwintering migrations have been impacted by the construction of reservoirs, dams and culverts, the removal of stream cover, and by the changes in water temperature, water flow regimes, and siltation these developments create. The construction of new roads has also opened previously unexploited populations to anglers.

Bull trout is considered threatened in Canada. The province of Alberta has responded to the need to protect bull trout and has implemented a Bull Trout Management and Recovery Plan to give bull trout the highest possible conservation priority. In keeping with these federal and provincial initiatives it is imperative that all the available and relevant biological data on bull trout be documented and communicated.

Summary results will be presented of the biological data compiled from the bull trout collected for the Mercury in Fish Project between 1991 and 1995. These will include the age, growth, condition factor, catch per unit effort, feeding and fecundity data. The mercury levels in bull trout from the study area will also be presented.

***May 3, Afternoon Concurrent Session A* 2:50 - 3:10 PM**

Greg McDade (Sierra Legal Defense Fund, Vancouver, BC)

Protecting British Columbia's Streams: A Sierra Legal Defense Fund Perspective on Fisheries and Forestry Lawsuits

This paper will provide an overview of the legal avenues available to public interest groups and individuals to address fish-habitat protection, pollution prevention and riparian protection amidst forestry activity in British Columbia. Particular reference will be made to the Fisheries Act (Canada) and the Forest Practices Code (B.C.), and to the Sierra Legal Defense Fund's ongoing involvement in fisheries and forestry lawsuits in British Columbia.

***May 3, Afternoon Concurrent Session B* 1:30 - 1:50 PM**

Charles Scrivener and Steve MacDonald (Dept. of Fisheries & Oceans, Vancouver & West Vancouver, BC)

Analysis of Spawning Gravels, Bedload Transport and Their Relationships with Sockeye Salmon in Stuart -Takla Watersheds

Objectives and techniques used to investigate spawning gravel quality and bedload transport in Gluskie, Forfar, Kynoch and Bivouac creeks are discussed. Results from 1990-93 are presented. Analysis of freeze-core samples indicated that unlike coastal watersheds, an armour layer of course gravel was not present on the surface of the streambeds because salmon spawning acts to mix the top 35 cm. of the streambed and resuspends fine particles. Streambed gravels were courser in Gluskie Creek than other watersheds because of steeper gradients. Gravels became more coarse with distance from the mouths of all streams. Streambed sediment was transported as bedload during the May and June snowmelt period and during salmon spawning in August. Numbers of spawners was positively correlated with volume of bedload transported among years and sites. Salmon redd depth was inversely correlated with geometric mean particle size of the streambed during each year. Comparisons of streambed composition in locations with and without redds indicated that salmon can condition the gravel at their spawning locations by removing fine particles. Fine particles were incorporated into the streambed behind beaver dams during the period of egg and alevin incubation. Gravel sampling activities have provided baseline information necessary to distinguish between natural and forestry induced changes in gravel quality.

***May 3, Afternoon Concurrent Session B* 1:50 - 2:10 PM**

Scott Cope (R.L. & L. Environmental Services Ltd., Castlegar, BC) and J. Steve Macdonald (Department of Fisheries and Oceans, Biological Sciences Branch, West Vancouver, BC)

Responses of Sockeye Salmon Embryos to Intragravel Incubation Environments in Selected Streams Within the Stuart/Takla Watershed

Before impacts of forest harvesting can be identified, the natural physical and biological influences on incubation processes must be understood within interior British Columbia watersheds. The study objective was to estimate overwinter survival of sockeye salmon (Oncorhynchus nerka) embryos within various redd micro-environments. Egg to pre-emergent fry bioassays, in conjunction with microhabitat environmental monitoring, were implemented to define a range of natural spawning conditions and their relative contribution to fry recruitment. Four adjacent tributaries (Kynock, Forfar, Gluskie, Bivouac creeks) of the Stuart\Takla watershed were studied during the 1993 and 1994 Broodyears.

Sockeye salmon successfully spawned over a wide range of habitats. Survival rates between habitat types were not significantly different in contrast to predictions generated from optimality models. This was due to the definition of "marginal" habitat. *In situ* redd simulations showed similar intragravel conditions in both low density (assumed marginal) and high density (assumed preferred) areas. Spawning adults avoided truly marginal areas with intragravel dissolved oxygen levels below 3.0 mg/l.

Physical (i.e. hydraulic regime, bedload characteristics) and biological (i.e. mass cleaning by high densities of spawning adults) processes result in uniformly high quality gravel conditions with permeabilities, surface water interchange, and intragravel dissolved oxygen levels associated with high incubation success. Riparian-zone substrates in the study streams were characterized by large amounts of lacustrine deposits. Reduced escapement levels, or sediment inputs which exceed current bedload transport, may impact incubation environment.

By spawning early in the season (July - Aug.), early Stuart sockeye enjoy advanced embryological development prior to the onset of low water temperatures. Embryos rapidly accumulate the thermal units necessary to hatch, thereby becoming mobile in time to avoid freezing and desiccation as water-levels decline and reach seasonal minima. Embryos and alevins of the early Stuart stock can apparently tolerate temperature conditions previously considered lethal, and emerge successfully in the spring after accumulating less thermal units than any other Fraser River stock. These mechanisms are closely linked to the stream thermal regime. Therefore, riparian forestry prescriptions must be closely monitored to detect and quantify any stream temperature changes that may impact the developmental timing of incubating salmonids.

***May 3, Afternoon Concurrent Sessions B* 2:10 - 2:30 PM**

Peter Tschaplinski (Ministry of Forests, Victoria, BC)

The Abundance and Distribution of Adult Sockeye Salmon Relative to Physical Habitat Characteristics in Streams Tributary to Takla Lake and the Middle River of Central British Columbia

The abundance and longitudinal distribution of adult sockeye salmon returning to spawn in Gluskie, Forfar and O'Ne-eil (Kynoch) creeks have been determined annually since 1992 to identify spawner habitat use and preferences. Spawner distribution relative to key physical habitat features is being determined by using aerial and ground-based habitat inventory techniques combined with both total-area enumeration and strip-counts for spawners. Habitat descriptions are obtained at three scales: (1) macrohabitat (stream reach), (2) mesohabitat (features such as pool, riffle and glide types including channel structure), and (3) microhabitat (substrate texture, water depth, velocities and temperatures). The overall goal in this project is to determine how forestry-associated changes in the thermal, hydrological and geomorphological regimes in the experimental watersheds affect variations in the structure, stability and distribution of fish habitats, sockeye spawner distribution and habitat use and ultimately egg-to-fry survival.

***May 3, Afternoon Concurrent Session B* 2:30 - 2:50 PM**

Steve MacDonald (Dept. of Fisheries & Ocean, Vancouver, BC) and Charles Scrivener (Dept. of Fisheries & Oceans, Nanaimo, BC)

Stream Temperature Regimes, Possible Logging Effects, and the Implications for Salmonids in the Takla Lake Area

Temperatures of the experimental streams have been recorded continuously since the summer of 1990 using electronic data loggers. Current information from interior watersheds indicates an elevation in summer stream temperatures after removal of riparian vegetation. Impacts on winter temperatures are not as well understood. An elevation of mid-summer temperatures in the Takla study area when adult sockeye salmon are returning to spawn, could have a variety of negative effects including: a) prespawning mortality due to elevated egg and alevin metabolism, b) temperature barriers at key locations on the migration route where temperatures are already approaching lethal limits, c) reduced fertilization success at temperatures above 19 degrees, d) increased embryonic development rates and early emergence to an environment unsuitable to rear sockeye fry (lethally low temperatures, poor food availability). A forestry-induced reduction in mid-winter stream temperatures which are normally below 1 degree from late October to April, could also impair sockeye incubation success. The initial results from investigations of these effects will be discussed during the presentation.

May 3, *Afternoon Concurrent Session B* 2:50 - 3:10 PM

T. R. Whitehouse (Dept. of Fisheries & Oceans, New Westminster, BC)

Assessment of Sockeye Salmon Spawner Abundance and Characteristics in Selected Streams Within the Stuart/Takla Watershed

Spawning ground enumeration programs provide critical quantitative data required to assess stock productivity trends, potential productive capacity and fishery management performance. Spawner assessments are undertaken annually in Stuart/Takla system tributaries to assess the numerical abundance of spawners, as well as biological characteristics of the spawning population. Enumeration studies have included several survey types ranging from limited visual counts, to visual counts coupled with carcass recovery programs, through to intensive total counts employing counting weirs. Biological data collected during sampling of the spawning populations include sex, size and age class structure data, pre-spawning mortality incidence, success of egg deposition within the female population, fecundity, and spawner health. These data provide a critical quantitative dataset enabling managers to assess production trends relative to fishery harvest and salmon population rebuilding objectives as well as land management issues and spawning habitat protection.

Saturday, May 4, 1996

***May 4, Morning Concurrent Session A* 8:30 - 8:50 AM**

D.A. Scruton, K.D. Clarke, and L.J. Cole. (Department of Fisheries and Oceans, St. John's, NF)

Water Temperature Dynamics in Small Headwater Streams in the Boreal Forest of Newfoundland, Canada: Quantification of 'Thermal' Brook Trout Habitat to Address Effects of Forest Harvesting.

Studies are underway in small headwater streams in the Copper Lake watershed, Newfoundland, Canada, to describe the temperature characteristics and determine temporal dynamics in relation to the quality of these fluvial habitats for brook trout (*Salvelinus fontinalis*). Studies involve the use of paired Hugrun recording thermographs, recording hourly, at the upper and lower end of each of five stream reaches from 1993 to 1995. These five reaches include four in headwater streams and one in a second order stream and include sites designated for different buffer zone treatments in relation to forest harvesting. This paper describes the temperature characteristics of these five sites prior to harvesting (unperturbed). The influence of upstream standing water and aspect (orientation to solar radiation) are discussed.

Daily minima, maxima, mean and magnitude of diurnal variation in stream water temperatures are used to define the dynamics in thermal characteristics of the study streams. These attributes are quantified in the context of temperature preferences for brook trout, stress and lethal limits, and in relation to growth potential. This approach is used to evaluate effects of forest harvesting on 'thermal' habitat for brook trout and the effectiveness of buffer strips of varying width to ameliorate effects. The results from one site (T1-1) in both pre- and post-harvesting periods, where 40% of the stream length has been clear-cut to the water's edge, is used to develop and demonstrate this approach.

***May 4, Morning Concurrent Session A* 8:50 - 9:10 AM**

K.D. Clarke, D.A. Scruton, L.J. Cole, and L.M.N. Ollerhead (Department of Fisheries and Oceans, St. John's, NF)

Large Woody Debris Dynamics of Four Small Boreal Forest Streams with An Initial Analysis of Relationship to Brook Trout Density

Large woody debris (LWD) dynamics and its' role on salmonid production in small boreal forest streams has largely been overlooked in forestry interaction studies. These attributes are being investigated as part of a large buffer zone research study through a series of annual LWD surveys and concurrent population estimates of brook trout (*Salvelinus fontinalis*) in four small boreal forest headwater streams in the Copper Lake Watershed, Newfoundland, Canada in 1994 and 1995. Large woody debris frequency and volume in the stream channel did not show any trends based on stream size while submerged volume increased with stream size. The small 1° streams had more LWD lying perpendicular in the stream channel (32-53%) than did the 2° stream (24-26%) and orientation characteristics were similar over the two years. LWD volume was stable in the smaller 1° streams over the two year period while frequency changed significantly. The exception to this observation was a stream which had 40% of its length clear-cut to the waters edge between surveys. This stream was observed to have both significant decreases in LWD frequency and volume. An analysis of LWD dynamics in relation to stream bank slope is also discussed. LWD was negatively correlated to brook trout densities bringing into question the role LWD plays in production of juvenile brook trout (primarily young-of-the-year and yearlings) in these small boreal forest streams.

***May 4, Morning Concurrent Sessions A* 9:10 - 9:30 AM**

J.H. McCarthy J.M. Green,(Department of Biology, Memorial University of Newfoundland, St. John's, NF), D.A. Scruton, and K.D. Clarke (Department of Fisheries and Oceans, St. John's, NF)

The Effect of Logging and Road Construction on Brook Trout Movement and Habitat Use in the Copper Lake Watershed, Newfoundland, Canada (Student Paper)

Movement of tagged brook trout (Salvelinus fontinalis) was monitored during early June to mid october in the Copper Lake Watershed, Newfoundland, Canada in 1994 and 1995. This research, which is part of a large buffer zone research study, was undertaken to determine the effects of clear-cut harvesting on brook trout movement and habitat utilization. Movement of trout was measured by recapture of individually tagged fish by counting fences, fyke nets, electrofishing, and angling. Movement was analyzed as an index of the extent of fish movement in streams using a statistical technique utilized by Eric Bergersen and Thomas Keefe. Preliminary investigation suggests that the tagged population in the treatment stream (20% of its length clear-cut to the water's edge) had no significant change in the index of movement after the treatment. The movement index in this stream also had no significant change after the treatment when compared to a control stream in the same watershed thus suggesting no change in behaviour and habitat use after logging. However, a comparison of the movement patterns, where direction of movements and habitat types were examined, showed a significant difference in the treatment stream after the clear-cut. This technique may also be applied to assess the benefit of a 20 meter buffer strip which is to be left on other treatment streams within the watershed.

***May 4, Morning Concurrent Session A* 9:30 - 9:50 AM**

K.D. Clarke, D.A. Scruton, (Department of Fisheries and Oceans, St. John's, NF) and J.H. McCarthy (Department of Biology, Memorial University of Newfoundland, St. John's, NF)

The Effect of Logging and Road Construction on Fine Sediment Yield in Streams of the Copper Lake Watershed, Newfoundland, Canada: Initial Observations.

Fine sediment infiltration was monitored by the Wesche sediment method in the Copper Lake Watershed, Newfoundland, Canada from June 1993 to October 1995 to evaluate the effect of two independent road crossings and logging on fine sediment yield in small boreal forest streams. The road crossings were observed to significantly increase fine sediment yield into the streams and these increases have persisted up to the present. The two stream crossings utilized differing construction techniques, a bottomless arch culvert and a whole cylindrical culvert, and there were no discernable differences in sediment yield between the two techniques. An additional analysis of the compounding effects of clear cutting to the waters edge will be evaluated once the 1995 samples are processed. An initial analysis of benthic community structure and abundance (1994) was not able to discern any significant differences in the effected streams as compared to two control streams in the watershed with the possible exception of a reduction in Plecoptera abundance in one of the effected streams. These analysis will be broadened to include the 1995 data once it is processed to discern any trends. Young of the year brook trout (*Salvelinus fontinalis*) density has significantly decreased in one of the effected streams while the other has fluctuated throughout the study. Analysis of brook trout density and biomass, by age class, is discussed.

***May 4, Morning Concurrent Session A* 9:50 - 10:10 AM**

Craig Spencer, (Biology Department, Augustana College, Sioux Falls, SD)

Impact of Timber Harvest on Sedimentation Deposition in Surface Waters in NW Montana Over the Last 150 Years: A Paleolimnological Study

Lake sediment cores from three lakes in northwest Montana reveal substantial changes in the rate of accumulation of fine sediments which are correlated with historical and land disturbance changes. Accelerated logging activity was correlated with up to 10-fold increases in sedimentation rates compared to background sedimentation rates prior to European settlement. Road construction appeared to be the greatest contributor to increased sedimentation rates. The largest increases in two of the study lakes (Whitefish and MacDonald lakes) were associated with land disturbance activities earlier this century, with evidence of lessened impacts from more recent logging activities. However, data from Swan Lake indicates elevated sedimentation rates which are correlated with large increases in timber harvest within the last two decades.

***May 4, Morning Concurrent Session B* 8:30 - 8:50 AM**

Terry M. Antoniuk (Salmo Consulting Inc., Calgary, AB)

Access Effects and Management in Northeast British Columbia

In 1993, seven natural gas producers commissioned a study to evaluate the effects of gas development in a 5,000 km² area of northeast British Columbia. This study assessed the potential effects of both existing roads and infrastructure, and activities that could occur between 1993 and 1998. Because specific project plans were not available, a regional development scenario incorporating a range of possible activities was used.

Potential effects of these activities were assessed using a semi-quantitative assessment procedure in which the rationale for all assumptions, calculations and conclusions was documented. Evaluation was restricted to eleven representative parameters or species selected based on their ecological or economic importance and sensitivity. Aquatic indicators were: buffering capacity; stream sediment load; Arctic grayling (Thymallus arcticus); and bull trout (Salvelinus confluentus).

Cumulative effects were concluded to be possible for all assessment parameters and species. Access creation and soil erosion were the project-related disturbances with most wide ranging effects. Measurable increases in total suspended solids levels were concluded to be likely in years with intensive construction activity. Increased sediment yield could occur over 10% to 40% of the study area in any year between 1993 and 1998, and was concluded to represent a long term, significant environmental effect.

Combined disturbances were predicted to have the potential to affect 75% to 100% of Arctic grayling and bull trout in the study area, mainly due to effects of sediment input, angling and poaching. Sediment deposition in spawning and nursery areas was considered to be the most significant concern for these fisheries because this can reduce survival and recruitment of juveniles. Evidence from Alberta and the United States indicates that cumulative effects of this magnitude reduce populations sufficiently that recovery in the short term (one generation) is unlikely. On this basis, combined disturbances were concluded to have the potential for long term effects on the two representative fish species in the absence of additional mitigative measures.

Since this study was completed, the province of British Columbia has introduced the Forest Practices Code. This Act and accompanying regulations and guides establish comprehensive standards for road and bride design and construction, timber harvesting, and operational planning. The applicability of these standards in mitigating aquatic effects is discussed.

***May 4, Morning Concurrent Session B* 8:50 - 9:10 AM**

Charles W. Huntington (Clearwater BioStudies Inc., Canby, OR)

Streams and Salmonid Assemblages Within Managed and Unroaded Landscapes in the Clearwater Basin, Idaho

Aquatic ecosystems in the Columbia Basin have been greatly affected by natural and anthropogenic disturbances over the last 150 years. Catastrophic wildfires, road construction, logging, mining, livestock grazing, water development and other activities have at various times and locations had deleterious effects on streams and native aquatic biota. Some of the damaged aquatic systems have recovered since disturbance, others appear to have stabilized at reduced levels of productivity and many continue to experience chronic degradation.

From 1989 through 1995, we examined stream conditions and salmonid abundance along 1769 km of streams on federally managed lands within the Clearwater Basin, Idaho. Fish habitat and riparian conditions were evaluated using a transect-based method, while fish populations were sampled at representative locations (985 total) along the streams examined. Analyses of the data we collected suggest that there are important differences between streams within the basin's managed (roaded) and unroaded landscapes. In this presentation I will discuss some of these differences in terms of habitat quality, salmonid assemblages and refuge areas for sensitive aquatic animals.

***May 4, Morning Concurrent Session B* 9:10 - 9:30 AM**

Micheal D. Sawyer (Rocky Mountain Ecosystem Coalition, Calgary, AB) and David W. Mayhood (RMEC & Freshwater Research Limited, Calgary, AB)

Cumulative Effects Analysis of Land-Use Activities in the Carbondale River Catchment: Implications for Fish Management

Recent studies have used geographic information systems (GIS) to assist in the spatial analysis of the cumulative effects of land-use activities in forested watersheds. Adapting watershed assessment methodologies developed by the US Forest Service we used a GIS to document and analyze the extent of human disturbance to a small river basin on the eastern slopes of Alberta's Rocky Mountains. The study basin, extensively used for logging, mining, grazing, petroleum exploration and development, and off-road vehicle travel, is judged to be reasonably representative of similarly-used basins on the Alberta eastern slopes.

Using the GIS we delineated a "Potential Sediment Source Zone", assessed the potential risk of sedimentation within the watershed, and inventoried human induced disturbance of vegetation within the watershed from which descriptive disturbance indices were developed. From this we identified and quantified point and non-point sources of sediment within the watershed to estimate the cumulative effects of human activities on water quality within the watershed.

We then compared the magnitude of disturbance to studies in the literature that have related similar disturbances to effects on fishes and their habitats. Several classes of disturbance appear to be sufficiently large individually to have detrimental effects on stream habitat for fish in the study basin. We argue that, cumulatively, damage to fish habitat and the fishes that use it is virtually certain. We conclude by making specific recommendations regarding the management and restoration of the watershed and the fishes which inhabit it. Further research needs are identified.

***May 4, Morning Concurrent Session A* 9:30 - 9:50 AM**

Gary Bank (PFRA, Red Deer, AB)

A Private Land Forest Inventory for Southern Alberta and Some Possible Uses

Nearing completion is an inventory of private land forests found in southern Alberta. It will cover the forested area from Calgary to Edmonton and east to the Saskatchewan border, exclusive of the Green Zone. The project is funded by five different partners which include two branches of Alberta Agriculture Food and Rural Development, Provincial Forest Service, ALPAC, PFRA and Forestry Canada.

The inventory is based on a combination of satellite image analysis and air photo interpretation. Forest cover information is presented at a scale of 1:50,000. This information is overlaid on a 1:20,000 base map. Each forest polygon is described by four different deciduous and conifer stand composition levels, by three height strata, two stand densities and two site moisture levels. The final product will be available in both hard copy and in a GIS format which will allow for analysis of associated data and overlay of other resource information such as soils, landforms, and wildlife.

Uses include the most obvious of simply knowing how much private land forest remains in Alberta. At present there is no reliable estimate of amounts of private land forest in Alberta. These forest areas are coming under increasing pressure as crown timber supplies decline and prices increase. The inventory could be used as an aid to land use and watershed planning, as a tool to recognize and promote rural economic development opportunities, and as a means of targeting extension and awareness programs. Municipalities may also be interested in the information to help determine forest volumes that could be harvested and impact on roads under their jurisdiction.

***May 4, Morning Concurrent Session B* 9:50 - 10:10 AM**

C. Wendell Koning, Ken I. Ashley, Pat A. Slaney and Andrew J. Paul (Ministry of Environment, Lands and Parks, Fisheries Centre, University of British Columbia, Vancouver, BC)

Stream Fertilization As A Fisheries Mitigate Technique For Purturbated Oligotrphic Trout Streams In British Columbia

Stream fertilization is a promising restoration technique being promoted within the Watershed Restoration Program of British Columbia. In purturbated systems, addition of fertilizer replaces lost nutrients and increases food chain productivity, thereby placing salmonid fish in better condition to survive the stressed conditions. Three rivers will be used to illustrate the work we are conducting, namely, the Adam River, Big Silver Creek, and in particular, the Mesilinka River. The Mesilinka River is a large northern river (mean summer flow, 112 m^3s^{-1}) located 280 km north of Prince George, British Columbia. The Mesilinka flows east into Williston Reservoir which empties into the Peace River. It is one of several oligotrophic streams inhabited by migratory and resident salmonids which were affected by construction of the reservoir, thereby flooding the lowermost and most productive stream reaches. To offset the lost fisheries productivity, liquid fertilizers (agriculture-grade nitrogen and phosphorus) were added to the river during the summer months of 1994 and 1995, after two years of pre-fertilization inventory gathering in 1992 and 1993. Target in-river concentrations were 5 ug L^{-1} dissolved inorganic phosphorous and 20 ug L^{-1} dissolved inorganic nitrogen. Compared to the pre-fertilization data, preliminary results (1995) from 5-8 km index reaches suggest rainbow trout and mountain whitefish numbers have increased two-fold and five-fold, respectively. Impact on the food chain (increased periphyton and benthic insect biomass) was detectible for > 15 km below the fertilizer drip stations. Based on results such as these, stream fertilization can be used in oligrotrophic streams as one technique (often within a larger mitigation package) for mitigation of impacts, including those of past forest harvesting practices.

***May 4, Morning Concurrent Session A* 10:30 - 10:50 AM**

Mark R. S. Johannes (NorthWest Ecosystem Institute, Lantzville, BC), Kim D. Hyatt (Department of Fisheries and Oceans, Pacific Biological Station, Nanimo, BC) and Michael C. Wright (M.C. Wright and Associates, Nanaimo, BC)

Impacts of Forest Harvest Practices on Salmonids and Their Habitats in the Kennedy Watershed, Clayoquot Sound

Clayoquot Sound, on the west coast of Vancouver Island, has become an international icon in the debate about the impacts of forest harvesting practices on some of the last intact coastal rainforests of North America. Stimulated in part by the Clayoquot debate, the Government of British Columbia recently formed a new Crown Corporation, Forest Renewal B.C. (FRBC), to address province wide concerns about ecosystem integrity andforest harvesting. A host of new initiatives will impose unprecedented change to forest management of Clayoquot Sound as part of a new approach to sustainable resource use. In 1994, one FRBC project was initiated in the Kennedy Watershed of Clayoquot Sound to examine the impacts of 30-50 years of forest harvesting on salmonid habitats and populations in order to identify and then develop options to implement restoration measures where damage has occurred.

Our working hypothesis was that forest harvest practices tend to fragment and simplify habitats, disrupt salmon life cycles and precipitate salmon population declines. To test this we compared the state of salmon populations and associated habitats in "matched" pairs of logged and unlogged streams. Results supported the general expectation that logged and unlogged streams differ with respect to habitat heterogeneity, habitat use by salmon and salmon abundance. Logged systems exhibited evidence for changes in the distribution, abundance and state of habitat units that are essential to salmon. Changes in patterns of recruitment and loss of substrate and large woody debris appear responsible for most of the logged versus unlogged habitat differences in streams. Salmonid patterns of habitat use differed greatly in logged and unlogged streams. Juveniles and adults exhibited more equitable use of off-channel and mainstem habitats in unlogged streams. Spawners were often confined to the lower, mainstem portions of small logged streams. Salmon production was lower in logged streams. Although differences in the current state of habitats and salmon populations associated with logged versus unlogged systems are consistent with the notion that past forest harvest practices have degraded both, the impacts, the mechanisms that generate them, and the prescriptions to reverse them remain incomplete.

***May 4, Morning Concurrent Session A* 10:50- 11:10 AM**

Peter J. Tschaplinski (BC Ministry of Forests, Victoria, BC)

The Effects of Logging, Climate Variation, and Ocean Conditions on Salmonid Populations of Carnation Creek, Vancouver Island, British Columbia

The Carnation Creek Fisheries-Forestry Interaction Program was initiated in 1970 and is the longest, continuous study of the effects of forestry practices on biological and physical watershed processes in North America. This case study was initially designed to compare the effects of different streamside harvesting treatments on stream channels, aquatic habitats, and fish populations in coastal British Columbia. Treatments varied from intensive clear-cuts where all trees were removed to the edge of the stream to areas where riparian strips of trees were maintained. Salmon and trout populations of Carnation Creek have been closely monitored for the past 25 years as an important component of this multi-disciplinary and multi-agency study. The objectives of this report are to describe the patterns in salmonid population dynamics through five pre-logging, six during-logging, and 14 post-logging years; illustrate that forest harvesting has complex and often variable effects upon population processes at the different life stages of each species; demonstrate that the production of salmonids from coastal streams depends not only upon processes occurring within the watershed, but also upon those in the marine environment; and, emphasize the value of long-term studies such as the one at Carnation Creek to clarify the complex interactions among land-use practices, fishing, marine climate change, and salmonid populations. Fish species at Carnation Creek have responded differently to forest harvesting. Chum salmon (Oncorhynchus keta) populations have shown the sharpest declines. Mean numbers of adults returning to the watershed declined by 2.6-times after logging. This decline is due partly to reductions in egg-to-fry survival because of decreased quality of spawning and egg-incubation habitats in the lower reaches of the stream used by this species. Reductions in the quantity and quality of seasonal rearing habitat appear to explain the roughly 50 % post-logging decline in abundance of coho fry (O. kisutch) rearing in Carnation Creek during summer. However, fewer coho juveniles have produced 1.5-times more smolts after logging due to improved overwinter survival, which is in turn correlated with increased winter water temperatures and summer growth. This increased smolt production has not resulted in more coho spawners returning to the watershed. Mean numbers of adult coho returning to the system have declined after logging by 33 % because of strongly depressed marine survivals resulting from earlier timing of spring smolt migrations and ocean climate shifts. Both freshwater and marine phases of salmonid life histories must clearly be considered from the perspective of resource conservation and management. Because climate-associated, marine survival variations cannot be controlled, we must always apply our best forest-harvest practices to ensure that adverse effects of decreased ocean survival are not compounded with the effects of inappropriate land-use.

***May 4, Morning Concurrent Session A* 11:10 - 11:30 AM**

John S. Richardson (British Columbia Ministry of Environment, Department of Forest Sciences, University of British Columbia) and William E. Neill (Department of Zoology, University of British Columbia, Vancouver, BC).

Associations Between Forest Harvest and Stream-Dwelling Amphibians in Coastal British Columbia

Surveys for Pacific Giant Salamanders (Dicamptodon tenebrosus) and Tailed Frogs (Ascaphus truei) were conducted in southwestern British Columbia in streams draining through forests of different ages and forest harvest histories. The larval stages of these two species spend at least two years as larvae in small, steep streams in the coastal western hemlock biogeoclimatic zone. Both of these amphibians are considered at risk in Canada based on limited range of distribution, low density, and the threat of land-use modification on their populations. The streams in which these species tend to occur have not been provided the protection of riparian reserve zones since they lack fish, and hence forests are often cut to the streambank during harvest. These surveys included searches for presence of the species and quantitative estimates of density at a subset of sites searched. Data for site descriptions were collected, including slope, wetted width, and canopy measures. Our set of descriptive habitat data was not able to discriminate between streams with or without either species. Both species occurred slightly more often in old-growth forest streams, but not significantly so. Both species were found at higher densities in streams draining through clearcuts, presumably a consequence of enhanced primary productivity known to occur in cleared-over streams. However, in spite of higher densities, the average mass of individuals found in cleared sites was lower than those from old-growth sites. Pacific Giant Salamanders occurred at intermediate levels of density and biomass in second-growth forest streams, but Tailed Frog tadpole densities and average biomass were much lower at such sites. These results suggest possible differences in species recovery rates after forest harvest. Hypotheses to explain these differences are currently being tested.

***May 4, Morning Concurrent Session A* 11:30 - 11:50 AM**

Dan Hogan (British Columbia Ministry of Forests, Vancouver, BC)

Forest Management and Channel Morphology in Small Coastal Watersheds: Results from Carnation Creek and the Queen Charlotte Islands

Sixteen watersheds have been studied on the Queen Charlotte Islands (QCI) to determine the temporal and spatial response of stream channels to landslide impacts. Detailed stream surveys covered over 60 km of channels. The watersheds have had a wide range of logging histories and the channels have experienced natural landslide disturbance which span more than a century. This study has been in progress for over 10 years (starting in 1982) and uses a synoptic approach (extensive post-treatment design) to compare logged and forested watershed streams over space and time. Annual channel surveys in Carnation Creek (CC) on Vancouver Island began in 1971 and are on-going. The intensive before-after treatment design used in the CC study provides much finer temporal resolution of channel change than the studies in the Queen Charlotte Islands. The CC results are used to confirm those from the QCI.

There is a direct link between landslide occurrence and channel morphology. Landslide incidence invariably lead to the formation of large woody debris jams in the streams. Specific morphological and sedimentological changes occur upstream and downstream of the jams; these changes have impacts on fish spawning, incubation and rearing environments. The influence of debris jams on stream morphology changes over time as the jams deteriorate. Channel morphology is radically altered during the first decade following landslide inputs but the channel begins to resemble undisturbed conditions after approximately 35 years. Extremely complex and diverse channels are typical after 50 years. The evolution of channel features is clearly evident over these time spans.

If logging on steep hillslopes accelerates landslide frequency, there will be a corresponding increase in the number of recently formed woody debris jams. Stream sections associated with these young jams are characterized by altered channel patterns, less variable sediment texture, channel width and depth, less stable sediment storage zones, deep scour and fill, as well as increased frequency, extent and duration of de-watered channel. Log jams are considered to be the fundamental factor controlling the physical condition of these streams, therefore, management of steep, unstable hillslopes must ensure that any shift in landslide frequency, and log jam age, be minimized to maintain channel integrity.

***May 4, Morning Concurrent Session B* 10:30 - 10:50 AM**

Paul G. Anderson (Golder Associates Ltd., Calgary, AB)

Sediment Generation From Forestry Operations and Associated Effects on Aquatic Ecosystems

Logging operations have been shown to have many effects on adjacent watercourses and on the aquatic ecosystems which they support in several ways. This may occur as a result of the introductions of woody debris, loss of riparian vegetation, accelerated stream bank and bed erosion, the alteration of natural channel form and process, and the reduction of stream habitat diversity. One of the most insidious effects of logging, however, is the elevation of sediment loads and increased sedimentation within the drainage basin.

Sediment generation from various forestry practices has been studied extensively in the past. Forestry practices which generate suspended sediments include all operations that disturb soil surfaces such as site preparations, clear-cutting, log skidding, yarding, slash burns, heavy equipment operation and road construction and maintenance. From these sources, by far the highest levels of sediment generation in streams are produced in association with the construction and maintenance of logging roads located near streams.

Three aspects of logging road development and maintenance have been shown to be of significance with respect to the elevation of sediment loads in streams: 1) in-stream and near-stream construction operations; 2) reduction in retention time and associated increase in erosion in the drainage basin; and, 3) mass soil movements and/or landslides associated with logging road design and placement.

A literature review was undertaken to examine the effects of increased sediment load and sedimentation on aquatic ecosystems with an emphasis on the forestry operations which generate elevated sediment loads. The review included the effects of sediment on fish (behavioural, physiological and population effects) and the effects of sedimentation on fish habitats (including spawning, rearing, food production, summer and overwintering habitats). A habitat effects relationship was developed which related the concentration and duration of specific sediment exposure events to the alteration of fish habitats. This relationship allows for post-disturbance evaluation of the potential effects on fish habitat.

Many advances have been made in the design and construction of logging roads over the past three decades. Many of these advances have been made in the design of road access systems, while other advances have been made in the development of more sophisticated mitigation techniques. These advances are described and discussed in relation to minimizing sediment generation in aquatic environments.

***May 4, Morning Concurrent Session B* 10:50 - 11:10 AM**

D.H.Van Lear (Department of Forest Resources, Clemson University, Clemson, SC), G.B. Taylor (University of South Carolina Law School, Columbia, SC) and W.F. Hansen (USDA Forest Service, Columbia, SC)

Sources of Sediment in the Chattooga River Watershed

Sediment was identified as a major water quality issue in the Chattooga River, a National Wild and Scenic River in the Southern Appalachians, but sources of sediment had not been identified. The objectives of this 1993-1995 study were 1) to evaluate the extent of fine sediments in the river's substrate, 2) to determine which tributaries were major contributors of sediment, and 3) to make recommendations to ameliorate sources of sediment. Major findings were: 1) The main river corridor is well vegetated and is not a major source of sediment, 2) Tributaries that are heavily impacted by land uses that compact and expose mineral soil are major contributors of suspended and bedload sediments, 3) The majority of sedimentation problems (80.2% of observable sediment sources) were associated with open graveled and unsurfaced roads. Other sources of sediment included highways, timber harvests, pastures with unfenced riparian zones, developments, and land fills. Heavy recreational use of unpaved roads necessitates frequent maintenance of road surfaces, which often increases sedimentation. Recommendations are made to reduce sedimentation sources to improve water quality and the health of aquatic communities. With proper restoration, the river and its tributaries can begin to recover from the land-use abuses that have accelerated sedimentation over the past century.

***May 4, Morning Concurrent Session B* 11:10 - 11:30 AM (Student Paper)**

Liane C. Spillios and Richard L. Rothwell (Department of Renewable Resources, University of Alberta, Edmonton, AB)

Freeze-Core Sampling For Sediment Intrusion From Road Crossings In Small Alberta Foothills Streams

Sediment intrusion into streambed gravel can impair aquatic habitat and result in fish mortality. Industrial development has been a factor in stressing bull trout (Salvelinus confluentus) and Athabasca rainbow trout (Oncorhynchus mykiss (Walbaum)) populations in Alberta's foothills. Road crossings are a primary source of erosion and sedimentation into streams. Local information on the extent and effects of sediment intrusion from road crossings is limited, and expertise about sampling and monitoring methods is lacking. This study of sediment intrusion levels provides baseline information and uncovers appropriate sampling methods. It is expected that the degree of sediment intrusion is higher downstream of road crossings than upstream.

Fieldwork began in June of 1995, and was conducted until November in the Hinton-Edson region of Alberta. Sample analysis is ongoing. A second year of fieldwork begins in June of 1996. In 1995, appropriate methods for study site selection and sampling were established with the following results. 1) Study streams were chosen if the stream was of appropriate size and had suitable spawning habitat (i.e. gravel) up and downstream of the crossing; 2) The downstream sampling microsites were chosen by the presence of appropriate sized spawning substrate. Upstream microsites were paired by matching substrate size and stream velocity to the downstream microsites; 3) Volumetric freeze-core sampling was precluded because frequent large rocks in the substrate jammed the sampler barrel; 4) A simple hollow probe with dry ice and ethanol as coolant was used successfully to obtain non-volumetric samples.

The study provides practical knowledge of how freeze-core sampling can be implemented in Alberta foothills streams. Results may provide a basis to continue monitoring the extent and effects of sediment intrusion from road crossings and other sources. More informed management decisions may be made with these developments.

***May 4, Morning Concurrent Session B* 11:30 - 11:50 AM**

Michael D. Purser (Confederated Tribes of the Umatilla Indian Reservation, Portland, OR) and Jonathan J. Rhodes (Columbia River Inter-Tribal Fish Commission, Portland, OR)

Overwinter Sedimentation of Clean Gravels in Simulated Redds in the Grande Ronde River, Oregon, USA: Implications for the Survival of Endangered Spring Chinook Salmon

Since 1992, overwinter sedimentation of gravels during the incubation period for spring chinook has been monitored in the Grande Ronde River in northeastern Oregon, USA to evaluate its effects on salmon survival. Spring chinook populations in the river have declined precipitously since late 1960's and have been listed as "threatened" under the Endangered Species Act. While high levels of mortality at downstream hydroelectric facilities are a major cause of these on-going population declines, habitat degradation has also contributed significantly by greatly reducing egg-to-smolt survival. The river has high levels of fine sediment in channel substrate caused by elevated sediment delivery roads, logging, mining, and grazing, in combination with natural sources of sediment, including fire. During the past fifty years, the majority of large pools in the river have been lost (McIntosh et al., 1994); increased sediment delivery from land management has been identified as a probable contributor to pool loss.

Overwinter sedimentation was monitored by placing cleaned gravels in rigid containers in in spawning habitat in sites constructed to mimic salmon redds. The canisters of cleaned gravels were emplaced in the constructed "redds" in the fall prior to the onset of spawning and retreived in the subsequent spring after salmon emergence. Channel morphology and surface fine sediment levels were measured concurrent with container emplacement and retrieval. In the Grande Ronde River, streamflow was continuously measured at gaging stations near the sampling points for overwinter sedimentation. Sediment accumulations within the canisters were determined using standard soil texture methods.

Results indicate that fine sediment filled all available interstitial spaces in the cleaned gravels consistently in the Grande Ronde River at the time of fry emergence, at levels that are expected to significantly reduce salmon survival-to-emergence (Bjornn and Rieser, 1991). Samples collected in adjacent rivers with lower levels of surface fine sediment than the Grande Ronde River also exhibited increases in fine sediment from overwinter sedimentation but at lower levels than in the Grande Ronde River. Stream discharge magnitude during the incubation period does not appear to play a major role in controlling overwinter sedimentation in the artificial redds. It appears that during all years monitored, winter streamflow is adequate to mobilize fine sediment, especially when levels of fine sediment at the substrate surface are high. The level of sedimentation within redds appears to be controlled primarily by the availability of surface fine sediment that is readily transported by streamflow during the incubation period.

While literature concerning the effects of fine sediment on salmon consistently indicates that salmon survival-to-emergence is reduced by fine sediment in spawning substrate, it has been argued that ambient substrate conditions cannot be used to infer substrate conditions within the redd or egg-pocket nor estimate survival because salmon winnow fine sediment from the redd during the act of spawning (Chapman and McLeod, 1987; Everest et al., 1987). Our data indicate that although salmon may winnow fine sediment out of redds, this condition is transitory in streams with high levels of fine sediment at the bed surface. In fact, the cleaning of gravels during spawning may actually increase the final amount of fine sediment in redds in streams with relatively high levels of overwinter fine sediment transport, because fine sediment intrusion is greatest in clean substrate with relatively large void spaces unobstructed by smaller particles (Lisle, 1989).

***May 4, Plenary Wrap-Up Session* 1:10 - 1:30 PM**

Robert Gill (A.G. Crook Company, Beaverton, OR) Paul L. Boehne (US Forest Service, La Grande, OR) and Henry A. Froehlich (Oregon State University.Corvallis, OR)

Sediment Delivery Following Road Construction and Timber Harvest in the Blue Mountains, Oregon

Many studies have focused on improving our understanding of the effects of timber harvesting activities on soil, water, and fisheries resources. This work has led to the development and widespread use of soil erosion prediction models by land managers. Widespread use has often resulted in model applications that are outside the bounds in which the models were developed.

There is currently no adequate method for predicting the quantity of sediment delivered to first and second order channels following road construction and harvesting in areas of ash-influenced soils in the Blue Mountains of northeastern Oregon. The objectives of this study were: (1) to determine the amount and rate of sediment delivery to ephemeral (first and second order) stream channels following road construction and logging, and (2) to evaluate the WWSED sediment yield predictions.

Methods included: in-channel and on-slope sediment trapping for quantity and rate determination. Measurements were completed from 1991 through 1993.

No statistically significant relationships between the quantity of sediment yielded versus either inherent or management disturbance factors could be concluded from this data set. While there appears to be no significant relationship between inherent or management induced disturbance factors and sediment yield, there has been a two-fold increase in sediment yield when comparing 1993 to 1991 sediment yields, and a ten-fold increase in sediment yield when comparing 1993 to 1992 sediment yields.

It can be concluded that while there was an increase in sediment yield in the Syrup Creek Study Area, there is no statistically significant relationship between this increase and inherent or management factors. This may be due, in part, to the limited data set with only three years of observations. It is likely that there are other inherent and management factors which would help explain the variation in sediment yields.

It has also been shown that the WWSED Model has drastically over estimated the sediment yield from this area. From this, we can conclude that the variability of natural systems is far more complex than can be simplified into a prediction model.

May 4, Plenary Wrap-Up Session 1:30 - 1:50 PM

D.H. Van Lear (Department of Forest Resources, Clemson University, Clemson, SC) H.R. Barwick, K.L. Manuel (Duke Power Company, Huntersville, NC), B.C. Dysart, III (Environmental Issues Management, Atlanta, GA), A.R. Abernathy retired, (Environmental Systems Engineering Department, Clemson University, Clemson, SC), S.D. Miller, (CH2M Hill, Boise, ID) and S. M. Dillard (RUST Inc., Greenville, SC)

Sedimentation Impacts on Benthic Macroinvertebrates and Rainbow Trout in a Southern Appalachian Stream

Benthic macroinvertebrates and wild rainbow trout (*Oncorhynchus mykiss*) were monitored in Howard Creek for 11 yr (1980-1990) before and after construction of a pumped-storage facility in northwestern South Carolina. Substrate changes, as detected by sand fraction analysis, were correlated with various construction activities, ranging from forest clearing to installation of erosion control structures. Total macroinvertebrate density in riffle sections was monitored quarterly using Surber samplers while fish were sampled annually by electroshocking. Natural variability and the significance of sediment-induced changes were assessed by graphical and correlation analysis, and included comparisons both to a control station and to 2 yr of preconstruction data. Fine sediments (<0.125 mm in diameter) significantly increased in the substrate during construction and were identified as the principal cause of both benthos and trout impacts. The very fine sand (VFS) percentage of the total sand fraction in the upper 5 cm of the substrate was strongly and negatively correlated with benthos density and trout catch rates. Sand fraction analysis of the substrate can provide a simple, sensitive, reasonably accurate, and economical indication of impacts to benthic macroinvertebrates and trout in mountain streams threatened by sedimentation.

May 4, Plenary Wrap-Up Session 1:50 - 2:10 PM

James L. Dunnigan, David H. Bennett (Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID) and Bruce E. Rieman (US Forest Service, Intermountain Research Station, Boise, ID)

Effects of Forest Practices on Westslope Cutthroat Trout Distribution and Abundance in the Coeur D' Alene River System, Idaho (Student Paper)

We sampled 76 streams using a stratified random sampling design in the Coeur d' Alene River basin to determine the spatial distribution of westslope cutthroat trout *Oncorhynchus clarki lewisi* during 1994 and 1995 with a single electrofishing pass. Cutthroat densities were adjusted from estimates of absolute abundance at randomly selected sites. Land management activities had no effect on spatial distribution of cutthroat trout and densities ranged from 0.3 fish/100 m^2 to 60.6 fish/100 m^2 (mean 95% C.I. of +/- 19.7 fish/100 m^2). Positive correlation was found between pool frequency and cutthroat trout abundance. Most cutthroat trout spawning was in the headwater streams and principally in second order streams. Lowest cutthroat trout population densities coincided with areas of the most intense forest practices and the highest degree of habitat fragmentation.

***May 4, Plenary Wrap-Up Session* 2:10 - 2:30 PM**

Michael Sullivan (University of Alberta, Edmonton, AB)

How Buffer Strips Cause Stability and Destroy Ecosystems

Aquatic systems in the boreal forest are dynamic over large time and space scales. Natural processes such as river meandering, forest succession, fires, and floods are instrumental in shaping the communities of animals in these systems. Many applied studies tend to focus on determining methods of reducing the immediate effects of forestry practices such as siltation and altered run-off. However the solutions often posed from these studies (buffer strips, stream bank stabilization, flood control) will often also tend to reduce the antural occurrence and succession of these vital formative processes. I will use examples from the boreal forests of Alberta to describe the natural changes that shape these aquatic systems and illustrate the loss of diversity that would result from stablilizing the perceived negative effects of forestry practices. Aquatic inventory projects should be directed to surveying systems along natural gradients of these processes (eg. streams in recent burns, middle-aged forests, and old-growth forests; streams along similar gradients of occurrences of major floods). The naturally occurring frequencies and distributions of these successional communities could then form the long-term goals of mitigating the detrimental effects of forestry.

***May 4, Plenary Wrap-Up Session* 2:30 - 2:50 PM**

P. Kennard(Tulalip Tribes Natural Resources Department, Marysville, WA), Geoge R. Pess, (Tulalip Tribes Natural Resources Department, Marysville, WA), T. Beechie (Department of Forest Resources, University of Washington, Seattle, WA) D.R. Berg (Edmond, WA) and B. Bilby (Weyerhaeuser Co., Tacoma, WA)

Riparian-In-A-Box: A Manager's Tool to Predict the Impacts of Riparian Management on Fish Habitat

"Riparian-in-a-box" is an applied large woody debris (LWD) recruitment and channel function model. It allows resource managers to quantitatively evaluate the future effects of management of stream-side stands on site-specific, in-channel characteristics such as LWD abundance, and pool frequencies and areas. Model inputs describe the proposed riparian stand (tree species, and numbers of trees and sizes) and the current channel conditions (channel type, amounts and sizes of LWD, and number and types of pools). The model uses growth and mortality functions to estimate future riparian conditions, a tree-fall model to approximate wood recruitment to the channel, and empirical large wood-pool relationships to predict in-channel conditions.

With this model, managers can evaluate the effectiveness of different riparian management options at achieving specific in-stream goals for numbers or sizes of LWD and pool amounts or areas. For example, fisheries managers may specify a pool surface area objective based on the channel type and local reference site conditions. The model can then be used to test how rapidly different management strategies attain the pool area objectives and for how long the goal is met. Managers can also combine model results with additional information (such as costs of riparian options, and the benefits to potential fish production from increased pools) to provide a rational basis for evaluating management options.

There are benefits to this approach. First, agreement among interested parties is promoted, because common management goals can be translated into quantifiable targets and proposed management actions can be compared unambiguously. Second, the evaluation of management implications is technically justified, because of the reliance on a process-based, scientific methodology that has been used successfully in the past. Additionally, the model can be readily improved as new information becomes available. Third, it allows all managers to determine, through monitoring, if the management scenarios are achieving the desired results.

ABSTRACTS FOR POSTER PRESENTATIONS

Peter Bergstrom (Swedish Univ. of Agricultural Sciences, Urrea, Sweden) and Kajsa Markusson (National Board of Fisheries, Orebro, Sweden)

Developing forest practices to protect fauna in small streams in Sweden

In Sweden forest practices until the end of the 1980s did not take into consideration the conservation value of small forest streams. Logging was performed without leaving any riparian buffer zone, and no measures were taken to lessen the sediment delivery or to minimize the effects of road crossings. As a consequence, forestry has had a large negative impact on stream habitat, fish migration and biodiversity of fauna.

A nation-wide survey revealed that stream sites subjected to logging or other intensive forest practices held significantly fewer populations of brown trout (*Salmo trutta*), and that trout reproductive success was lowered. Other changes in fish species abundance and distrubution were also significant, as well as changes in water vegetation and water temperature.

In 1995, the World Wildlife Fund, the Board of Fisheries, the University of Agricultural Science and three of the larger forest companies initiated project SILVA, which aims at developing forest practices that will preserve the physical habitat and the biota in small streams. The project primarily focusses on strategies for logging along streams.

Field experiments will be carried out in 24 different streams, all with populations of brown trout and some also with the freshwater pearl mussel (*Margaritifera margaritifera*). The streams were carefully selected to minimize abiotic differences. Logging will be carried out by leaving a:

- thin (5m) continuos riparian zone;
- thin (5m) fragmentated riparian zone;
- leaving a broad (20m) intact riparian zone.

The results will be compared with reference sites with intact forest and sites completely logged along the streams. The study starts 1996 and will continue until 1999. Abundance of fish and benthic invertebrates will be quantified, along with basic chemistry, vegetation, bottom substrate and temperature.

D.C.Bragg, (D.W. Roberts (Department of Forest Resources and Ecology Center, Utah State University, Logan, UT) and J. Kershner (Fish Ecology Unit, Intermountain Forest and Range Experiment Unit, USDA Forest Service, Utah State University, Logan, UT)

Modelling Coarse Woody Debris Dynamics In Small, Spruce-Fir Dominated Riparian Systems Of The Central Rocky Mountains, U.S.A. (Student Poster)

Coarse woody debris (CWD - pieces of wood >10 cm d.b.h. and >1 m length) was historically considered undesirable within many stream systems in the western U.S. because of the perceived hindrance to commerce or fish movement, resulting in its widespread removal. These removals are now recognized to be detrimental to stream development and function, but managers are largely uncertain how to ameliorate this condition. We have developed a model that permits the use of a popular forest growth and yield simulator (the Forest Vegetation Simulator, or FVS) to predict the minimal possible CWD production for streams over time. Developed for use in small (1st through 3rd order) streams in spruce-fir forests of the Bridger-Teton National Forest in northwest Wyoming, the model provides the conceptual linkage for its application to other regions and vegetation types in that it uses empirically-derived mortality estimates, coupled to stochastically determined CWD formative processes, to simulate the dynamics of CWD entrance into streams. A number of streams were sampled on the Bridger-Teton National Forest during the summer of 1995 to provide some of the empirical framework for both model development and scenario-testing. These moderate-to-steep gradient (2-10%), low-sinuosity streams drained basins of 400 to 10,000 ha, ranged from 3.0 - 17.6 m bankfull width, and contained 4.8 to 54.5 m^3 CWD/100 m of stream. In addition to stream CWD, adjacent riparian forests were also sampled for stand attributes and CWD characteristics. These forested stands were mature or old-growth, largely Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), blue spruce (*Picea pungens* Engelm.), and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), 116.5 to 489.4 m^3ha^{-1} of living tree biomass, with 57.2 to 217.4 m^3ha^{-1} of forest CWD. Treatments of no stand harvest, no stream clearing (control); no stand harvest, stream clearing (baseline); selection harvest, stream clearing (moderate effect), and clearcut, stream clearing (heavy effect) were modelled on select stands to estimate the CWD response of riparian forests. This model has the potential to assist managers in linking forest and stream ecosystems, and allow management strategies to be crafted to fit the needs of both timber production and riparian habitat preservation.

ABSTRACTS FOR POSTER PRESENTATIONS

Eero Jutila (Finnish Game and Fisheries Research Institute, Helsinki, Finland)

Observations of the Effects of Humus and Sand Loading on the Survival of Brown Trout Eggs in Brooks Exposed to Forest Drainage

In the catchment area of the River Isojoki, Western Finland, the survival of brown trout eggs was studied in brooks with natural state and in brooks exposed to forest drainage. Newly fertilized eggs, together with pebbles were put in Vibert-boxes into rapids of forest brooks, and the hatching success into the yolk sack phase was controlled next spring. Eggs with the same origin were also incubated in one rapid of the main river, and as a control, in a hatchery locating close by that rapid.

The survival of eggs was highest (mean 82%) in the natural brook of Lohiluoma in the ground water areas of Lauhanvuori National Park. The survival was lowest (mean 0%) in the very sanded brook of Huykanluoma, which flows through easily eroding sandy soils. The negative effects of soil erosion were also observed in the brooks of Pajuluoma and Lylylyoma. In the brook of Pajuluoma, there were two incubation rapids with mean survival of 14% in the upper and 10% in the lower one. The forest drains emptying into the brook from a new drainage area may affect the survival in the lower rapid, where visually approximated more humus and mineral material was sedimented in and on the incubation boxes. In the brook of Lylyluoma, there was two incubation sites in the same rapid with the mean survival 77% in the upper and 57% in the lower one. There was immediately upstreams the incubation rapid a newly made clear cutting and drainage area, where soil was prepared for forest planting. In the lower incubation site with deeper and slower flow than the upper one, humus and mineral material similar with the soil upstreams in the drainage area was sedimented in the incubation boxes.

On the basis of these observations, forest drainage especially together with soil preparation seem to increase soil erosion and can thus increase the mortality of brown trout eggs incubating in the brooks. The negative effects of soil erosion can first be observed in suboptimal flow and bottom areas by lowering survival of eggs. By high amounts of eroded humus and mineral particles, the reproduction of brown trout is restricted only to optimal flow conditions and also there the survival may be very low. This is supported by the observations in the main river. The mean survival of eggs was about 75% in the hatchery, but in the neighbouring rapid the incubation boxes were covered and filled with dark sand and mineral material, and the mean survival was as low as 2%. Even though the natural survival rate in the main river might be better than observed it is obvious, that the effects of increased soil erosion cumulate in the main river and may threaten the survival and reproduction of both local stocks in the brooks and the natural sea trout stock in the main river.

L.Z. Florence, H.V. Nguyen, M. Hiltz, K.L. Smiley, S. Wu and M. Herbut (Alberta Environmental Centre, Statistical Support Services Section, Vegreville, AB)

Statistical Methods For Analyzing Fish Data When Sample Sizes Are Small

We present non-parametric, computer-intensive methods for statistical data analyses of fish populations when sample sizes are 'small'. While resampling and Monte Carlo methods are not substitutes for having larger sample sizes, they offer some of the best alternatives for estimating size, growth and contaminant concentrations, when samples are inadequate and/or sparsely allocated among cells. This paper demonstrates some of the computational methods based on the 'bootstrap', 'jackknife' (Efron 1982), and other more recent resampling strategies (Manly 1992).

ABSTRACTS FOR POSTER PRESENTATIONS

Robert France (McGill University, Dept. of Biology, Montreal, PQ) and Robert Peters (McGill University, Department of Biology, Monteal, PQ)

Summary of Results Concerning Element Transfer Between Riparian Forests and Littoral Zones of Canadian Shield Lakes

The extent of land-water ecotonal coupling for small headwater lakes in northwestern Ontario has been studied since 1992 and has produced over a dozen papers either currently in press or under review. Annotated results of this work will be summarized in the present poster. Topics covered include: Macroinvertebrate standing crop in littoral regions of allochthonous detritus accumulation: implications for riparian forest management; Predictive model of the effects on lake deforestation; Comparison of macrobenthos communities in the littoral zones of boreal headwater lakes with logged and undisturbed riparian forests; Empirically estimating the lateral transport of riparian leaf litter to lakes; The influence of beaver lodges in structuring the integrity of littoral communities in boreal headwater lakes; Decreased carbon and nutrient input to boreal lakes from particulate organic matter following riparian clearcutting; Land-water linkages: habitat loss for cold stenotherms in lakes as a consequence of riparian deforestation; Persistence of coarse woody debris in boreal lakes in relation to the decreased input from riparian clearcutting; Boreal forestry and warm and coolwater fisheries: influence of riparian clearcutting and litterfall on soil erosion; Macroinvertebrate colonization of coarse woody debris in Canadian Shield lakes in relation to expected changes in riparian tree species following clearcutting; and Boreal forestry and coldwater fisheries; spatial relationships between riparian trees, litterfall, and soil retention with reference to buffer strip management.

Andrew M. Gordon, N.K. Kaushik (Department of Environmental Biology, University of Guelph), M. Ridgway (Fisheries Research Branch, Ontario Ministry of Natural Resources, Maple, ON), S. Marshall (Department of Environmental Biology, University of Guelph, Guelph, ON), W. Cole (Ontario Forest Research Institute, Ont. Min. Nat. Res., Sault Ste. Marie, ON), E. Mallory (Department of Environmental Biology, University of Guelph, Guelph, ON), B. LaZerte (Ontario Ministry of Environment and Energy, Dorset, ON), R. Brooks (Department of Zoology, University of Guelph, Guelph, ON), K. Bowen, R. McCart, R. Pope, A. Back, J. Roberts (Department of Environmental Biology, University of Guelph, Guelph, ON) R. Guyette (School of Natural Resources, University of Missouri, Columbia, MO), D. Cunnington (Department of Zoology, University of Guelph, Guelph, ON), Z. Lan, P. Zhang, A. Kuechle, S. Zhang, G. LeBreton, M. Ficker (Department of Environmental Biology, University of Guelph, Guelph, ON), A.G. Gordon (Ontario Forest Research Institute, Ont. Min. Nat. Res., Sault Ste. Marie, ON), J. King (Department of Zoology, University of Toronto, Toronto, ON) and W. J. Crins (Ontario Ministry of Natural Resources, Huntsville, ON).

Ecological Interactions On The Aquatic-Terrestrial Interface Of An Oligotrophic Source Lake In The Central Ontario Highlands

Linkages between lakes and surrounding terrestrial habitat have long been recognized as important in terms of energy flow in both directions. However, despite this awareness, the nature and dynamics of the processes linking these systems and the role of the ecotone in mediating these processes, have not been well-studied.

In an attempt to understand the structure of the forest-lake ecotone and the complex interactions that occur at this aquatic-terrestrial interface, we have begun a series of long-term investigations on an oligotrophic source lake in the Algonquin Highlands of central Ontario. Our study site is Scott Lake, located at the Swan Lake Forest Research Station in Algonquin Provincial Park.

We are currently concentrating on the major energy and nutrient transfers from the surrounding terrestrial system to the littoral zone of the lake, including litterfall, movement of coarse woody debris, throughfall and sub-surface flow. Our studies include the investigation of the control exerted on the major aquatic organisms (e.g. fish,zooplankton) by these terrestrial inputs and the relationship of these inputs to terrestrial habitat characteristics such as canopy structure and nitrogen mineralization. The role of coarse woody debris in the littoral zone is also being explored as a functional source of energy and nutrients for the aquatic food web. Other vectors of energy transfer (e.g. salamanders and insects) are also being studied.

These processes and vectors are being studied within the development of a riparian habitat classification system which possess both structural and functional components. Implications for shoreline use and management are discussed.

ABSTRACTS FOR POSTER PRESENTATIONS

Paul J. Hveneggard and Dave T. Walty (Fisheries Management Division, Alberta Environmental Protection, Peace River, AB)

The Cooperative Fisheries Inventory Program

The cooperative fisheries inventory program is a long-term multi-agency initiative between Alberta anglers, the Department of Fisheries and Oceans, Alberta Fish and Wildlife and the timber harvest industry with the intent of collecting and providing current fish and fish habitat data for inclusion into timber harvest planning. Data are collected in a standardized and duplicable format, then stored in a database designed to serve as a fisheries information layer in a geographical information system (GIS) already used by industry for planning. This pro-active approach to timber harvest planning improves fisheries resource protection through efficient integration of fisheries data into the planning process. This poster displays the partnership strategy towards program support, multi-agency benefits and the transfer of information from field data collection to usage in the planning process.

Eero Jutila and Jarmo Koskiniemi (Finnish Game and Fisheries Research Institute, Helsinki, Finland)

Genetic Differences of the Brown Trout Stocks in the River Isojoki Basin

The fish fauna and the distribution of brown trout was surveyed by electrical fishing in fifty forest brooks of the River Isojoki Basin, Western Finland. Brown trout was caught in 27 brooks, and in this connection also brown trout samples were collected for genetic studies. The enzyme genetic variability of the brown trout stocks was examined by the electrophoresis. All the brook samples differed significantly from the cultivated stocks of the R. Isojoki sea trout. The brown trout in the brooks could be divided into five genetically differentiated stocks. The brown trout stocks in the brooks in the lower part of the river form three clearly differentiated stocks. Also the tributaries of Karijoki and Heikkilanjoki have their own differentiated stocks.

The number of differentiated stocks may be higher, because all the potential brown trout brooks were not studied. The results have anyway an important challenge both for the conservation of fish tocks and for the forestry. Differentiated stocks have always some genetic material, which is lacking in other stocks, and on the other hand no single stock can have all the genetic maerial of the whole fish stock. The different brown trout stocks should always be taken into consideration in the activities affecting brook waters.

In the forest management e.g. forest drainage and dredging of brooks cause potential risks for the biodiversity of fish stocks. In the R. Isojoki Basin, during the last few decades decrease or disappearance of brown trout stocks were reported in 14 brooks in the postal fisheries inquiry of local people. The reason for this was generally considered to be forest drainage and dredging of brooks. The negative effects of these activities could also be observed by the field studies made in the R. Isojoki Basin.

ABSTRACTS FOR POSTER PRESENTATIONS

J.H. McCarthy (Department of Biology, Memorial University of Newfoundland, St. John's, NF). D.A. Scruton (Department of Fisheries and Oceans, St. John's, NF), J.M. Green (Department of Biology, Memorail University of Newfoundland, St. John's NF), and R.S. McKinley (University of Waterloo, Biology Department, Waterloo, ON)

Use of Radio Telemetry to Evaluate Movements, Habitat Use, and Spawning of Brook Trout in the Copper Lake Watershed, Newfoundland, Canada. (Student Paper)

Movements of 20 brook trout (*Salvelinus fontinalis*) in two lakes (17.5 and 82.4 ha) within the Copper Lake Watershed, Newfoundland, Canada were monitored between August 9 and October 7, 1995 using surgically implanted radio transmitters. This research was undertaken as a component of a larger buffer zone study to help determine the effects of clear-cut harvesting on the fish population dynamics of the watershed. Fish were tracked daily with a hand-held receiver from several fixed land locations; and represented the largest fish size class in the watershed (>110 grams). Movement of fish was varied with 88% exhibiting home ranges less than one third the area of their 'home lake'. Three fish moved into headwater streams to spawn and none moved between lakes. Examination of home ranges and movements indicated an association with lacustrine spawning sites. Lake spawning of brook trout in Newfoundland has rarely been documented and these observations will assist in evaluating the importance of lacustrine and fluvial spawning habitats.

Daniel Miller (Department of Geological Sciences, University of WashingtonSeattle, WA)

Assessing Physical Controls On Deep-Seated Landsliding

Deep-seated landslides pose a dilemma for land managers who must utilize certain natural resources while protecting others from adverse environmental impacts. In the Pacific Northwest such landslides periodically dominate sediment input to certain channel systems, with consequent impacts to channel and riparian morphology and associated aquatic habitat. It is therefore imperative that the controls on landslide activity be identified when making landuse decisions. These controls, however, can be difficult to distinguish: empirical techniques work well for mapping areas affected by landsliding, but are often incapable of predicting the impacts of land use on specific landslides. Numerical models of the physical processes of deep-seated mass movement can provide additional information for evaluating hazards where empirical evidence is insufficient or ambiguous. Coupled with a geographic information system (GIS), such models can be used to examine the spatial influence of specific environmental perturbations. Models can be formulated to accommodate information at a variety of scales so that both regional mapping (e.g., 1:24000-scale topographic and geologic maps) and/or detailed site surveys can be utilized. These strategies are illustrated with both a regional and site-specific example in northwest Washington state. For both cases, deep-seated landsliding over the past several decades had caused degradation of an important fishery, yet historic data were insufficient to clearly identify the primary factors controlling landslide activity. Of particular interest is landslide sensitivity to increases in pore pressure, which may be affected by timber harvest in the groundwater recharge area. Modeling results clarify the relative influence of different environmental factors and identify the specific sensitivities of individual landslides: certain landslides are found to react primarily to pore-pressure changes, others to stream erosion of the toe. These results focus further field efforts and help provide a rational basis for landuse decisions.

ABSTRACTS FOR POSTER PRESENTATIONS

Robert Morrison (Water Resources Services, Alberta Environment Protection, Calgary, AB)

Bow Basin Plan - A Water Management Strategy for the Future of the Bow River Basin

Two key tasks of the Bow Basin Plan are:

- to determine how land management influences the flow and quality of water
- to develop measures to ensure that land management does not jeopardize instream and withdrawal uses.

The Plan is concerned about all aspects of aquatic and riparian ecosystems including human uses of those ecosystems such as fishing, canoeing, hiking, grazing, and timber management. Analysis and evaluation for the Plan will consider the cumulative impacts of development and use.

The Plan focuses on priority issues and relies heavily on indicators of ecosystem health and impact from human activity. It is a partnership between the public and government based on reliable scientific data, well-understood trade-offs between benefits and costs, and consensus-based deliberations.

Proper management of the forested area of the Bow River Basin is vital to the protection of water quality and the maintenance of a reliable water supply. The consequences of managing forested land are important not only to the local people and industries, but to downstream water users such as municipalities, recreationists, and farmers.

Seppo Peuanen, Pekka J. Vuorinen, Marja Vuorinen and Christina Tigerstedt (Finnish Game And Fisheries Research Institute, Helsinki, Finland)

Effects of Iron, Aluminium, Humic Acids and Low pH on Brown Trout *(Salmo Trutta)* and Grayling *(Thymallus Thymallus)* Gills and Physiology

Effects of iron (II+III; 2 mg/l) alone (brown trout) or with aluminium (250 *ug/l/* grayling) on one-summer-old fish were studied at pHs 5 and 6 with or without humic preparations (15 mg/l) in three-day laboratory exposures. The recovery of grayling from metal exposure at 3 and 13° C was also investigated. Gills were damaged at both pHs, more at pH 5. The lamellae adhered together and hypertrophy of the epithelial cells led to a significant increase in the diffusion distance in the gills, which decreased the oxygen uptake and impaired the ion regulation (low plasma Na^+ and Cl^- concentrations). The blood glucose concentration increased in both brown trout and grayling in the presence of metals. Some individuals of both species died due to the exposure to iron or iron and aluminium at pH 5 without added humic acids. The presence of humic acids decreased the toxicity of iron and aluminium more in grayling than brown trout. However, even in grayling, the oxygen uptake did not fully recover at either pH. Grayling were able to recover within six days from the one-week metal exposure at 13° C, but did not fully recover at 3° C. It is concluded that iron is toxic to fish in concentrations commonly detected in waters affected by forest management operations (e.g., ditching); the effects are more pronounced in cold waters. The presence of humic substances do not completely prevent the damages to fish.

ABSTRACTS FOR POSTER PRESENTATIONS

Chris Reynolds (Earth Mirror Consulting, Calgary, AB)

Stream Ecology And Bull Trout Awareness Campaign: Getting the Information Out

The bull trout (Salvelinus confluentus), once the most abundant stream trout along Alberta's east slope streams, is in trouble. It has disappeared from most of its previous range in Alberta. Its voracious appetite makes it vulnerable to overfishing and in times past, far more bull trout have been caught than produced. Adding to this problem was the slow reproductive rate of the bull trout. The places where bull trout live have also been affected. The specific spawning habitat requirements of the bull trout are uncommon and many of its spawning areas have been damaged or destroyed. The bull trout has also encountered problems in getting where it needs to go. Habitat degradation results from many decisions —— individual, corporate, and agency for example, including:

- dams and improperly designed culverts which block migration routes to spawning grounds;
- grazing patterns on riparian areas;
- road construction practices that block or sediment streams;
- logging on private and public lands which uses practices which affect watersheds;
- floodplain developments and resulting flood control engineering.

A challenge exists to create ecological literacy about stream ecology using the bull trout as an emblem of the issues. Recent designation of the bull trout as Alberta's provincial fish and its high public profile as a species of concern makes it an excellent ambassador for the healthy streams it requires to live.

As with all initiatives like this, it's success or failure will depend on the community's ability to embrace a new way to view their relationships with their local environment. Land owners, resource managers, teachers, communities, and individuals of all ages must begin to question the ecological impacts of the choices they make every day.

This poster session will present the steps being used to reach target audiences effectively, repeatedly and with continuity.

D.A. Scruton, K.D. Clarke (Department of Fisheries and Oceans, St. John's, NF), J.H. McCarthy, S. Forsey(Department of Biology, Memorial University of Newfoundland St. John's, NF), D.M. Whitaker(Biopsychology Program Department of Psychology, Memorial University of Newfoundland, St. John's, NF), G.I. McT. Cowan, E. Baggs(Department of Biology, Memorial University of Newfoundland St. John's, NF), W.A. Montevecchi (Biopsychology Program Department of Psychology, Memorial University of Newfoundland, St. John's, NF), J.M. Green (Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland), I. Bell (Newfoundland Department of Environment 0 Water Resources Management Division, Comer Brook, NF), and L.J. Moores (Newfoundland Department of Natural Resources - Newfoundland Forestry Service, Corner Brook, NF).

The Copper Lake Buffer Zone Study: Project Site Description and General Study Design

In Newfoundland, Canada, current recommended buffer strip sizes for environmental protection related to forest management practices are based on 'best available information' from research conducted in other jurisdictions. Region-specific considerations are essential to fully understand forestry and fish/wildlife interactions and to establish the need for and benefits of mandatory protective buffer zones, including appropriate size (width). The Copper Lake Buffer Zone Study, an on-going multi-agency and multi-disciplinary research study, was conceived to conduct region-specific research on the benefit of providing buffer strips in riparian zones to protect fish, wildlife and water resources. The study is intended to quantify environmental perturbations arising from forest harvesting operations and investigate the ability to ameliorate these perturbations through the provision of an unharvested riparian leave strip of varying widths. This paper describes background information on the project and baseline data collected over the first two years of study. This paper provides a general description of the study site, identifies the roles and objectives of the various study participants, outlines the general study design, and provides some detail on the various study components and methods to be employed. Aquatic study components include monitoring programs for physical environmental characteristics such as hydrology, water quality, stream temperature, sedimentation and large woody debris dynamics. These physical attributes will aid in our analysis of biological trends in benthic invertebrate abundance, brook trout population dynamics and brook trout movement/migration patterns within the watershed.

ABSTRACTS FOR POSTER PRESENTATIONS

D.A. Scruton and L.M.N. Ollerhead (Department of Fisheries and Oceans, St. John's, NF)

Historical Forest Harvesting in Atlantic Salmon Rivers in Bay St. George, Newfoundland, Canada: Evaluation of Possible Effects

Atlantic salmon (*Salmo salar*) populations in 13 watersheds draining into Bay St. Georges, Newfoundland, have demonstrated significant declines in both the commercial and recreational fisheries since the early 1970's. A working group was struck to determine the cause for decline including evaluating wether extensive forest harvesting operations within these watersheds had affected available habitat and fish production. Historic forest harvesting data for the watersheds was compiled from available sources (maps, files, and aerial photographs), with areas harvested digitized as polygons within the Newfoundland Forest Service GIS. This information was then analyzed within a SPANS GIS including recreating the harvesting history within each drainage basin. The forest harvesting history for each watershed was tabulated on an annual basis, as the area cut (in km^2 and as % of the total area cut), and then compiled and mapped in 5 year time blocks as area cut and cumulative area cut (both in km^2 and % area cut).

Information on the spatial extent and timing of forest harvesting, and associated resource road construction, formed the basis for analysis of habitat change as related to harvesting history. A detailed analysis of the hydrology of two gauged watersheds, to address large scale changes in flow patterns, was inconclusive, largely related to the incremental nature of the harvesting pattern. Resource road construction associated with harvesting has increased access, with concurrent increases in angling pressure and poaching likely, which may be a contributing factor to stock declines. Stream crossings are also a source of siltation and, in some instances, have created obstructions to upstream habitats. Although historical harvesting activity likely has had adverse effects on fish habitat, no cause-effect could be established between harvesting (extent and timing) and declines in salmon runs.

Janice Traynor and Craig Johnson (Foothills Model Forest, Hinton, AB)

WAM-Developing a Watershed Assessment Model to Consider Fisheries and Aquatic Habitat Values in Land Management Planning

The Foothills Model Forest Watershed Assessment Model (WAM) utilizes GIS and database information to evaluate management alternative for hydrologic, aquatic habitat and fishery considerations. The WAM framework incorporates current understanding of the interactions between land-use activities, the physical environment and biological environment, specifically the aquatic environment.

The development of the WAM framework, as part of the ecologically based Foothills Model Forest Decision Support System, will allow managers to assess alternative management options, learn from the process and consequently better understand the links between terrestrial and aquatic systems. Analysis of land management alternatives within such a system will yield information on resource relationships and the relative impacts of alternative management options.

ABSTRACTS FOR POSTER PRESENTATIONS

P. Tschaplinski (Ministry of Forests, Victoria BC), C. Scrivener (Dept. of Fisheries & Oceans, Nanaimo, BC), S. Macdonald (Dept. of Fisheries & Oceans, West Vancouver, BC), P. Beaudry (Ministry of Forests, Prince George, BC), T. Whitehouse (Dept. of Fisheries & Oceans, New Westminster, BC), D. Hogan (Ministry of Forest, Victoria, BC), J. Heinonen (Dept. of Fisheries and Oceans, Vancouver, BC), A. Gottesfeld (University of Northern BC, Prince George, BC) and E. Petticrew (UNBC Faculty of Natural Resources and Environmental, Prince George, BC)

Stuart-Takla Fisheries-Forestry Interaction Project

The relationships between forestry activities and the productivity of aquatic ecosystems in the central interior of British Columbia are not well known because relatively little research has been undertaken in this region. Because of regional differences in climate, topography, hydrology, and soils, the results of over 25 years of research conducted on coastal BC systems is frequently not applicable in the interior. The Stuart-Takla Fisheries-Forestry Interaction Project is a long-term, multi-agency, and multi-disciplinary study of the effects of modern forestry practices on interior stream ecosystems, fish populations, and fish habitats. This multi-watershed study, initiated in 1990, is the first of its kind in the interior of British Columbia.

The Stuart-Takla drainage is located in the northernmost part of the Fraser River basin. This area contains high-value forestry, fisheries, and recreational resources. It is especially important for the production of sockeye salmon. The Fraser basin is one of the most important salmon producing systems in North America. Over 25% of the annual production of sockeye salmon from the Fraser River originates in the Stuart-Takla drainage. Research on fisheries-forestry interactions is thus vital to ensure that these prime salmonid spawning and rearing habitats are protected in the future. The information obtained will be essential for making ecologically sound decisions about integrated resource management, and for testing, evaluating, and refining current harvesting and resource protection provisions for interior forests within the new Forest Practices Code.

The project presently consists of twenty component research programs and features experimental controls in both space and time. Fisheries-forestry studies are included within four broad research subjects: stream morphology and fish habitats, sediment dynamics, thermal dynamics, and hydrology. Forestry associated effects will be evaluated relative to changes in the abundance of sockeye salmon determined from annual enumerations of adult spawners returning to the study streams in July and August, and fry leaving these natal streams in spring. Plans are currently underway to designate the Stuart-Takla study as an Experimental Watershed, with future research expanding to concentrate on ecosystem management.

Presenters Addresses

Last Name	First Name	Firm Name	Address	City	Province	Postal Code/zip	Country
Abernathy	A.R.	Clemson University		Clemson	SC	29634	U.S.A
Allan	C.J.	University of North Carolina		Charlotte	NC	28223	U.S.A
Ashley	Ken	MoELP	2204 Main Mall UBC	Vancouver	BC	V6T 1W5	Canada
Back	A.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Barwick	D.H.	Duke Power Company	13339 Hagers Ferry Rd	Huntersville	NC	28078-7929	U.S.A
Beaty	K.G.	Freshwater Institue	501 University Cres.	Winnipeg	MB	R3T 2N6	Canada
Beechie	T.	University of Washington		Seattle	WA	98125	U.S.A
Berg	D.R.		15806 - 60th Ave. W.	Edmonds	WA	98026	U.S.A
Bergstrom	Glen	Alberta Environmental	9 Flr. Bramalea Building	Edmonton	AB		Canada
Bergstrom	Peter	Swedish University		Umea		S-901 83	Sweden
Bilby	Robert E.	Weyerhaeusr Co.		Tacoma	WA	98477	U.S.A
Boehne	Paul L.	U.S.F.S.	408 Cedar St.	La Grande	OR	97850-1214	U.S.A
Bowen	K.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Bozek	M.A.	Centre for Northern Forest		Thunder Bay	ON	P7B 5E1	Canada
Bragg	Don C.	Utah State University		Logan	UT	84322-5215	U.S.A
Brooks	R.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Clarke	Keith	Dept. of Fisheries & Oceans	P.O. Box 5667	St. John's	NF	A1C 5X1	Canada
Cole	L.J.	Dept. of Fisheries & Oceans	P.O. Box 5667	St. John's	NF	A1C 5X1	Canada
Cole	W.	Ontario Forest Research Inst.	P.O. Box 969	Sault Ste. Marie	ON	P6A 5N5	Canada
Connor	Edward J.	R2 Resource Consultants Inc.	15250 NE - 95 Street	Redmond	WA	98052	U.S.A
Crins	W.J.	Natural Resources, Ont.	P.O. Box 9000	Huntsville	ON	P0A 1K0	Canada
Cunnington	D.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Davidson	Paul W.	University of British Columbia		Vancouver	BC	V6T 1Z4	Canada
Dillard	S.M.	Rust Inc.		Greenville	SC	29615	U.S.A
Dysart, III	B.C.	Environmental Issues Mgmt.	224 Broadland Ct NW	Atlanta	GA	30342	U.S.A
Ficker	A.	University of Guelph		Guelph	ON	N1G 2W1	Canada

Presenters Addresses

Last Name	First Name	Firm Name	Address	City	Province	Postal Code/zip	Country
Florence	L.Z.	Alberta Envirinmental Centre	Postal Bag 4000	Vegreville	AB	T9C-1T4	Canada
France	Robert	McGill University	1205 Avenue. Dr.	Montreal	PQ	H3A 1B1	Canada
Froehlich	Henry A.	Oregon State University		Corvallis	OR	97331	U.S.A
Gilmore	Daniel W.	Canadian Forest Products Ltd.	Postal Bag 100	Grande Prairie	AB	T8V 3A3	Canada
Gordon	Andrew M.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Gordon	A.G.	Ontario Forest Research Inst.	P.O. Box 969	Sault Ste. Marie	ON	P6A 5N5	Canada
Gordon	A.G.	Ontario Forest Research Inst.	P.O. Box 969	Sault Ste. Marie	ON	P6A 5N5	Canada
Green	J.M.	Memorial University of Nfld.		St. John's	NF	A1B 5X9	Canada
Guyette	R.		University of Missouri	Columbia	MI	65211	U.S.A
Hansen	W.F.	USDA Forest Service	9931 Broad River Rd	Columbia	SC	29210-4021	U.S.A
Hartman	Gordon		1217 Rose Ann Drive	Nanaimo	BC	V9T 3Z4	Canada
Hecky	R.E.	Freshwater Institue	501 University Crescent	Winnipeg	MB	R3T 2N6	Canada
Hvenegaard	Paul	AB Environmental Protection	Bag 900-26,	Peace River	AB	T8S-1T4	Canada
Hyatt	Kim D.	North Pacific Int'l Chapter		Nanaimo	BC	V9R 5K6	Canada
James Lichatowich	Lars Mobrand &	Mobrand Biometrics		Vashon Island	WA	98070	U.S.A
Johnston	M.H.	Centre for Northern Forest		Thunder Bay	ON	P7CB 5E1	Canada
Jutila	Eero	Finnish Game and Fisheries	Box 202	Helsinki		00151	Finland
Kaushik	N.K.		University of Guelph	Guelph	ON	N1G 2W1	Canada
Kellerhals	Rolf	Consulting Engineer		Harriot Bay	BC	V0P 1H0	Canada
Kershner	Jeff	USDA-FS Fish Ecology Unit	Utah State University	Logan	UT	84322-5210	U.S.A
King	J.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Korchinski	Merle	Kaizen Environmental	333 - 50th Avenue SE	Calgary	AB	T2G 2B3	Canada
Kuechle	A.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Kushneriuk	R.S.	Centre for Northern Forest		Thunder Bay	ON	P7B 5E1	Canada
Lan	Z.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Land	Robert W.	University of British Columbia		Vancouver	BC	V6T 1Z4	Canada

Presenters Addresses

Last Name	First Name	Firm Name	Address	City	Province	Postal Code/zip	Country
Lazerte	Bruce		Dorset Research Centre	DORSET	ON	P0A 1E0	Canada
LeBreton	G.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Macdonald	J.S.	Dept. Fisheries & Oceans	4160 Marine Drive	West Vancouver	BC	V7V 1N6	Canada
Mallory	Elaine			Richmond	PQ	J0B 2H0	Canada
Manuel	K.L.	Duke Power Company	13339 Hagers Ferry Rd	Huntersville	NC	28078-7929	U.S.A
Markusson	Kajsa	Pappersbruksallen 22	S-702 15	Orebro			Sweden
Marshall	Terry	Natural Resources Ont.		Thunder Bay	ON	P7B 5E1	Canada
Mayhood	David W.	RMEC & Freshwater	1715 - 7 Avenue N.W.	Calgary	AB	T2N 0Z5	Canada
McCart	R.	University of Guelph		Guelph	ON	N1G 2W1	Canada
McCarthy	J.H.	Memorial University of Nfld		St. John's	NF	A1B 3X9	Canada
McCullough	Greg	Dept. of Fisheries & Oceans	501 University Crescent	Winnipeg	MB	R3T 2N6	Canada
Merkowsky	Alan		864 University Drive	Saskatoon	SK	S7N 0J7	Canada
Miles	Mike	M. Miles and Associates Ltd.	645 Island Road	Victoria	BC	V8S 2T7	Canada
Miller	Daniel	University of Washington	Box 351310	Seattle	WA	98195-1310	U.S.A
Miller	S.D.		700 Clearwater Lane	Boise	ID	83712-7708	U.S.A
Morrison	Robert	AB Environmental Protection	203, 2938 - 11 Street NE	Calgary	AB	T2E 7L7	Canada
Neuwirth	Maria	MT Environmental Systems	20 Citadel Pass Cst NW	Calgary	AB	T3G 3V1	Canada
Nguyen	Hai	Alberta Environmental Centre		Vegreville	AB	T9C 1T4	Canada
O'Neil	Jim	R.L. & L. Environmental	17312 - 106 Avenue	Edmonton	AB	T5S 1H9	Canada
Ollerhead	L.M.N.	Dept. of Fisheries & Oceans	P.O. Box 5667	St. John's	NF	A1C 5X1	Canada
Pattenden	Rick	R.L. & L. Environmental	17312 - 106 Avenue	Edmonton	AB	T5S 1H9	Canada
Paul	Andrew J.	University of British Columbia	2204, Main Mall,	Vancouver	BC	V6T 1Z4	Canada
Pess	George	Tulalip Tribes	7615 Totem Beach Road	Marysville	WA	98271	U.S.A
Peters	Robert	McGill University	1205 Ave. Dr. Penfield	Montreal	PQ	H3A 1B1	Canada
Peuranen	Seppo	Finnish Game and Fisheries	P.O. Box 202	Helsinki		Fin-00151	Finland
Reiser	Dudley	R2 Resource Consultants Inc.	15250 NE - 95 Street	Redmond	WA	98052	U.S.A

Presenters Addresses

Last Name	First Name	Firm Name	Address	City	Province	Postal Code/zip	Country
Rhodes	Jonathan J.		729 NE Oregon, Suite 200	Portland	OR	97232	U.S.A
Ridgway	M.	Natural Resources Ont.	Box 5000	Maple	ON	L6A 1S9	Canada
Rieman	Bruce E.	Intermountain Research	316 East Myrtle	Boise	ID	83706	U.S.A
Roberts	J.	University of Guelph		Guelph	ON	N1G 2W1	Canada
Rothwell	Rich L.	University of Alberta		Edmonton	AB	T6G 2H1	Canada
Schwalme	Karl	Alberta Environment Centre	Bag 4000	Vegreville	AB	T9C 1T4	Canada
Scruton	David	Habitat Research & Assmt.	Box 5667	St. John's	NF	A1C 5X1	Canada
Slaney	Pat	Ministry of Environment	2204 Main Mall, UBC	Vancouver	BC	V6T 1Z4	Canada
Smiley	Kevin	Alberta Environmental Centre	Bag 4000	Vegreville	AB	T9C 1T4	Canada
Sneddon	Tom	MT Environmental Systems	20 Citadel Pass Cst.NW	Calgary	AB	T3G 3V1	Canada
Swanson	Robert H.	R. H. Swanson and Associates	P.O. Box 1431	Canmore	AB	T0L 0M0	Canada
Taylor	G.B.	University of South Carolina		Columbia	SC	29212	U.S.A
Tigerstedt	Christina	Finnish Game and Fisheries	P.O. Box 202	Helsinki		Fin-00151	Finland
Traynor	Janice	Foothills Model Forest	Box 6330	Hinton	AB	T7V 1X6	Canada
Van Lear	David H.	Clemson University	Box 341003	Clemson	SC	29634	U.S.A
Vuorinen	Pekka J.	Finnish Game and Fisheries	P.O. Box 202	Helsinki		Fin-00151	Finland
Vuorinen	Marja	Finnish Game and Fisheries	P.O. Box 202	Helsinki		Fin-00151	Finland
Wright	Michael C.	Wright & Associates	2231 Neil Dr., R.R. #3	Nanaimo	BC	V9R 6T5	Canada
Zhang	P.	University of Guelph		Guelph	ON	N1G 2W1	Canada

Forest - Fish Conference:

Land Management Practices Affecting Aquatic Ecosystems

c/o Trout Unlimited Canada, P.O. Box 6270, Station D
Calgary, Alberta, T2P 2C8

Ph: (403) 221-8369 Fax: (403) 221-8368
e-mail: troutunl@freenet.calgary.ab.ca

REGISTRATION FORM

Registration Deadline: April 25, 1996

Please Print or Type

First Name_____Last Name_____

Affiliation_____Position:_____

Address_____

City/Town_____Prov./State_____Postal/Zip Code_____

Tel: Bus.( )_____Res.( )_____Fax.( )_____E-mail_____

How did you hear about the conference?_____

Registration Fees (please circle whether paying in Canadian or U.S. funds)

Early (up to Apr. 8, 1996)	195.00^{Can.}$ or 145.00^{U.S.}$ X	_____	= $ _____
Regular (after Apr. 8 1996)	225.00^{Can.}$ or 165.00^{U.S.}$ X	_____	= $ _____
Additional Banquet Ticket	$ 40.00$^{Can.}$ or $ 30.00$^{U.S.}$ X	_____	= $ _____

TOTAL $_____

Payment can be made by Cheque, Visa or Mastercard.
Please make cheque payable to: **Forest-Fish Conference**
Please circle: VISA or MASTERCARD Number_____Expiry date_____

Included in the registration fee are:
- one copy of the published proceedings from the conference;
- one ticket to the May 3 banquet and lunches on May 2, 3 & 4.

Hotel rooms are not included in the registration fee. Hotel rooms are $74.00/night (single or double plus applicable taxes). Send hotel registrations (enclosed) to the Marlborough Inn.

CANCELLATION POLICY: Cancellations received prior to noon Apr. 15/96 will be subject to a $50.00 administration fee. NO refunds will be issued after noon, Apr. 15/96.

Registration/check-in desk open times: May 1 (7:00-9:00 PM) & May 2 (7:30-8:30 AM).

Please copy this form and send it to a colleague who you think may be interested in attending.

PLACE STAMP HERE

APPOSEZ UN TIMBRE-POSTE

Coast Plaza Hotel

1316 - 33rd Street N.E.
Calgary, Alberta, Canada
T2A 6B6

Coast Plaza Hotel

GUEST NAME: _____
COMPANY NAME: **The Forest-Fish Conference**
ADDRESS: _____
CITY: _____
PROV./ST _____ ZIP/POSTAL CODE: _____
PHONE: ( ) _____ EXT . _____
ARRIVAL DATE: _____ ARRIVAL TIME _____
DEPARTURE DATE: _____
SMOKING: YES ☐ NO ☐ NUMBER OF OCCUPANTS: _____
CREDIT CARD# _____ EXP. DATE: _____
SINGLE: _____ DOUBLE: _____ MARQUIS: _____
1 BED _____ 2 BEDS _____

SIGNATURE: .....

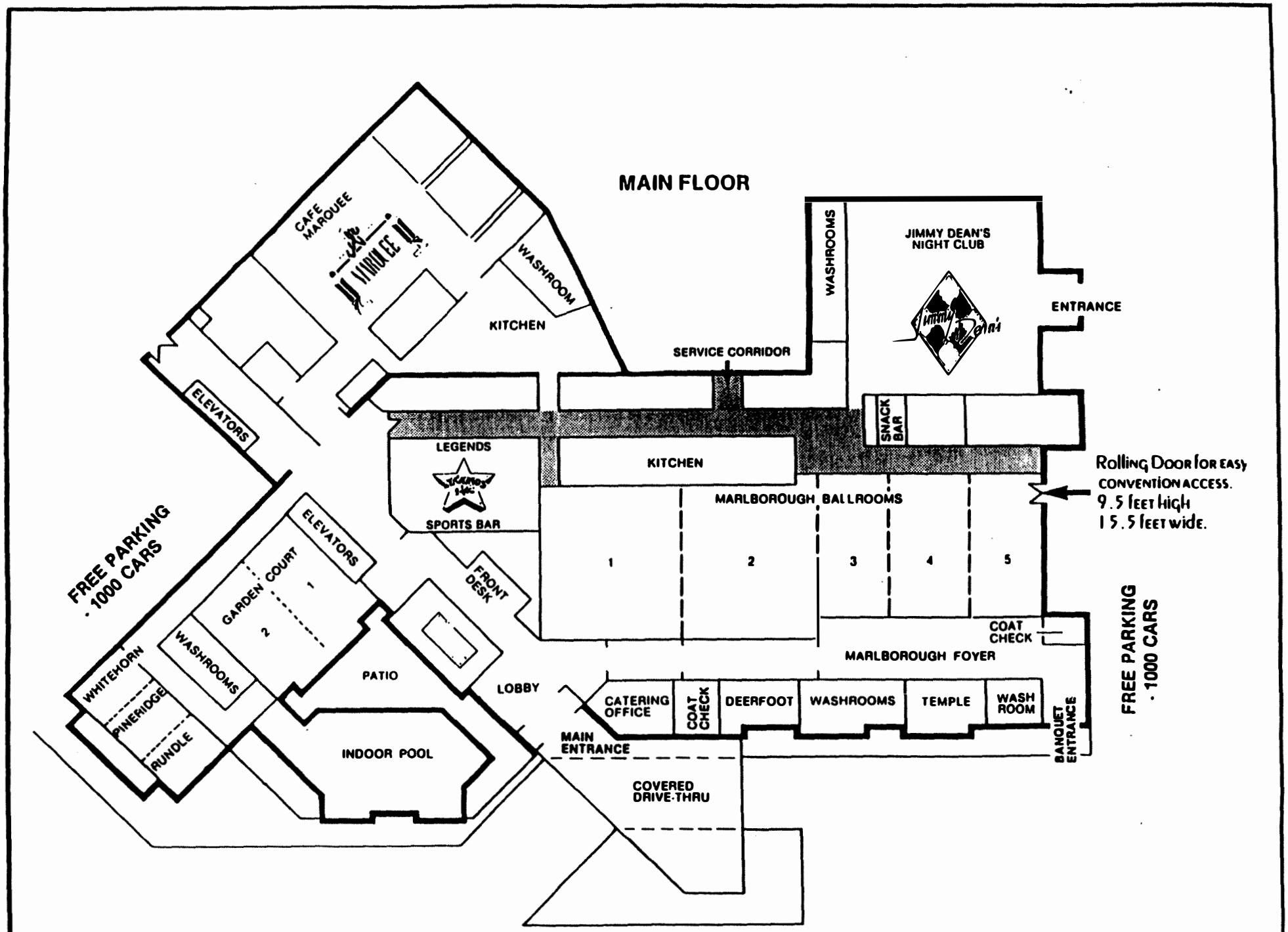
Welcomes You
To The Forest-Fish Conference

May 1 - 4, 1996

CHECK IN TIME: 3:00 p.m.

Room held until 18:00 H unless otherwise guaranteed.
Cut off date for reservations is 30 days prior to scheduled Convention date.
A deposit equal to one night's accommodation is required to guarantee your reservation.
(In Canadian Funds).

TELEPHONE: (403) 248-8888
FAX: (403) 248-0749
TOLL FREE: 1-800-661-1464


MAIN FLOOR
CAFE MARQUEE
WASHROOM
KITCHEN
SERVICE CORRIDOR
WASHROOMS
JIMMY DEAN'S NIGHT CLUB
ENTRANCE
ELEVATORS
LEGENDS
SPORTS BAR
KITCHEN
SNACK BAR
Rolling Door for easy convention access.
9.5 feet high
15.5 feet wide.
MARLBOROUGH BALLROOMS
1
2
3
4
5
FREE PARKING
· 1000 CARS
ELEVATORS
GARDEN COURT
1
2
FRONT DESK
WASHROOMS
WHITEHORN
PINERIDGE
RUNDLE
PATIO
LOBBY
COAT CHECK
MARLBOROUGH FOYER
CATERING OFFICE
COAT CHECK
DEERFOOT
WASHROOMS
TEMPLE
WASH ROOM
MAIN ENTRANCE
BANQUET ENTRANCE
INDOOR POOL
COVERED DRIVE-THRU
FREE PARKING
· 1000 CARS