

PhD Theses

Bourque, Charles. 1993. Sulfur dioxide absorption by spruce forests downwind from a coal-fired generator.

ABSTRACT

Total annual per hectare amounts of sulfur dioxide (SO₂) absorbed by forest canopies downwind from an elevated point source were examined by computer simulations and by measurements based on PbO₂-sulfation plates. The simulations involved four modules for modelling the release, transport and absorption of SO₂: (1) a turbulence module, (2) a dispersion module, (3) a foliar absorption module, and (4) an SO₂-loading assessment module. Daily amounts of absorbed SO₂ were calculated for downwind distances from 0 to 42 km, for smokestack heights from 30 to 200 m, and for different weather conditions, which included neutral conditions, and transitions from stable to unstable conditions. Per hectare rates of SO₂ deposition and absorption were calculated as affected by wind speed, turbulence, and canopy moisture, from dawn to dusk. Year-round influences of changing weather conditions on the SO₂ deposition pattern as affected by precipitation, atmospheric stability, wind speeds and wind directions were estimated by way of Monte Carlo simulations. These simulations were calibrated for the area surrounding the SO₂-emitting power generator at Grand Lake in Central New Brunswick (SO₂ emission rate ~ 30,000 tonnes per year). The predicated rates of canopy-absorbed SO₂ were similar to those obtained with the PbO₂ plates. The comparison, however, revealed that topography is an important factor in modifying actual SO₂ absorption rates. In total, the annual amount of SO₂ absorbed within 42 km of the source was about 2% of the total annual SO₂ emissions. Increasing the smokestack height from 72 m (current height) to 200 m would reduce this number to about 1%.

Keywords: Atmospheric turbulence, canopy ventilation, plume dispersion, Lagrangian models, foliar absorption, weather variability, Monte Carlo simulation

Meng, Fan-Rui. 1994. Sulfur dioxide effects on net photosynthesis and cumulative CO₂ fixation in Red Spruce stands.

ABSTRACT

The general objective of this thesis is to quantify the effects of SO₂ on cumulative CO₂ fixation in red spruce (*Picea rubens* Sarg.) stands.

Rates of net photosynthesis and stomatal conductance of twigs were measured under field conditions before and after twig detachment on clear midsummer days. It was found that these variables did not change significantly within 6 minutes after twig detachment. Thereafter, the rate of net photosynthesis and stomatal conductance decreased.

Foliage of mature red spruce trees was exposed to SO₂ with a branch-chamber fumigation system. Rates of net photosynthesis and stomatal conductance were measured on current-year foliage. Rates of foliar SO₂ absorption were estimated with regression models. It was found that effects of SO₂ on foliage-level net photosynthesis and stomatal conductance were negative, and in direct proportion with estimated SO₂ absorption.

Net photosynthesis and dark respiration of foliage on red spruce trees downwind from coal-burning power plant were determined. Sulfur dioxide effects on needle surface wax, foliage elemental concentrations and surficial elemental distribution were also noted. It was found that rates of net photosynthesis of current-year foliage were not significantly affected by low rates of SO₂ exposure. Dark respiration, however, was positively related to SO₂ exposure.

A canopy-level model was developed to calculate cumulative CO₂ fixation and transpiration of red spruce foliage in response to SO₂ exposure. Atmospheric SO₂ concentrations and local daily weather records (daily sunshine hours, daily maximum and minimum air temperature, daily minimum relative humidity, daily mean wind speed) served as model inputs. It was found that cumulative CO₂ fixation and cumulative transpiration should decrease linearly with increasing SO₂ absorption. Also, cumulative CO₂ fixation should be more strongly affected by SO₂ than transpiration. Hence, stand-level water use efficiency would be decreased by SO₂.

This research provides a bridge to quantify the effects of SO₂ on stand-level cumulative CO₂ fixation based on foliage-level experiments and observations.

Roy, Roger James. 1996. Towards an ecological georeferenced framework for forest management planning.

ABSTRACT

An integrated, ecologically comprehensive framework for spatial timber volume projection (STVP) is proposed which can be used to: (1) explicitly consider the effects of the spatial variation of forest ecosystem physical site factors (climate, parent material, relief) on local timber yields, (2) project future forest-level merchantable and operable timber volumes, (3) quantify the degree of variability associated with these projections, and (4) identify the location of potential timber management units (harvest blocks).

The proposed ERP (Ecologically comprehensive, Raster, Probability Vector, Deterministic) approach differs from the commonly used CVD (Current vegetation, distribution) framework in that it: (1) uses an ecologically comprehensive set of predictor variables at a level of resolution appropriate for determining site type, (2) uses a set of yield curves with an associated probability distribution instead of a single curve for each point in the forest landscape, and (3) can be used to generate raster-based timber yield response surfaces useful for visualizing how timber volume is expected to vary across the landscape and through time for different management scenarios and yield expectation levels.

A case study was done to identify differences between forest-level timber volume projections obtained with the ERP and CVD approaches. Three areas of variability in timber yields were selected for this study (i.e., low, medium and high variability in terms of soils and topography). Forest-level estimates of timber volume forecasts were based on estimates of the variability associated with local yield curves. Results of this study indicated that: (1) the variability associated with total merchantable volume projections was reduced, (2) total operable areas and volumes, and the spatial distribution of merchantable volume, operable volume and potential harvest blocks differed strongly between the forecasted differences, and (3) the greatest differences were not always obtained for the study area with the greatest ecological variability.

While an ERP approach would have the advantage of putting STVP on a firmer ecological basis, a considerable amount of additional work is required before it could be applied operationally. Some of these additional requirements are identified in the paper. Other possible applications of the ERP approach to management concerns other than STVP are also suggested.

Keywords: Forest management planning, Forest Management Information System (FMIS), Spatial Timber Volume Projection (STVP), Geographic Information System (GIS), Ecological Land Classification (ELC), Spatial models, Timber yield variability

Moayeri, Mohammad Hadi. 2000. Mass balance related sustainability of forest biomass production: Concepts and applications.

ABSTRACT

A computational mass balance framework was formulated for evaluating the long-term sustainability of potential biomass growth rates (productivity) For this, a forest sustainability model (ForSust) was developed to address: (i) potential forest biomass acidification; (ii) constraints on biomass production due to nutrient limitation and soil acid production; (iii) likely impacts of various forest disturbance scenarios on forest biomass production; (iv) soil acidification (critical acid deposition loads and related soil weathering) as net balances of atmospheric inputs, plant nutrient uptake and mineral soil weathering; (v) effects of soil acidification on forest biomass production indicators such as canopy transparency (%).

The model performance was evaluated with data that belong to the six well-studied biomass growth, by comparing model-simulated and field-estimated performance tests agreements between the various model simulations and leaching rates. The resulting cumulative accumulations of biomass production rates and the available field observations and atmospheric deposition (mainly N) by way of soil were numerically consistent with the model was applied for 12 jack pine and 10 sugar maple sites that belong to the Acid

Rain National Early Warning System of the Canadian Forest Service (ARNEWS) and may therefore reduce forest biomass for most cases serious Ca, Mg, and K deficits maintained. The results further showed that biomass nutrient input/output balances can sugar deficits occur even without biomass removal exceedances and subsequent base cation

The model was further applied for 125 ARNEWS forest sites located from Newfoundland to Alberta. For many of these sites, there was a positive relationship between canopy transparency (defoliation %) and there was a positive relationship negatively affected by high rates of atmospheric S and N deposition sensitive soils may to identify: (i) sites where intensified harvesting levels may be used maintaining the expected biomass production rates; (ii) sites where intensified harvest a problem in view of enhanced soil nutrient leaching and related effects on sustainable soil nutrient supplies and subsequent forest health. Keywords: atmospheric deposition, biomass growth, forest harvesting, forest health, leaching, mass balance, nutrient availability, sustainable productivity, uptake, weathering

Zhu, Xinbiao. 2001. The role of xylem cavitation and shoot and root freezing injuries in Yellow birch decline: Experiments and model.

ABSTRACT

The primary purpose of this study is to systematically test whether shoot dieback in birch trees is related to thawing and re-freezing events in winter that lead—in turn—to shoot and/or root freezing injuries, to reductions in spring root pressure and to a subsequent recovery from the winter-induced xylem cavitation. For that reason, extent of shoot dieback, shoot xylem cavitation, shoot and root freezing injury and root pressure were measured in yellow birch (*Betula alleghaniensis* Britt.) under simulated and natural winter conditions.

Shoot xylem cavitation was determined as percent loss of hydraulic conductivity. Shoot and root freezing injuries were measured by way of relative electrolyte leakage (REL) and triphenyl tetrazolium chloride (TTC) reduction. It was found that formation of winter shoot xylem cavitation was related to thaw duration, to freezing temperature, and to shoot desiccation. For seedlings and mature trees, shoots lost 75 to 100% of their hydraulic conductivity, thereby indicating that shoot xylem cavitation is an unavoidable winter phenomenon. Springtime root pressure in this species, however, was observed to eliminate winter cavitation almost completely.

While REL and TTC approaches were found to be suitable to diagnose freezing injury of roots, only REL was deemed good enough to diagnose shoot injury. A soil freezing temperature of -10°C was found to cause a 10% increase of root REL in potted yellow birch seedlings. This soil temperature also caused a considerable reduction of root pressure, hence leaving a large amount of post-spring xylem cavitation intact. The residual cavitation was—in turn—associated with shoot dieback of potted yellow birch.

Zhu, Zhanxue. 2001. Simulating monthly soil leaching rates using a forest biomass and nutrient cycling model.

ABSTRACT

The objectives of this study were to develop a forest biomass and nutrient cycling model, and to test this model with pre- and post-cutting field data from the Nashwaak Experimental Watershed Project (NEWP, which represents a mixed hardwood site in Chapleau in north-central Ontario. These data included information about nutrient concentrations in atmospheric deposition and in soil leachates, and ancillary information as required for model initialization. Ancillary information addressed forest cover type, stand amounts of biomass and N, S, Ca, Mg, and K contents in foliage, wood, roots, initial mineral soil nutrient contents in soil solution, on ion-exchange sites, and in soil overall. The time resolution of this model was monthly, to track changes in nutrient deposition, mineralization, uptake, and leaching throughout the year, based on mean monthly changes in temperature and precipitation.

A modular design was used to partition each forest ecosystem into separate modules that individually address: (1) water and heat (to estimate throughfall, interception, evapotranspiration, snow accumulation, snowmelt, soil temperature, soil infiltration, percolation, run-off, interflow, and potential stream discharge from precipitation and air temperature records); (2) biomass (to estimate photosynthetic production and

its subsequent allocation to foliage, wood, and root biomass, as well as litterfall and decomposition); (3) soil acidity (to estimate net H ion balance in the soil, in the context of atmospheric deposition, nutrient uptake, soil weathering, and soil ion retention); and (4) nutrient cycling dealing with N, S, Ca, Mg, and K (to estimate nutrient uptakes, mineralization, and nutrient leaching in connection with atmospheric deposition, organic matter decomposition, and soil weathering).

The resulting model was tested with the pre- and post-harvest nutrient concentration data in the soil leachates from the forest sites. From these data, it was determined that post-harvest soil leaching had increased ~5-fold for NO₃-N, 80% for NH₄-N, 71% for K, 20% for Ca, and 14% for Mg two years after the watershed-wide stem-only harvest operations at NEWP. For the tree-length harvesting on the jack pine sites, soil leaching increased ~2.5-fold for NO₃-N, 14% for NH₄-N, 50% for K, and 14% for Mg three year after harvesting. For whole-tree harvesting on the jack pine site, soil leaching increases were relatively small with 11% for NO₃-N, 13% for NH₄-N, 9% for K, and 7% for Mg for the same time period. Thereafter, these increases further diminished to pre-harvest levels within 5 years or so. Post-harvest increases for Ca were negligible at both locations.

The model simulated the field-observations quite well: for the soil nutrient concentrations, the r² values of model predicted versus field observed ranged from 0.25 to nutrient concentrations in stream water, the r² values ranged from 0.65 to 0.98; for the monthly stream flows, the r² values ranged from 0.43 to 0.61; for the nutrient leaching and stream flows, all r² values exceeded 0.90.

With the model, and through the related mass balance assessment, it was realized that current N and K supply for jack pine uptake would mainly be due to soil organic matter mineralization (83 and 66%, respectively). In contrast, the supply of Ca and Mg would mainly be due to soil mineral weathering (50 and 52%, respectively). Reducing the existing amounts of soil nutrient availabilities and forest floor organic matter accumulations on these sites through high harvesting intensities would likely result in a diminished and therefore non-sustainable nutrient supply situation.

The overall model formulation is consistent with general expectations regarding forest growth. The model may, therefore, be used to evaluate forest sustainability criteria and indicators that specifically deal with site-specific forest nutrient cycling and related nutrient availabilities within the context of sustainable forest harvesting, soil conservation and the evaluation of stream water quality.

Keywords: Season; monthly precipitation, air and soil temperature; soil moisture; forest biomass production; nutrient supplies and demands; nutrient cycling; soil leaching; nutrient contents, concentrations and fluxes; harvesting versus control; jack pine stand; mixed hardwood watershed

Nasr, Mina. 2015. Geospatial analysis of total mercury concentrations in stream and lake sediments across Canada.

ABSTRACT

This study focused on geospatially analyzing and mapping total mercury concentrations (THg) in stream and lake sediments across Canada, as compiled by the sediment surveys of the Geological Survey of Canada, Quebec, and Nova Scotia (total number of samples = 254,133). The objective was to quantify how sediment THg varies by atmospheric Hg deposition, climate, geology, topography, stream and lake morphology, vegetation/land cover type, and sediment composition pertaining to other elements and to organic matter (determined through loss on ignition: LOI).

On average, upland sediments have slightly but still significantly higher THg values (streams: 97.8 ± 1.4 SE; lakes: 113.2 ± 1.1 SE, ppb) than lowland sediments (streams: 90.1 ± 2.2 SE; lakes: 90.4 ± 0.2 SE, ppb). Lake sediment THg increases with increasing lake depth and decreasing lake area (p-value < 0.0001). Stream sediment THg increases with increasing stream depth and decreasing flow rate, order, and width (p-value < 0.0001).

Mean sediment THg decreases from forests to tundra, barrens, and ice- and snow-covered basins (p-value < 0.0001). In wetland-dominated basins, sediment THg decreases by approximately a factor of two as the wet-area portion per basin increases from 0 to 40 %. Swamp dominated basins have higher sediment THg than marsh and bog/fen dominated basins (p-value < 0.0001). Highest sediment THg

occurs downstream from high Hg-containing geogenic and anthropogenic sources, with sediment THg related to other heavy metals such as copper and zinc (p -value < 0.0001).

The examination of 10th, 25th, 50th, 75th and 90th percentiles of sediment THg displays parallel trends with increasing LOI, being lowest at LOI = 0 and highest at 30 to 50 %. This suggests that geogenic THg contributions to sediments decrease as the organic THg contributions increase. The latter relates positively to mean annual atmospheric Hg deposition and precipitation rates, and more so for lakes than for streams. The regression coefficient between lake sediment THg and mean atmospheric Hg deposition and precipitation rates amounts to 0.432 (p -value < 0.0001) per National Topographic System (NTS, 1:250,000) tile.

The standardized fish Hg concentration of the Fish Mercury Datalayer for Canada (FIMDAC) relate positively to lake sediment THg, but negatively to mean annual July temperature. This association explains 38.2 % of the mean fish Hg concentration variations per NTS tile. Hence, the climate and atmospheric Hg variations across Canada not only contribute to the Hg concentration variations in sediments but also in fish.

Furze, Shane Robert. 2018. A high-resolution digital soil mapping framework for New Brunswick, Canada.

ABSTRACT

For decades researchers have been studying forest soils and summarizing findings in the form of soil surveys with thematic soil maps depicting soil associations, broad polygons representing groups of individual soil types. With growing availability of high-resolution spatial data, it has become possible to model and map how individual soil properties vary, both spatially and with depth, across the landscape at high resolution.

This dissertation demonstrates how this can be accomplished for the Province of New Brunswick (NB), Canada by way of digital soil mapping (DSM) based on (i) existing soil information and related data sets, (ii) principles of soil formation as dictated by location-specific changes in topography, surficial geology, and climate. For this purpose, existing elevation data sets were fused via error reduction procedures to generate a comprehensive province-wide digital elevation model (DEM) at 10m resolution. The resulting DEM was then used to delineate a variety of data sets detailing spatial variations in topography, hydrology, and climate. Various sources of spatial geology depictions were combined by way of similarities in classifications resulting in re-delineations of landform and lithological attributes. In combination, the data layers generated were used to determine how specific soil properties ($n = 12,058$) vary, both spatially and with increasing depth, across the province at 10m resolution. These determinations were made possible by way of machine-based random forest regression modelling.

This dissertation provides details in terms of how (i) a province-wide soil database was generated from existing soil survey reports, (ii) how missing soil data were substituted through the process of pedotransfer function development and analysis, (iii) how the province-wide DEM layers were fused, and (iv) how the DSM procedure was formulated and executed. The soil properties selected for modelling and mapping purposes refer to soil depth, drainage, bulk density, texture, coarse fragment content, and soil organic matter content. In turn, these properties, in combination with spatial data sets (topography, geology, and climate), can be used to model and map other soil variables such as, e.g., pH, soil water retention at field capacity and permanent wilting point, and cation exchange capacity.

Jones, Marie-France. 2019. Mapping Soil trafficability by way of temporal hydrology modeling and spatial wet-areas-mapping.

ABSTRACT

Heavy forest operations can lead to extensive soil disturbances in the form of soil compaction and displacement resulting in deep rut formations, and increased erosion. To mitigate these effects through forecasting, this thesis reports on a Soil Trafficability Model (STRAM) to estimate daily soil moisture, penetrability and potential machine-specific soil rut depths, using the Forest Hydrology Model ForHyM in conjunction with digital high-resolution wet-area and soil property maps. Model development was

guided using in-field data for model validation. The data so acquired refer to (i) biweekly year-round observations of soil moisture and penetrability conditions at select sites in Fredericton, (ii) reporting on GPS-tracked wood-forwarding machine clearances in select harvest blocks across northwestern New Brunswick, and (iii) analyzing soil moisture, soil penetrability and rut depths inside and outside some of the wood-forwarding tracks, by harvest block conditions.

It was found that, through multivariate regression analysis (MR), 40 to 60% of the field-determined soil penetrability variations by way of the cone penetrability index (CI) could be related to combined variations in pore space, coarse fragment content and weather-affected variations in soil moisture. The variations in wood-forwarding machine clearances and rut depths followed a similar pattern, but the number of passes over the same track needed to be taken into account as well. Block-specific variations in elevation, forest cover type and time of operation and machine-specific variations in foot-print pressure also contributed to the rut depth variations. Using Random Forest (RF) techniques considerably improved the fitting of the field-determined variations in soil moisture, cone index and wood-forwarding rut depth to greater than 80%. From MR to RF, the uncertainty range narrowed for best-fitted pore-filled soil moisture content from ± 15 to $\pm 4.5\%$, for best-fitted soil cone penetrability from ± 0.7 to ± 0.4 MPa, and for best-fitted rut depth from ± 13 to ± 5 cm.

MEM Reports

Amankwa-Gyimah, Righteous. 2025. Estimating mean annual discharge at road and border stream intersection using Ghana as a case study.

ABSTRACT
(Unavailable)

MF Reports

Li, Yanyi. 2018. Site-specific water quality analysis of sediments and surface waters in Fredericton.

ABSTRACT

Water is the source of life, covering 71% of the earth's surface. Water is an important part of the external environment, involving life, production and other aspects. Because of water pollution, available water resources become contaminated. This report provides information on year and seasonal changes in water-affecting variables at 11 locations within the Fredericton area, New Brunswick, from river water to small streams, and upslope basin areas and water-affecting inputs, the variables refer to pH, dissolved oxygen (DO), electrical conductivity (EC) in stream and river water and sediments. Through box plotting and regression analysis, it was found that the sediment and water quality parameters varied by location, year, and season. In general, sediment DO < water DO, sediment pH < water pH, and sediment EC \approx water EC. Locations downstream from a road salt storage and road application had much higher sediment EC values than elsewhere. Dissolved DO was particularly low in sediments during spring, summer and fall, and highly variable in water, likely due to continuing changes in water flow rates, and the presence of photosynthesizing and respiring plants in water. Water and sediment pH values were on average lowest in winter. Possible reasons for these variations are discussed by location, season and year in terms of general expectations.

Keywords: water, sediment, dissolved oxygen, pH, electrical conductivity

Chen, Wei. 2020. Assessing pesticide loading and concentration with assistance of integrated hydrological models in streams of small to medium- sized watersheds.

ABSTRACT

Pesticides are increasingly used around the world along with the expansion of intensive crop cultivation and food production. Pesticide residues from agriculture fields being carried to surface and ground water

impose a potential threat to the aquatic ecosystem as well as to human health. However, monitoring potential threat of pesticide residuals in river systems is expensive and difficult. Previous studies indicated that traditionally used grab sampling methods could potentially underestimate the maximum concentrations of pesticide residues in streams by 10 to 1000 times. The objective of this study was to assess pesticide loading and concentration with assistance of integrated hydrological models in streams of small to medium- sized watersheds. Soil and Water Assessment Tool (SWAT) was selected for simulating hydrological processes together with pesticide loading and in stream pesticide concentration. Model predicted pesticide loading and pesticide concentration was compared with three years measured data from Black Brook Watershed and two Sub-basins within the same watershed. We found that the model predicted pesticide loading and in stream concentrations of three pesticides had the same seasonal trend with field surveys with some discrepancies. The discrepancies are likely caused by three main factors. 1. Model predicts the daily pesticide loading and daily average pesticide concentration and while actual pesticide concentrations change rapidly during stormflow period. 2. Current field sampling method could not capture the rapid change of pesticide concentration due to mechanical limitations. 3. Input data on exact pesticide application date were not available. In general, the pesticide modelling results indicate that the model is an effective tool in loading and concentration prediction in small agricultural watershed. We also found the model predicted pesticide loading during baseflow period were relatively high compare with near zero pesticide concentration observed. This suggest there is a need to improve in pesticide routing algorithm in SWAT model and current estimation during based flow period should be manually adjusted.

MFE Reports

Meng, Xiangfei. 2006. Design of GIS based forest road layout and environmental assessment tool. ABSTRACT

Poor road drainage has a potential of causing damage to roads, especially unpaved forest roads. In turn, forest roads can change water flow patterns, which may lead to local soil flooding, ditch erosion, siltation in down-slope water bodies, and the degradation of aquatic habitat in lake and stream bottoms. In this study, I developed an ArcView 3.3 GIS tool called FOROAD, to facilitate forest road layout by automatically avoiding steep slopes, wet areas and by minimizing the crossing of flow channels. Where stream crossings cannot be avoided, the tool also specifies culvert location and size according to drainage area and local climate normals.

MSc Theses

Meyer, Wietse Lense. 1984. Organo-metal-phosphate Complexation. ABSTRACT

The possible formation of organo-metal-phosphate complexes in forest soils was examined in this thesis by means of potentiometric titration analysis and chemical modelling. The potentiometric analysis is employed to generate quantitative information about the stability constants of such complexes. These constants allowed the prediction of chemical speciation of aluminum (Al), iron (Fe) and phosphorus (P) under certain soil conditions. The titration studies were conducted at a temperature of $25 \pm 0.1^\circ\text{C}$ under nitrogen at an ionic strength (I) of $I = 0.2\text{M KCl}$ using specially formulated complex-forming solutions within a pH-region from 2.5 to 4.5. The solutions contain Al^{3+} or Fe^{3+} ions, organic acids (salicylic, phthalic, oxalic or citric acid) and phosphate ions. The titrations are done with an optimally adjusted titration system to minimize systematic and (or) sporadic titration errors. The calibration of the pH-electrodes and the determination of the concentrations of the chemical components in the complex-forming solutions are facilitated by computer-analysis of the pertinent potentiometric titration curves using recently developed computer programs. Solutions containing metal-ions, organic acids and

phosphate-ions are also titrated potentiometrically and analyzed with state-of-the-art computer programs to generate values for the stability constants of the various complexes formed in the titration process. The magnitude of the stability constants so determined suggested that the Al^{3+} and the phosphate-complexing power of selected organic acids decreased in the order salicylate > citrate > oxalate > phthalate. Also, iron (Fe^{3+})-ions were found to be more strongly bound by salicylate- and phosphate-ions than Al^{3+} -ions.

The stability constants for some of the above complexes are used to assess the overall growth response of *Picea mariana* [Mill.] B.S.P. (black spruce) seedlings to various Al^{3+} concentrations in plant nutrient solutions by way of chemical modelling. The results indicated that chemical speciation of the Al- and P-components of the nutrient solutions appear to be correlated with the actual seedling uptake of Al^{3+} -ions when the possible formation of organo-metal-phosphate complexes was taken into account.

Keywords: Chemical speciation, nutrient solutions, organo-metal-phosphate complexes, pH-effects, potentiometric analysis, stability constants

MScEM Theses

Green, Hannah. 2024. Assessing the landscape drivers of cold-water temperatures at tributary confluence plumes: A multi-spatial analysis.

ABSTRACT

The impact of climate change and human disturbances affects the thermal regime of rivers, increasing the need for conservation of thermal refuges. Tributary confluence plumes are a classification of thermal refuges on the Restigouche River watershed. The objectives of this thesis were to use landscape attributes to predict water temperatures at tributary confluence plumes at two spatial scales (global and reach-specific) and identify how landscape drivers vary at the sub-catchment. Model 3D explored three variables, and a second model (12D) included the addition of nine other variables. We increased global variability explained between model 3D ($R^2 = 0.07$) and model 12D ($R^2 = 0.88$). We classified reach-scale models under three categories of high relative importance: bedrock, climate and canopy cover. We recommend that the Kedgwick (canopy), Restigouche and Upsalquitch Southeast (climate) tributaries be of high priority for protection, while continuing exploration into the effects of geomorphology on the watershed.

MScF Theses

McGrath, Timothy Peter. 1985. Forest biomass accumulations: A parametric approach.

ABSTRACT

A donor-controlled component model is proposed to develop a conceptual and parameter-based modelling method for the study of annual soil organic matter and plant-biomass increments of forest stands. The types of biomass carrying components addressed are foliage of above-ground wood of live trees, above-ground wood of dead trees, forest floor, roots and the solum beneath the forest floor. These components are interrelated by biomass transfer processes such as leaf productivity, wood productivity, litter-fall, and organic matter decay from the forest floor and solum. Also considered is a special leaf-area component to allow a general simulation of the overall biomass accumulation of forest stands growing from open to fully-stocked canopy conditions.

The formulation of the model leads to a convenient matrix representation of the various biomass accumulation processes in terms of biologically meaningful transfer coefficients. Knowledge of these parameters should allow for biologically realistic biomass simulations of developing forest stands via analytical and/or numerical integration procedures.

These forest biomass transfer models are also used to extract parametric information from existing forest biomass data for selected forest stands involving jack pine (*Pinus banksiana* Lamb.), Scots pine (*Pinus*

sylvestris L.), aspen (*Populus tremuloides* Michx. and *Populus grandidentata* Michx.) and northern tolerant hardwoods (mainly *Acer rubrum* L., *Acer saccharum* Marsh., *Betula alleghaniensis* Britton, and *Fagus grandifolia* Ehrh.). This is done by generating best-fitted normalized and site-class specific biomass yield curves (as modelled) from biomass data found in the literature for forest stand components such as total above-ground biomass, above-ground wood biomass, foliage biomass and forest floor biomass as well as for leaf area index, a non-biomass component. Some of the results so obtained are used to simulate the component-by-component biomass accumulation of northern tolerant hardwood forest stands when influenced by (i) the overall rate of nutrient supply on account of, e.g., forest floor decay and aggregation and (ii) by “epidemic” infestation of gypsy moth (*Lymantria dispar* L.).

Ouimet, Rock. 1985. Effects of aluminum speciation on nutrient and aluminum uptake of Black spruce in sand-culture experiments.

ABSTRACT

Described in this thesis are several experiments carried out to determine the effects of total concentrations of aluminum, oxalic acid, calcium, pH, and the resulting chemical speciation of aluminum in sand cultures on nutrient and aluminum uptake of black spruce (*Picea mariana* (Mill.) B.S.P.) seedlings. The experiments revealed that increasing the total concentration of Al in the growth medium reduced P and Ca uptake by the shoots, but K uptake was enhanced. Additions of oxalic acid to the growth media had a negative effect on Al uptake, and a stimulating effect on K, Ca, P, and S uptake. Increase of the total calcium concentration of the growth medium did not affect seedling growth or Al uptake. Increasing the pH to 4.5 caused a reduction only in the shoot Al content.

A computational analysis of the equilibrium speciation of Al in the various growth media suggested that:

1. aluminum speciation affects not only Al uptake but also the uptake of Ca, K, and P by black spruce seedlings;
2. soluble inorganic Al species and organic Al species of low degree of ionization seem to contribute to plant Al uptake while highly negatively charged organic Al species do not provide Al to plants;
3. inorganic soluble Al species increases water loss by black spruce on a root weight basis while organic Al species have no effect or reduced water loss probably because of calcium oxalate precipitation on or in the roots;
4. Uptake of P is positively related to increased proportions of H_2PO_4^- and $\text{AlOx}(\text{HPO}_4)_2^-$ in the growth medium.

Overall, it is suggested that the degree of ionization of the aluminum species rather than the chemical make-up of the Al complexes appeared to control the rate of uptake by black spruce in these experiments. Keywords: aluminum speciation, bioassays, black spruce, calcium, chemical equilibrium, nutrient uptake, oxalic acid, pH

Mellerowicz, Kajetan Tadeusz. 1989. Elemental contents (Al, Fe, Ca, Mg, K, Mn, P) and field response of two New Brunswick forest soils and of Black Spruce to simulated acid precipitation.

ABSTRACT

A 2-year study was carried out to examine indirect effects of simulated acid rain on 6-year-old black spruce (*Picea mariana* [Mill.] B.S.P.) saplings growing in two plantations with soils of contrasting sulfate retention (REECE and STONY BROOK soil associations). Solutions of 2 (control), 5, 10, 25, and 50 ppm of sulfuric acid with background ions concentration equalling amounts encountered in natural precipitation were applied to the mineral soil underneath saplings with average growth once a week during each of the two summer seasons. Total seasonal irrigation amounted to about one-fourth of natural precipitation per season. Soil cores and plant foliage and roots were sampled twice a year before and after irrigation. Water-soluble and exchangeable fractions of soil Al, Fe, Mn, Ca, Mg, K, dithionite-extractable Al and Fe, available P, and water-soluble and HCO_3^- -extractable SO_4 were determined. Elemental contents of Al, Fe, Mn, Ca, Mg, K, and P in plant needles and roots were also measured. Both soils responded to acid rain treatment with a small decrease in soil pH, and an increase of water soluble sulfate. On the REECE soil, water-soluble Fe and Mg increased. On the STONY BROOK soil, water soluble Ca

decreased. Exchangeable K and Mn increased on both soils, and exchangeable Ca and Mg increased on the STONY BROOK soil. Sulfate extracted with HCO_3^- increased on the REECE soil. Foliar aluminum increased with treatment on both soils. Foliar Ca and Mn and root Al and P increased with treatment on the STONY BROOK soil. Treatment-induced changes seemed to indicate that the acid-sulfate input was buffered by cation exchange (STONY BROOK soil) and by release of hydroxyl ions in sulfate retention (REECE soil). Overall increase in exchangeable bases presumably resulted from treatment-enhanced weathering due to exchangeable hydrogen. X-ray analysis of roots did not show any treatment effect on the Al distribution across root cross-sections. Photographs showing mycorrhizal hyphae within cortex of fine roots are presented.

Keywords: Acid rain, aluminum, *Picea mariana* [Mill.] B.S.P., cations, pH, plant elemental content, sulfate adsorption, weathering

Jewett, Kevin. 1995. Hydrogeochemical observations and simulations for pre- and post-harvest conditions at the Nashwaak experimental watershed project.

ABSTRACT

Clearcut harvesting effects on stream discharge volumes and nutrient leaching were examined using pre- and post-harvest hydrogeochemical data from the Nashwaak Experimental Watershed Project (NEWP). Stream discharge volumes, ion concentrations in soil solution and streamwater, and various environmental variables were analyzed. Stream discharge volumes decreased initially after cutting, then increased to a peak in the fifth post-harvest year, returning to pre-harvest rates in approximately 15 years. The cumulative cutting effect on stream discharge was 946 mm, less than a 10% increase over expected stream flow volume for uncut situations. Harvest effects on ion concentrations were short-lived (1 to 3 years for soil solution, 4 to 6 years for streamwater). Cumulative effects for K, Ca, Mg, and $\text{NO}_3\text{-N}$ for basin-wide export due to stream discharge amounted to 51, 261, 622, and 304 mole, $\text{ha}^{-1} \text{yr}^{-1}$, respectively. Post-harvest changes in soil solution $\text{NO}_3\text{-N}$ concentrations were most pronounced under hardwood sites and delayed by 1 to 2 years in soil solutions and 2 to 3 years in streamwater. Soil solution and streamwater ion concentrations were analyzed using multiple regressions, considering various environmental variables.

Keywords: clearcutting, Ca, harvesting effects, hydrology, K, Mg, Na, $\text{NH}_4\text{-N}$, $\text{NO}_3\text{-N}$, pH, soil leachate, stream discharge rates, streamwater quality

Keys, Kevin S. 1995. An ion exchange resin disc method for estimating percolation ion fluxes in forest soils.

ABSTRACT

Results of research conducted to determine the feasibility of using ion exchange resins contained in fixed-area discs to estimate soil percolation ion fluxes are presented. The research objective was twofold: (i) to determine if the ion exchange resin disc method was a viable alternative to the solution sampler method for estimating percolation ion fluxes through forest soils; and (ii) to evaluate the accuracy of the resin disc method in estimating these ion fluxes.

Several laboratory and field tests were conducted to develop and evaluate the resin disc method. These included: (i) ion extraction tests; (ii) ion capture efficiency tests; (iii) solution flow/resin disc interaction tests; (iv) resin stability tests; (v) percolation flow, upward flow, and diffusion flow ion flux tests; and (vi) performance comparisons between resin discs, porous cup solution samplers, and zero-tension trough solution samplers.

Results from laboratory and field tests showed that the ion exchange resin disc method was a potentially viable alternative to the solution sampler method for percolation ion flux estimation. Resin discs (triple-discs) were developed which were effective in capturing percolation ion fluxes with little or no bias from non-percolation fluxes and/or root uptake. In addition, effective ion extraction procedures were developed which led to reliable determination of calcium, magnesium, aluminum, and manganese by way of atomic absorption spectrophotometry (AAS); and reasonably reliable determination of nitrate and sulfate by way of ion chromatography. Iron and potassium determination was somewhat less reliable due to extraction

solution (EDTA/NaCl) interference with AAS analysis. Determination of ammonium by steam distillation was problematic due to residual EDTA nitrogen contamination of analysis samples.

Further testing is suggested to increase confidence in (and possibly improve) the resin disc method as a means for estimating soil percolation ion fluxes.

Keywords: forest soil, ion exchange resin, ion flux, porous cups, resin discs, solution samplers, zero-tension troughs

Yanni, Shelagh. 1995. Hydrogeochemical assessment of water in forested watersheds at Kejimikujik National park: Discharge rates, chemical composition, and ion fluxes.

ABSTRACT

Water quality has become an important factor for the future of our forests, aquatic life, and, in some cases, drinking water supplies. Forested watersheds provide several sources and sinks for nutrient flow en route to the stream: input from the atmosphere and geological sources; wet deposition passing through the forest canopy as throughfall and stemflow; water and nutrients passing through the forest floor and mineral soil; and some water and nutrients caught up in wetlands.

Kejimikujik National Park was chosen to study the patterns in stream water quality and watershed nutrient budgets for several watersheds, and to examine whether vegetation type, soil type, and landform associations were factors that affected the patterns. This study area has been the focus of the Long Range Transport of Air Pollutants Study across Canada since 1978, and has included a large-scale environmental monitoring program (the Kejimikujik Watersheds Study). The study included preparation of monthly and yearly summaries for watershed-based water and ion concentration fluxes and budgets, and a field study to ascertain dominant soil types, vegetation types, and landforms in each watershed.

It was found that watersheds at KNP do not vary much in terms of climate, vegetation type and topographical conditions. However, differences were found in water quality among watersheds with respect to the timing (and magnitude in some cases) of maximum and minimum concentrations of particular ions. Stream type (lake inlet versus lake outlet) was the main contributor to these differences, and also to the differences found for nutrient budgets among watersheds. Nutrient concentrations in the soil solutions differed among watersheds depending on the dominant vegetation types supported by the soils. Patterns emerged within soil profiles, specific to the August conditions when soils were sampled. Exchangeable cation concentrations followed the same patterns, but differences between watersheds were not as pronounced. Soils under softwood forest cover had higher turnover times (calculated as total soil ion concentration/ stream water ion concentration flux ratios) than soils under mixedwood forest cover, except for H and Al. The ranking of longest to fastest turnover times for each ion was consistent for both watershed cover types. In terms of forest nutrition, Mg was lost the fastest, then Ca and K.

Key Words: exchangeable cations, flux, hydrogeochemical, ion budgets, ion concentrations, Kejimikujik National Park, soil solution, streamwater quality, watershed, wetlands.

Zhu, Zhanxue. 1998. Modeling the effects of harvesting on nutrient cycling and long-term site sustainable productivity.

SUMMARY

In this thesis, a forest soil vegetation atmosphere nutrient cycling model (ForSVAm) was developed and its application to predict the effects of harvesting on nutrient cycling and long-term site sustainable productivity was studied. This was done by

1. Reviewing the published literatures related forest nutrient cycling model and sustainable forest management (Chapter 2);
2. Determining the nutrient cycling model overall structures by analyzing stand level forest ecosystem compartments (Chapter 3);
3. Explore the function of hydrogen on nutrient cycling and quantifying the hydrogen ion net production based on charge balance of elements (Chapter 4);

4. Developing the biomass submodel based on the relationship with temperature, hydrological, and soil nutrients (Chapter 5);
5. Developing the base cation cycling submodel based on the first or the second order chemical reaction and the effects of hydrogen, temperature, and hydrological processes on base cation chemical reaction and nutrient transfer between compartments of forest ecosystem (Chapter 6);
6. Developing the nitrogen cycling submodel based on the first or the second order chemical reaction and the effects of hydrogen, temperature, and hydrological processes on nitrogen mineralization, nitrification, denitrification, and nitrogen transfer between compartments of forest ecosystem (Chapter 7);
7. Developing the sulfur cycling submodel based on the first or the second order chemical reaction and the effects of temperature, and hydrological processes on sulfur chemical reaction and nutrient transfer between compartments of forest ecosystem (Chapter 8);
8. Determining the model parameters based [on] the data from literature review and testing the model reliability by the data from Nashwaak Watershed Experimental Project (Chapter 4, 5, 6, 7, and 8);
9. Applying the developed nutrient cycling model to determine sustainable nutrient harvesting rate at NWEF sites.

Case, Bradley S. 2000. Interpreting the spatial distribution of select soil properties in two New Brunswick upland watersheds by way of the flow accumulation concept.

ABSTRACT

This thesis investigates functional interrelationships among lateral water flow and accumulation, soil chemistry and soil physical characteristics at two contrasting upland watershed project areas near Gounamitz and Island Lakes in Northern New Brunswick. Soils and substrates are well drained at the Gounamitz Lake site, while soils at the Island Lake site suffer from restricted permeability at a half metre depth.

Flow accumulation, wetness index and slope gradient values, as topographic metrics of lateral subsurface water flow, were estimated for 38 and 41 plot locations at the Gounamitz Lake and Island Lake sites respectively. Guided by both plot-level observations (landscape position, flow regime, slope shape) and digitally-modelled flow networks, I derived a set of best-estimate values for flow accumulation at each plot. Wetness index was calculated as a function of both field-estimated slope gradient and flow accumulation.

Spatial differences in depth, % coarse fragment content and % clay of A, B and subsoil layers, as well as overall soil layer and rooting zone depth, were found to be weakly related to topographic metrics. Soil chemical concentrations within these same layers, however, displayed stronger relationships overall with water flow indices. In general, trends were found to be consistent between sites, but the strength of these correlations differed. Total elemental nutrient amounts per hectare of rooting zone were also influenced by topography, soil acidity and soil clay content; relationships were both linear and non-linear and varied by nutrient type.

Simpson, Brian N. 2000. Water quality effects of forest operations on fourth, fifth, and sixth order streams.

ABSTRACT

This thesis deals with 16 watersheds in northwestern New Brunswick ranging in size from 3,000 ha to 70,000 ha that have been monitored since. The parameters analyzed were: turbidity, sediment load, TOC, EC, pH, hardness, SO₄, NO₃, total P, total N, TDS, Na, K, Ca, Mg, Cl, and NH₄.

An automated database application was used to summarize the data by way of queries, tables, and graphs. Using GIS, biophysical watershed characteristics were developed for each watershed: total area, area harvested, road length and density, stream crossings and density, stream length and density, % area clearcut, % area planted, softwoods vs. hardwood, substrate, drainage, and elevation. Potential relationships between forest operations and stream water quality were examined via correlation analysis, factor analysis, and regression analysis.

No direct statistically significant relationships were found between: a) % area of forest operations and other land-uses (up to 41.8% of the watershed) to water quality; and b) density of stream crossings (up to 0.875 crossings/km²) to water quality.

Multivariate statistics indicated that:

- Turbidity increases with watershed size
- Turbidity decreases with increasingly well-drained watersheds
- Phosphorus decreases with increasing softwood content
- Clearcutting increases electrical conductivity
- Older plantations decrease electrical conductivity

Keywords: water quality, watersheds, biophysical characteristics, GIS, forest operations, land use, stream crossings

Balland, Vincent. 2002. Hydrogeologic modeling of the flow of cations and anions in select watersheds of Eastern Canada with special focus on snowpack effects.

ABSTRACT

Streams in Eastern Canada appear to be subject to acid pulses, with some of these occurring during snowmelt seasons. A field sampling study was conducted to determine the general dynamics between snow accumulation and subsequent snowmelt and the snowmelt-induced acid pulses in stream water. This study revealed that snowpacks accumulate snow differently based on forest cover conditions (open, hardwood, softwood). Also, H⁺ ions were found to leave the snowpack before most of the snow had melted.

Much work was done in terms of revising the forest hydrology model ForHyM, which simulates major water and energy flows through forest stands, including snowpack accumulation, snowmelt, soil infiltration, and stream discharge. The model now includes procedures to calculate snow density and amounts of ions released from the melting snow. Detailed regression analyses were done to empirically relate important hydrologic parameters (saturated hydraulic conductivity, porosity, field capacity and permanent wilting point) to soil conditions as affected by texture, organic matter content and depth of the soil. A user-friendly interface was built to facilitate calibration and model applications.

Data collected during field work in Fredericton, New Brunswick, and data from Kejimikujik National Park, Nova Scotia, were used to calibrate the ForHyM revisions. Specifically, model output was compared with corresponding field observations for snowpack depth, snowmelt chemistry, and stream discharge.

The model was used to simulate relations between H⁺ pulses in snowmelt due to variation in atmospheric acid deposition and potential climate change. These simulations predict that decreased deposition for acidity will lead to proportional reductions in H⁺ concentrations in snowmelt water. Also, warmer climate conditions up to 4°C will lead to smaller snowpack accumulations, due to less snowfall and more rain.

This – in turn – should also lead to substantial reductions in the production of the snowmelt acid pulses.

Keywords: hydrology, model, daily, snowpack, snowmelt, softwood, hardwood, open field, climate change, acid deposition, acid pulses, and stream water

Pomeroy, Joseph H. 2002. Stream turbidity signatures within the Hayward Brook watershed study.

ABSTRACT

This thesis is about studying the turbidity signatures of 5 forest streams that are part of the Hayward Brook Watershed Study in southern New Brunswick, Canada. These signatures were derived over a period of 6 years, using special turbidity probes located at specific locations within each of 5 second-order streams. It was found that each stream had its own turbidity signature, and that this signature was affected by

- watershed size,
- watershed topography,
- weather and season,
- stream channel stability,

- location of turbidity measurement probe
- land-use pattern within watershed.

In this, land-use pattern refers to

- roads that intersect the watershed,
- road configurations and substrates,
- forest operations and road traffic (frequency, timing and type).

Forest streams with the least traffic and operations within their catchment areas had mildly active turbidity signatures, with short and well spaced turbidity events. Forest watersheds with much traffic or containing a severely eroded road had very active turbidity signatures involving many large overlapping peaks. Forest streams within watersheds with road maintenance and harvest operations returned to pre-harvest turbidity signatures by the end of the second post-harvest year.

The continuous turbidity measurements were converted to suspended sediment concentrations, to determine total annual sediment yields per watershed. The resulting yields were placed into the context of expected soil losses as calculated by way of the Universal Soil Loss Equation. This equation generated numbers in good agreement with the field-derived values.

A stochastic model (Random Turbidity Pulse Model) was developed to simulate the high-event component of the stream turbidity signature and the related sediment yields. This model was parameterized by extracting 3 land-use generalizable parameters from the observed frequency distributions for peak duration, peak height, and time interval between peaks for each of the 5 streams. The resulting model was calibrated to conform with the field-observed sediment yields for each of the 5 streams.

Keywords: forest streams, watersheds, turbidity signatures, suspended sediment yields, soil loss, stream turbidity model

Stanley, Brenton William. 2002. The Hayward Brook Watershed Study: hydrogeochemistry and responses to forest operations.

ABSTRACT

Eight streams in the Hayward Brook Watershed, in southeastern New Brunswick, were monitored for stream discharge, stream chemistry and water quality since 1993. Watersheds ranged in size from less than 200 ha to over 900 ha, containing the full spectrum of stand types found in the Acadian forest. Monitoring was done on a continuous basis for water quality parameters such as pH, conductivity, turbidity, and through weekly grab sampling of streamwater. Grab samples were subsequently analyzed in the laboratory for a comprehensive list of physical and chemical parameters. Continuous monitoring revealed a strong weather dependency of pH, conductivity in streamwater. Weekly grab sampling essentially missed this weather dependency, because variations in these streamwater parameters occurred at the scale of hours. Nevertheless, the weekly grab samples were essential for data quality checking of the continuous records. Often, through problems with maintaining the automatically recording probes, data records were systematically above or below the weekly data, indicating systematic drifts and errors from one probe calibration date to another. For the adjusted continuous records and from the weekly grab samples, it was found that:

1. Streams very close to each other, within the identical ecophysical region had significant differences in streamwater chemistry and water quality parameters;
2. Harvesting less than 20% of the treatment watersheds had no significant impact on stream discharge or water quality;
3. The continuous recording of readily measured water quality parameters could be used to predict other, less easily measured water quality parameters;
4. Streamwater chemistry and water quality parameters, as they varied over time within each basin, were strongly affected by weather and season, in accordance with rate of stream discharge.

In particular, select base cation concentrations in streamwater differed by an order of magnitude between adjacent watersheds, especially in summer during low flow conditions. The main cause for this was seepage from soil substrate types with highly different rates of soil weathering. Other ions generally

showed minor differences from basin-to-basin. Also, most ion concentrations were relatively similar during spring snowmelt. Differences in pre- and post-harvest stream discharge could not be attributed to forest harvesting. Also, differences in water chemistry and water quality parameters could not be attributed to forest harvesting, except for zinc. Zinc levels increased to four times above the analytical detection limit in one stream immediately following the installation of a galvanized steel culvert. Conductivity and discharge were the most effective parameters in predicting stream chemistry, and proved most effective as predictors of other water quality parameters in the larger watersheds where relative differences between high and low flow conditions were less than in the small-sized watershed.

Allen, Darren John. 2003. Spring dieback of yellow birch in North America: Historical examination of weather and frost hardiness.

ABSTRACT

Existing process-based models (Birch Dieback Model, ForHyMII) were used to simulate impacts of winter thaws and recurring frost events on shoot and root hardiness, and the potential for frost-induced tissue damage in yellow birch (*Betula alleghaniensis* Britt.). ForHyMII was used to calculate soil moisture, soil temperature and soil frost from daily weather records for air temperature, snow and rain. The Birch Dieback Model was used to track shoot and root hardiness in terms of growing degree-days. Normally, no frost-induced damage should occur when tissue temperatures are higher than the corresponding frost hardiness temperatures. With the dieback model, % tissue damage is related to number of degrees (°C) that air and soil temperatures drop below the shoot and root hardiness temperatures, respectively.

A Weather Reader algorithm was used to analyze daily weather records from all existing Canadian and American weather stations of the study area, from 1930 onward. Specifically, the Weather Reader was used to compile daily precipitation and daily minimum, mean and maximum air temperatures, and was used to calculate accumulated degree-days for each event, from start to end. In addition, an annual summary was prepared for each station showing the number of defined thaw events that occurred, and the maximum accumulation of degree-days of the most severe thaw event for each year. The compiled data were mapped to display the geographic patterns of the most severe thaw events, and these maps were then compared with the timing and extent of historically observed birch decline episodes. It was found that the years of 1936, 1944, 1945 and 1981 were particularly anomalous in terms of region-wide winter thaw extremes, and also in terms of observed birch decline events. This coincidence was tested with the Birch Dieback Model, to confirm that tissue damage on account of reduced frost hardiness in root and shoots should have occurrence in the years that dieback was noticed, and to confirmed lack of potential for major frost-induced damage in other years.

Since there are considerable efforts in modeling future weather based on varying climate-change scenarios, it is suggested that the newly developed Weather Reader algorithm and the process-based hydrology and frost hardiness models could become important tools to assess the future of yellow birch (and other hardwoods) under various climate change scenarios, over time, and across North America.

Keywords: yellow birch (*Betula alleghaniensis* Britt), shoot dieback, winter climate, thaw-freeze events, Geographic Information Systems (GIS), geostatistics, freezing injury, process-oriented model, Forest Hydrology Model, Birch Dieback Model

Fowler, F. Craig. 2003. Modelling watershed responses to agriculture and forestry in the potato belt of North-Western New Brunswick.

ABSTRACT

The objective of this Thesis was to model measured impacts of agriculture and forestry on stream discharge, sediment loads, and chemical loads in the potato belt region of north-western New Brunswick. The area that was chosen is the dominantly forested Little River basin (143 km²) which includes the Black Brook basin (14.5 km²) at St. Andre. This smaller basin is one of the experimental watersheds of the Agriculture and Agri-Food Canada, and is mainly used for potato cropping. For the smaller basin, detailed records about land management, weather, stream discharge as well as sediment and nutrient loads

have been collected since 1990. Similar records for the forested portion of the larger basin are sparse, and only cover the period from October 2000 to December 2001. Based on these records, it was found that sediment loads and N and P losses as generated from the upland soils within the Black Brook basin were generally higher by an order of magnitude than similar losses from the forested portion of the Little River basin.

The SWAT modelling framework (SWAT: Soil and Water Assessment Tool) was used to estimate the impacts upland operations on stream discharge, on soil erosion losses and subsequent stream sediment loads (N and P). In this framework, upland conditions are represented by spatially homogeneous hydrological response units that represent each specific soil type and land use combination. With SWAT, discharge, sediment loss and nutrient losses are calculated for each of these units and are routed downstream according to the local flow accumulation network, from the sub-basin level to the main stem of the stream. The spatial resolution of the hydrological response units depends on diversity of land-use, and number of recognized soil types. A decrease in field and soil differentiation leads to a decrease in specific hydrologic response unit assignments.

This Thesis provides a brief review and outline of the SWAT model and its application to the Black Brook and Little River Basins. This involves applying SWAT to the Black Brook Basin without calibration, to determine which parameters need site-specific calibration, and which parameters do not in terms of predicting stream discharge, sedimentation and N and P losses. A sensitivity analysis was done to determine whether a change in soil resolution would affect the SWAT calculations. The calibrated model was then applied to: the forested part of the Little River Basin, and the entire Little River basin, including the Black Brook Basin. All calculations were summarized at the monthly and annual scale. The following was found:

- Stream discharge calculations were somewhat affected by method used to estimate rates of evapotranspiration.
- Sediment losses required no additional calibrations but were based on the assumption that no soil conservation practices were put in place.
- Estimated values for N and P leaching were generally too low in comparison with the actual field observations.
- Reducing the resolution of the soil information from 7 to 2 soil types increased the calculated sediment yields by a factor of 7; in contrast, stream discharge increased by a factor of 1.2.
- For hardwood and mixed wood forests, SWAT simulated lower stream discharge and sediment yields than what was measured. For softwoods, these estimates were even lower.
- In reference to the entire LRB, stream discharge was underestimated by approximately 43 mm, and sediment yields were overestimated by approximately 7 t ha^{-1} .

Discrepancies between model calculations and field observations are mainly due to a number of key assumptions and related model formulations, as follows:

- Soil and land use within each hydrological response unit are not entirely uniform.
- SWAT calculates soil losses based on surficial sheet erosion; line sources such as stream channels, rills and gullies and point sources such as lagoons, ponds, and manure piles are not part of the SWAT algorithm.
- Failure to include nutrient point sources leads to strong underestimates of N and P losses from the agricultural basin.
- Failure to include line sources underestimates total sediment loads from forests and fields.
- Calibrating SWAT with the no soil conservation practice assumption leads to unrealistically high rates of sheet erosion estimates in order to compensate for essentially equivalent sediment losses from streams, rills and gullies.
- Since soil conservation practices are in place in many areas of the Black Brook Basin, it follows that actual sediment loss from this basin would be even higher otherwise.

Applying the SWAT model to any particular watershed with multiple land uses is a time consuming task. Time consuming matters deal with assembling and compiling relevant data and other pieces of information from varying sources. Pre-processing requirements for SWAT are also considerable in the

sense that considerable efforts were involved for developing an artifact-free digital elevation model for the area. Since this is the first comprehensive application to SWAT to watersheds involving forestry and/or agriculture, much time was spent in the proper calibration of various SWAT parameters. Even at this stage, further testing and calibration activities are recommended before the SWAT model can be used to make reliable predictions regarding land-use dependent impacts on watershed-wide stream discharge, sediment loads and nutrient losses. Top that end, the model formulation needs to include year-by-year change in land use as forced by local crop rotations, and quantitative assessments regarding: soil erosion from line sources (stream channels, rills, and gullies), and nutrient losses from point sources (lagoons, ponds).

Otorowski, Catherine Irene. 2004. Mercury in gulls of the Bay of Fundy.

ABSTRACT

Mercury contamination in gulls along the coast of the Bay of Fundy was investigated to determine mercury exposure and the role of gulls in mercury cycling. Mercury and methyl mercury concentrations were measured in blood, feathers, and eggs of herring gulls (*Larus argentatus*) and great black-backed gulls (*L. marinus*), as well as in soil, terrestrial plants, water seepage, and rockweed beds on and adjacent to the Hospital Islands. Methylmercury concentrations in feathers ranged from 6–48% of total mercury in herring gulls and 20–91% in great black-backed gulls. Gulls breeding in the Bay of Fundy did not appear to be at risk from mercury contamination, nor did they contaminate the surrounding marine ecosystem. Mercury concentrations in herring gulls were similar to those found elsewhere in North America but lower than those in one European study.

Steeves, Matthew T. 2004. Pre- and post-harvest groundwater temperatures, and levels, in upland forest catchments in Northern New Brunswick.

ABSTRACT

This thesis investigates the effects of forest harvesting on shallow groundwater temperatures and levels at 10 small upland catchments within two study areas in northern New Brunswick, Canada. Three harvesting treatments were implemented:

1. Whole-tree
2. Stem-only
3. Stem-only with extra slash added

One study area was located near Gounamitz Lake, characterized by well-drained soils and tolerant hardwood stands. The other study area was located near Island Lake, characterized by poorly-drained soils and mostly coniferous tree species.

Monitoring wells were placed at the base of each catchment, just above the seepage areas on the flow accumulation lines. In each well, shallow groundwater levels and temperatures were recorded every two or four hours by automated probes.

Shallow groundwater levels and well temperatures increased in all treated catchments following harvesting. Mid-summer water table peaks increased by as much as two meters relative to the controls. Well temperatures increased by as much as 2.5°C, and temperature increases were advanced by as much as three months. However, differences from one treatment to the other were not obvious.

The hydrology model, ForHyM, was calibrated to reproduce the shallow groundwater level fluctuations observed on all catchments. The model was also used to:

1. Estimate the depth at which shallow groundwater flows
2. Determine the causes of changes in the shallow groundwater temperature patterns
3. Calculate increases in soil temperatures resulting from canopy removal

Keywords: clearcutting, harvesting, groundwater flow, shallow groundwater, water temperature, soil temperature, groundwater levels, hydrology, model, whole-tree, stem-only, slash, soil permeability, wells, upland catchments, watersheds

Zhang, Chengfu. 2005. Modelling of forest litter decomposition and nitrogen mineralization.

ABSTRACT

A 3-compartment model was formulated to simulate the dynamic development of mass, N concentrations and C/N ratios in decomposing forest litterbags, over time, across a wide range of climate, site and litter type conditions, based on 8 predictor variables and 12 best-fitted parameters. The compartments refer to the fast, slowly and very slowly decomposing fractions of the litter. The model was calibrated with the 1992 to 2000 litterbag data of the Canadian Intersite Decomposition Experiment (CIDET), involving 10 different litter types (Trembling Aspen, American Beech, Douglas Fir, White Birch, Jack Pine, Black Spruce, Tamarack, Western Red Cedar, Bracken Fern, Plains Rough Fescue). These bags were distributed across 21 sites (18 upland and 3 wetland sites), located in 7 provinces and territories (Labrador, Quebec, Ontario, Saskatchewan, Yukon, Alberta, and British Columbia). Annual precipitation across these sites varies from 261 to 1782 mm. Mean annual air temperature ranges from -9.8 to +9.3 C. The predictor variables refer to water- and acid-extractable portions of the litter (to specify the fast fraction), and to ash content (to specify the slow and very slow fractions). The variables that capture the influence of climate on litter decomposition are mean July and January air temperatures, and annual precipitation. The rate of N mineralization was found to depend on the initial N concentration of the litter, and on the C concentration of the forest floor on which the litterbags were laid. This thesis summarizes: the model, the statistical procedures, the equations, the best-fitted results, and the finalized parameters.

Nasr, Mina. 2007. Mercury levels in fungal fruiting bodies from interior and coastal forests of the Bay of Fundy region, New Brunswick, Canada.

ABSTRACT

Ectomycorrhizal (ECM) fungal fruiting bodies have been proposed as suitable accumulators of heavy metals such as mercury (Hg). This study was to examine ECM fungal fruiting bodies as suitable indicators of environmental Hg pollution, and to estimate an annual Hg sequestration by the fruiting bodies from the underlying soil substrate. Sampling of common fungal fruiting bodies, underlying soil, and surrounding mosses were conducted from selected forests on Grand Manan Island, the south-west shore region at Lepreau and New River Beach, and the interior at Fredericton, of the province of New Brunswick, Canada. Across this gradient, atmospheric fog-borne Hg input decreases from island-to-coast-to-mainland.

This study determined total mercury concentration (THg) variations of the fungal fruiting bodies by taxonomical groups (family, genus, and species), type of body part (cap and stalk), developmental stages, and elemental sulphur (S), nitrogen (N), and carbon (C) contents. THg concentrations of the fungal tissue were positively correlated with fungal S content, decreased from cap to stalk, and decreased with increasing developmental stages (emerging > mature > senescent).

THg concentrations of the fungal fruiting bodies increased with increasing THg concentrations of F-layer, and decreasing total S levels and soil depth. Also, the fruiting bodies surrounded by *Polytrichum juniperinum* and *Pleurozium schreberi* (with the highest mean THg concentrations) had higher mean THg concentrations than bodies near *Sphagnum* sp. and *Ptilium crista-castrensis* (with the lowest mean THg concentrations) and non-moss sites.

Sweeney, Laura. 2007. Mercury cycling through finfish aquaculture within the lower Bay of Fundy: possibilities for control in support of the health of coastal communities.

ABSTRACT

Attention has been focused on food safety and the nutritional value of farmed finfish products because of increasing global demands on aquaculture. Our research has the goal of determining inputs of Hg into the aquaculture cycle and modeling resulting Hg through-puts. We present a mass-balance model to quantify biomass and Hg accumulation in farmed fish, from feed to fish. In collaboration with several fish farms in New Brunswick, fish, feed, and waste samples were collected on a regular basis and analysed for total Hg. In addition, laboratory trials were conducted to determine the rate of administered methyl Hg absorption and release from farmed Atlantic haddock under controlled tank conditions. We now have determined that Hg concentrations in locally derived fish feed are not significantly different from Hg

concentrations in internationally produced diets, with values ranging from 14ppb to 56ppb (dry wt, $p < 0.01$). Compared with wild Atlantic salmon, Hg concentrations in farmed fish remained consistently low with increasing fish size, but wild fish concentrations increased (respective means, 84ppb and 260 ppb (dry wt, $p < 0.01$)). Hg administered to Atlantic haddock in form of a fixed dose, is distributed throughout fish from the liver, with a gradual release into muscle tissue, where Hg will reside with a half-life of between 20 and 30 days.

Chi, Xinyan. 2008. Hydrogeological assessment of stream water in forested watersheds: Temperature, dissolved oxygen, pH, and electrical conductivity.

ABSTRACT

This research focuses on analyzing and modeling pre- to post-harvest variations in stream water quantity (stream discharge) and quality (temperature, dissolved oxygen, pH, and electrical conductivity) in relation to year-round daily weather, for two contrasting study areas, Pockwock-Bowater and Hayward Brook Forest Watershed Projects in Nova Scotia and New Brunswick, with 4 and 5 intensively monitored forest streams, respectively. The Forestry Hydrology Model (ForHyM) was used for deriving new algorithms for relating: (1) stream temperature to measured air and simulated riparian soil temperature, (2) dissolved oxygen to measured or simulated stream temperature and discharge rate, (3) stream pH and electrical conductivity to simulated variations of gravitational soil moisture content.

Inter-catchment differences in these relationships could be expressed with catchment-specific coefficient adjustments. Catchment-specific adjustments were attributed to substrate differences in water-transmissivity, being low and high for the Pockwock-Bowater and Hayward Brook areas, respectively. Shallow flows would produce a greater sensitivity of stream temperature and dissolved oxygen to the air temperature, lower stream pH, and increase electrical conductivities during each water-flow event. Deeper flows would do the opposite, with electrical conductivities decreasing during each flow event. Harvest effects on stream water quality were generally small, being positive for stream discharge and temperature, variable for electrical conductivity, and difficult to discern for stream pH and dissolved oxygen due to inconsistent data quality, and restricted harvesting per basin, varying from 0 (control basins) to 46.5%.

Glode, Jason. 2008. Analyzing and modeling windthrow along riparian zones in Newfoundland.

ABSTRACT

Remnant timber in riparian zones is vulnerable to wind damage following logging, which can compromise riparian zone functionality. This study identifies the extent of wind damage in riparian zones in west-to-central Newfoundland and develops a predictive windthrow model and risk map using tree, neighbourhood, and stand-level variables. Measurements were taken from 1814 windthrown trees in 138 plots across 52 riparian zones. Riparian zones experienced 0–76% of trees windthrown, averaging 12%. Important variables included exposure and stand structure, with damage increasing with decreasing topex500 ($p = 0.037$) and increasing fetch ($p = 0.021$) and direx60 ($p = 0.001$). The extent of windthrow was not related to cut block shape ($p = 0.536$), structure ($p = 0.174$), or size ($p = 0.869$). Four models were developed to enable the mapping of windthrow risk maps along riparian zones and cut block edges.

Noseworthy, Joshua. 2011. A mass balance, biogeochemical framework for assessing forest biomass harvest sustainability.

ABSTRACT

A computational framework was developed to calculate and map long-term forest biomass harvest sustainability across Nova Scotia, Canada, based on forest mensurational, biochemical and mass-balance principles. Processes that would affect sustainability refer to primary nutrient supplies (N, Ca, Mg, and K via atmospheric deposition and soil weathering) and losses (forest harvesting, soil leaching). The effects of biomass harvesting were represented by way of four harvest scenarios: no harvesting, stem only, full-tree brown (no foliage) and full-tree green (with foliage), for each forest stand based on current tree compositions. All model calculations were done within a geospatial context using the current data layers

for atmospheric deposition, climate, digital elevation, bedrock geology, forest inventory, and soil distribution, all consistent with recent updates for wetlands, flow channels, floodplains, and coastlines. The framework contains a dynamic link between the geospatial layers to a spreadsheet-based evaluator, to allow for realistic stand-by-stand sustainable harvest-scenario analyses and designs.

Campbell, David Matthew Howley. 2012. TRAIL: Optimizing trail locations by terrain conditions and other considerations, at high resolution.

ABSTRACT

This thesis informs about a new GIS-based extension tool to delineate and evaluate trail routes through already accessed or non-accessed terrain, with the purpose of avoiding trouble spots, minimizing construction costs and reducing ecological damage. The process refers to the Trail Routing, Analysis, and Investigative Layout tool (TRAIL), and works as an extension on the ESRI ArcMap platform. TRAIL provides a platform for designing ecologically sensitive and cost effective recreational trails which can be extended to include a forest operations context. Case studies are explored to demonstrate the merit of TRAIL as a general linear feature planning model. The TRAIL tool is based on a detailed assessment of soil trafficability, as governed by type of usage (vehicle type, management practices), and physical characteristics (landscape position, vegetation, and mechanical soil properties such as the resistance to penetration).

Jutras, Marie-France. 2012. Modeling stream discharge in forest catchments across Canada: Hydraulic conductivity calibrations.

ABSTRACT

This thesis informs about the process of (i) using soil texture, organic matter and soil depth to predict hydraulic conductivities at soil saturation (K_{sat}), and (ii) refining these predictions by way of catchment-level calibrations.

The process also involves the application of the Forest Hydrology Model (ForHyM2). This model uses daily rain, snow, and mean air temperature, as well as basic soil (forest floor, rooted mineral soil, and subsoil) and catchment (slope, aspect, elevation) specifications as inputs. Model output refers to changes in soil moisture and temperature, snowpack (depth, water equivalents, density) and flow rates (run-off, percolation, interflow, baseflow) at the daily level, summer through winter, with and without forest canopies.

The catchment calibrations focused on matching the model output snowpack depth and stream discharge with actual data at six well-calibrated forest catchments across Canada (Nova Scotia: Moosepit Brook, Pockwock Lake; New Brunswick: Hayward Brook; Quebec: Lac Laflamme; Ontario: Turkey Lakes, Basin 31; and British Columbia: Rithet Creek).

The resulting multi-year calibrations yielded good agreements with R^2 values of about 0.65, 0.77, 0.86, and 0.98, at the daily, weekly, monthly, and annual level, respectively. The multiplier adjustments concerning the predetermined hydraulic conductivity for downward flow (infiltration) varied from 0.5 to 2, but were still in general agreement with actual field-determined values.

For lateral flow (interflow), these adjustments were more variable, because terrain and soil conditions were not uniform as set within the ForHyM2 formulation. The soil texture, organic matter and slope mediated impacts on modelled K_{sat} , interflow, infiltration, baseflow and stream discharge were analyzed for the Turkey Lakes and Moosepit Brook watersheds by way of a sensitivity analysis. As to be expected, increases in the sand content would increase infiltration and baseflow rates over interflow. Increasing the slope would favour interflow over baseflow. Changing the organic matter leads to non-linear responses, with optimal infiltration and interflow rates at an OM content of 15–25%, due to organic matter-induced soil granulation in mineral soil layers. For organic soils, K_{sat} as well as infiltration and interflow would be affected by the state of organic matter composition, being high within fibric layers, and orders of magnitude lower within sapric layers.

Moore, Jeanne. 2012. Refining detail of forest ecosite classification for the Fundy model forest in New Brunswick.

ABSTRACT

The original method for forest ecosite classification in New Brunswick was refined using geospatial data, digital elevation model (DEM), cartographic depth to water index (DTW), and explicit values for soil morphological attributes to predict ecosite values at high resolution (10m). Two hundred and forty plot-based field observations in the Fundy Model Forest were used to verify results. Ecosite values were based on the edatopic grid, defined by soil moisture regime and soil fertility. Predicted ecosites were 85% correctly classified when compared to observed conditions, an improvement of 30% over the original Ecological Land Classification (ELC) map, with ecosites 2, 5, and 7 correctly classified 93%, 88%, and 85% respectively. Mapped area of ecosite 7 (rich conditions) increased by 74%. Vegetation type and forest cover type were the most influential variables at initial nodes of a regression tree, while DTW and mottles had greater influence at terminal nodes.

Chisholm, H. Kyle. 2014. Modeling and mapping shallow water properties.

ABSTRACT

Shallow water property values referring to dissolved oxygen (DO), pH, electrical conductivity (EC), temperature and colour were measured along transect plots within and across wetlands in northwestern Alberta at the Ecosystem Management Emulating Natural Disturbance (EMEND) site, the University of New Brunswick (UNB) Forest and a stream-channel permeated Jack Pine (*Pinus banksiana*) plantation in Fredericton, New Brunswick, and a wetland in Saint John, New Brunswick. These measurements were then analyzed in relation to wetland class (bog, fen, marsh, swamp) and the resulting soil hydraulic conductivity (HC) values; contrasting climate, and topographically determined terrain conditions. Local climate conditions refer to precipitation (ppt), evapotranspiration (AET) and terrain conditions refer to the DEM-derived cartographic depth-to-water index (DTW), flow accumulation (FA), slope, potential relative radiation (PRR), and tree height, using LiDAR (Light Detection and Ranging) point-cloud data. Seasonal water property changes were also addressed. It was found that pH, EC, and temperature were generally lowest for bogs (generally low input from mineral groundwater, slow organic matter decomposition rates, and thick organic layers) and highest for marshes (increased seepage input from upland mineral sources, and water table generally close to surface); DO had highest values for bogs, and lowest values for marshes.

The water properties were best quantified by way of the following regression variables: DO: \log_{10} DTW, \log_{10} PRR, \log_{10} HC and season (temperature) ($R^2 = 0.35$); EC: AET/ppt ratio multiplied by PRR, and EMEND wetland class ($R^2 = 0.60$); pH (away from bogs): \log_{10} DTW, \log_{10} FA and \log_{10} EC Raster ($R^2 = 0.48$); pH (within bogs): tree height and \log_{10} HC ($R^2 = 0.14$); Temperature: \log_{10} DTW, season, and wetland class ($R^2 = 0.23$); water colour: pH, \log_{10} HC, and \log_{10} Slope ($R^2 = 0.15$).

These regression results were then used to map the water properties within and around the wetlands within the 4 study locations using (i) area-wide LiDAR-DEM determinations for DTW, slope, FA, PRR, and tree height, (ii) image-derived wetland classification, and (iii) regional specifications for AET/ppt. These maps were then overlaid with the corresponding transect derived data, for visual comparison purposes. In detail, these maps showed how water properties vary as a continuum within and across DTW-influenced neighborhoods around each mapped and categorized wetland, from summer to fall. The conformance between actual and predicted water property values suggest that the procedures used can be generalized over wider areas where conditions similar to the study areas exist. Practical applications would refer to land and water use planning within and around wetlands, including wetland and flow channel conservation and reclamation, quantifying water DO, EC, pH, temperature and colour contributions for use in Environmental Site Assessment monitoring, and for determining possible upstream disturbance.

Hiltz, Douglas. 2014. Predictive vegetation type mapping using cartographic depth-to-water, slope, aspect, and elevation.

ABSTRACT

This thesis describes a method for modelling vegetation type according to species-specific soil moisture preferences from hydric to xeric across the landscape at one meter resolution. This method assesses the occurrence and abundance of all vegetation at the species and genus levels and for vegetation index (VI) classes as these range from xeric (1) to hydric (8). Subsequently, it relates these classes to the depth-to-water index (DTW) and the terrain wetness index (TWI). This is done for two areas: the Willmore Wilderness Park within the Rocky Mountain and Foothills natural regions of Alberta, and the EMEND (“Ecosystem Management Emulating Natural Disturbance”) area within the dry mixedwood subregion of the Boreal Forest natural region of Alberta. The field work proceeded by noting the occurrence and abundance of vegetation in 1x1 m² plots, and also in 5x5 m² plots (Willmore only). The mapping work proceeded by deriving the local flow channel, DTW and TWI patterns from the currently available 1 m LiDAR-derived bare-earth digital elevation model (DEM) for both areas. For the purpose of sensitivity analysis, the flow-channels and DTW were derived with initiation points of 4, 1, and 0.25 ha of minimum flow accumulation. For optimization purposes, the DEM-derived values for TWI, slope, and aspect at 1 m resolution were zonally averaged across quadratic cells spanning 5, 10, 20, 40, 80, and 160 m along each side. VI based on plot occurrence and abundance by species and genus was best correlated with the DTW patterns [i.e., $VI = a + b \log_{10}(DTW)$], with a and b as calibrated regression coefficients) that were associated with the 1 ha flow initiation flow channel network. These VI determinations could also be related to TWI, but the correlation was highly dependent on TWI averaging, with best results obtained with the 40x40 m averaged TWI values across each of the two areas. Slope and aspect influenced the plot-based VI determinations, but only weakly, likely due to sparse sampling across very steep slopes. Regression results for VI versus DTW (1 ha flow initiation) produced generally good correspondences between the plot-determined VI values and the resulting regression-modeled VI map. Results for plot-determined VI conformance by occurrence alone proved better than by abundance. Plot VI values that strongly deviated from their mapped values were identified, and examined in terms of their species composition and local disturbance pattern as revealed through high-resolution surface imagery. This analysis suggested that vegetation species interactions and local disturbance may have influenced the vegetation composition of outliers, with opportunistic species dominating and reflecting drier or wetter conditions than may be the case under non-disturbed vegetation cover. During this work, the algorithm for the DTW derivation was improved by tracking the least-cost path to each landscape cell from its nearest DTW = 0 location (presumed surface water location according to the 4, 1 or 0.25 ha flow channel network) by elevational rise only. Doing so improved the DTW and VI especially across the wetland portions of the Willmore Wilderness Park and EMEND areas. Through plot-based indexing of vegetation type by soil wetness (VI), and correlating the same to LiDAR cartographically derived depth-to-water index DTW, it is possible to model and map the moisture-based VI variations across the Willmore Wilderness Park and the EMEND area at 1-metre resolution. Results have shown a 40- 50% capture of the individual plot-by-plot VI variations under regression analyses and up to 97% capture of vegetation-moisture relationships under classified regression analyses.

Smith, Amanda C. 2014. Wood decomposition and nitrogen mineralization modelling across North and Central America.

ABSTRACT

This thesis focuses on modelling above- and below-ground mass loss and nitrogen (N) dynamics based on wooden dowels [*Gonystylus bancanus* (Miq.) Kurz] of the decadal Long-term Intersite Decomposition Experiment (LIDET) data. These dowels were placed at 27 locations across North and Central America, involving tropical, temperate and boreal forests, grasslands, wetlands and the tundra. The dowel, inserted vertically into the soil with one half remaining exposed to the air, revealed fast mass and N losses under warm and humid conditions; and slow losses under wet as well as cold and dry conditions. The model formulation, referred to as the Wood Decomposition Model (WDM), related these losses to (i) mean annual precipitation, mean monthly January and July air temperatures primarily, and (ii) mean annual actual evapotranspiration (AET) secondarily at each location.

The resulting calibrations conformed well to the time-in-field averages for mass remaining by location: $R^2 = 0.83$ and $0.900.90$ for the lower and upper parts of the dowels, respectively. These values dropped, respectively, to $0.410.41$ and $0.550.55$ for the N concentrations, and to $0.280.28$ and $0.430.43$ for N remaining.

Keywords: annual actual evapotranspiration, LIDET, Long-term Intersite Decomposition Experiment, mass loss, modelling, nitrogen mineralization, North America, precipitation, temperature, Wood Decomposition Model

Goguen, Monique. 2016. Modeling and mapping distributions of common bryophytes across New Brunswick using a lidar-derived depth-to-water index.

ABSTRACT

Plant species distribution is known to vary along environmental gradients. This project uses a cartographic depth-to-water (DTW) index to model the potential distributions of six common mosses and one leafy liverwort in New Brunswick at a landscape scale. Species composition and relative abundance of bryophytes were measured along transects traversing the landscape, from wetlands to uplands. Frequency of occurrence patterns were quantified using regression models. Species were found to sort along the moisture gradient; *Bazzania trilobata*, *Dicranum polysetum*, *Polytrichum commune*, *Hylocomium splendens*, and *Pleurozium schreberi* had greater probabilities of occurrence in well-drained forested areas, whereas hydrophytic mosses such as *Sphagnum fuscum* and *Sphagnum girgensohnii* were predominantly in low lying wet areas. The results support the prediction that wetness-related changes in distributions of bryophytes can be modeled using the depth-to-water index in combination with other environmental variables such as forest type. This research contributes to existing knowledge regarding bryophyte species' responses to environmental factors.

Ogilvie, Jae J. 2017. Flow-line and wet-areas conformance testing of wetland locations using LiDAR and SRTM elevation data.

ABSTRACT

This thesis reports on discerning flow networks and wetland borders across forested lands using digital elevation models (DEMs) and Light Detection and Ranging (LiDAR)- generated point cloud data for two contrasting forest zones. This selection refers to the boreal forest zone in northern Alberta's Ecosystem Management Emulating Natural-Disturbance (EMEND) study area, north of Peace River, and to the temperate forest zone typical of the Acadian Forest in central New Brunswick, as represented by the University of New Brunswick forest in Fredericton (UNB Forest) study area. The DEMs refer to globally available Shuttle Radar Topography Mission (SRTM) elevation rasters with 30 and 90 m spatial resolution, and bare-earth DEMs generated from classified LiDAR point cloud data, interpolated at 1 metre (m) and resampled at 10 m and 30 m spatial resolutions. The methodology involves comparing how DEM-delineated flow-line and wetland border predictions at 1, 10, 30 and 90 m spatial resolution relate with corresponding infield GPS-tracks. It was found that wetland delineations were best when using a combination of DEM-generated wet area model thresholds pertaining to: DEM resolution at 1 m spatial resolution; cartographic depth-to-water index (DTW) < 1 m with flow lines formed at a 4 hectare (ha) minimum upstream contributing area threshold and presence of LiDAR-discerned hydrophytic vegetation patterns, as in raised bogs. The resulting best fitted wetland borders conformed to the GPS-tracked borders within ± 20 m nine times out of ten, while false positive and false negative wetland area determinations dropped below 20%. Flow-line locations were best derived from the 1m LiDAR DEMs once hydro-conditioned through general depression and road-specific breaching. Flow-line and wetland-border differences between the EMEND and UNB Forest delineations were mainly due to sharper wetland-upland transitions and deeper incision of ephemeral, intermittent and permanent flow channels on rugged (UNB Forest) as opposed to flat terrain (EMEND).

Lemieux, Kamille E. 2022. LiDAR-based potato crop suitability mapping along the upper Saint John River valley in New Brunswick.

ABSTRACT

This thesis reports on potato crop suitability mapping along the Upper Saint John River Valley in New Brunswick based on province-wide available high-resolution light detection and ranging (LiDAR) derived digital elevation model (DEM). Potato crop suitability rating was done by way of multi-criteria evaluation accounting for (i) topsoil and subsoil texture, (ii) soil calcareousness, (iii) soil coarse fragment content, (iv) depth-to-compaction of soil, (v) soil drainage (depth-to-water table (DTW)), and (vi) elevation (slope percent). It was found that:

1. the tax assessment values of farmlands and farm and woodland combinations reflect the soil suitability for potato cropping across the Saint John River Valley, as mapped;
2. some of the field-surveyed soil property and associated tuber yield variations can be quantified and mapped using the LiDAR-DEM derived flow channels and associated DTW layers; this verification was done based on three published field-survey reports that deal with potato cropping near Saint-André, Florenceville, and Hartland, NB.

Owusu Afriyie, Nana Agyei. 2023. GIS based modelling for forest road alignments, culvert placements and logging trail delineation.

ABSTRACT

Establishing stable forest road and trail networks requires proper trail and culvert placements. Past procedures involved manual surveying and hand digitizing road-stream crossings to estimate expected stream discharge for each location. This thesis reports on research-developed semi-automated ArcGIS/ArcMap tools to (i) align already digitized roads with DEM-recognized roadbeds, (ii) locate road-stream crossings and determine potential culvert locations and diameter, (iii) determine expected stream discharge and (iv) determine least-cost trail paths using DEM-generated cost rasters.

Results show that hand-digitized roads veered off DEM roadbeds, sometimes by 20 meters or more. Similarly, mapped culvert locations do not always align with actual road-stream crossings. Also, existing culverts tend to accommodate 50 mm/day but not necessarily 100 mm/day discharge events, thereby leading to washouts. This thesis explores and demonstrates how the developed tools combined with the 1-m resolution LiDAR-DEM coverage for New Brunswick can bring road, culvert, and trail locations into better hydro-topographic alignments.

MScFE Theses

Labelle, Eric R. 2008. Assessing soil disturbances caused by forest machinery.

ABSTRACT

Forest soils are an essential part of the forestry ecosystem as they provide various vital functions. The increased use of heavy equipment in forest operations has increased the risk of soil disturbance by compaction. This study was carried out to

1. determine whether there was soil disturbance by compaction and if so, quantify the increase of density directly in the field;
2. explore the mitigating effect of slash on soil compaction;
3. analyze the persistence of the disturbance; and
4. suggest best management practices aimed at reducing negative impacts on soils.

To address these objectives, soil density and moisture content were recorded before and after forest operations at different research sites and were monitored periodically for a two year period to observe the influence of the freeze-thaw cycles on soil rehabilitation. The study used a nuclear moisture-density gauge to monitor in-place soil density and moisture over a multi year period. To address the impact of off-road traffic, these parameters were monitored after different traffic frequencies (one, three, five, and 10 forwarding cycles).

Results indicate that 85% of under-track readings increased after harvesting. This soil density increase varied from 2 to 90% with an average of 17% for both Gagetown and Black Brook sites. The mitigating

effect of slash depended highly on the amount present on the forest floor. A slash mattress of 21.2 kg/m² (approximately 40 cm thick) helped to reduce soil compaction by 40% at a 5 cm depth up to 60% at a 30 cm depth compared to a thinner 10.2 kg/m² slash mattress. After a two year monitoring period, soil density continues to be higher than pre-harvest measurements meaning that the soil has not yet recovered from the disturbance.

Keywords: Soil compaction, soil disturbance, soil rehabilitation, ground pressure, forest machinery, nuclear moisture-density gauge

BScF Theses

Hawkes, Michael Raymond. 1980. Some factors which relate snowmelt and evapotranspiration to diurnal streamflow fluctuations in the Lake Brook basin of the Nashwaak experimental watershed project.

ABSTRACT

The objective of this study was to determine the effects of snowmelt and evapotranspiration on daily streamflow fluctuations. For this study, two no-rain periods in May, 1978 at the Lake Brook basin of the Nashwaak Experimental Watershed (NEW) Project in central New Brunswick were examined. During the snowmelt period, streamflow was maximal at approximately 2400 hours, and minimal at approximately 1300 hours. Streamflow during the leaf-out period was maximal at approximately 1000 hours, and minimal at approximately 0100 hours. The two periods of streamflow have been examined to see what differences exist between them.

Keywords: snowmelt, evapotranspiration, streamflow, baseflow, net solar radiation, air temperature, watershed

Archibald, Roxanne Marie. 1981. The effects of fertilization on containerized black spruce seedlings at a forest tree nursery.

ABSTRACT

Three crops of containerized black spruce (*Picea mariana* (Mill) B.S.P.) seedlings, from the same seed source, were grown with slightly different fertilization schedules.

High shoot-root ratios, lack of sturdiness, and poor seedling quality could be contributed to a fertilization schedule starting too early. Starting the schedule late produced a planting stock as found in crop C. Intermediate results (crop B) were obtained by starting the fertilization schedule late and increasing the rates of fertilization after the thirteenth week of the growing period.

Fertilizer use by the three crops were somewhat poor due to high leaching losses. It is recommended that the open irrigation fertilization system be closed to recirculate the fertilizers and therefore allow adjustment of nutrient levels in the peat moss growing medium to produce optimal growth throughout the active growing season.

Buggie, William J. 1981. Peat harvesting in New Brunswick: An engineering proposal for on site water treatment.

ABSTRACT

Peat harvesting affects peat bog drainage by increasing runoff, and by contaminating the ecosystems downstream with peat silt, nutrients (nitrogen and phosphorus), and mineral and organic acids.

In this study a water treatment system containing a settling pond and a filtration dam is proposed (1) to hold one-in-two year stormflows, (2) to allow half of this water to pass through the system in three days. Crushed limestone, spread along the discharging side of the filtration dam, is used to neutralize the runoff. This system, according to a quick cost assessment, is economically feasible.

Lavigne, Daniel Roma. 1981. Planning by goal programming: A case study for multiple-use of forested lands.

ABSTRACT

A case study is provided to demonstrate the usefulness of the goal programming procedure for multiple land-use planning of forested lands. Four land-use policies containing timber harvests, dispersed recreation, developed recreation, hunting and wildlife management are considered for a parcel of land incorporating 11,070 ha. The goals for each type of land use are analyzed in terms of

- (i) the various land-use capability coefficients,
- (ii) a number of priority settings, and
- (iii) the various planning horizons (spanning from a 2 year planning horizon to a 36 year planning horizon, where all present-day merchantable timber has been cut at the annual sustainable rate).

It is shown that conflicts in land-use, and optimal land-use allocations are strongly dependent on

- (i) the land capability coefficients,
- (ii) the goals,
- (iii) the priorities associated with each goal,
- (iv) the planning horizon, and
- (v) the type of land-use policies considered.

It is also shown that multiple-use conflicts can be resolved by either changing the priorities associated with the conflicting uses, or by extending the planning horizons from short- to long-term, or by a combination of both.

Keywords:

Annual sustainable cut, constraints, developed and dispersed recreation, goal programming, hunting, land capabilities, land-use planning, linear programming, multiple-use, priorities, timber, wildlife

Rainer, Elizabeth A. 1981. Forest roads: Backslope erosion control.**ABSTRACT**

Studies on the effectiveness of three erosion control treatments were conducted on forest road backslopes near Grande Prairie, Alberta. Results showed:

- Hay mulch cover on seeded plots eliminated rill erosion.
- Burlap berms stabilized plots against rill erosion but seed germination and vigor were poor.
- Seeding with a grass-legume mixture alone was not fully effective but did reduce rill formation.

Erosion depth varied by site. Control plots eroded to an average depth of 0.29 cm within seven weeks, and extensive rill formation occurred.

Keywords: forest roads, backslopes, erosion control, seeding, mulching, burlap berms, environment

Robertson, Robin G. 1981. Predicting deer track depths in snow from snow survey station and climatological station data.**ABSTRACT**

Data collected during the years 1973 to 1980 were analysed in an attempt to produce regression equations which would predict deer sinking depths in snow. The independent variables chosen, and the regression equations produced are shown in table form. It may be possible to predict deer sinking depths in snow in January and February in New Brunswick.

Keywords: New Brunswick, snow, white-tailed deer (*Odocoileus virginianus*), track depths, snow survey station, climatological station, wildlife management

Udit, Balkaran. 1981. Rates of forest litter decomposition and mineralization as affected by clearcutting.**ABSTRACT**

Rates of forest litter decomposition and nutrient release in the L and F layers of the forest floor of a mixed forest (balsam fir, red spruce, red maple) in Central New Brunswick were determined by litter-mesh bag analysis. A comparison is made between cut and uncut forest stands. Over a two-year period, it was found that litter under the closed forest stand decomposed at an average annual rate of 8.0%. On the clearcut area this rate was found to be 13.0%. Nutrient release rates occurred in the order $K > Mg > Ca > P > N$.

The forest floor on the cut area was, in general, drier than that of the uncut area. The pH of the forest floor was unaffected by clearcutting.

Keywords: acidification, clearcutting, forest floor, litter-mesh bags, litter decomposition, moisture content, nutrient release

Ramnarine, Seepersad. 1982. Modelling and verifying the effects of acid precipitation on forest soil leachates: A simple approach.

ABSTRACT

A model for predicting the effects of acid precipitation on the acid ($H^+ + Al^{3+} + Fe^{3+}$)- and base ($Na^+ + K^+ + Ca^{2+} + Mg^{2+}$)- cation losses from forest soils via leaching as a function of time was formulated. The model was verified by examining published results for one indoor and five outdoor lysimeter studies (with precipitation pH values ranging from 2 to 6), and five watershed studies. In each case, the predictions of the model were in acceptable (but not perfect) agreement with the observed acid and base cation losses.

Required input information for the model includes:

- (i) the total amounts of acid and base cations received by the forest soil (lysimeter or watershed) from precipitation and mineral weathering (minus normal leaching losses);
- (ii) the exchangeable base cation content and total number of cation exchange sites of the forest soil (including the organic surface deposits) prior to the onset of acid precipitation.

The 11 case studies were selected from other relevant studies because they met these information requirements in completeness. The prediction of acid cation composition of forest soil leachates is important for considering the generally negative effects of such cations (especially the dominant Al^{3+} ions) on plant growth and ground- and stream water quality.

Keywords: acid precipitation, forested watersheds, lysimeters, modelling, soil leachates

Scruton, John A. 1982. Volunteer Balsam fir growth on abandoned fields for Christmas tree production: Factor analysis of tree, soil, and site characteristics.

ABSTRACT

Twenty plots were located in the vicinity of Fredericton, New Brunswick to determine the effects of general soil and site characteristics upon the growth, form, and development of volunteer balsam fir [*Abies balsamea** (L.) Mill.] in old abandoned fields for the cultivation of Christmas trees. Factor analysis was conducted on observations describing the sites, soils, and tree growth of each plot. It was found that Christmas tree shape and form appears to be enhanced by soil organic matter accumulations, which, in turn, are related to low bulk density of the soil, ease of soil penetration, and the presence of grass species as the dominating form of ground vegetation. Excessively drained sites appear to reduce height growth thus leading to low quality trees. Soil acidity and exchangeable calcium and magnesium content may also affect Christmas tree production.

Keywords: balsam fir [*Abies balsamea** (L.) Mill.], Christmas trees, factor analysis, form, organic matter, site, soil

Brewer, Jon Allison. 1983. Effects of Aluminum, acidity, and organic acid on germination and early growth of Black Spruce seedlings (*Picea mariana* [Mill.] B.S.P.).

ABSTRACT

Black spruce (*Picea mariana* [Mill.] B.S.P.) seedlings were grown in sand/nutrient culture dishes (17 days) under 90 separate treatments combining three oxalic acid levels (0.0 mM, 5.6 mM, and 16.7 mM), five aluminum-ion (Al^{3+}) levels (0.0 mM, 1.85 mM, 3.71 mM, 7.41 mM, and 11.10 mM), and six pH-levels (3.0, 3.5, 4.0, 4.5, 5.0, and 6.0). Oxalic acid tended to increase growth rate, decreased germination time, and interacted with the Al^{3+} and pH-treatments to affect aluminum and phosphorus uptake. Al^{3+} -uptake increased with increasing Al^{3+} -levels while growth rate, oven-dry seedling weight, P-uptake, and germination time were decreased. The results suggest that Al^{3+} -toxicity is probably related to a pH-dependent response mechanism at the root surface and peaks at pH-values between four and five. The

observed Al^{3+} -toxicity pattern of black spruce seedlings is therefore similar to the observed response mechanism of fish gills (*Salmo trutta* L.) to enhanced Al^{3+} concentrations in stream and/or lake waters.
 Keywords: acid precipitation, aluminum toxicity, black spruce seedling, organic acid, *Picea mariana*

Frame, Donald Craig. 1983. A general approach to forest biomass analysis by way of computer simulation.

ABSTRACT

A general-purpose computer program (SIM) has been written to develop dynamic and site-adaptive forest stand biomass models. A simple modelling approach is used so that the smallest plausible number of biomass components and associated interactions may be chosen for achieving realistic stand biomass estimates over time. This method allows complete flexibility with respect to model choice and hypothesis testing. Any stand biomass model, once accepted, can be used to examine a great variety of "what if" situations regarding future stand biomass development based on certain initial forest conditions. Pertinent forest biomass information, however, does not appear to be readily available from published records. It is hoped that the modelling approach adopted here may serve as a tool to develop general guidelines for the collection of appropriate forest biomass information.

Keywords: forest biomass models, systems analysis, computer simulation.

Kowlessar, Vishnu. 1983. The soil-root interface in forest soils: Production of organic acids.

ABSTRACT

Organic acids are known to occur in exudates of roots, microbes and in leachates from the surface litter horizons, in soils. Water soluble extracts taken from (i) root exudates of some conifer species, (ii) the floor of a mature forest stand after a fertilization experiment and (iii) the wall exudate of an ectomycorrhizal fungus *Collybia butyracea* were analyzed by HPICE ion exchange chromatography to identify and quantify some of the organic acids present. Chromatograms were interpreted to determine identity and amount in relation to standards established for known concentrations of organic acids. The organic acids in root exudates varied in types and amounts present. Distribution in the forest floor was apparently influenced by urea fertilization. Production by *C. butyracea* related directly to the presence of substrate. As the substrate was exhausted re-absorption of the organic acids produced seemed to occur.

Organic acids exuded by root and associated ectomycorrhizae appear to have an immediate but temporary effect in the rhizoplane, while forest floor organic acids influence the whole rhizosphere. All acids found in the soil are capable of being involved in some form of solubilization, mobilization and transport of nutrient mineral matter in forest soils.

Keywords: *Collybia butyracea*, forest floor, HPICE chromatography, organic acids, root exudates

Saunders, Kimberly. 1983. Verification of the effects of acid precipitation on lake systems.

ABSTRACT

A quantitative model was used in an attempt to predict the long-term rate and amount of lake acidification caused by a steady rate of acid precipitation. The model was verified using data from six lake watersheds. Overall, the predictions of the model were in good agreement with observed acid cations lost and retained in the watersheds. Required input information for the model included:

1. the total amounts of acid and base cations received by the lake from direct precipitation, soil leachates and natural sources;
2. the total amounts of acid and base cations lost by the lake from lake run-off;
3. the exchangeable base cation content and total number of cation exchange sites of the soil prior to the onset of acid precipitation.

The six sites were selected from the literature because they met these information requirements.

Keywords: acid precipitation, lake watersheds, modelling, soil leachates

Allen, Peggy. 1984. Container design effects on Black spruce seedling growth before and after outplanting.

ABSTRACT

Black spruce (*Picea mariana* (Mill.) B.S.P.) seedlings were greenhouse-grown in containers according to an experimental design involving (i) container-type (conventional styroblock containers versus plywood containers), (ii) aeration-type (root cavities produced with (a) polyethylene bags containing no holes, 4 holes, or 44 holes or with (b) netted vexar bags), and (iii) bag-geometry (taper versus straight). These seedlings, following continued indoor growth of six months, developed significant differences with respect to oven-dried root weight and shoot/root ratio on account of container-type, aeration-type and bag-geometry. It was found that some but not all of the initial morphological differences between the various container treatments persisted after an additional growth period of four months following outplanting. Best outdoor seedling performances were associated with seedlings that were grown in straight polyethylene bags with few or no holes. Seedlings raised in tapered bags lagged in outdoor performance due to initial root development restrictions. Seedling responses were also examined in terms of nutrient uptake and mycorrhizal development following outplanting. Nutrient uptake of nitrogen and iron appeared to be correlated with an increase in shoot and root weight. Mycorrhizal formation was most frequent with seedlings grown in bags allowing varying degrees of aeration.

Keywords: black spruce seedlings, container types, experimental design, mycorrhizae, nutrient analysis, outplanting, shoot/root ratio

Fulton, Randolph T. 1984. Effects of acidity, aluminum and oxalic acid on the growth and early development of Black spruce seedlings (*Picea mariana* [Mill.] B.S.P.).

ABSTRACT

Black spruce seedlings (*Picea mariana* [Mill.] B.S.P.) were grown in Styrofoam cups containing a sand medium under 90 separate treatments combining three oxalic acid levels (0.0mM, 5.6mM, and 16.7mM), five aluminum-ion (Al^{3+}) levels (0.0mM, 1.85mM, 3.71mM, 7.41mM, and 11.10mM), and six pH-levels (3.0, 3.5, 4.0, 4.5, 5.0 and 6.0). Oxalic acid tended to increase growth and interacted with the Al^{3+} and pH-levels to affect both aluminum and phosphorus uptake. Aluminum uptake increased with increasing Al^{3+} levels while the total oven-dried biomass and the phosphorus uptake decreased. The results lend support to the theory that aluminum toxicity is related to a pH-dependent response mechanism at the root surface which peaks at pH-values between four and five as was observed in a previous study involving black spruce seedlings and in the response mechanism of trout gills (*Salmo trutta* L.) to increased aluminum concentrations in stream or lake waters.

Keywords: acidity, aluminum toxicity, oxalic acid, black spruce seedling, *Picea mariana*

Moerman, Dennis Eric. 1984. A multivariate site analysis of spruce/fir stands in northwestern New Brunswick.

ABSTRACT

Soil, site, and stand data were collected on twenty plots located in spruce/fir stands in northern New Brunswick. Two types of multivariate analysis, factor analysis and discriminant analysis, were used to determine those variables and variable groups correlated to site productivity. Factor analysis was used first to reduce the data set variable by variable, and then to provide information about the factors as implied by the reduced variable set. This analysis revealed that rooting depth, soil and duff pH, duff depth, nutrient levels, topography, and parent material type were correlated to site productivity. Discriminant analysis showed that various combinations of optimally selected variables can be used to develop suitable discriminant functions for site class predictions.

Keywords: Site productivity, site index, factor analysis, discriminant analysis, soil, site, stand, spruce, fir

Ellis, Tim. 1985. The effects of aluminum, calcium and pH on the early growth and development of Yellow birch seedlings (*Betula alleghaniensis* Britton.).

ABSTRACT

Yellow Birch seedlings (*Betula alleghaniensis* Britton) were grown in plastic cups containing a sand medium under 54 separate treatments combining three aluminum-ion (Al^{3+}) levels (0 ppm, 1 ppm and 10 ppm), three calcium (Ca^{2+}) levels (1.5 ppm, 15 ppm and 150 ppm), and three pH levels (3.0, 4.0 and 5.0). Aluminum tended to increase growth. Increasing levels of calcium and pH tended to decrease growth. The results lend support to the theory that lower levels of soluble aluminum are toxic to harmful micro organisms such as Actinomycetes and that increasing levels of pH and calcium promote the growth of harmful micro organisms.

Keywords: acidity, aluminum toxicity, micronutrient, yellow birch seedling, **Betula alleghaniensis* Britton*

Manasc, Justin. 1985. Tree-ring analysis of Red spruce (*Picea rubens* Sarg.) in forest stands downwind from the Grand Lake thermal generating station in New Brunswick: Possible impacts of Air (SO_2) pollution.

ABSTRACT

Tree-rings and bark of red spruce (*Picea rubens* Sarg.) are analyzed to test the hypothesis that acid deposition due to atmospheric emissions of SO_2 is causing indirect damage to forest vegetation through changes in the soil chemistry (Ulrich, 1983). The Grand Lake Thermal Generating Station is the focus for this study, primarily due to its prominence as a source of SO_2 -emissions. Eight zones of differing radial distance from this "point source" are delineated and the wood of trees in two age classes is sampled at four red spruce-dominated stands within each zone. Five-year core segments are pooled with respect to zone, time of wood formation and age class. Bark-plus-cambium samples are pooled with respect to zone only. The resulting pooled samples are analyzed chemically by x-ray fluorescence spectrometry for concentrations of the elements: S, Al, P, Ca and K. In addition, mean five-year periodic increments are calculated for each pooled wood sample as an indicator of growth performance. Significant (0.05 level) temporal, spatial or age-related trends are observed for all five elements measured in the xylem as well as for incremental growth. In particular, strongly correlated time- and distance-dependent trends in Al- and S-concentrations and inversely correlated Ca-concentrations may indicate recent soil acidification in some of the zones sampled. Increases in the uptake and immobilization of all elements except Ca during a period of observed decline in incremental growth (i.e., since the mid-1960's) of both old and young trees seems to further support the conclusion that changes in the availability of those elements to tree roots are reflected by the historical tree-ring record. The spatial (i.e. zonal) patterns observed in xylem elemental concentrations are interpreted in the light of possible local meteorological influences on dispersal of the emitted smoke plume. It is concluded that the chemical composition of xylem may be a sensitive indicator of early forest ecological changes induced by wet- and dry-deposited SO_2 -pollution. Biogeochemical interactions within forests are complex and, thus far, poorly understood, so that only general trends of ecological change can be inferred from the tree-ring record and no definite conclusions regarding pollution damage to forests can be drawn.

Keywords: Acid precipitation, air pollution, elemental biogeochemistry, point source studies, tree-ring analysis

Taviss, Ian H. 1985. The forest floor: A study concerning forest litter acidification.

ABSTRACT

The acid-base adsorption behaviour of fresh forest litter is quantified in terms of its major dissociation constants (i.e. pK-values) and the respective functional acid-group concentrations for the early stage of the decay process. The assessment of these parameters is through potentiometric titration analysis and subsequent chemical modelling.

A comparison is made between (i) softwood and hardwood litter type, (ii) rate of decay under open and closed canopy conditions, and (iii) degree of initial acid (H^+ ion) or base (OH^- ion) excess. Over a four month period, the acidic nature of the material — as reflected in the pH-values — remains unchanged while the excess acidity (or alkalinity) and the dry weight is lost rapidly. The results further indicate that

HW litter is more palatable to decay organisms while SW litter is slightly more acidic. Very little difference is seen in the rates of decay and rates of acidification on account of the two canopy conditions.

Wort, Andrew D. 1985. Timber harvest scheduling: A case for hierarchical decision making via goal programming.

ABSTRACT

A procedure is described for the development of a hierarchical goal-programming model for timber-harvest decision-making. The procedure is illustrated for a practical case study concerning timber harvest scheduling. In this study, two decision-making levels (a central forest management branch and several woodlands departments) are characterized by a goal-programming procedure. Furthermore, a binary search model (WOSFOP) is utilized as a basic tool for stand-harvest scheduling. The results so generated may be useful for selecting optimal decision-making strategies concerning timber harvest at both hierarchical levels.

Keywords: hierarchical decision-making, goal programming, timber harvest scheduling

Wightman, R. A. 1986. Computer simulations for biomass and nutrients allocations in selected forest stands.

ABSTRACT

A six component biomass allocation model was used to simulate site-class specific nutrient allocations (N, P, K, Ca and Mg) in forest stands of jack pine (*Pinus banksiana* Lamb.), and aspen (*Populus tremuloides* Michx., *Populus grandidentata* Michx.). Site-class related simulations were also done for stands of northern tolerant hardwoods (mainly *Acer rubrum* L., *Acer saccharum* Marsh, *Betula alleghaniensis* Britton, and *Fagus grandifolia* (Ehrh.) The results of these simulations, in turn, provided information about stand-internal nutrient demands and supplies, and also about the net base equivalents of wood biomass in relation to stand age and site-class.

Scott, Michael C. 1987. Elemental uptake (Al, P, Ca, Mg, K) by Black spruce seedlings from nutrient solutions/ peat/ sand cultures: Effects of water-soluble inorganic and organic aluminum in the rooting medium.

ABSTRACT

Two-year-old black spruce seedlings (*Picea mariana* (Mill.) B.S.P.) of greenhouse-grown paper-pot stock were grown in hydroponic solutions, sand, and peat cultures. They were treated with nutrient solutions for 28 days to examine the effect of water-soluble inorganic aluminum (Al) and organically complexed Al (using citrate and oxalate as non-colloidal ligands) on elemental uptake (Al, P, Mg, K, Ca). Captan fungicide (a wettable powder) was used to stabilize the organic acids, and its effect on nutrient uptake was also examined.

Plants took up Al in proportion to the Al concentration of the rooting medium, with Al uptake from oxalate treatments slightly higher than from inorganic treatments. Phosphorus uptake mirrored Al uptake in roots, but not in shoots. Root concentrations of Mg and K weren't affected by Al treatments, though shoot K increased significantly. High inorganic Al levels decreased root Ca, while organic Al treatments showed no effect. Free oxalate raised Mg, K, and Ca uptake in roots but not in shoots. Al and P uptake were greatest in solution-grown seedlings. Mg, K, and Ca levels peaked in peat-grown seedlings, with sand-grown ones being intermediate.

Citrated Al enhanced root uptake of Mg, K, and Ca in sand and solution-grown seedlings. Oxalated Al increased Al and P uptake. Several interactions occurred between medium and ligand type. Captan didn't affect root uptake of Al, P, or Ca, likely due to complexation by its wettable powder constituents.

Keywords: aluminum (Al³⁺), Al treatments, black spruce (*Picea mariana*), Captan, citrate, oxalate, uptake (Al, P, K, Mg, Ca), organic Al

Strucel, Irene. 1987. Water uptake by Black Spruce seedlings from nutrient solutions/peat/sand cultures: Effects of water-soluble inorganic and organic aluminum in the rooting medium.

ABSTRACT

Two-year-old black spruce (*Picea mariana* (Mill.) B.S.P.) seedlings were grown in treated nutrient solutions as well as peat and sand cultures for 4 weeks to examine the effect of increasing levels of water soluble inorganic and organically complexed aluminum on water uptake and moist plant weight. Aluminum treatment levels ranged from 0 to 1.8 mmol (0 to 48 mg/L Al). Two experiments were conducted: one in early spring (end of May until end of June), and one in mid summer (end of July until end of August) to examine seasonal effects, should they occur. It was found that the effect of Al on water uptake depended on the stage of seedling development. Water uptake and moist plant weight of seedlings grown in solution were reduced early in the growing season (shortly after budburst) by nutrient solutions with elevated levels of Al, but were not affected by the same treatments later in the growing season, when the new seedling shoots were fully elongated. Treatments with oxalate-complexed Al had no significant effects on water uptake and moist plant weight for both experiments. Medium type affected water uptake and moist plant weight strongly. For example, water uptake by the seedlings from peat was double that taken up from solution, while uptake from the sand culture was intermediate. These differences were most likely related to differences in aeration of the growth medium. Moist plant weights remained approximately constant for the seedlings grown with the peat and sand cultures, but moist plant weights of the seedlings grown with solution were reduced by 20 to 30% at the end of the treatment period. Keywords: aluminum (Al³⁺), Al treatments, black spruce (*Picea mariana* (Mill.) B.S.P.), moist plant weight, organic Al complexation, water uptake

Sugg, Allan Edward. 1987. Sulfate adsorption and desorption in a humo-ferric podzol: The results of applying simulated acid precipitation to soil lysimeters.

ABSTRACT

The upper horizons (LFH, Ae, Bf and BC) of a sandy humo-ferric podzol were analysed in the laboratory and by field lysimeters to determine its pattern of sulfate adsorption and desorption. Laboratory analysis was done to determine short- and long-term sulfate adsorption isotherms that resulted from short-term (30 minute) and long-term (30 day) contact between the soil and a SO₄-containing soil solution. The solubility of aluminum and other cations (Fe, Ca, Mg, K) associated with the adsorption isotherms were also determined. Field lysimetric work was conducted by applying solutions of simulated acid precipitation to 16 lysimeters for 30 days, to test the effect of sulfate concentration, time of soil-solution contact and irrigant volume on the amount of (i) total, (ii) surface-sorbed, and (iii) water soluble SO₄ retained by each soil layer.

The Bf horizon was found to adsorb the greatest amount of sulfate, but showed little tendency to desorb sulfate once retained. Total and adsorbed SO₄ in the soil increased with sulfate concentration in the applied treatments, and with the time of soil-solution contact, but decreased with increased treatment volume.

The pH of the soil varied with soil horizon. The replacement of the original soil solution with irrigant solution led to slightly increased levels of soil pH for most of the treatments. Following the initial increase in soil pH by the irrigant solutions, there was a noticeable decrease in soil pH with increasing levels and repeated application of dilute H₂SO₄ to the lysimeters. Also, the pH levels were strongly affected by daily amounts of acidic solution added to each lysimeter (increased daily volumes decreased soil pH).

Harris, Darrell. 1988. Optimizing the seeding operation for forest seedling production.

ABSTRACT

A Binomial model was developed to simulate actual seed and seedling distributions using data supplied by the Kingsclear Provincial Tree Nursery for Paper and Jiffy pots. This model was tested against the actual seed counts, and was used to determine whether seeding and germination rates affect transplanting and thinning costs, on the condition that each cell in each growing-tray will contain exactly one viable seedling. It was found that substantial savings can be realized in thinning and transplanting costs by reducing the variability of seed counts per cell, by way of precision seeding. Precision seeding depends

partly on the type of mechanical seeding device being used, and partly on the alignment of cells in the growing-trays.

Keywords: Jiffy pots, Paper pots, seed and seedling distributions, thinning, transplanting

Deal, John Arnold. 1989. Foliar leaching and needle surface of Black spruce seedlings growing on two acid-treated soils with contrasting sulfate absorption.

ABSTRACT

One-year-old black spruce (*Picea mariana* [Mill.] B.S.P.) seedlings, growing in a greenhouse on forest soil substrates with contrasting SO_4 absorption, were irrigated for four months with seven levels of H_2SO_4 (five for A-horizons), ranging from pH 2.7 to 4.4, twice a week for 10 days to determine whether soil acidification affects foliar leaching. The results indicate that acid irrigation of the soil is not a primary factor contributing to ion leaching of spruce foliage. Instead, soil-related and growth-related factors were responsible for most ion variation in the foliar leachates. A scanning electron microscope was used to study the epicuticular wax of the black spruce needles by soil, needle age, and H_2SO_4 treatment. Sulfuric acid treatments seemed to cause accelerated wax degradation by forming plate-like wax structures on one of the soil substrates (spruce forest soil from a heavily podzolized Ae horizon). In particular, stoma on one-year-old foliage had a plate-like epicuticular wax, whereas current foliage had a dense web consisting of rod-like wax structures. X-ray microprobe analysis indicated differences in the elemental distribution by surface of the needles (“stomatal web” vs “smooth needle surface”).

Kavanagh, Joe Carl. 1990. Soil and plant responses to acid nitrate applications: A greenhouse experiment with podsolized soil and Black Spruce seedlings.

ABSTRACT

Nitric acid was applied to A and B horizons of two New Brunswick lowland soil types (REECE and STONY BROOK) planted with black spruce (*Picea mariana* [Mill.]). The soils were irrigated for four months with seven HNO_3 treatment levels. Aa analysis of the leachate, roots and foliage were done to determine the effects of acid irrigation on the soils and the indirect effects on black spruce seedlings. All four soils exhibited decreases in pH as well as increased cation leaching of Ca, Mg, K, Na, Mg and Zn. Toxic effects possibly due to root Al and foliage Mn were found on two separate soils.

O'Brien, Elizabeth M. 1992. Assessing effects of climate and soil variables on radial growth of *Picea rubens* in the Lake Brook Basin.

ABSTRACT

Climate variations have an important effect on forest growth. This study reports the annual tree ring index for a red spruce (*Picea rubens* Sarg.) stand in the Lake Brook Basin of the Nashwaak Experimental Watershed. Hydrologic and soil temperature models (CEA Research Report No. 841-G-726, Parts 2–3) were applied to reconstructed climate data to generate information about soil moisture levels and soil temperature. This information was then regressed with tree ring data to identify probable relationships between tree ring index and the climate record. The resulting regression analysis indicated that about 74 percent of year-to-year variations for the red spruce radial growth were in part attributed to:

- September precipitation
- October evapotranspiration
- Monthly temperature for February and lagged November
- Monthly precipitation for January to March, and lagged October
- Soil water content for June and lagged November

Keywords: dendrochronology, radial tree growth, hydrologic model, soil temperature model, red spruce – *Picea rubens* Sarg

Rogers, Steven Lee. 1992. Radial growth variations for Red Spruce in relation to soil moisture and temperature at the Acadia Forest experiment station and the University of New Brunswick woodlot.

ABSTRACT

The relationships between red spruce (*Picea rubens* Sarg.) radial growth variations and regional climate and site-specific variables were determined for a stand at the Acadia Forest Experiment Station and at the University of New Brunswick woodlot, both of which are near Fredericton, New Brunswick.

Growth-affecting variables were determined by comparing yearly ring variations of red spruce trees to:

Monthly mean air temperature

Monthly precipitation

Simulated values for soil moisture deficit, snowpack, and ice penetration

Five key variables collectively accounted for 80.6% of the year-to-year tree diameter growth variations:

Previous November air temperature: negatively related to growth

April air temperature (current year): positively related to growth

Average precipitation (August to December, previous year): positively related to growth

Soil moisture content in September: positively related to growth at moderate levels

Soil moisture content in October: negatively affected growth when either high or low

Keywords: Dendrochronology, hydrologic model, New Brunswick, radial tree growth, red spruce (*Picea rubens* Sarg.), soil temperature model

Yanni, Shelagh. 1992. Tree ring analysis of Red Spruce (*Picea rubens*), in relation to climate at Kejimikujik National Park, Nova Scotia.

ABSTRACT

Tree rings of red spruce (*Picea rubens* Sarg.) from two watersheds in Kejimikujik National Park, Nova Scotia were analyzed in terms of climate-related growth patterns. Climate records—including monthly air temperature, precipitation, and rainfall—and soil information (such as forest floor depth, rooting depths, and texture) were entered into hydrological and temperature models designed to simulate microclimatic variables:

1. Soil water content
2. Soil temperature
3. Frost penetration into the soil
4. Snowpack depths and water equivalents

Multiple regression analysis was used to examine how these climate and soil variables affected the radial growth of red spruce.

Year-to-year variation in the red spruce radial growth index was primarily driven by:

- Composite monthly precipitation ($PPT_{comp} = 3 \times [PPT_{previous\ August\ to\ November} + PPT_{March}] \div 5$)
- Mean annual temperature
- Composite monthly temperature ($T_{comp} = T_{March} + 1.4 \times T_{August}$)
- Soil moisture content in October of the previous year

Composite monthly precipitation and mean annual temperature were the most influential factors. Other significant contributors included both prior and current year's growing season conditions.

Keywords: Dendroclimatology, hydrological model, red spruce (*Picea rubens* Sarg.), soil temperature model, tree ring analysis

Crawford, William. 1993. Fertilization of Red Spruce (*Picea rubens*, Sarg) with ammonium nitrate: Analysis of the rings.

ABSTRACT

A small, 113 ha forested watershed in the upper Nashwaak River Basin was fertilized with 115 kg/ha ammonium nitrate (NH_4NO_3) using fixed-wing aircraft in 1975. Trees were felled in 1991/92 during a clearcut operation. In 1992, tree stumps were randomly selected from fertilized and unfertilized areas, and discs were cut from the stumps. The tree discs were analyzed by digitizing tree ring widths from pith to periderm.

Compared to unfertilized trees:

- Suppressed trees (10 cm diameter) became even more suppressed after fertilization
- Intermediate trees (14 cm diameter) showed no initial response, but had a delayed response 5 years after fertilization
- Dominant fertilized trees (18 cm diameter) responded strongly for up to 10 years

Per hectare volume increments were estimated using empirical relationships between DBH and height, DSM and DBH, DBH and volume, and basal area and volume. Volume increments were found to be immediate after fertilization.

Basal area increments were:

- Lower in high-density stands after thinning
- Long-lasting (up to 20 years) in low-density thinned stands
- Lower in all thinned stands compared to fertilized stands
- Similar in control stands (not fertilized or thinned)

Keywords: Nitrogen fertilization, thinning, red spruce, tree rings, basal area, volume increments

Hetherington, Derek Forbes. 1994. Soil conditions at select upland forest sites in provincial parks and conservation areas in Southern Ontario.

ABSTRACT

Four upland locations in Southern Ontario were chosen to assess soil climate in this region. The locations were:

- Wheatley Provincial Park
- Ferris Provincial Park
- Dorset Watershed
- Maple Keys Conservation Area

The soil climate was analyzed using two models:

- Forest hydrology model (ForHym)
- Soil temperature model (ForStem)

Findings showed that soil climate varied by location. Notably:

- Snowpack water equivalent and ice depth increased with latitude, due to lower air temperatures.
- Cumulative streamflow discharge varied depending on soil texture and depth of forest floor—finer textures and thinner forest floors led to less infiltration and more runoff.
- Soil moisture was also site-specific, influenced by texture and depth of soil.

Keywords: Forest hydrologic model, soil climate, soil temperature model, Southern Ontario

Isaac, Cornelius. 1994. Mechanisms and factors influencing the movement of water through soils.

CONCLUSION

A unique part of the hydrological cycle is the soil-plant-atmosphere continuum (SPAC) because the same basic principles apply to water movement and retention in soil, plants, and water.

Soil structure relates to the arrangement, orientation, and organization of primary soil separates or aggregates. While structure itself is not measured, some of its components are, including particle density, dry bulk density, volumetric solid content, void ratio, specific surface area, and volumetric content.

Water in soils moves based on energy gradients known as potentials. These include matric, osmotic, gravity, and pressure potentials. The basic equation governing water flow is Darcy's Law, which states that water flux is proportional to the hydraulic conductivity of a soil and the change in hydraulic potential between two points.

Soil water movement can be categorized as infiltration, saturated flow, unsaturated flow, preferential flow, and water vapor movement. These are influenced by factors like soil structure and texture, temperature, topography, soil fauna, and solute concentration.

Water regimes in vegetated fields can be described using a water balance model. Its components include:

- Storage
- Precipitation
- Surface runoff

- Evapotranspiration
- Upward soil water flux
- Deep drainage or percolation

While soil water availability has a range of potential that remains constant for a given soil, plant access to that water is heavily influenced by atmospheric conditions.

Robichaud, Dana A. 1995. Water quality of forest sites at an upland-wetland transition zone in New Brunswick.

ABSTRACT

The findings of an investigation to determine the effects of forest sites on water quality in an upland/wetland transition zone are presented. The investigation was done around a northern bog near the Regent Street bog in Fredericton, New Brunswick (see Figure 2). Water samples were collected from forest sites within the transition zone between the bog and its adjacent forest stands. The samples were analyzed to determine the chemical content of the samples (pH, Ca, Mg, Na, Cl, NH₄-N, SO₄-S, NO₃-N, Na, Cl, and K). It was found that forest sites with a high red maple content have an effect on the aluminum and iron content of the water. Forest sites with a high eastern cedar or trembling aspen content tend to contain water with a high pH, in contrast pH levels were low for the black spruce swamp. Forest sites with a high balsam fir and/or white birch content tend to have an effect on the manganese content of the water. It was further found that monovalent ions (Na, K, and Cl), and bivalent ions (Ca, Mg, and SO₄-S) formed correlated sets of variables (see Table 4). Levels of NH₄-N were found to be generally high in and next to the alder swamp that covers a significant part of the bog area (see Figure 1). Levels of NH₄-N were also found to be high in and next to softwood stands i.e. stands composed of red spruce and pines. In contrast, NH₄-N levels were found to be low in the black spruce swamp (see Figure 1), where Ca and Mg levels were also low.

Case, Bradley S. 1996. The influence of water flow and accumulation on spatial distributions of soil properties in two New Brunswick upland watersheds.

CONCLUSION

The relationship between lateral water flow and soil development and distribution has long been suggested in theory by Jenny (1941, 1980), Hugget (1975) and Conacher and Dalrymple (1977) while investigations, varying in study design and scale, have provided substantial supporting evidence (e.g. Walker et al. 1968; King et al. 1983; Pennock 1987; Carter and Ciolkosz 1991; Hairston and Grigal 1991; Odeh et al. 1991; Brubaker et al. 1993; Moore et al. 1993). This investigation used the topographic metrics of flow accumulation and steady-state wetness index to predict spatial patterns of soil properties mainly because: 1) they have rarely been used in a soils research context; 2) they are recognised as important, hydrologically-significant indices of subsurface water flow and accumulation (Speight 1974; O'Loughlin 1984; Moore et al. 1991, 1993a,b) and; 3) they provide a quantitative means of identifying and delineating the possible form and function of established relationships.

Results clearly showed that elevation data readily available from the Province of New Brunswick were too coarse to adequately characterise topography and to derive topographic attributes at this study scale. Although "expected values" of flow accumulation and wetness index derived from field observations were a justified alternative in this case, the desired aim is to be able to adequately and accurately derive consistent values for a range of hydrologic attributes using automatic methods for any point in the landscape (Moore et al. 1993).

The problem in areas such as the Island Lake and Goumaznit Lake sites is the lack of an efficient way to obtain fine-scale elevation data with automatic methods due to thick forest cover. The two survey methods presented in this thesis certainly provide a manual means to obtain this data, provided that care be taken to minimise positional and vertical sampling error and to maximise registration of co-ordinates. Most likely new GPS or satellite imagery analysis technologies will provide a solution to this dilemma in the near future.

Despite the limited ability to obtain accurate topographic attribute values from DEMs for the study areas, spatial patterns of soil physical and chemical properties and nutrient pools were nonetheless significantly related to expected values of flow accumulation, wetness index and slope at both sites. Most noteworthy was the fact that, for most variables, the form of relationships was similar across soil layers at both sites and that the strength of the relationships appeared to be a result of the permeability of the underlying substrate. This finding lends credence to the ubiquitous influence of lateral water flow as mediated by the strength of the hydraulic gradient. Landscape contrasts, as found at these two sites, are key to garnering a better understanding of ecological processes that are potentially common across landscapes.

Although topographic attributes showed substantial spatial correlations with soil properties, results also suggested that soil chemicals and total nutrient pools were partially related to parent material. The multivariate nature of soil development, as influenced by a host of “state factors” (Jenny 1980) is widely recognised. Certainly there is a degree of randomness in the distribution of physical soil variables, as outlined in Chapter 5, that is especially evident in glacial environments. I suspect, however, that a greater proportion of unexplained variance could be accounted for in this study with an inclusion of micro or meso-scale climatic factors and by exploring other metrics that accurately describe landform shape, water flow and moisture conditions. Further, this study essentially represents one sample in time; temporal fluctuations in chemical properties in particular may be substantial (Hammer et al. 1987) and should not be ignored.

Watersheds provide the logical framework for investigations concerning hydrologic processes because they are self-contained, defined by local topography, hierarchically structured and easily delineated with automatic methods. Also important is the relevance of watershed units to forestry operations. Headwater stream watersheds in New Brunswick are abundant, of relatively low-relief and, as such, are areas that are frequently accessible for harvesting. Intermittent feeder streams within these sites therefore play an important role in contributing to the overall water quality of higher order streams and yet are generally overlooked during harvest. Investigations such as this, at the very least, create a greater awareness of the importance of headwater stream watersheds and may contribute to the establishment of specific best management practices (BMP's) for forestry activities such as road location and buffer-strip design.

Crawford, James R. 1996. The intrinsic and transient properties of planted *Pinus banksiana* (Lamb.) and *Picea mariana* (Mill. B.S.P.) on upland soils within the Fundy model forest.

ABSTRACT

Intrinsic and transient properties of jack pine (*Pinus banksiana* (Lamb.)) and black spruce (*Picea mariana* (Mill. B.S.P.)) on upland soils within the Fundy Model Forest were analysed for Mg, Ca, K, Fe, Mn, Al, P, and N concentrations. Nutrient concentrations within foliage, twigs, stemwood, and bark were used to determine (i) sustainability of plantations, (ii) how much nutrients were tied-up within the biomass pool, and (iii) how much nutrients would be exported from the site due to silvicultural activities.

K, Ca, Mg, Mn, Al, and Fe levels were determined using atomic absorption spectrophotometry. P levels were measured using the Vandate method, and N levels via the Kjeldahl method.

Higher plantation nutrient levels were found for the black spruce sites, except for N and Al, which were higher in jack pine sites. Black spruce was moderately deficient in most nutrients, while jack pine ranged from deficient to sufficient.

Trends observed:

Decreasing nutrient levels with age of foliage for Mg, P, and N

Increasing trends for Ca, Mn, and Al in both species

Foliage had the highest nutrient concentration, followed by twigs, bark, and stemwood (with exceptions for Mg, Ca, Fe, and Al)

Generally, nutrient levels declined with increasing tree age in both species. Results suggest that jack pine and black spruce were not sustainable in the Fundy Model Forest without fertilizer addition.

Perry, Paul. 1996. Investigating into the presence of Cadmium and Mercury in the waterways of Southern New Brunswick and its presence on the surrounding biota.

ABSTRACT

The Geological Survey of Canada Open File 1638 (1987) mapped out the concentrations of heavy metals in the southern region of New Brunswick. Mercury and Cadmium concentrations were examined to find areas of higher than usual concentration and try to determine possible reasons for such anomalies. In addition a follow-up survey was conducted to see if there is a transfer of these metals into the surrounding soil, vegetation and fungi.

Somerville, John. 1996. Forest operations in buffer zones effects on nutrient exports from basins.**ABSTRACT**

Buffer zones adjacent to watercourses are critical areas when harvesting or manipulating land. Developing strategies for harvesting within buffer zones is essential for preserving the integrity of these watercourses. This study examines forest operations conducted in buffer zones and their effects on nutrient exports from forested basins.

Water quality data from three case study locations in New Brunswick—Central Highlands, Central Lowlands, and Fundy Model Forest—were processed into nutrient fluxes by employing a hydrological model paired with weather station data. Stream flow measurements were simulated based on weather data.

Water quality readings, specifically ion concentrations, were transformed into nutrient fluxes using the hydrological model for stream discharge. The total nutrient fluxes exported from the watersheds were calculated in grams and equivalents, and results were presented annually per hectare.

Keywords: Nutrient fluxes, Water quality, Buffer Zones

Christie, Nathan A. 1997. Soil and biomass nutrient levels along a topographic gradient within a Black Spruce plantation in the Fundy model forest.**ABSTRACT**

The Fundy Model Forest is located in southeastern New Brunswick and contains an array of soil associations and topographical landscape differences. This study was done in the northern portion of the forest with and undulating to flat landscape on Salisbury soil.

The study was done on a gentle slope in a 11 year old black spruce (*Picea mariana* Mill) plantation. Trees at the top of the slope were significantly smaller with less density than the trees downslope. Also noted was the high occurrence of (*Kalmia angustifolia* L.). The objective was to determine which variables contribute to this trend. Four plots were established running 70 m downslope. Two soil pits were dug at each plot and soil horizon and bulk density samples were taken. Soil samples were analyzed for anions and cations in the laboratory. Biomass was sampled for six representative trees per plot and analyzed for nutrients in the laboratory. Tree species, diameters, heights and a ground vegetation survey was also done. There is general trend that tree biomass nutrient levels decrease downslope. This may be attributed to high biomass and nutrient dilution. The opposite occurs where soil nutrient levels increase downslope. In general total tree biomass increases downslope. Soil drainage decreases with slope, therefore it is speculated that nutrient leaching is occurring at top slope thus supplying added nutrients to the plots downslope.

Easthouse, Kari. 1997. Pet calibration and testing of the forest hydrology model ForHym for Saskatchewan.**ABSTRACT**

The forest soils hydrology model ForHym model was adjusted for the province of Saskatchewan by matching predicted to actual stream discharge for seven sites throughout the province to develop a new potential evapotranspiration calculation. The model was then tested at a monthly level for Little Bridge Creek in Saskatchewan and showed satisfactory results. Modeling was then done for the Man River area in Saskatchewan at a daily level. Due to the site being a recharge area, changes had to be made to the model, which included increases in infiltration into the forest floor and rooting soil as well as an increase in the permeability of the soil and subsoil. After these changes, good agreement was seen between

observed and predicted soil moisture at the daily level. Required modifications to the model to account for albedo changes with site preparation are also discussed.

Kenny, Kevin J. 1997. The comparison of environmental impacts caused by conventional logging verses cable logging on steep slopes.

ABSTRACT

The findings from the literature search will compare the environmental damage caused by conventional and cable logging are presented. It was found that the use of conventional logging methods produce more site disturbance, erosion, compaction and sedimentation than a cable logging system. It was also found that conventional logging caused more loss of site productivity and advanced regeneration damage than a cable system. It is recommended that on steep slopes, that are environmentally sensitive, cable logging be used rather than conventional logging methods.

Mitchell, Bradley. 1997. A comparison between growth on four year old Jack pine and Black spruce plantations established on imperfectly drained stony brook soils in the Fundy model forest.

ABSTRACT

Two of the plantations with associated benchmarks on Stony Brook soil were used in this study. Although Black Spruce is usually associated with imperfectly drained sites as compared to Jack Pine, it was discovered that the Jack Pine (*Pinus banksiana* Lamb.) plantation productivity was considerably higher than the Black Spruce (*Picea mariana* Mill.) plantation.

The main objective of this study was to look at trends between tree growth as related to:

- Nutrient concentrations/availability
- Microtopography
- Rooting depth
- Soil depth

All on Stony Brook soils.

Rossiter, M. Andre. 1997. Chemical properties of soils sampled for the forest biomass growth project (The Fundy model forest).

ABSTRACT

Soil samples were taken from various plots throughout the Fundy Model Forest. Chemical properties of Eight black spruce (*Picea mariana* (Mill B.S.P.)) plantations and nine jack pine (*Pinus banksiana* (Lamb.)) plantations with varying ages were sampled. Five benchmark sites were also sampled and used for comparable measures. Water extractable concentrations (Ca, Mg, K, Na, Fe, Al, Mn, Cl, NO₃, SO₄), Ammonium Chloride extractable concentrations (Ca, Mg, K, Na, Fe, Al, Mn), Sodium bicarbonate extract (SO₄), and potassium chloride extract (NH₄) were sampled. In general, it was found that water extractable nutrients (with the exception of Ca and NH₄) had been relatively affected the same way, and generally to the same degree, in both jack pine and black spruce plantations. Overall Ca and Al levels were higher on jack pine sites than black spruce sites. Exchangeable K, Mg, and Mn remained on jack pine plantations more readily than on black spruce plantations. Other exchangeable concentrations (Ca, Na, Fe, Al, NH₄, and SO₄) increased, decreased, or remained the same with relatively the same trend. C/N ratios generally increased in all layers as plantation age increased. PH values generally decreased with age due to the abundance of acidic coniferous needles. The assart effect occurred with several ions sampled. High initial concentrations would usually tend to level -off and decrease (or increase) toward the expected benchmark concentrations. From this analysis, it was found that black spruce had slightly more negative effects on the chemical properties sampled.

Saulnier, Blair T. 1997. The response of Red Spruce (*Picea rubens* Sarg.) to urea fertilizer in Nova Scotia: A 10 year study.

ABSTRACT

Nitrogen is an important factor for the growth of trees as it is used in roots to synthesize amino acids, the building blocks of proteins, DNA, RNA, and chlorophyll (Wilson, 1984 and Turgeon, 1991). Nitrogen is often a limiting nutrient to red spruce (*Picea rubens* Sarg.) growth in eastern Canada (Shepard, 1989). In order to examine the implications of nitrogen fertilizing, two red spruce sites in Nova Scotia were chosen. On these sites, three different rates of urea fertilizer were applied in order to determine different effects on red spruce growth. One site in Sunnybrae, Pictou County, was merchantably thinned in the late 1970s, with cut strips (skidder trails) between the plots. The other, on 7 Mile Road, Halifax County, was pre-commercially thinned in 1979. The sites that were chosen were both uniform in basal area, topography, drainage, age, and soil type. The productivity of the land for the two sites were similar, 5 m³/ha/yr and 4.5 m³/ha/yr, respectively.

At both sites, 12 permanent sample plots were established, and three replicates of 0, 100, 200, and 300 pounds per acre (lbs/ac) of urea were applied in 1980. The plots were measured in 1980, 1985, and 1990 for diameters (dbh) and heights. From these measurements, basal area and total volumes were calculated. Analysis of variances were performed with a 99% confidence, and no fertilizer rate significantly affected the mean percent growth on Sunnybrae with respect to the control. Seven Mile Road was divided into two portions as there were significant differences between controls ($P < 0.01$). The northern portion responded most significantly ($P < 0.01$) to the 200 lbs/ac rate and increased the mean total volume growth by 43% in the first five years and by 8% in the second five years, with respect to the control. On the southern portion, there were significant ($P < 0.01$) responses: mean total volume increased by 20% with the 300 lbs/ac fertilizer rate in the first five-year period. There were no increases in mean growth of the fertilized plots in the second five years.

The effects of fertilizer on tree growth were more complex than originally thought. Responses to fertilization of red spruce were variable depending on site and location. Generalizations on the response of red spruce growth with respect to urea fertilization in Nova Scotia are inconclusive. This type of study should be conducted with fewer variables.

Keywords: urea, fertilization, *Picea rubens* Sarg., Nova Scotia

Simpson, Brian N. 1997. Quantifying sustainability for twenty-five forest sites in New Brunswick. ABSTRACT

A database necessary to run a steady-state mass balance model was constructed for twenty-four upland forest sites in New Brunswick. This database comprised soil information, by horizon and by type and geological information was gathered covering temperatures, precipitation and other wet discharges and fluxes were calculated for watersheds proximal to the study stream areas. The overstory vegetation analysis for each site was used and converted to usable form.

The steady-state mass balance model was then modified to produce mean annual increment forecasts for six different scenarios:

1. Whole-tree
2. Branches, wood and bark
3. Conventional
4. Debarked
5. Fire simulated
6. No harvesting

It was then run, producing critical acid load and sulfur and nitrogen exceedance information, as well as biomass growth and sustainability predictions. The results of this indicate that whole-tree harvesting systems are harder on a forest site than conventional harvesting systems, and that whole-tree systems may or may not compromise a site's future sustainability.

Exceedance and critical acid load information was developed as well, although it was discovered that exceedance and MAI are not directly correlated. The ForCrit model also seems to be able to predict the MAI with reasonable accuracy.

Delorey, Steven J. 1998. 1998 Algal Bloom investigation.

ABSTRACT

In July 1998, a significant algal bloom occurred in Holmes Brook, part of the Hayward Brook Watershed Study near Petitcodiac in Southeastern New Brunswick. Despite a 60 m buffer zone protecting the Brook from an adjacent upslope clearcut, the algal bloom still took place. A possible explanation is that seepage water from the clearcut area may have contributed to the bloom. However, this hypothesis was not supported by the results. Ion concentrations in surface seepage water and water from the surrounding soils were found to be lower than in the Brook downstream. It is suggested that the nutrient source for the bloom likely entered Holmes Brook from below via deep percolation and subground upwelling. This process may have been enhanced by increased water supply at the clearcut area due to reduced evapotranspiration after harvesting and recent road/ditch construction. These changes could have shifted the aerobic/anaerobic balance in the soil, resulting in the mobilization of iron, manganese, and phosphorus. Conditions in the streambed showed distinct discoloration from iron oxide deposits, indicating that the algal growth may have been driven primarily by increased phosphorus release from subsoils into ponded surface water.

Moffatt, Gregory R. 1998. Watershed Analysis with a geographic information system.**ABSTRACT**

Geographic Information Systems are fast becoming an integral tool in natural resources management. This approach lends itself particularly well to studies of the effects of land-use (particularly forest operations) on stream water quality at landscape scales. As an example, a method was defined for delineating watersheds feeding thirteen water quality monitoring stations installed by Fraser Papers, Inc. in northwestern New Brunswick. Forest and soil data for the area within the watersheds were isolated from the data for the outlying area. These data were summarized to provide quantitative characteristics of each watershed, and mapped to provide a spatial overview of the configuration of vegetation, silvicultural treatments, and soil properties.

Betts, Matthew. 1999. A landscape approach to conserving the Appalachian hardwood forest.**EXECUTIVE SUMMARY**

Appalachian Hardwood Forest (AHF), also termed St John River Valley Hardwood Forest (SJRHF), refers to a distinct assemblage of tree, understory vascular plant, and bryophyte species that exist in western New Brunswick and northeastern Maine. AHF is more floristically diverse than most other New Brunswick forest types and contains a number of plants that are uncommon, rare and very rare in other parts of the Maritime provinces. Phase I of the Nature Trust of New Brunswick's Appalachian Hardwood Forest Conservation Stewardship Project (March- August 1997) identified 108 AHF sites ranging from 112 ha to less than 1 ha. Phase II of the AHF Conservation Stewardship project has sought to promote private stewardship in the St. John River Valley (Ecodistrict 19) through landowner contact.

Early in Phase II of the AHF project, it was recognized that an approach which seeks to protect the small remaining fragments of AHF is insufficient to ensure biodiversity conservation across the entire region. The traditional approach that manages 'islands of green' while ignoring ecological context is unlikely to succeed in maintaining species over the long term. This is because at the local (patch) level, ecological processes such as gene flow, the interaction among local populations of wildlife, and fragmentation effects are not taken into account. If biodiversity is to be conserved, research and planning must occur at the landscape scale.

This project provides a landscape approach to conserving the Appalachian Hardwood Forest. Geographic Information Systems (GIS) and satellite imagery (LANDSAT TM) were considered the most effective tools to complete such a large-scale analysis within a reasonable time frame.

The objectives of the Landscape Ecology Mapping Project (LEMP) were:

(1) To examine approaches to landscape ecological planning in other jurisdictions.

A number of governments and non-governmental organizations are in the process of implementing landscape approaches to biodiversity conservation. These range from simple attempts to delineate existing areas of ecological importance as is the case in Ottawa, Ontario, to more wide-ranging plans to restore

entire landscapes and create ecological networks as is the case in the European Ecological Network and the Florida Reserve Network.

(2) To identify landscape-level ecological areas and processes that are important to the overall biodiversity of the region.

The use of indicator species aided in the identification of important large patches of forest that exist in the St John River Valley. The most prominent large contiguous forest area exists in the Kintore Hills area. The region surrounding Williamstown Lake is important for its high concentration of large coniferous forest patches and wetlands. Existing corridor areas between tolerant hardwood patches were also identified. However, due to the highly fragmented nature of the study area, few corridors exist for species associated with mature forest.

Three habitat associations/ features of particular ecological importance to the Nature Trust of New Brunswick were mapped at the landscape scale: (i) tributaries of the Meduxnekeag River, (ii) mature cedar stands on calcareous soils, (iii) mature hemlock stands.

(3) To map and quantify existing landscape patterns such as degree of fragmentation, edge effect, and total habitat area.

By all measures used in this study (patch size, mean nearest neighbour, interior/ edge ratio), habitat in the St John River Valley is highly fragmented. It is quite likely that coniferous forest would have been characterized by a high degree of patchiness even in the era of pre-European colonization. Thus, species dependent on this cover type may not be as greatly affected by fragmentation. However, landscape distribution of tolerant hardwood forest has undergone a radical transformation over the past 400 years. What was once a forest characterized by infrequent natural disturbances and few large open patches, is now divided into small patches divided by agricultural land and regenerating clearcuts. While no local studies have been conducted, if findings from other hardwood/ agricultural landscapes have applicability in western New Brunswick, it is likely that species that are adapted to mature deciduous forest are highly affected by this fragmentation. Rates of local extirpations of bird and plant species in small patches may be elevated. Nest predation and parasitism rates are likely to be higher. As distance between patches increases, metapopulation dynamics may be disrupted for a number of species. Appalachian Hardwood Forest plants, most of which have very slow dispersal rates, are probably among the taxa most sensitive to fragmentation effects.

(4) To map areas of ecological importance that have previously been identified by other agencies.

This study identified three major existing habitat designations. Mature Coniferous Forest Habitat (MCFH) and Deer Wintering Areas (DWA) both exist on New Brunswick Crown land in the LEMP study area. In total 48 of the Nature Trust of New Brunswick's Environmentally Significant Areas (ESAs) are within study area boundaries. None of these three designations provides permanent protection. In fact, no formally protected natural areas exist in the area examined. Further, due to the predominance of private land in the region, even the recent Protected Areas Strategy for New Brunswick, does not include representation of this area.

(5) To provide a representation of landscape change in the St John River Valley over the past ten years through the comparison of 1984 GIS data and 1995 satellite imagery data

Over the 1984-1995 period, 10.5% of the forest has been clearcut. This estimate does not take into account small cuts, new agricultural developments, or growth of human settlement. Cedar uplands and Appalachian Hardwood Forest sites are probably under the most threat due to the long time it takes these ecosystems to regenerate. The pace of habitat fragmentation has not been reduced. Thus, ecological damage ranges beyond the impact of habitat loss alone. Core habitat areas identified in the first part of this study have been fragmented by cuts over the past 11 years.

(6) To provide a landscape-scale plan for the conservation of biodiversity in the St. John River Valley.

With the use of GIS, a network of core areas and corridors was delineated. An attempt was made to delineate cores that contained the highest percentage of existing mature forest as well as a large portion of critical habitat identified in the earlier stages of this project. A total of 14 core areas and 12 corridors covering 25,522 ha (9.3%) of the land base were identified. Seventy-one percent of the area identified as

necessary to the Conservation Network already falls into 'immature' or 'mature' categories indicating that good management, rather than restoration, will be the main aspect of implementation.

While the degree of fragmentation is high in the study area, and the rate of change is unlikely to be declining, it is not too late to begin proactive planning for biodiversity conservation at the landscape scale. Unlike many western European countries that have begun costly landscape restoration processes, New Brunswick is still in a position where protection and conservation of existing ecological areas is an option. It is recommended that a combination of private stewardship and government incentives be used to implement a conservation strategy which addresses Appalachian Hardwood Forest and other critical habitats identified by this study.

Sullivan, John J. 1999. The effects of height growth of Black Spruce (*Picea mariana* [Mill.] B.S.P.) and Jack pine (*Pinus banksiana* Lamb.) in relation to soil bulk density.

ABSTRACT

The objective of this thesis is to determine the effects of soil bulk density on tree height growth of plantation black spruce (*Picea mariana* [Mill.] B.S.P) and jack pine (*Pinus banksiana* Lamb.) a number of years after planting. The purpose of this study is to help extend the limited knowledge of how soil bulk densities affect tree height growth.

To begin the method of data collection had to be determined, therefore, two different methods in determining soil bulk densities were compared. These two methods were the cup method and the excavation method. After analyzing the collected results from these two methods, the cup method was chosen because the results were less variable and the sampling procedure was more efficient.

The areas sampled were located in York County, New Brunswick. The black spruce study site was located in Scotch Lake, and the jack pine site was situated within the University of New Brunswick woodlot. Within each plantation twenty trees were sampled for soil bulk densities. Ten trees being located near a landing site and ten trees situated towards the interior of the plantation. This sampling strategy was conducted to obtain extreme results of the effects soil bulk densities have on tree growth. Samples were taken at the drip line of each individual tree and each tree was measured for total height and yearly growth from ages three to eight years.

Once all the samples were collected, they were then analyzed. Each sample was oven-dried for 48 hours at 100° C, sifted for coarse fragments, and weighed. After the raw data was compiled, a data analysis was conducted. Here minimum and maximum bulk density values were removed from the data to reduce the influence of the extremes in the final results.

When the data analysis was completed, the average soil bulk density for each individual tree in each plantation was plotted against the corresponding tree heights and average years growth. These two scenarios showed a negative relationship between soil bulk densities and tree growth, however, the relationship between average years growth and soil bulk density displayed a slightly better correlation. After determining the effect of soil bulk density on tree growth, a bivariate scattergram was conducted between soil bulk density and average years growth. This produced similar trends in both plantations. Simple linear regressions were also conducted using these two variables, comparing the actual and best fit values. These regressions also illustrated that increases in soil bulk densities has a greater effect on black spruce development than jack pine.

These results were also compared to several other studies and similar trends were noticed. It is hoped that this thesis can aid in further research helping us better understand the relationship between soils, plants, ecosystems and human interventions.

Williams, Dana P. 1999. Analysis of Spatial and temporal variation in soil moisture during the growing season on the Lunn Farm, Woodstock, New Brunswick.

ABSTRACT

Soil moisture content varies considerably with time and space. Soil moisture is affected by climate, soil texture, soil structure, landscape position, vegetation type, and land management practices. Understanding

soil moisture quantity and variability is crucial for assessing plant growth and mortality, identifying optimal plant growing conditions, and making inferences about soil properties.

A field study was conducted to measure spatial and temporal variations in soil moisture on the Lunn farm in Woodstock, New Brunswick. A Trace machine with Time Domain Reflectometry (TDR) and 15 cm probes was used for measurements. Soil moisture data were collected on six dates (July 14, July 20, July 30, August 5, August 14, and August 19) at intervals of 25 m and 5 m across the field. Surface elevation was also measured at each point.

Results showed that the variance of measurements from the 25 m interval was significantly greater than those from the 5 m interval, based on traditional analysis of variance. Mapping revealed areas in the field that fell below the “trigger level.” These spatial variations suggest that site-specific irrigation strategies are more effective than irrigating the entire field.

A regression model was developed to predict soil moisture variations using benchmark site moisture data and a soil drainage map. The benchmark moisture was measured with the Trace machine, and soil drainage classes were derived from slope and flow accumulation.

Keywords: soil moisture, temporal and spatial variability, trigger level, regression equation

Brown, Johnathon S.S. 2000. The effects of salination in the Corbett Brook watershed area.

ABSTRACT

The study focused on salt concentrations of Corbett Brook, in the UNB Woodlot, and the surrounding watershed area from September 1998 to January 2000. The watershed was believed to be becoming salinated by road salt application and by salt leaching into the stream system from the government salt storage domes. The purpose of the study was to determine how these human factors of salt pollution were affecting the brook.

Flemming, Connie. 2000. The effects of mycorrhizal fungi inoculation on the growth of Black Spruce (*Picea mariana* [Mill.] B.S.P.) seedlings.

ABSTRACT

For the past couple of years the Kingsclear Provincial Forest Nursery has been involved in studies to determine the effects of mycorrhizal inoculation on various tree species in New Brunswick. In 1999 black spruce (**Picea mariana** (Mill.) B.S.P.) seedlings were inoculated with the mycorrhizal fungus **Hebeloma longicaudum** (Pers.:Fr) Kummer. These inoculated seedlings, as well as seedlings used for control purposes, were outplanted at various locations in New Brunswick. A sample of approximately 50 seedlings (50 control and 50 treated) from each location was randomly selected and measured to see if the applied inoculant had an effect on the seedlings. The parameters measured include shoot height (mm) and diameter (mm). Measurements were taken in 1999 and again in 2000 to determine height growth. It was determined that inoculation was not beneficial to the growth of black spruce on these particular locations.

Kelly, Nadine E. 2000. The development of a potential unique areas map and forest community guide for the Chipman Doaktown district.

ABSTRACT

The purpose of this thesis is to develop a map that identifies potentially unique areas as well as a forest community guide that aids foresters in identifying rare, uncommon and indicator plant species that may be present in the areas.

The study was a section of land that intersects both the continental lowlands eco-region and the Chipman/Doaktown district.

Gap analysis is the process of superimposing various forest layers onto a base map to illustrate where sensitive areas occur throughout a landscape. This was the approach chosen to illustrate where potentially unique areas occur.

Since the continental lowlands are generally of low elevations and gentle slopes, the potential unique sites selected reflected these characteristics. The ending result was a map that identified ten potential sites. To accompany the foresters when surveying these sites, a forest community guide illustrating, pictorially and

descriptively, stand types and various site characteristics (indicator species and rare plants) was developed.

This thesis also highlights the positive and negative aspects of gap analysis as well as numerous limiting factors. Recommendations have also been included to ensure that future gap analyses are performed correctly and accurately.

Mayrand, Krista D. 2000. Predicting and quantifying groundwater locations within the Hammond river watershed to then predict water quality.

ABSTRACT

The objective of this thesis was to predict water quality in the Hammond River watershed based on Digital Elevation Model (DEM) maps and an Arc View flow accumulation model, in conjunction with cover type (forest, agriculture or other). Based on this study, no definite conclusions could be drawn about relationships between cover type, watershed size or placement in terms of providing good water quality for organisms. The multiple regression statistics conducted would indicate tendencies that the greater the amount of forest the cooler the water temperature.

Noddin, Michelle M. 2000. Comparison of the reliability of line and mass point data in digital elevation models when estimating the number and diameter of culverts.

ABSTRACT

This thesis describes a case study using culverts at the UNB woodlot to compare the reliability of digital elevation models (DEM) and digitized contour data. Arc View GIS was used to map the digital location of the culvert position based on local topography as captured by: 1) digital elevation models based on a 20 x 20 metre sampling grid, and 2) a detailed 193 7 topographic survey. Mass point data and line data were used to delineate water drainage patterns. Reliability was compared by: 1) comparing point data predicted culvert location with actual location, 2) comparing line data predicted and actual location, 3) relating diameter size with flow accumulation and actual stream location for point data, and 4) relating diameter size with flow accumulation and actual stream location for line data.

Lee, Joanne H. 2001. Norway Spruce seedlings in Jiffy pots: Optimizing growth with grit mixtures.

ABSTRACT

This study involved using seven different top dressing types on Norway spruce (*Picea abies*) seedlings at the Kingsclear Provincial Nursery. These top dressing types consisted of a control (no top dressing), non-oiled silica, oiled silica, calcitic limestone, calcitic Nu-Gro pelletized, dolomitic limestone, and dolomitic pelletized. The objectives of this study were to find the top dressing type that produced an optimum media pH, between 5 and 5.5, and also produced optimum seedling quality. Except for the top dressings, all growing conditions were constant. For each top dressing type, foliar and media analysis were conducted in the laboratory, and morphological features such as top height, root collar diameter, and dry weight were measured. This data was used to assess the nutrient status in the foliage, media and quality of the seedlings.

The data was statistically analyzed using box plots and linear regression. The results showed that the top dressings that produced the optimum media pH were the control, dolomitic limestone, oiled silica, and non-oiled silica. The top dressing that produced the best balanced root collar/shoot ratio was dolomitic limestone. Therefore, from this study, dolomitic limestone would be the best top dressing to use to meet the objectives of having the optimum pH and the best quality seedlings.

Morrison, Cheryl. 2001. Patch dynamics of the Christmas mountains following a large scale natural disturbance.

ABSTRACT

On November 7, 1994 the Christmas Mountains were treated to a severe winter storm including wind speeds up to 150 km/hr. It resulted in the blowdown of over 2.15 million m³ of wood. The effect of

thinning operations that were in the area at the time of the blowdown is unknown and this is an attempt to begin to quantify the effects.

124 patches were randomly selected and classified as either natural, salvage cut or previous cut. The area and perimeter for each patch were determined and the boundary length (total length of boundary per unit area) will be used to determine type of edge along with visual assessments.

By comparing the three types of patches and their measurements, and orientation, location etc., it was determined that within managed areas, patches are larger and the edges are normally harder, straighter and have a lower boundary length than patches within unmanaged areas.

Khan, Amanda. 2003. Comparison of digitally mapped water saturated areas to New Brunswick Department of Natural Resources buffer zone guidelines for three sites in the province.

ABSTRACT

Water table depth prediction maps were created for three sites in New Brunswick, which are Fredericton, Gouanamitiz and Island Lake. This thesis illustrates and compares predicted water saturated zones to Department of Natural Resources Geographical Information System (GIS) buffer zones. The calculation of water table depth prediction maps is based on Digital Elevation Modelling (DEM). Results show that NB DNR buffer zones do not adequately include areas that are wet/swampy all year and not operable; as well as areas that are only considered operable during dry season. These water table depth maps can be used in forest operational planning by indicating the best time of the year to conduct harvesting by site.

Meaney, Joe P. 2004. Partial cutting techniques within riparian buffer zones to prevent windthrow in Central Newfoundland.

ABSTRACT

The Department of Forest Resources and Agrifoods, in conjunction with Corner Brook Pulp and Paper (CBPPL) and the NL Buffer Zone Working Group, conducted a study to evaluate several riparian zone management prescriptions. The objective of the prescriptions was to capture merchantable fibre without negatively impacting the integrity of the riparian zones. A secondary or more long-term objective was to evaluate methodology that may reduce the incidence of windthrow in these zones. Three techniques were conducted: removal of one out of every three trees, two out of every three trees, and an insert technique which permitted the harvester to enter into the buffer approximately four to five meters.

The 1/3 method removed a gross merchantable volume of approximately 10 m³/ha while the 2/3 method removed approximately 37 m³/ha from the buffer. The insert method extracted on average approximately 25 m³/ha. The insert levels were reduced in each of the blocks in which there was harvesting within the buffer. However, stocking was reduced only in block 4 (Insert Method) by 6% from a pre-harvest stocking of 100% to 94% after harvesting operations. Machine productivity decreased with all methods of harvesting within the buffer. The productivity decreased from an average of 11.58 m³/PMH to 9.67 m³/ha for the 1/3 method, from an average of 5.37 m³/PMH to 5.22 m³/ha for the 2/3 method and finally from an average of 8.13 m³/PMH to 6.16 m³/ha for the insert method. Residual damage from the 1/3 method and 2/3 method, blocks 2 and 3 respectively, were both assessed to have 7% of residual stems damaged. Blocks 4 and 5, which utilized the insert method, had 9% and 11% of residual stems damaged. A wind survey was conducted in the study area and 11% of the residual total skid distance area was 1.1% disturbed. Shortly after harvesting surveys determined that a windstorm in the Black Lake area. There was no evidence of blocks 1-3 there was windthrow damage; these blocks were the 1/3 method and the 2/3 method. There was, however, blowdown evident in the control block.

Glode, Jason Chad. 2005. Selective harvesting of riparian zones in Western Newfoundland.

ABSTRACT

The Department of Natural Resources, in conjunction with Corner Brook Pulp & Paper and the NL Buffer Zone Working Group, conducted a trial to evaluate selective harvesting in a 20m and 100m riparian harvest. The objective was to capture additional merchantable fibre without leaving any negative impacts on the integrity of the riparian zone. Another objective for the 20m riparian was to evaluate three different

harvesters for riparian logging. The three types of machinery used in the 20m trial were the Timberjack 608-block 1, John Deere 753 feller buncher-block 2, and Timberjack 1270-block 3. The machines utilized in the 100m riparian were the John Deere 753 and Timberjack 1270. In the 20m riparian, machines were allowed to enter approximately four to five meters inside the zone while in the 100m riparian zone treatment would extend 80m leaving 20m untreated. The idea behind the harvest was selectively removing larger diameter, dominant stems.

The Timberjack 608 used in block 1 removed a gross merchantable volume of 118m³/ha. The John Deere 753 that worked in block 2 removed 47.5 m³/ha of merchantable timber. The Timberjack 1270 used in block 3 removed a total of 80 m³/ha while the control block remained unchanged with 110.40 m³/ha. The entire 20m riparian zone had 58.5m³/ha after an average 81.5m³/ha of merchantable timber was harvested. In the 100m riparian zone the John Deere 753 cut extraction trails and the Timberjack 1270 selectively harvested the trees. The gross merchantable volume extracted was 51.40m³/ha, a decrease from 125.5 m³/ha initially to 74.1 m³/ha post harvest.

Residual damage was minor throughout both respective blocks and block 1 had 3.8% of residual stems damaged. Block 2 had 3.5 % of residual damage and block 3 had 4.1%. The 100m riparian zone had 4.1% of remaining merchantable volume damaged. The entire operating area had 14% of remaining merchantable volume remaining on the cut. The area, which was broken into two harvesting systems, SW3 and SW4, had 13.6m³/ha and 9.567m³/ha unutilized. The major difference between the two systems was the snow depths received that winter.

Post-harvest snow depths were measured to help show depths received that winter. Post-harvest there was no ground disturbance evident in the 100m riparian zone for the SW4 system. There was no ground disturbance evident in the 100m riparian zone for the SW4 system however, SW3 was upgraded to the SW3 system and 162 o% upgraded for the SW4 system.

The 20m riparian zone was revisited 3 months later to determine zone following harvest. Windthrow assessments were taken in all blocks from 1 stem in the control block to 14 stems in block 1, 6% in block 2 and 1.4% windthrow rate for the entire 20m trial. The majority of the windthrow occurred on the outer edge. The 100m riparian zone had 11 windthrows accounting for a 0.08% windthrow rate.

(Disclaimer)

The views, conclusions, and recommendations are those of the author. The exclusion of certain manufactured products does not necessarily imply disapproval nor does the mention of other products necessarily imply endorsement by the Newfoundland Department of Natural Resources.

Anderson, Adam. 2006. Field comparison of synthetic fiber and steel cable mainlines in Western Newfoundland.

ABSTRACT

The Newfoundland & Labrador Department of Natural Resources, in conjunction with FERIC and the Riparian Zone Working Group are conducting trials to evaluate the use of synthetic fibre mainlines on operations where line skidders are being used. The objective of these trials is to test the synthetic mainlines in a variety of applications and to determine the equipment limitations, as it is seen as a viable method to access sensitive sites (i.e. fragmented forests, remote areas, or poor sites with tough logging chances).

This report presents the results of a particular trial which took place in the Cold Brook area, north of Stephenville, Newfoundland, in conjunction with Whiteswood Harvesting. The trial took place in the summer of 2005 on a manual shortwood skidder clearcut operation. Two skidders were equipped with synthetic mainlines. At the beginning of the trial, a TJ 230D was equipped with a synthetic mainline, and a TJ 230 with a steel cable mainline. Approximately halfway through the trial the TJ 230 was equipped with a second synthetic mainline. All stems were manually felled and transported to roadside in piles (2.5 meter lengths) by piggybacking on the skidders. The goals of this particular trial was to evaluate the performance of steel cable versus synthetic fibre mainlines, to determine equipment limitations of the synthetic fibre mainlines, to assess impact on operator physiology, to assess impact on productivity, and to conduct a literature review and contact other users.

When operator #1 utilized the synthetic mainline his average cycle time without delays included, was 18.16 minutes/cycle. When using a steel cable mainline, operator #2 had an average cycle time without delays included, of 20.76 minutes/cycle. After switching to the synthetic fibre mainline, operator #2 had an average cycle time without delays included, of 17.68 minutes/cycle. Production increased when using the synthetic fibre mainlines. When operator #1 utilized the synthetic mainline his average production was 5.35m³/PMH. When operator #2 utilized the steel cable mainline, his average production was 5.07m³/PMH. After switching to the synthetic fibre mainline, operator #2 had an average production of 5.86m³/PMH. No rope breakages occurred throughout the duration of this trial, and both operators and the owner had a positive opinion of the synthetic fibre mainline and felt that it had some definite benefits when compared to steel cable mainlines.

Noble, Kayla. 2012. Hydrological Risk in Costa Maya Mexico.

ABSTRACT

This thesis outlines hydrological risks in the Costa Maya region of Quintana Roo, Mexico. Literature review provides background on the area of interest and hydrological risks of concern. Wet areas and flood risk mapping is completed for the area to highlight patterns of flood susceptibility that could aid in land management. A technique to improve low resolution DEM data was attempted in low lying areas of the peninsula to improve the mapping of flow channels and enhance flood risk maps. Community structure, programs, laws and regulations are outlined in the discussion to understand how the area is currently and could improve mitigating hydrological risks in the future.

Goguen, Monique. 2013. Examining the relationship between Bryophyte communities and the cartographic depth to water index.

ABSTRACT

Water availability is a key factor in the growth of bryophytes. Bryophyte species grow in abundance in wetland ecosystems, where the water table lies at or near the surface. Using Light Detection and Ranging (LiDAR) technology it is possible to create a cartographic depth-to-water (DTW) index of the landscape, which predicts where wet areas will occur. The main objective of this project was to examine the relationship between bryophyte communities and the water table by using a LiDAR-derived cartographic DTW index. The study area was in a wetland located in Fredericton, New Brunswick. For this study, moss transition boundaries were tracked around the wetland using a global positioning system (GPS). In addition, moss species composition and relative abundance were recorded at a series of sample points. Finally, the data was inputted into a geographic information system (GIS) and mapped using DTW data layers (1 m resolution). The tracked moss boundaries were best aligned with the DTW layer when using a stream flow-initiation area of 4 hectares. In terms of growth and abundance at the sample points, *Sphagnum* moss was the species of bryophyte that showed the strongest correlation with the predictive depth-to-water level. The DTW mapping process was found to be useful as a tool for predicting the spatial distribution of moss species, particularly for *Sphagnum* moss.

Poley, Violet. 2023. Relating Soil Organic Carbon to Depth-to-Water by statistical analysis.

ABSTRACT

(Unavailable)