WORKSHOP PROCEEDINGS

sustainable forest management network

réseau sur la gestion durable des forêts

Western Student Workshop

October 2–3, 1998
University of Alberta
Edmonton, Alberta

A Network of Centres of Excellence
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ISBN 1-55261-010-1

Proceedings of the

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INTRODUCTION

This first Sustainable Forest Management (SFM) Network Western Student Workshop arose out of a concern that many students were either unfamiliar with the Network's scope or unaware of research being undertaken by other researchers and students within the Network. The workshop was intended to bring SFM students together to share ideas, learn about each other, and meet other Network students. This workshop was organized by a group of Edmonton-based SFM Network students, with the assistance of Network staff, in the hopes that all who attended would learn more about the network and find opportunities for important interdisciplinary discussion.

A total of approximately 60 people, including students from Vancouver, Calgary, Edmonton, Winnipeg, and Montreal, took part over the two days. Also present at the workshop were representatives from industry and the Alberta Provincial Government. The response for this workshop exceeded all expectations, and all of the time available for oral presentations was filled with students wanting to share their research plans and outcomes. For the times between sessions, the walls of the conference room were lined with poster presentations.

Special measures were taken to provide information for new students who wanted to find out how their work contributes to the SFM and to provide the context and time for networking. To this end, the workshop welcome and introduction was delivered by Dr. Vic Adamowicz, the newly appointed Program Leader, who outlined the accomplishments and goals of the SFM.

Presentations, both oral and poster, revealed the diversity and relevance of SFM graduate student work. The subject matter of many presentations was clearly related, and engendered discussion after individual presentations. Session breaks were also filled with dialogue between students, attending faculty, government and industry representatives. The BBQ on Friday night provided another venue for informal interaction. The activity during the informal discussion periods was perhaps the strongest indicator that the workshop had provided a successful setting for networking.

Those who came to the conference demonstrated that the high standard of research that is expected by the SFM is being achieved. This workshop and the publication of its proceedings are meant to contribute to SFM dissemination efforts to further communication and networking between SFM students, faculty, and government and industry representatives.

For all of the participants, this was an excellent opportunity to learn about the projects of students from different provinces, universities, and departments. Special thanks are offered to the workshop organizers, and the generous sponsorship of the Sustainable Forest Management Network.

Molly Turnbull
University of Alberta Ph.D. Student

ORAL PRESENTATION ABSTRACTS

ALBERTA

UNIVERSITY OF ALBERTA

A Stochastic Characterization of the Natural Disturbance Regime of the Boreal Mixedwood Forest with Implications for Sustainable Forest Management

Presented by: Glen Armstrong, Renewable Resources
Supervisor: Drs. J.A. Beck and W.L. Adamowicz

The annual area burned on an 8.6 million ha study area in the boreal mixedwood forest of northeastern Alberta, Canada, was characterized as a serially independent random draw from a lognormal distribution. This characterization was applied in Monte Carlo simulations which showed that estimates of the mean annual burn rates, even with long sample periods, are highly imprecise. Monte Carlo simulation was also used to simulate the development of a forest subject to lognormally distributed annual burn rate in an attempt to characterize the equilibrium age class structure. No equilibrium age class structure could be identified from the simulation results. The validity of equilibrium age class distribution models (e.g., the negative exponential and Weibull) and analysis that relies on these models is questioned for forests where the annual burn rate is highly variable.

What is the Appropriate Spatial Scale for Identifying Landscape Effects on Small Mammal Abundance?

Presented by: Christine Corkum, Biological Sciences
Supervisor: Dr. S. Boutin

Landscape pattern is determined by the patchiness of vegetation at a number of spatial scales. Scale varies with the resolution of a vegetation map (grain), as well as the overall size of the area under consideration (extent). Our objective is to measure landscape structure at a number of spatial scales, by varying grain and extent, and relate the consequent landscape variables to the abundance of small mammals in Alberta's boreal mixed-wood forest. Abundance of *Clethrionomys gapperi* (red-backed vole) and *Peromyscus maniculatus* (deer mouse) was determined by live trapping in the Owl River and Goodwin Lake area of northeastern Alberta. The landscapes censured represented similar levels of heterogeneity but varied in disturbance regime. Both species are general in their habitat requirements relative to species normally studied by landscape ecologists, providing an opportunity to examine landscape effects on animals that use most habitat types to some degree. Generalists do not perceive resource patches as finely as specialists and they require less area to meet their needs. Therefore, in spring when abundance reflects resource suitability, *P. maniculatus* is expected to respond to landscape structure at a coarser grain and smaller extent than *C. gapperi* since past research indicates it is less specialized. However, in the fall when abundance reflects dispersal, *P. maniculatus* may respond at a larger extent than *C. gapperi* because of its greater mobility. Future

collaborations within the SFMN will allow comparisons across regions, and interspecific comparisons in the same study area, to further address questions about spatial scale.

Treatment of High Strength Pulp Mill Effluents by Freeze-Thaw
Presented by: Roderick Facey, Civil and Environmental Engineering
Supervisor: Dr. D.W. Smith

Experiments conducted in the laboratory have shown freeze-thaw to be an effective treatment method for high strength pulp mill effluents to substantially reduce the initial volume of contaminated liquid. Freezing rate, method of thawing, and temperature and time frozen for the effluent were identified as important parameters that affect separation efficiency. Scanning electron microscopy studies of ice specimens collected from frozen samples showed the effluent's constituents were concentrated to form fragile, settable floc/precipitate-like structures whose morphology was found to be dependent on the freezing conditions. At freezing temperatures approaching the effluent's minimum freezing point (-2ºC), the frozen state physical properties of the floc/precipitate structures consisted of thick, porous wafers arranged in "honey comb" like patterns. The average thickness of these wafers was 30.2 microns in a range of 9.2 to 68.4 microns. At higher freezing rates for an initial freezing temperature of -15ºC, the wafer-like structures produced were thinner, more compact with no visible porosity, and arranged in sheet like patterns. The average thickness of these wafers was 1.9 microns in a range of 0.8 to 4.5 microns. The relationship between wafer thickness and separation efficiency improved with increasing wafer thickness, which was, in part, dependent on freezing rate. The floc/precipitate structures produced during freezing were fragile and susceptible to break-up from disturbances during thawing. The method by which the frozen effluent was thawed was crucial in achieving high separation efficiencies. Thawing from the top down, in which the ice was not allowed to float, resulted in poor separation. Thawing the frozen effluent from predominately the bottom up, in which the ice was allowed to float, substantially improved separation. This observation was attributed to the downward flow pattern of the melt water having greatly assisted in minimizing the disturbances to fragile floc/precipitate structures during thawing, as well as in the concentration and settlement of this separated material. Constituent removals of as high as 80% were reported in the top 70 % liquid volume when the waste effluent was slowly frozen and then immediately thawed from predominately the bottom up. Increasing the time frozen while simultaneously decreasing the freezing temperature of the frozen effluent further improved separation upon thawing.

Living Arrangements: The Relationship between Red Squirrel Distribution and Landscape Structure in the Harvested Mixedwood Boreal Forest
Presented by: Jason Fisher, Biological Sciences
Supervisor: Dr. S. Boutin

Ecology by definition is the study of organisms in their home. Few researchers would claim that a home or patch is an isolated unit unto itself, yet few have investigated the influences of landscape-scale arrangement of neighbouring habitat patches on the distribution of an organism, nor considered how far-reaching such influence may be. This

study was designed to examine these effects in the mixed-wood boreal forest on the AlPac FMA. Red squirrel (*Tamiasciurus hudsonicus*) distribution was measured on grid systems in harvested, control and burned landscapes, and related to landscape structure quantified at a number of spatial scales. The home-range size of a squirrel, measured by radio telemetry, was hypothesized to be indicative of a the scale at which landscape effects would be significant predictors of distribution, but preliminary data suggest this is not the case. However, it appears that in heterogeneous areas where spruce (squirrel's primary habitat) is scarce, home ranges encompass adjacent cutblocks and aspen patches, perhaps as supplementary food resources. Future analysis will focus on the relative importance of landscape structure on aspen-dwelling vs. conifer-dwelling squirrels as suggested by vegetation data. By understanding the role of large-scale heterogeneity and patch distribution, it is hoped that landscape design protocols can be developed that lessen the impact of harvesting on wildlife.

Regional Forest Resource Accounting: A Northern Alberta Case Study
Presented by: Michel Haener, Rural Economy
Supervisor: Dr. W.L. Adamowicz

Natural resource accounting is a potential tool for assessing the socioeconomic sustainability of forestry practices. The contributions of resource accounting to policy assessment and planning are quite well established. In the area of forestry, several countries (most notably Sweden) have attempted to augment the contribution of timber production to national income with the production of value from other forest assets and services. However, resource accounting at finer resolutions is not common. The formulation of a resource accounting framework that generates useful information regarding the sustainability of regional development in the context of a forest ecosystem is the problem investigated in this study.

This study develops a forest resource account for a region of public forestland in northern Alberta. The account includes both commercial and non-commercial uses of the forest. The commercial services considered include forestry, fishing, and trapping. The non-market service values include recreational activities (recreational hunting, fishing and camping), environmental control services (carbon sequestration), and provision of resource for subsistence purposes. The non-use or passive use services of biodiveristy maintenance are also considered. The values of these component services in 1996 are estimated and then aggregated to determine the annual net income provided by the forest. The findings provide valuable information related to the relative size of component values and identify the need for improved information related to several important forest services. Maintaining this type of regional forest resource account over time will provide valuable information to forest managers regarding the sustainability of regional forest income.

The Economic Incentives of the Allowable Cut Effect: An Empirical Analysis From a Public Policy Perspective for FMA's in Alberta

Presented by: Larry Hegan, Rural Economy
Supervisor: Dr. M.K. Luckert

The Allowable Cut Effect (ACE) is being used as an incentive to encourage more voluntary enhanced forest management (EFM) by tenure holders of timber rights on Crown forest land. Economists have for some time debated the economic validity of the ACE. As an artifact of sustainable yield (SY) policy, the ACE is criticized for distorting the returns to EFM investments, which contributes to a lower net value of wealth derived from timber harvesting that is volume-constrained over time. However, if SY forestry is considered as a given form of policy, then the ACE is argued by some to have economic merit by reducing the costs imposed with SY. This paper then explores the extent of investment incentives from the ACE for FMAs in Alberta under various scenarios of EFM and SY policy. Prior to the empirical analysis, a review of the economic literature on the ACE places the context of this analysis from a public policy perspective. Then the forest modeling program Woodstock (ver.2) and the linear programming solver C-Whiz, were used to simulate various timber supply optimization runs over a 200-year period for a forest within a typical FMA. The parameters for constructing the various simulations were: a mature or juvenile starting age class for the forest, a form of intensive or extensive EFM investment, annual allowable cut (AAC) for just coniferous or both deciduous and coniferous volumes, and different levels of flexibility allowed around the AAC. The results indicate that there are limited opportunities, based on FMAs collecting the positive net return to stumpage values, for the ACE to create incentives for voluntary EFM.

Are Black-Backed and Three-Toed Woodpeckers Burn-Dependent?

Presented by: Jeff Hoyt, Biological Sciences
Supervisor: Dr. S. Hannon

In recent years, increased logging of old growth forests and the suppression of fire within the boreal forest, has produced many questions about what will happen to species that appear to be dependent on these habitats and processes. To answer these questions, extensive habitat association data is required. Two species that appear to be dependent on burned and old growth habitats are Black-backed and Three-toed woodpeckers. Habitat association surveys have been conducted in burned, old growth and mature coniferous forests to determine which habitat types Black-backed and Three-toed woodpeckers are occupying. Initial survey results suggested that Black-backed woodpeckers are solely occupying burned areas and Three-toed woodpeckers are occupying burned and old growth areas in similar abundance. During the spring of 1998, surveys were conducted in different aged burns to determine how long burns remain suitable habitat for Black-backed and Three-toed woodpeckers. In addition, foraging and nesting requirements were examined to strengthen the ability to predict what are suitable habitats for these species within the forested landscape. These data are necessary if we hope to incorporate these species' needs into future forest management planning.

Scale Modeling for Carbon Dynamics and Disturbance Regimes of Boreal Forests in Central Canada
Presented by: Hong Jiang, Renewable Resources
Supervisor: Dr. M.J. Apps

Carbon dynamics of boreal forest ecosystems is sensitive to climate change and disturbance regimes. Carbon dynamics of boreal forests under fire and harvest disturbances in Central Canada (Saskatchewan) was simulated by CENTURY, a processing model of terrestrial ecosystems. Boreal forests of Central Canada (Saskatchewan) include high, mid-, and low boreal ecoclimatic regions. In each region, about 10 typical sites were selected, climate and soil data were collected for the input parameter file of CENTURY, and the disturbance regime and intensity of fire and harvest organized into the executive file. Fire and harvest disturbance regime were uniform (100 yr interval, simulation 5000 yrs). The indicators of carbon dynamics of boreal forest ecosystems are biomass, net primary productivity, litter, soil organic matter and soil pool. Through calculating the mean and standard error of each ecoclimatic region of boreal forest, the simulation result of sites was integrated into region by statistics analysis, then the difference between boreal forest regions compared. Simulation results show that different boreal ecoclimatic regions in Central Canada (Saskatchewan) have different responses in carbon pool capacity change and carbon allocation pattern for fire and harvest disturbance.

The Impacts of Forest Fire on Aquatic Ecosystems in the Boreal Sub-Arctic
Presented by: Preston McEachern, Biological Sciences
Supervisor: Dr. E.E. Prepas

An introduction to a joint SFM-Industry-First Nations project will be presented. The primary goal of the project is to model aquatic chemistry under natural and disturbed conditions. I will outline initial questions and hypotheses and use examples from data collected over the last two years to lead participants to new theories and my current research direction.

Water quality data collected during 1996 and 97 from 32 lakes in the Caribou Mountains of northern Alberta (59°N 115°W) will be presented. During the summer of 1995, 110,000 ha of this peatland dominated landscape were consumed by a wildfire. The selected lakes reside in watersheds that were either burned in 1995, burned in previous fires, or unburned in over the 50 years of available fire records. With these data, I address the questions: 1) What are the effects of forest fire on nutrient and major ion concentrations in lakes? 2) Can these changes be empirically explained by landscape and morphometric features? 3) How do chemical changes effect algal assemblages and biomass?

Towards a Co-operative Forest Management Strategy: The Whitefish Lake First Nation Case Study
Presented by: David Natcher, Anthropology
Supervisor: Dr. C. Hickey

In 1994, the Whitefish Lake First Nation (WFLFN) and the Province of Alberta entered into an agreement that called for cooperative approaches to land, wildlife, and fisheries management in the area surrounding Whitefish Lake reserve (approx. 2,700 sq. km). In January of 1998, the terms of the WFLFN Co-Operative Management Agreement underwent implementation. Specific goals of the agreement include economic development initiatives, education and training programs for Whitefish Lake residents, and the implementation of a cooperative management regime for local lands and resources. Through these negotiations, WFLFN was successful in establishing the only First Nation – Province of Alberta Co-operative Management Agreement to date as recognized under the terms of a Treaty Entitlement.

Specific to the objectives of the Sustainable Forest Management Network, and a primary component of the co-operative management agreement, was the undertaking of a land use and occupancy study of the Whitefish Lake community. It was recognized that any attempt to make informed land 'management' decisions required an understanding of community land and resource use patterns. Therefore, this study was designed to incorporate the cultural (non-market) values of community residents with the economic interest of resource developers operating in the area; thus the quantification of both market and non-market values was initiated. The ultimate purpose of this study is not to restrict future land and resource use, but rather, to be used as a guide for sound land use initiatives that serve to preserve and protect the cultural values of the Whitefish Lake residents.

Multiple-Scale Analysis of Barred Owl Habitat in the Boreal Mixedwood Forest of Alberta
Presented by: Ben Olsen, Biological Sciences
Supervisor: Dr. S. Hannon

During the course of an owl community inventory (1994–1996), we found that the barred owl is a common year-round resident of the boreal mixedwood forest near Calling Lake, Alberta. Barred owls responded at 20 of 53 call-survey locations, representing 12 different territories within the study area. Fifteen adult and five juvenile barred owls were radio collared in order to (1) locate nesting sites, (2) determine foraging habitat use and summer home range size, and (3) monitor the pre-dispersal movement of juveniles around natal areas. Barred owl nesting sites (n = 10) were characterized by a high density of large diameter (>34 cm dbh) snags compared to random locations within owl territories (n = 30). Cavity trees used by barred owls were larger in diameter (mean = 51.6 cm) than random cavity trees within owl territories (mean = 42.1). At the home range scale, barred owl territories contained a higher proportion of old-growth forest (>90 yr) than young forest (<60 yr) compared to the landscape. However, within owl home ranges, owls selected foraging habitats randomly. Patch size was more significant in

determining foraging habitat selection that stand age and cover type. Since barred owl habitat selection is influenced by spatial scale, forest management practices at the cut-block and township level will likely affect barred owl habitat availability and pattern. Based on our observations, we discuss management guidelines which are important for the conservation of barred owl habitat in the boreal mixedwood forest.

Macroeconomic Indicators of Sustainability for the Province of Alberta
Presented by: Angela Pearson, Rural Economy
Supervisor: Dr. T.S. Veeman

Various "rules" for sustainable development have been put forward in recent years, but none of these can be readily operationalized. This leaves the next best alternative of tracking our progress toward a sustainable path using the indicators of sustainability. Macro indicators of sustainability have the advantages of relatively broad applicability and unambiguous interpretation. Two macro indicators of sustainability are assessed and empirically implemented in this research: environmentally-adjusted gross domestic product (GDP), and the Pearce-Atkinson measure (PAM) of weak sustainability.

Resource extraction industries are major contributors to Alberta's economy: in 1996, forestry and related manufacturing industries made up to 2% of Alberta's GDP, while oil and gas extraction contributed 14%. In this research, adjustments are made to GDP to reflect the depletion of forest and petroleum resources, and other environmental issues, particularly those relative to the forest industry. GDP adjustments for natural resource depletions are found to be as high as 10% of GDP at certain points during the study period, from 1961 to 1995, in spite of steady progress in the discovery of new oil and gas reserves. Further, the GDP adjustments for harvested timber have risen, in the 1990s, to about 10% of the adjustments for oil and gas depletions.

Measures of changes in capital stock are also presented, following the Pearce-Atkinson measure of weak sustainability. In this paradigm, natural and man-made capital are regarded as substitutes. Preliminary data indicate that Alberta's economy is sustainable on the basis of this criterion.

Individual Time Preference in Forest Management
Presented by: Cameron Taylor, Rural Economy
Supervisor: Dr. M.K. Luckert

A forest management plan may be characterized by a number of attributes which affect the timber and non-timber benefits produced over time. Varying these attributes will generate different time paths of benefits that may be more or less desirable to the public. This study examines four specific attributes and how they might affect an individual's preference for a particular time path and the management plan from which it comes. The four attributes to be investigated are: basic time preference (as an internal rate of return within each time path), the ordering of gains and losses, uncertainty, and goods effect. An econometric model was developed to try and explain how these factors might affect individual preference between alternate forest management scenarios.

A questionnaire was developed which presented a choice between two alternative forest management scenarios, each describing a 100 year time frame. Each scenario involved two goods, timber, and recreational usage, whose annual levels were determined by the attributes of the scenario. The goal was to examine individual choice behaviour and to estimate parameters of an individual's utility function that relate to the four attributes being studied.

Results from the study showed that individuals preferred forest management scenarios that produced a stable flow of benefits over the duration of the scenario. In the questionnaire, respondents favoured scenarios with attributes that led to flatter time paths, while rejecting scenarios with attributes producing large movements away from evenflow levels.

Monitoring Health in Invisible Populations: Health and Forest Use in Metis Communities
Presented by: Molly Turnbull, Public Health
Supervisor: Dr. N. Gibson

Currently there is no culturally sensitive method for assessing Métis population health. The Métis culture, and understandings about health, are strongly based on forest use. As the Métis often fall under the category of *Aboriginal* in health literature, the distinctions between Métis culture and First Nations' culture are overlooked. Through negotiated research methods, this project seeks to develop culturally-sensitive health indicators and produce an instrument that communities can administer to assess Métis population health. Research will be conducted in three forest industry dependent Métis communities in Northern Alberta. Methods will be employed that increase validity and foster positive working relationships with community leaders for future research.

Alberta Sawmill Study
Presented by: Michael Yamanaka, Occupational Medicine
Supervisor: Dr. T.L. Guidotti

The objective of this project is to study what the representative wood dust levels in sawmills are, and whether they meet occupational exposure limits. Nine Alberta sawmills were measured for area wood dust levels. In addition, individual workers had personal wood dust levels measured for each of the four occupational groups (cleanup, maintenance, panermill production, and sawmill production). Samples were collected in the winter 1996 and the following summer 1997. For area monitoring, all nine mills had mean total wood dust levels below the occupational exposure limit of 5 mg/m^3. For the personal monitoring samples, all nine mills had mean respirable wood dust levels below the occupational exposure limit of 1 mg/m^3. IOM sampling (another method of personal monitoring which takes into account larger wood dust particle size) revealed that one mill exceeded the wood dust exposure limit with all occupational groups combined. The findings demonstrate that the mills surveyed meet the current occupational exposure limits for total and respirable wood dust levels. With respect to IOM sampling, one mill

did not meet the standards. The results of the work suggest that the expansion of the forest products industry in Alberta can be undertaken with acceptable protection of occupational health.

Pulp Mill Effluent Induced Coagulation and Flocculation in Receiving Waters
Presented by: Xiuguo Yang, Civil and Environmental Engineering
Supervisor: Dr. D.W. Smith

Controversial conclusions have been drawn in terms of pulp mill effluent induced coagulation and flocculation in receiving waters. Thus, it is of importance to investigate if flocs can be formed after mixing pulp mill effluent and river water. Coagulation and flocculation studies were conducted using the grid mixing system. A low vertical speed of 2 mm/s was used for the study. Turbidity, total solids, total suspended solids, total settled solids, particle size distributions were used to characterize flocculation performance. The experimental results confirmed that the addition of pulp mill effluent could induce coagulation and flocculation in river water, since a quantity of flocs formed, and the turbidity and small sizes of particles of 1 to 20 μm significantly decreased. Moreover, the results of mass balance indicated that the mass of the total solids increased after flocculation. It is postulated that some dissolved solids settled out of the suspension, which attributed to the increased mass. It was also found that the formed flocs were able to settle to the bottom of the flocculator in a short period of time. Therefore, the flocculated water had much lower turbidity and particle counts. The major conclusion is that the pulp mill effluent can induce the coagulation and flocculation of materials in the receiving water and pulp mill effluent mixture.

UNIVERSITY OF CALGARY

Germinant Establishment Following Fire in the Southern Mixedwood Boreal of Canada
Presented by: Isabelle Charron, Biological Sciences
Supervisor: Dr. E.A. Johnson

The establishment following fire of four tree species, *Pinus banksiana* Lamb., *Pinus mariana* (L.) Mill., *Picea glauca* (Moench) Voss, and *Populus tremuloides* Michx., was studies in the mixedwood boreal forest of Saskatchewan, Canada. The main objective of the study was to estimate the recruitment densities of germinants as a function of seedbed type. Field observations indicate that there are significant differences in seedbed frequencies between sites. The study also demonstrates that all species establish preferentially around tree boles where there is exposed mineral soil and humus. Mineral soil and humus, which represent about 50 percent of available seedbeds following a fire, account for at least 90 percent of the germinants that establish from dispersed seeds. In addition, there is evidence for an inverse relationship between germinant survival and organic layer thickness. The study shows that a sequence of stage-specific survival values can be used to accurately estimate recruitment densities. Finally, it demonstrates that there are essentially only three cohorts following fire; that germinant mortality declines

with time; and that survival subsequently approaches one, and becomes independent of seedbed type. The results of the study now give investigators a standard for comparison with post-clearcut recruitment densities.

Analysis of Cohort Life Tables for Upland Tree Species in the Southern Mixedwood Boreal Forest of Saskatchewan
Presented by: Sheri Gutsell, Biological Sciences
Supervisor: Dr. E.A. Johnson

Cohort life tables were reconstructed for the five upland tree species in the southern mixedwood boreal forest of Saskatchewan in order to examine two questions related to forest development patterns. Results indicate that succession, i.e., species replacement in time, and gap-phase replacement do not play a significant role in the dynamics of these species. In *P. banksiana* and *P. mariana* stands, canopy composition is determined within the first three years after fire. Age-height curves show that in mixed stands, a conspicuous change in the canopy from *P. banksiana* to *P. mariana* is due to differences in growth rates between the species. In mixed stands of *P. glauca*, *P. tremuloides*, and *A. balsamea*, canopy composition is determined within the first five years after fire and may include all three species. Age-height curves show that the conspicuous change in canopy from *P. tremuloides* to *P. glauca* to *A. balsamea* is due to differences in growth rates between the species. The idea of mimicking natural disturbance such as wildfire in forest management in the boreal forest must focus on early establishment and mortality processes rather than succession of gap-phase replacement.

Effects of Commercial Thinning on Patterns of Diversity and Abundance in Bark Beetles (Coleoptera: Scolytidae)
Presented by: Trevor Hindmarch, Biological Sciences
Supervisor: Dr. M. Reid

This study relates bark beetle (Coleoptera: Scolytidae) diversity and population sizes with changes in forest structure associated with commercial thinning. Beetles were captured in funnel traps baited either with the pheromones ipsdienol and lanierone, or the tree volatile a-pinene, in four commercially thinned lodgepole pine stands and their unthinned counterparts near Whitecourt, Alberta. Preliminary analyses suggest that both diversity and population sizes were higher in thinned stands than in unthinned stands. Coarse woody debris and microclimate variables (temperature, humidity, and wind speed) were also monitored in these stands. Thinning resulted in large, instantaneous inputs of coarse woody debris, followed by periods of near normal inputs. Thinned stands were warmer, drier, and windier than their unthinned counterparts. Since bark beetles rely on fresh coarse woody debris as habitat and are sensitive to changes in microclimate, they may be good indicators of changes in forest structure, and future analyses will relate the increase in diversity and population sizes to the abundance of coarse woody debris and microclimate within these stands.

Combining Ecological Variables and Remotely Sensed Data to Determine Biological Diversity in a Boreal Forest Ecosystem
Presented by: Anthony Warren, Geomatics Engineering
Supervisors: Drs. D.A. Clausi and M.J. Collins

Under investigation is a method to integrate spatial information derived from earth process models with remotely sensed data for the purpose of mapping the spatial distribution of biological diversity in a boreal forest ecosystem. This method uses a classification algorithm based on the Dempster-Shafer Theory of Evidence which allows disparate data sources to be combined using probabilistic evidence in a supervised environment. Potential data sources include Landsat TM satellite data, synthetic aperture radar, a digital elevation model (DEM) and derived ecological and geomorphological spatial data centered over Prince Albert National Park, Saskatchewan.

Data is often used in classifications without justification and is included because it *might* increase the overall accuracy. In the context of this research, remotely sensed data will take an ancillary role with emphasis given to ecological and geomorphological relationships. For instance, there is evidence to suggest that the level of diversity can be predicted using hill-slope position and therefore justify the use of a DEM in the classification. Also, techniques for deriving *meaningful* probabilistic evidence for these data sources are of primary interest and continue to be investigated. Preliminary classification results will be presented.

BRITISH COLUMBIA

UNIVERSITY OF BRITISH COLUMBIA

Effect of Elevated Operating Temperatures on the Removal of Methanol from Synthetic Kraft Pulp Mill Condensates Using a High Temperature Membrane Bioreactor
Presented by: Pierre Bérubé, Civil Engineering
Supervisor: Dr. E.R. Hall

The feasibility of biologically treating recovery cycle condensates from a kraft pulp mill for re-use as process feedwater, using a high temperature membrane bioreactor, was investigated. It was possible to develop a mixed culture of thermotolerant methanol-utilizing bacteria on synthetic condensates containing methanol, dimethyl sulphide and dimethyl disulphide at temperatures ranging from 55ºC to 70ºC. The maximum feasible operating temperature for the biological removal of methanol from condensate using a membrane bioreactor was 60ºC. A maximum methanol uptake rate of 1.36 mg/L·min (substrate uptake rate of 0.81/day), was observed at an operating temperature of 60ºC. Above 60ºC, the methanol uptake rate declined sharply. Methanol was neither limiting or inhibitory at the methanol concentrations examined. Over 99% of the methanol was removed from the condensate at operating temperatures ranging from 55ºC to 60ºC. There were no suspended solids in the treated effluent of the membrane bioreactor. The

methanol uptake rate at 60ºC was higher than those reported for conventional biological treatment systems operating at much lower temperatures.

The Economics of Multiple Use of Forestlands
Presented by: Bryan Bogdanski, Forest Resources Management
Supervisor: Dr. G.C. van Kooten

Economists have addressed many of the fundamental questions regarding the use of forestlands to produce the optimal level of goods and services. These efforts fall into two distinct foci. The first centre of thought has approached the problem by treating forestland as a single stand of forest of uniform age. The treatment of time further divides this body of literature. The modeling frameworks are either static or dynamic. The second centre of thought has treated forestland as a collection of stands or in other words a forest unit. This body of literature is again further separated into models that include a time dimension and those which do not.

As a whole, the current economic literature on multiple-use forestry has had modest success in addressing questions of how, what, how much, and when to produce a multiple of goods and services from forestlands. The economic literature has had much less success with the question of where to produce what at the forest level scale. In short, current economic modeling approaches of the multiple-use problem do not fully account for the actual spatial and temporal aspects of forestland use.

In this paper, a two-period, three-stand model is used to illustrate the spatial and temporal aspects of the multiple use forestland resources. This model, although highly abstract, provides a basis for advancing the understanding of the economics of multiple-use of forestlands. When simplified into various special cases, the model generates results which are analogous to previous theoretical results. Further, this framework is sufficiently robust to address questions associated with land-use zoning of forestlands and intensive forestry management.

Life Cycle Assessment for Sustainable Forest Management
Presented by: Paulo Castro, Civil Engineering
Supervisor: Dr. E.R. Hall

This research focuses on the evaluation of the potential and role of life cycle assessment (LCA) methodologies within the context of sustainable forest management in the boreal forest. Work includes a review of current LCA and suggests a possible framework for its implementation with the aim of rendering the complex task of sustainable forest management (SFM) easier to tackle. It is suggested that the LCA technique *per se* might not be powerful enough to handle such an enormous task. However, the underlying concept of life cycle thinking might be a good candidate for dealing with some of the encompassing issues characterizing SFM. LCA is basically a methodology that evaluates the environmental burdens associated with a product or activity over its entire life cycle. This involves identification and quantification of materials, energy use, and waste discharges to the environment, followed by a characterization of the respective impacts.

Current methodologies, based on life cycle thinking, are still evolving in an effort to improve the evaluation of environmental effects and to incorporate additional environmental issues including socio-economic aspects.

Biological Treatment of Wood Leachate
Presented by: Kevin Frankowski, Civil Engineering
Supervisor: Dr. K.J. Hall

Rainfall percolating through chip piles, hog fuel, and log storage areas will leach wood chemicals. This leachate is often characterized by high carbon content, strong color, and high concentrations of tannins and lignins, resin acids, phenolics, and other related compounds. Not only do these compounds result in the leachate having a very high BOD (biochemical oxygen demand), but often it also very toxic to aquatic life. This has serious implications from an environmental discharge viewpoint and can lead to sitting and regulatory problems.

In an attempt to address some of these concerns from a practical perspective, a wetland-based biological treatment process is being developed. Its objectives are to develop a low-cost, passive treatment process that is capable of reducing the leachate's toxicity to the point where it is acceptable for discharge. Lab-scale studies employed a variety of techniques, including bioassays and Toxicity Identification Evaluations (TIEs), microcosm studies, and detailed chemical characterization. The laboratory experiments have achieved a 25-fold reduction in toxicity and the process appears to be very amenable to field-scale application. The next step is to test this process under field conditions. Successful trials will produce a constructed wetlands treatment system that requires a bare minimum of operational attention, hardware infrastructure, chemical addition, or materials and by-products handling. Possible applications and adaptations include treating stormwater runoff from staging areas and log yards, collection and treatment of leachate from chip piles and hog fuel, and detoxification of non-point source contamination from parking lots and other work areas.

Hydraulic Study of ASBs
Presented by: Wayne Jenkinson, Civil Engineering
Supervisor: Dr. E.R. Hall

The hydraulic characteristics of aerated stabilization basins (ASBs) are generally poorly understood. It has been found in practice that the mechanical surface aerators in a basin can have a very significant impact on the flows. Despite this, the arrangement of aerators in ASBs has predominantly followed a trial-and-error approach. Analysis generally consists of dye-tracer studies that provide only a responsive analysis of the ASB system and in only a limited way describe the mechanics of the mixing and transport phenomena. Moreover, tracer studies are useful only in analysis and provide no aid in prediction of performance.

Computational fluid dynamics (CFD) techniques have been used to predict the hydraulics of settling ponds without aeration and have been demonstrated as useful tools. This study

endeavors to carry the CFD analytical techniques to application in aerated basins. It is believed that the impact of aerators will greatly complicate the CFD technique and that the impact of mechanical aerators requires special study. A laboratory study is set up to study the hydraulic impacts of a small-scale mechanical surface-aerator in a flow-through tank. The aerator will have a 1/10 HP rating and will circulate water between 0.3 to 2 L/sec, approximately. The aerator will be tested in a 12-foot square basin with variable bulk-flow and depth control. Measurements of velocity and turbulence will be taken with an acoustic Doppler velocimeter (ADV) throughout the basin. The results of this study will be incorporated into a commercial CFD model called FLUENT. Tracer studies will also be performed to determine if a proper relationship can be gleaned between the aerator configuration and the basin dispersion number.

The Diet of the Short-tailed Weasel (*Mustela erminea*) and Harvesting Practices
Presented by: Kim Lisgo, Centre for Applied Conservation Biology
Supervisor: Dr. F. Bunnell

Little is known about the short-tailed weasel (*Mustela erminea*) in North America, particularly in the mixedwood boreal forest. *M. erminea* is one of the smallest carnivores in Canada, specializing on small mammals. In 1995–96, I conducted a live-trapping program to examine the dietary habits of weasels in the southern portion of the mixedwood boreal forest near Lac La Biche, Alberta. Scats were collected from traps and occasionally from the tops of large rocks and logs. I found the weasel's diet to consist of voles (*Clethrionomys gapperi*, *Microtus pennsylvanicus*, *Phenacomys intermedius*), lemmings (*Synaptomys borealis*), deer mice (*Peromyscus maniculatus*), jumping mice, (*Zapus hudsonicus*), shrews (*Sorex* sp.), chipmunks (*Eutamias minimus*), red squirrels (*Tamiasciurus hudsonicus*), birds and eggs. Voles and lemmings were most commonly eaten, accounting for 45.2% to 80.2% of the weasel's diet, depending on the season. I also found that red-backed voles (*C. gapperi*) were preferred over deer mice (*P. maniculatus*). These findings may have implications for management harvesting practices. In Europe and New Zealand, during years of low vole abundance, weasel numbers declined due to poor breeding success. Declines in vole populations accompanied by explosions in deer mice have also been found to occur following logging. It is possible that logging practices in Alberta's mixedwood may reduce the availability of voles, the weasel's most favoured food source, resulting in poor breeding success.

Measuring the Metabolic Activity of a Selected Member of the Resin Acid-Degrading Activated Sludge Community
Presented by: Annette Muttray, Microbiology and Immunology
Supervisor: Dr. W.W. Mohn

Resin acids are released into the waste water stream during wood pulping and account for most of the acute toxicity of wastewater to fish. The removal of resin acids by microorganisms is essential for wastewater treatment, and the microbial activity, or growth rate, of resin acid-degrading bacteria is estimated using the RNA:DNA ratio. Four bacterial isolates were grown on various carbon sources to obtain different growth rates.

Chemical colorimetric assays of the nucleic acids in pure cultures showed a positive linear correlation between growth rate and RNA:DNA ratio in three of four resin acid-degrading bacteria. We developed a new quantitative and species-specific hydridization method to measure metabolic activity of a single strain in a mixed community. The correlation of growth rate to RNA:DNA ratio was confirmed in one isolate called DhA-33 using hybridization. The method was tested on pure cultures of DhA-33 and on activated sludge, and had a detection limit for the target cells of 106 cells in 1 mL of sludge (approximately 0.1% of the total population). We measured RNA:DNA ratio over the time period of an entire batch culture of DhA-33 and detected an increase in the ratio when the cells were in the logarithmic growth phase and a decrease in the stationary phase. The RNA:DNA ratio is lower when DhA-33 has to compete with other sludge microorganisms. The RNA:DNA ratio can be used as an indicator of metabolic activity of single members in a mixed community.

Supercritical Water Oxidation for Waste Disposal
Presented by: Tazim Rehmat, Chemical Engineering
Supervisor: Dr. R. Branion

Under supercritical conditions (>375°C and 3500 psi), water is able to dissolve many organic compounds that are not very soluble at atmospheric pressure. In the presence of oxygen, these compounds can be oxidized to carbon dioxide and water. However, under supercritical conditions, many of the inorganic compounds, which are very soluble in water under normal conditions of temperature and pressure, are insoluble. These insoluble inorganics may deposit on heat transfer surfaces and foul them, or even block the flow through a supercritical water oxidation reactor.

Our 2 L/min minute supercritical water reactor with its component supercritical water generation system, fouling test section, and sampling system are described.

Solubility measurements for sodium sulfate and sodium chloride under supercritical conditions are reported. Fouling of heat transfer surfaces with these salts is discussed. Use of a mathematical model for fouling is discussed and its predictions compared to experimental measurements.

Rates of oxidation of glucose and various other organic materials and wastes are discussed. The effects of organic concentration, oxygen concentration temperature, and residence time on removal rate are reported.

Bird-Habitat Associations and Predicted Effects of Logging on Bird Habitat in the Aspen Boreal Mixedwood
Presented by: Nyree Sharp, Centre for Applied Conservation Biology
Supervisor: Dr. F. Bunnell

It has recently become profitable in the Alberta mixedwood boreal forest to harvest aspen trees for pulp and paper production. Logging practices have the potential to alter the physical structure and resident vertebrate communities of the forest. Simulation models

are an important tool in the study of such broad-scale habitat alterations. SIMFOR is a spatially-explicit model that integrates the predicted effects of forest harvest on specific habitat attributes and the response to these effects by vertebrate species. I have explored these effects by focusing on the resident bird community. I first grouped the bird species into habitat-dependency groups, or guilds, based on their life history requirements. Then, using data provided by an extensive study in northern Alberta, I developed statistical relationships between these guilds and certain habitat attributes which life history characteristics suggest would be important for those species. I also developed projections of the availability of these attributes over time, using existing data and modeling. I entered these trends and relationships into SIMFOR, along with maps and harvest schedules for a representative township in Alberta. This allowed me to project the amount of suitable habitat that will be available over time for each guild, and also the spatial distribution of that habitat. The bird guilds showed a variety of responses to logging. Those with more specific habitat requirements, such as primary cavity nesters, were predicted to decline under current forest management plans. Those with less specific habitat requirements and a preference for early seral stages were predicted to respond positively to logging in the short term. These results suggest that a variety of stand ages should be maintained over the management area, with a particular emphasis on providing a continuous supply of those attributes of old stands with which some guilds are closely associated. Some form of adaptive management would seem the most efficient way of evaluating the effects of management decisions on bird habitat and allowing alternatives to be explored.

Corporate Responses to Climate Change: Can Canadian Corporations Live Up to the Kyoto Commitment?

Presented by: Takuya Takahashi, Forest Economics and Policy Analysis
Supervisor: Drs. G.C. van Kooten and I. Vertinsky

In December 1997, Canada signed the Kyoto Climate Accord, which commits it to reduce emissions of CO_2 to 6% below 1990 levels by the years 2008–2012. How this commitment is implemented will have a significant impact on the Canadian economy. At this moment, the Federal and Provincial governments have not instituted any regulations or incentive schemes to meet this target, relying on voluntary efforts made by industry.

We use a survey device to examine how Canadian industries are responding to this challenge. We address the following questions: 1) How much effort are Canadian corporations making to reduce CO_2 emissions? 2) What factors induce companies to make such efforts? 3) What actions (e.g., limiting emissions, joint implementation, tree planting) do firms prefer?

With regard to the second question, different disciplines have suggested different models of corporate environmental response. As a working hypothesis, we employ the eclectic view that different forces simultaneously affect corporate environmental responses. That is, in addition to "hard" economic factors, such as the competitiveness and technology of the industry, "soft" factors, such as the corporate culture, management's beliefs and public pressures, will be considered in our model and tested empirically.

We focus on the forest sector because of its ability to sequester carbon through tree planting and because of its importance to the Canadian economy. Our study gives insights into the effectiveness of voluntary corporate environmental initiatives in the absence of strong governmental interventions.

Limitations for Biological Removal of Resin Acids from Pulp Mill Effluent
Presented by: Alan Werker, Civil Engineering
Supervisor: Dr. E.R. Hall

Pulp mills in Canada rely on biological treatment systems for the removal of resin acids that are released from wood during pulping and bleaching. These are priority contaminants for the pulping industry, since they are frequently associated with events of toxicity breakthrough. Although, tighter mill control has helped to minimize the losses of resin acids in wastewater, acute toxicity removal in downstream biological treatment systems may still be insufficient, particularly under dynamic loading conditions. The nature and cause of these limitations are not fully understood. This paper summarizes results from a laboratory scale study on the fate of resin acids during biological treatment. The results indicated that physico-chemical and biological interactions influenced the success in biological treatment. Changes in pH, within the typical range for biological treatment, significantly altered the bioavailability of resin acids and the ecology of microorganisms responsible for resin acid biodegradation. Changes in resin acid loading during continuous treatment also affected the biomass community structure. The capacity of a treatment system to degrade resin acids was found to be a function of the contaminant loading. Time lags for microbial enzyme induction in response to a shift-up in resin acid loading were significant and were also affected by the treatment system pH. Hence, the prevailing bioreactor operating conditions, in conjunction with the period and amplitude of loading transients, were shown to have an impact on the extent of biological removal of resin acids. Consequently, biological systems can be severely compromised by influent transients of hydrophobic acute toxicants such as resin acids.

Detoxification of Logyard Run-off
Presented by: Michael Zenaitis, Chemical Engineering
Supervisor: Dr. S.J.B. Duff

Recent concern has been expressed by environmental authorities over the toxicity to aquatic organisms of the run-off from sawmill logyards and other dryland sorts. Certain wood extractives, while needed by trees to protect them from insect or fungal attack, can be toxic to aquatic life at quite low concentrations when they are leached from the trees in the yards and then enter the nearest waterway. This research project involves the study of the treatment of this run-off so as to reduce its toxicity and allow it to be safely reintroduced into the surrounding ecosystem. Criteria to be used in determining an appropriate remediation technology will include: cost, ease of use of the system, and the ability to function in a variety of environmental conditions. This latter point can be of special concern in the case of mills in areas such as the North Coast of British Columbia which are prone to heavy rainfall.

Influence of Accumulated Dissolved and Colloidal Substances on Paper Properties and the Potential of Enzyme Treatment for Compound Removal
Presented by: Xiao Zhang, Wood Science
Supervisor: Dr. J.N. Saddler

The dissolved and colloidal substances (DCS) found in the white water of newsprint mills are composed primarily of carbohydrates, extractives, lignins, and inorganic materials. It is recognized that the concentration of these compounds will increase with increase mill water system closure, causing problems in the papermaking process, and reducing paper quality. Paper hand sheets were prepared using various types of white water to identify the effects that the detrimental substances might have on paper properties. When fungal culture filtrates obtained from Trametes versicolor were used to treat the white water samples, a significant decrease in the extractive and carbohydrate content was observed.

MANITOBA

UNIVERSITY OF MANITOBA

Forest Succession and Disturbance Dynamics in the Duck Mountains of West-Central Manitoba
Presented by: Cary Hamel, Botany
Supervisor: Dr. N.C. Kenkel

The objective of this study is to determine successional pathways for the Duck Mountain forests, and to examine how natural and human disturbances affect these successional trajectories. Forest succession trends will be inferred from current size and age-class distributions of tree species. In the summer of 1998, I enumerated seventy 10 x 10 m plots and determined plant composition and cover at each of six canopy heights: canopy trees, 15 m; subcanopy trees, 10-15 m; small trees and tall shrubs, 2-10 m; saplings and low shrubs, < 2 m; graminoids, forbs, and fern allies, usually <1 m; and bryophytes and lichens, forest floor. Seedling abundance and stem diameters were also measured, and the largest individual of each tree species was aged. Epiphytic vegetation and evidence of herbivory were also recorded. A soil pit was dug at each plot to identify soil horizons; soil will also be analyzed for pH, conductivity, particle size, and nutrient status. Preliminary survey results suggest that successional trends within the region vary widely: while some stands are self-replacing, others show evidence of strong shifts in floristic composition. Past selective logging of white spruce has altered the composition of many stands. Balsam fir occurs in the subcanopy of some stands, and is expected to become more abundant with continued fire suppression. I plan to enumerate an additional 130 plots in the summer of 1999. The 1998 and 1999 data will be used to develop a synoptic forest succession model that considers stand management practices such as fire suppression, selective logging of merchantable timber, and post-logging advanced softwood regeneration.

POSTER PRESENTATION ABSTRACTS

ALBERTA

ALBERTA RESEARCH COUNCIL

Biofiltration of Gaseous Emissions from Forest Products Manufacturing
Presented by: Karen Budwill, Alberta Research Council
Supervisor: Dr. R.N. Coleman

Biofiltration is an effective air pollution control (APC) technology to treat industrial gaseous emissions that have relatively low concentrations of toxic or obnoxious compounds. Biofiltration works on the principle that gaseous contaminants are degraded when passed through a matrix (e.g., soil, peat, bark) containing an active microbial population. The gaseous contaminants must undergo a phase transfer, from gas to the aqueous biofilm, in order for contact between the contaminant and the microorganisms to occur. Although biofilter designs tested to date have been very effective in removing compounds which are water soluble, compounds which are hydrophobic in nature (e.g., dimethyl sulphide, DMS, a common component of pulp mill emissions) are poorly removed. This is believed to be due to the reduced ability of hydrophobic compounds to diffuse into liquids as a result of their low partition coefficients in water. The objective of this project is to enhance the capability of biofiltration technology with respect to the treatment of hydrophobic volatile compounds. We have investigated the modification of the filter bed in enhancing biofilter removal efficiencies of n-hexane (model hydrophobic compound) and applied the findings from these investigations to the treatment of DMS. The goal is to provide scale-up information and on-site demonstration for applications in the forest products industry.

UNIVERSITY OF ALBERTA

The Influence of Riparian Buffer Width on Algal Production, Biomass and Species Diversity in Alberta's Boreal Lakes
Presented by: Nicole Armstrong, Biological Sciences
Supervisor: Dr. E.E. Prepas

Recent expansion of Alberta’s forest harvesting industry is expected to lead to increased disturbance of boreal lakes through enhanced nutrient runoff and erosion. A collaboration between several universities, governments, and industries has been forged to determine whether buffers of intact forest left around lakes can mitigate the potential impacts of forest harvesting, and if so, what width of buffer must remain to maximize timber extraction and minimize environmental impacts. As one of many stemming from this multidisciplinary study, this project examines the impact of four different buffer widths (20, 100, 200 and 800 m) on algal community dynamics within Alberta’s boreal lakes. Since little is known about the relative proportions of phytoplankton and epiphyton

within western boreal lakes, I propose to examine how differences in buffer width influence both the relative proportion of algal primary production and biomass, and the resulting species composition. My hypothesis is that as buffer width decreases, increased nutrient enrichment will favor littoral algae such as epiphyton while leaving pelagic phytoplankton communities unchanged. Changes in both the relative proportion of each algal assemblage and the resulting species composition may impact higher trophic levels that likely depend differently on each assemblage. It is hoped that this study will contribute significantly to our understanding of algal dynamics in western boreal lakes and will provide background data necessary to interpret potential changes in algal communities following forest harvesting. Preliminary results from the 1998 field season will be presented with a particular emphasis on algal biomass and nutrient dynamics.

Forest Management Lessons from Fire-Skips and Ground-Beetles of the Northern Rockies
Presented by: Kamal Gandhi, Biological Sciences
Supervisor: Dr. J.R. Spence

Large-scale forestry and land-use activities are known to disrupt ecological and evolutionary processes and change original faunal community structure. Land-managers in recent years are therefore pushed to search for less ecologically destructive harvesting practices while maintaining a constant timber flow. To gain insight into whether and how natural disturbance patterns can be accommodated into harvest strategies to maintain forest integrity and biodiversity, I started out to study beetles (Coleoptera: Carabidae, Staphylinidae) of fire-skips' of the northern Rockies in coniferous forests of western Alberta in 1997.

Fire-skips are residual patches of forests that are left on a landscape after a wildfire and may serve as biotic storehouses for old-growth specialists and enhance recolonization. Preliminary results indicate that fire-skips do provide refuge for old-growth species and may sustain locally endemic beetle species. Fire-skips seem to be not only an integral landscape feature of high-elevation forests but are also important in sculpting and maintaining late-successional arthropod community structure.

Environmentally Sensitive Productivity Analysis of the Canadian Pulp and Paper Industry, 1959-1994: An Input Distance Function Approach
Presented by: Atakley Hailu, Rural Economy
Supervisor: Dr. T.S. Veeman

Most empirical studies of productivity to date have considered only marketed or desirable outputs and have neglected changes in the production of pollutant outputs. This neglect of negative externalities is also evident in studies that have attempted to assess the impact of environmental regulation on productivity growth. This study employs parametric input distance functions that incorporate both desirable and undesirable outputs to provide a more complete representation of the production technology from which environmentally sensitive productivity and efficiency measures can be generated. This framework can also be used to generate information on the shadow prices of pollutant outputs or pollution

abatement costs to producers that are useful inputs for environmental policy making. The method was applied to data from the Canadian pulp and paper industry for the period from 1959 to 1994. Four desirable outputs, two water pollutant outputs (BOD and TSS) and seven inputs were identified in the estimation of the input distance function. Our results indicate that productivity measures that ignore pollutant outputs substantially underestimate the performance of the industry. Our environmentally sensitive approach indicates that the total factor productivity of the industry has been growing at the rate of 1.00 percent per year over the period from 1959 to 1994, considerably higher than the 0.19 percent per year estimate obtained without considering pollutant outputs. Our shadow price estimates, however, indicate that the cost to producers of pollution control has been rising. The main conclusion of this study is that productivity improvement, from the social viewpoint, has been stronger than conventional measures would suggest.

Pre-Disturbance Density of Aspen Defoliators: A New Approach
Presented by: Louis Morneau, Biological Sciences
Supervisor: Dr. J.R. Spence

Phytophagous insects play an important role in ecological functions. Unfortunately, the effects of forest harvest and surface burning on lepidopteran defoliator diversity are not yet fully understood. An innovative tree sampling method is used on aspen and spruce to look at the density of defoliators before disturbance occurs. Emphasize is put on forest pests of the boreal mixedwood forest of Alberta. Relationships between different characteristics of sampled trees are used to estimate quantitatively larval density on a foliage basis. Applying these estimations to the forest canopy at a stand level will give a new picture of defoliator population levels. Thus, ecological understanding of impacted invertebrate community will be improved. This study will also enhance our ability to choose harvesting strategies that do not exacerbate pest outbreaks.

Hantavirus: Public Health Implications for the Boreal Forest
Presented by: Komali Naidoo, Public Health Sciences
Supervisor: Dr. T.L. Guidotti

The re-emergence of hantavirus pulmonary syndrome (HPS) in North America, with the outbreak in 1993 in the Four Corners region of the U.S, brought much attention to the occurrence and incidence of this virus. In Canada, the first recognized case occurred in British Columbia in 1994. As of February 1998, there were 25 laboratory-confirmed HPS cases in Canada, 16 of which were reported from Alberta. Although HPS is a relatively rare disease in Canada, its investigation is relevant in developing a model for understanding the effects of ecosystem change on human health. Boreal forest perturbation, and other situations of ecosystem disturbance, may increase the risk of hantavirus, as a consequence of changes in population dynamics of the deermouse (primary carriers of HPS). This has relevant health implications for hunters and trappers; aboriginal populations primarily through lifestyles and housing issues; and forestry workers and biologists, as well as implications for forest management practices.

Specific N Release from Organic and Mineral Boreal Forest Horizons at Five Temperatures Related to Soil Field Temperatures
Presented by: Jilene Offord, Renewable Resources
Supervisor: Dr. W.B. McGill

Soil temperatures were monitored in two Alberta field sites from May, 1997 to present. In association with this monitoring, organic and mineral Ae horizons were collected from two locations in Alberta representing natural sites (Lac La Biche and Whitecourt), and two locations in Quebec representing disturbed sites greater than 50 years old (mature fire and mature logged). Intact organic horizon cores (LFH) and homogenized mineral Ae cores were incubated at five temperatures (0, 6, 12, 22, 32°C) for 313 days. Every 14–28 days, each core was leached with 0.01 M $CaCl_2$ for mineral N determination. To accommodate variability in soil N content and site history, results were normalized to a soil N basis. Accumulation of NO_3^-–N took approximately 100 days to be detected from all soil horizons. The specific cumulative mineral N (NH_4^+ + NO_3^-) release over 313 days from mineral Ae horizons ranged from 25 to 90 mg N/g N, while the specific cumulative mineral N release from organic horizons ranged from 16 to 40 mg N/g N. In general, Alberta and Quebec mature fire organic and mineral Ae horizons released more mineral N than Quebec mature logged soils. Specific cumulative mineral N release was greater from all soil horizons incubated at higher temperatures. At lower temperatures, specific nitrification rates from the mineral Ae horizons were similar among soils. However, as temperature increased, the specific rate of nitrification from Quebec mineral Ae horizons decreased. Specific nitrification rate was greater from Alberta organic horizons at all temperatures. Specific cumulative NH_4^+–N release exceeded specific cumulative NO_3–N release from both horizons. As temperature increased, the rates of NH_4^+–N and NO_3–N release from the organic horizons tended to converge.

Potential for Phosphorous Export from Gray Luvisolic Soil After Logging
Presented by: Ivan Whitson, Biological Sciences
Supervisors: Drs. E.E. Prepas and D. Chanasyk

Expansion of logging in northern Alberta may threaten lakes with accelerated eutrophication. Efforts to reduce phosphorus (P) export by modifying logging practices may however be ineffective because we do not understand the process of P transport through the subsurface in soils typical of upland areas in the region. My study will address this issue in two ways: first, I will examine the process of subsurface movement of P on a logged hillslope with fine-textured Luvisolic soil, and second, I will determine if harvesting may change the rate of subsurface P movement in these soils. Near-surface lateral flow is expected to be the primary path for P leaching on these soils. In my study, lateral flow components are estimated by use of a hydrologic tracer, calcium bromide, by evaluation of a water balance, and by interception of flow by zero-tension lysimeters. The extent of a lateral flow component will also be inferred from measurements of saturated hydraulic conductivity in the A and B horizons. Lateral and vertical pathways will be characterized in terms of P adsorption/desorption behaviour, soil-solution chemistry, extractable iron+aluminum oxides and pH. P concentration will be determined on leachate collected during summer precipitation and winter snowmelt from water wells

and lysimeters. The effect of harvesting on potential P transport will be assessed by comparing four parameters between logged and unlogged forests: 1) duration of soil frost, 2) water content, 3) pattern of movement of calcium bromide, and 4) concentrations of extractable P.

UNIVERSITY OF CALGARY

Comparing the Relative Contributions of Geomorphology and Disturbance Processes to Landscape Patterns of Plant Species Richness
Presented by: Sylvia Chipman, Biological Sciences
Supervisor: Dr. E.A. Johnson

Three landscape plant richness maps (resolution 30 m) of an approximately 3000 km^2 mixedwood boreal forest were produced: a classified map and two predicted maps. The classified richness map was produced using LANDSAT TM imagery based on richness measures for 101 sampled stands in Prince Albert National Park, Saskatchewan. One species richness map was constructed from a Digital Elevation Model based on known moisture and nutrient gradients along hillslopes, and the other was constructed using a time-since-fire map. The classified richness map was compared with both the predicted maps using the kappa coefficient of agreement. Hillslope processes, rather than disturbance, are the primary determinants of plant richness patterns. This is attributed to the adaptation of vegetation to the prevalent moisture and nutrient gradients. They are prevalent due to the similarity in which the geomorphic processes of erosion and resistance generate the gradients across the landscape. Therefore, the idea, in conservation biology, of manipulating plant richness by imitating disturbance would be ineffective since it is the relatively unchanging hillslope processes that are the primary determinants of the landscape patterns of plant richness.

BRITISH COLUMBIA

UNIVERSITY OF BRITISH COLUMBIA

Development of an Immunoassay Procedure for Monitoring Resin Acid Levels in Pulp Mill Process Waters
Presented by: Hector Gamboa, Wood Science
Supervisor: Dr. J.N. Saddler

The pulp and paper industry is moving towards mill water system closure for environmental and economic reasons. Resin acids are toxic diterpenoids present in the process waters of mechanical pulp and newsprint mills which may cause problems for mill closure. A simple, accurate, fast, reliable analytical method is necessary to monitor their levels. An enzyme-linked immunosorbent assay procedure for resin acids in process waters is being developed using polyclonal antibodies raised in rabbits. However, components present in the process waters prevented a direct analysis by ELISA, therefore

a simple solid phase extraction (SPE) procedure using an amino propyl column was developed to purify the water samples. With SPE prior to ELISA, the 50% inhibition concentration (IC_{50}) and the detection limit were determined as 5.5 ppb and 1.48 ppb, respectively. This assay's sensitivity suggests that an enzyme immunoassay system can be a promising method for monitoring resin acids in process waters of mechanical pulp and newsprint mills.

Distribution and Abundance in Pulp Mill Effluent Treatment Systems of a Resin Acid-Degrading Bacterium and a Catabolic Gene Encoding Resin Acid Biodegradation

Presented by: Zhongtang Yu, Microbiology
Supervisor: Dr. W.W. Mohn

It is essential that microorganisms effectively degrade toxic resin acids in biotreatment systems treating pulp mill effluents. *Pseudomonas* sp. BKME-9 and *Zoogloea* sp. DhA-35 are resin acid-degraders isolated from two different biotreatment systems treating bleached kraft mill effluents (BKME). Strain BKME-9 was found to have a cluster of eight genes believed to encode enzymes involved in resin acid biodegradation. One of those genes, *dhaA1*, is essential for growth of BKME-9 on resin acids and is similar to genes encoding the large subunit of aromatic ring dioxygenases. Genes apparently homologous to *dhaA1* were found in six other resin acid-degrading strains. PCR primers targeting *dhaA1*, the 16S rDNA of BKME-9, and the 16S rDNA of DhA-35 were designed and found to be specific for *dhaA1*, BKME-9, and DhA-35, respectively. Qualitative PCR assays were done with biomass samples from 20 biotreatment systems of pulp mill effluents. Using the 16S rDNA primers specific for BKME-9, the assay was positive with eleven of the samples. Using *dhaA1* primers, the assay was positive with ten of the samples. A quantitative PCR assay, using a competitive target, indicated that 140 or fewer copies of *dhaA1* were present per mL of mixed liquor in those treatment systems. Strain BKME-9 appeared to be persistent and contribute to the biodegradation of resin acids when it was added to a mixed microbial community of an activated sludge in which BKME-9 or *dhaA1* was not detectable, growing in a bleached kraft mill effluent.

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