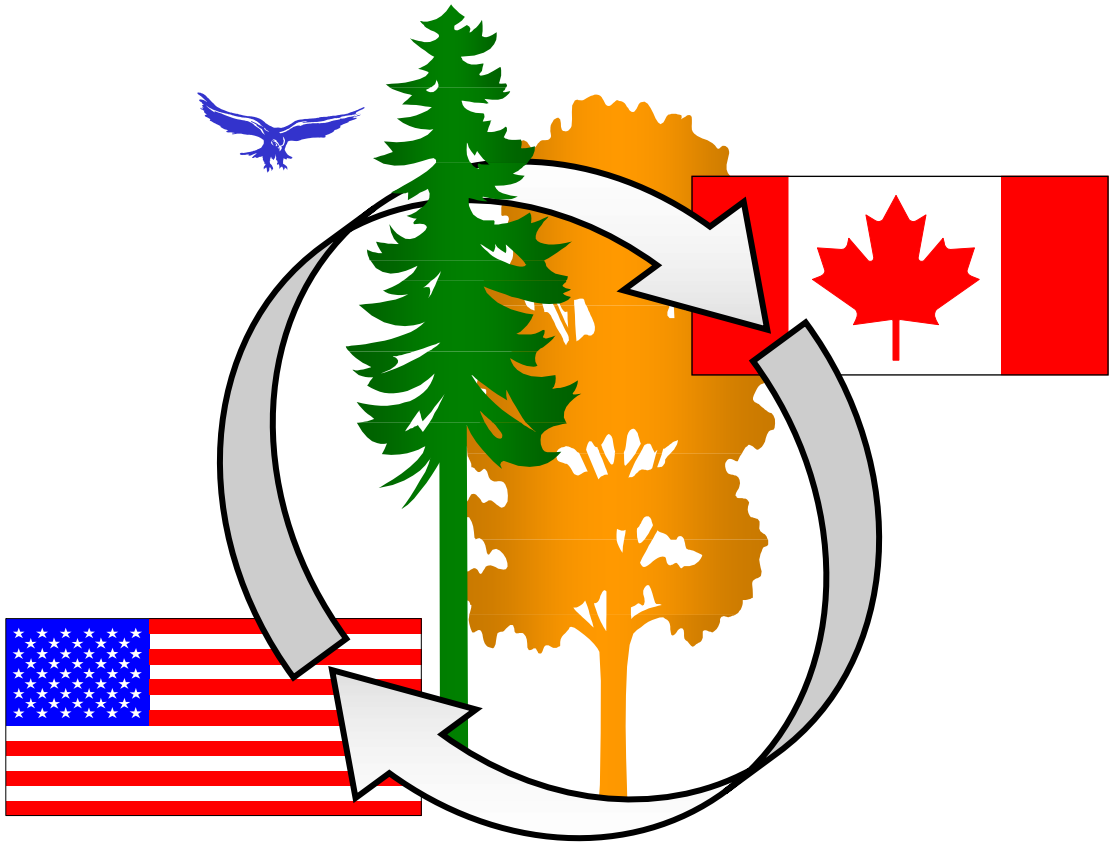

Eastern CANUSA Forest Science Conference

October 15–16, 2004

University of New Brunswick
Fredericton, New Brunswick

Conference Proceedings

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Conference Proceedings

Compiler:

David A. MacLean

Hosted by:

University of New Brunswick
Faculty of Forestry and Environmental Management

And

University of Maine
College of Natural Sciences, Forestry, and Agriculture

INTRODUCTION

Welcome to the second Eastern CANUSA Forest Science Conference! The northeastern United States and eastern Canada share a vital and common link to the northern forest. In addition to strong economic dependence, people of the region derive considerable recreational, aesthetic, and ecological values from this forest. The future of the region clearly relies upon the sustainable management of this highly valued resource.

Because of the northern forest's importance to the region, forest managers and researchers from the northeastern states and eastern Canadian provinces are working continuously to find solutions to a wide variety of natural resource problems. Great work is occurring on both sides of the US/Canadian border that can be further enhanced by regular information exchange about issues affecting the northern forest. A forum was needed to promote ongoing discussions and collaborations about the latest forest problems, methods, findings, and technologies. Hence, the first ECANUSA Conference was held in 2002 in Orono, Maine.

This conference was developed to provide a regular venue for communications among forest managers, forest scientists, policy makers, students, natural resource professionals, and others interested in forest resource issues from both sides of the Canadian/US border. This document contains short papers from invited speakers and one-page abstracts from the oral and poster presentations delivered at the conference.

CONFERENCE ORGANIZING COMMITTEE

University of Maine	**University of New Brunswick**
Robert Wagner (Co-Chair)	David MacLean (Co-Chair)
Steve Shaler	Y.H. Chui
Fred Servello	Graham Forbes
Dan Harrison	John Kershaw
Jeremy Wilson	Tom Beckley
Keith Kanoti	Sarah Taylor

ACKNOWLEDGEMENTS

We thank Chris Green and Liz Whamond of the Faculty of Forestry and Environmental Management, University of New Brunswick for their invaluable assistance with conference logistics, registration, and compilation of the Program and Proceedings.

Financial support was generously provided by the University of New Brunswick.

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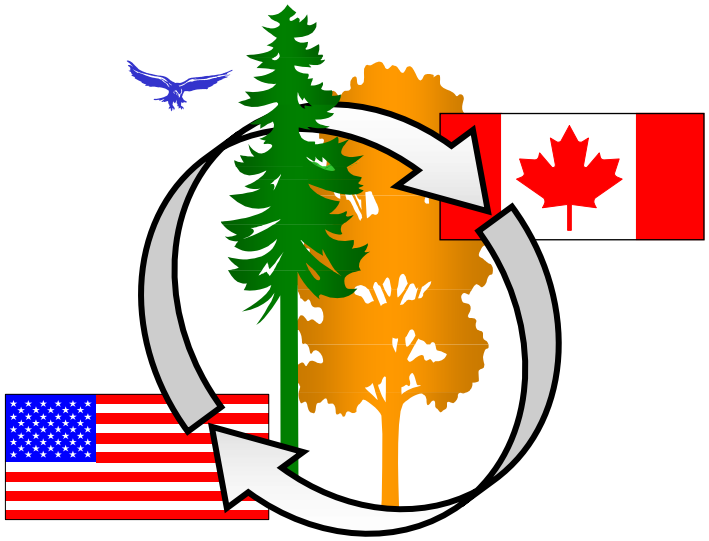

CHANGING MAINE FOREST LANDOWNERSHIP: IMPLICATIONS FOR FOREST MANAGEMENT AND BIODIVERSITY

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Early this year, the Manomet Center for Conservation Sciences received a grant from the National Commission on Science for Sustainable Forestry to study the topic indicated in our title. The study addresses the Northern Forest region of New York and northern New England, but we will focus this talk on Maine, where the greatest amount of ownership turnover has occurred. Project completion is expected in spring 2005. This talk reports on the initial phase of the work – documenting major landownership changes in the past quarter century.

We have conducted extensive "strategic" interviews to get an overall picture. The next step is to compile a database that will indicate for us a number of specific traits of recent timberland transactions. With the aid of a number of experts, we are assembling a dataset of transactions larger than a quarter township (5-6,000 A, more or less). We are attempting to identify the identity of seller and buyer, the acreage of the parcel involved, and the date. In addition, we will identify all the easement transactions of this size and larger. We are seeking coverage from 1980 to mid- 2004. We have assembled chronologies of ownership change for a number of major owners. This part of the effort is in its final stages now. On the basis of our strategic interviews with experts on the land market, and the current version of the database, we have made a number of interesting observations. These are confined to Maine for purposes of this presentation.

From the time of Sir William Pepperell to William Bingham and the out of state lumber barons of the 19th century, large landowners have come and gone in Maine over the centuries. In many instances, their passing occurred with little notice and little impact on the land. After the turn of the century, the paper companies began assembling large ownerships. In most instances, these did not reach their largest extent until the 1960's or even later. The stability and continuity of ownership by these companies was unprecedented in Maine's history. By the 1970's, Maine held the largest concentration of industry ownership of any state in the nation. This situation seemed permanent. For many of us who began our careers during that time, the changes have been wrenching.

For reasons outside the scope of this presentation, this impressive ownership pattern entered a period of rapid change in the mid eighties. By the mid-90's, much of the transfer of land had been from one industry owner to another. Impacts on the land had been modest, and breakups of large tracts were the exception. The pace of change increased until, between 1999 and 2004, a series of dramatic events occurred. One was the breakup of the Great Northern holdings, lands that had symbolized paper company solidity and power over most of a century. The announcement of the Pingree/NEFF conservation easement (750,000 acres) inaugurated a new era. This consisted of well-established conservation groups, raising funds from individuals

and foundations, buying easements and occasionally the fee on extremely large tracts. In addition, by the end of the century half the remaining industry ownership was held by Canadian concerns – another unprecedented development. Finally, several highly successful logging contractors, previously stigmatized by some as "liquidators", emerged as a class of "New Timber Barons", retaining sizable areas for longterm management. Not one of these changes could have been predicted by close observers in 1998. The landownership situation seems to be a work in progress and new surprises may be in store for us. The phenomenon we are evaluating keeps changing before our very eyes.

Interestingly, some of the lands involved in many of these land sales ended up in public ownership. But in Maine, by and large, the public sector did note acquire extensive fee interests. Where government became intimately involved was in the purchase of large-scale "working forest conservation easements", which totalled well above 1.5 million acres by mid 2004.

In order to appraise the implications of these events for forest management and biodiversity, we plan to conduct structured interviews with a large sample of participants in these transactions to document changes, if any, in important aspects of their forest management practice, support of research, and their policies related to biodiversity. This effort is under way at this writing. But we have some preliminary observations. First, we are finding that the old categories of owners are blurring and are less useful in understanding management policies. Second, the landownership picture seems to be headed for a future in which longterm stability is the exception rather than the rule. We shall have to learn to live with this. Third, the easements are a very important outcome of this re-sorting of ownerships. While they eliminate the threats of widespread subdividing and scatteration of leisure homes, they generally provide minimally for the most vulnerable components of biodiversity, such as late-successional forest. Fourth, other factors such as markets and technology are affecting management practices and biodiversity. Such factors may be only loosely related to ownership. Finally, most of the new owners do not have intensive management on their agenda, though there are a few interesting exceptions.

Based on results of these interviews, we will venture some judgments on our bottom line questions: is forest biodiversity in Maine better off today than it was 4 years ago? Eight years ago?

HARVEST INTENSITY GOT ME HERE; WILL PARTIAL HARVESTING GET ME THERE?

Kenneth M. Laustsen

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As the most heavily forested state in the country, the forest resources of Maine have been utilized for over 300 years. Over the last forty-five years, the USDA Forest Service and the Maine Forest Service have cooperated in collecting, estimating, analyzing, and publishing data documenting the recent change, the current status, and future prospects of those resources.

Between the 1972 and 1995 periodic inventories, the combined forces of the spruce budworm epidemic, salvage harvesting, market expansion, and owner/management changes all coalesced together to impact the forest with an unprecedented intensity. A review of the extent and type of practices will be provided to set the context, because for many, the future looked bleak.

The fallout of those activities and a widespread concern about the sustainability of Maine's resources resulted in plethora of divergent outcomes over the next several years: legislation that restricted forest practices; the governor's Council on Sustainable Forest Management; a ban clearcutting referendum (the Compact); an in-depth analysis and publication of a long-term wood supply (Timber Supply Outlook for Maine, 1995 – 2045); a forest practices referendum (2A or is it 2C); and the implementation of an annualized statewide inventory, and legislative policy on liquidation harvesting.

Maine is now poised with the pending publication of its 5th Year report, the first comprehensive analysis of inventory and growth since 1995. Some salient points will be made in order to understand the *status quo*, the current construct of Maine's forest resources.

Finally and prospectively, opportunities will be offered for partial harvesting systems to have a dual role in maintaining certain structure while concurrently enhancing the development of Maine's next forest.

- FOREST MANAGEMENT IN NEW BRUNSWICK - THE JAAKKO PÖYRY STUDY, THE LEGISLATIVE SELECT COMMITTEE ON WOOD SUPPLY, AND WHERE DO WE GO FROM HERE?

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Purpose

In late 2001, the New Brunswick Forest Products Association (NBFPA) submitted a letter to Jeannot Volpé, New Brunswick Minister of Natural Resources. This triggered a 3-year sequence of events, whose potential to change New Brunswick forestry is more profound than any development since passage of the Crown Lands and Forests Act 25 years ago. In this paper, we chronicle these events and identify some resulting and important challenges that confront the New Brunswick forestry community as it faces the future.

A Brief History of Events

The Letter

Notable among the many requests in the NBFPA 2001 letter to Minister Volpé were ones for (a) an immediate increase in the harvest from Crown land, (b) intensification of management to enable a doubling of harvest in the future, and (c) revision of non-timber forest management goals to enable these harvest increases.

This controversial letter was triggered by a growing concern within the forest industry about the security of future wood supply and related implications for industrial competitiveness. Such concerns stemmed from: (a) the unreliability of the 10% of the industrial softwood requirement imported from neighboring jurisdictions; (b) potential wood supply shortfalls from the woodlot land base, given recent overharvesting in some parts of the province; and (c) the decline since 1992 of softwood harvest from Crown land, as a result of increased management emphasis on non-timber values. These collectively painted a bleak industrial outlook, which, through its letter, industry lobbied the Minister to correct. The letter was soon leaked and prompted a strong negative and public reaction from the environmental community.

The Jaakko Pöyry Report

Minister Volpé was not convinced to act upon industry's request but, given the nature of the issues raised, did agree to jointly fund with industry a third-party examination of New Brunswick's forest management policies and practices. Finnish forestry consultant Jaakko Pöyry Consultants was engaged in February 2002 to, among other things, compare New Brunswick forestry to that in other countries and to examine possibilities for increasing wood supply from Crown land.

After ten months of analysis, the so-called Jaakko Pöyry report[1] was publicly released. It contained the following six recommendations.

1. A timber supply objective should be set for each Crown License area, which would be binding on both the Government and the Licensee. Timber supply objectives should be set for the range of species harvested commercially for each License.
2. The industry and New Brunswick Department of Natural Resources (DNR) should jointly fund and support research and development of science-based forest management practices.
3. The public should participate in reviewing the objectives of management for New Brunswick's Crown lands, to provide a mandate for the direction and magnitude of change in forest management.
4. The DNR should reduce overlap in management and oversight of Crown lands.
5. Special management zones should be critically reviewed and, where possible, additional harvesting permitted.
6. Conservation values of private lands should be taken into account when evaluating the need for set-asides and special management on public lands. This should include a process to establish a form of voluntary conservation designation on private industry lands and woodlots.

Recommendations 1, 4, and 5 provoked a strong negative reaction from many interested parties outside industry circles, but by far the most controversial element of the report was not a formal recommendation of the consultants at all. Instead, it was a management scenario analyzed in the report, which suggested that intensified management and expanded plantation establishment could increase growth and thereby achieve a doubling of future harvest, while still "meeting all other environmental and social objectives for Crown Land usage".

The Jaakko Pöyry report generally, and the so-called "doubled wood supply strategy" specifically, turned up the heat under the long-simmering concerns and disagreements about forest management in New Brunswick. In several public forums and through the media, concerned individuals and organizations engaged in a vigorous debate about New Brunswick forestry, some condemning and others endorsing the vision presented in the Jaakko Pöyry report.

In fact, the debate about forestry in New Brunswick was elevated to such a level, with expressed opinions so strong and diverse, that in the summer of 2003 the Conservative Government of Premier Bernard Lord established a Legislative Assembly Select Committee on Wood Supply. The Select Committee mandate was to examine "opportunities and strategies arising from the Jaakko Pöyry report to increase available wood supply from Crown Land in New Brunswick" and to examine "opportunities and strategies for the future direction of Crown forest management".

Several parties, including the Conservation Council of New Brunswick, had long lobbied for the creation of such a committee to review New Brunswick's forest management and to gain more

[1] Jaakko Pöyry Consulting. 2002. New Brunswick Crown Forests: Assessment of Stewardship and Management. Report prepared for the New Brunswick Forest Products Association and the New Brunswick Department of Natural Resources and Energy. 60p. Available at http://www.gnb.ca/0078/reports/JPMC/jpmc-e.asp

public input to formulation of forest policy. It is somewhat ironic that, in commissioning the Jaakko Pöyry report, industry helped the Council to realize its wish.

The Legislative Select Committee on Wood Supply

The Select Committee was chaired by Mr. Kirk MacDonald, Conservative Member of the Legislative Assembly (MLA) for the riding of Mactaquac, and comprised 11 members representing the Conservative, Liberal, and New Democratic parties. To accommodate the overwhelming number of individuals and organizations who wished to make public presentations to the Committee, 13 public hearings were held, almost double the number originally scheduled. In all, some 200 oral briefs were made before the Committee, and over 250 letters and written briefs were submitted.

The public hearings were marked by deeply-felt concerns and convictions about New Brunswick forests and their connections to the provincial society and economy. Many well-reasoned and substantiated cases were made—as were many factually questionable ones—in support of vastly differing visions of how New Brunswick forests should be managed. Except for the matter of First Nation rights to the forest resource, no topic relevant to New Brunswick forestry went unaddressed at the hearings. The Select Committee process represented what is likely the most open and complete public airing of forestry perspectives in the history of New Brunswick. In addition, the staff of DNR released their own review of the Jaakko Pöyry report in January 2004[2].

After the final public hearing in December 2003, the Committee deliberated and prepared its report[3], which was endorsed by the all-party Committee and publicly released on September 15th 2004. The report contained 25 recommendations. The essence of these recommendations (as we have interpreted and condensed them) is presented below, by the four categories by which they are organized in the report[4].

1. *Governance and Accountability:* Several recommendations were made to greatly strengthen the connection between the public and its forest. Among these were increased public involvement in objective setting, more meaningful and complete reporting to the public of the forest status and management performance, better provision of objective information about forest management, and establishment of a Provincial Forest Advisory Committee comprising various interests and with the role of advising the Minister of Natural Resources on matters related to forest policy.
2. *Forest Management Objectives:* On the grounds that they are more environmentally and

[2] Staff Review of the Jaakko Pöyry Report. 2004. New Brunswick Crown Forests: Assessment of Stewardship and Management. New Brunswick Department of Natural Resources, Fredericton, NB. Available at http://www.gnb.ca/0078/reports/Jaakko_Poyry_FINAL-e.pdf

[3] Legislative Assembly of New Brunswick Select Committee on Wood Supply. 2004. Final Report on Wood Supply in New Brunswick. Report submitted to The Legislative Assembly of The Province of New Brunswick, First Session, Fifty-fifth Legislature.

[4] All recommendations are fully presented, along with the underpinning rationale, in the Legislative Assembly Select Committee on Wood Supply report, available at http://www.gnb.ca/legis/business/committees/reports/Wood/legwoodfinal-e.pdf

economically robust, the Committee recommended formulating timber supply objectives that reflect and maintain the natural diversity and character of the Acadian forest. This includes quantifiable wood supply objectives for all commercial tree species, and a call for reduced use of clearcut harvesting; further, it implies quantification of the character of the Acadian forest.

3. *Allocation of the Resource and Distribution of Benefits:* The Committee was concerned that benefits from the public forest were not adequately and equitably distributed across society and formulated several recommendations for redress. Among these were allocation of harvest opportunities to small, independent local contractors, allocation of harvest volume to new value-added enterprises, encouragement of the non-timber forest product sector, and stabilization of local employment opportunities.
4. *Provincial Wood Supply:* To promote sustainable timber supply across all land ownerships and to treat private landowners fairly, the Committee recommended the establishment of a dedicated and stable silviculture fund matched to forest management objectives, continued support of negotiations between private woodlot owners and industry, and increased royalty rates to reflect the premium associated with security of wood supply from Crown forests.

Review and reaction to the Select Committee report contents are ongoing, and as is the case with all such reports, the Government is not obliged to act on all or any of the recommendations made. Given the complexities of the issues, the government's formal position will likely be some time in coming.

Mill Closures

Nearly coincident with the release of the Select Committee Report were two recent major announcements that further complicate the already complex forest management scene in New Brunswick. On September 14th, 2004, St. Anne Nackawic Pulp and Paper closed its mill and announced bankruptcy, and on September 20th, UPM-Kymmene announced that its Miramichi kraft mill would cease operations in January 2005. These two mill closures represent the loss of 800 direct jobs and are a huge economic blow to the forest-dependent towns of Nackawic and Miramichi. Some have suggested that the Select Committee failed to make recommendations that would avert mill closures, the like of which coincided with release of the report.

Challenges for the Forestry Community

Assuming that the NB government endorses the main elements of the Select Committee report (which is by no means a certainty), and given the recently announced mill closures, we foresee several very significant challenges to the forestry community to effectively implement the recommendations and to bring about a more prosperous forestry future in the province. These challenges are interconnected but cut across multiple disciplines, much like this Eastern Canada/USA Forest Science Conference. The challenges pose some important research and development questions that we believe fall under the broad base of expertise and interests represented at this conference. Our list is not a comprehensive one and our views may be off-the-mark in some cases. Nonetheless, we offer the following five items as stimuli for discussion and thought by those who are interested in advancing forest management in the Province.

1. Public Participation

Increased public participation is the one element of the Select Committee report about which all parties are sure to agree, at least in principle. But what forms of public participation will actually be effective in New Brunswick? We appreciate that the issue of public participation in decision-making is not a new one and there is much experience elsewhere. Nonetheless, some critical questions remain. How can the government effectively and efficiently solicit informed, representative, and constructive input from across society, including both interest groups of all persuasions and average citizens? How can government inform the public in clear and meaningful terms about complex management alternatives and their associated trade-offs, and then gauge public preferences to those alternatives? How can government engage the public in a way which does not mire decision-making or render decision-making sluggish, ineffective, or unresponsive to changing circumstances? Answering such questions will require the expertise of those versed in social science, public communication, and collective decision-making.

2. Wood Supply Objectives

While the Select Committee did not endorse the "binding" wood supply objectives proposed in the Jaakko Pöyry report, it did recommend the establishment of specific wood supply objectives for all commercial tree species. As with public participation, the principle here is sound, but the "make or break" questions lurk in the details. How should such objectives be formulated and on what basis? Despite the recommendation to set objectives with due consideration for the Acadian forest characteristics, there still exists much leeway to favor one species over another, or to promote different product qualities. There is probably a wide historical natural range of variability in species composition within the Province, as a function of natural disturbances like fire, insect outbreaks, and wind and ice storms. Furthermore, how should such targets be formulated to enable maximum flexibility to respond profitably to unknown and unknowable future market situations? To changes in the environment? To the unfolding strategies and initiatives adopted by competitor jurisdictions? The mix of long time horizons for forest growth in New Brunswick, changing and unpredictable markets and social preferences, rapidly advancing technology, and impending climate change create a very challenging problem to define appropriate and robust wood supply objectives. Capacity and the time frame required to attain such objectives must also be considered. Addressing the problem will require the creative and collective effort of forest managers, forest industry specialists, and those who can look beyond the confines of the present industrial make-up in the province.

3. Deriving Value and the Nature of the Future "Industry"

The Committee recommendations that related to non-timber forest products, community employment stability, and emphasis on value-added initiatives, coupled with the recent mill closures, pose critical questions about what the future make-up of the "forest industry" in New Brunswick should be. How can the province derive maximum value out of its raw material supply? How can it develop and competitively serve markets that suit that raw material supply? How can it attract the capital investment required to derive the value and maintain the employment benefits for which these recommendations were formulated? Is there a place for $400 million dollar pulp mills in New Brunswick, or should industrial development proceed on a smaller scale, requiring less investment and less certainty about long-term wood supply? Can such an industry provide the economic contributions that New Brunswick has historically

derived from its forest? What non-commodity related forest enterprises can New Brunswick excel at? Such questions are not necessarily new ones, but with recent developments, they have taken on a new relevance and urgency. Addressing them will require some creative planning and thinking that bridges disciplines of resource management, social development, economics, and market development.

4. Characterizing the Acadian Forest

Implied in the Committee's wood supply objective recommendation is the need to characterize the Acadian forest is a way that is meaningful in ecological terms and relevant in management terms. Such a task is akin to that performed by the Department of Natural Resources Fish and Wildlife Branch in specifying wildlife habitat requirements, except that it is likely to be more complex, more difficult, more subjective, and more time consuming. Given the natural variability in the forest in time and space, and given our long history of intervention through harvesting and protection, what exactly does the Acadian forest look like? What are appropriate targets for forest structure and composition at fine and coarse scales, given our understanding of the Acadian forest? And is the historical Acadian forest necessarily the target, or are there bounds within which New Brunswick society should be able to choose the future forest composition? Much innovative work is underway on this topic and much historical information exists, but bringing results to bear in a management context will require significant continued effort and thought.

5. Quantitative Analyses

One lesson from the Jaakko Pöyry report, and from the variety of public submissions to the Select Committee, is that the already difficult and contentious choice an of appropriate management strategy for New Brunswick's forest is made all the more so by the very incomplete information about New Brunswick's management options and outcomes. Current forest management analyses in New Brunswick have examined the status quo management strategy in detail, but only in terms of wood supply and some forest conditions. Little evaluation has been made in economic or social terms, despite their importance that is so evident in the Select Committee's recommendations. Further, only one alternative to the status quo strategy was examined, that being the Jaakko Pöyry doubled wood supply strategy, which arguably was somewhat superficial in depth and limited in scope. We believe many of the recommendations put forth by the Committee would benefit from a more comprehensive approach to exploring all practicable management options for New Brunswick's forests. Several questions must be answered prior to implementing such an approach. What alternative forest management strategies exist? How can they be characterized and their potential impacts forecast into the future? How can the likely outcomes be gauged in a comprehensive way and in relevant terms comprising environmental, economic, and social dimensions? How can the robustness of contemplated strategies be assessed relative to uncertainties in markets and social preference? Notwithstanding the inevitable uncertainty that accompanies forecasting the future, such analyses could provide a clearer picture of management options and reveal a more complete view of opportunities and outcomes. This would be a major step toward providing a more solid foundation for choosing a course of action by which to manage New Brunswick's forests.

One Step Forward?

The University of New Brunswick, Faculty of Forestry and Environmental Management, in cooperation and with major external funding from forest industry in New Brunswick and Nova Scotia and the governments of New Brunswick and Canada, is establishing a *Canadian Institute of Forest Policy and Communication* (*CIFPAC*). This UNB Institute and Forest Policy Professor will take the lead on bringing the best science to bear on contentious forest policy issues in New Brunswick and Canada. *CIFPAC* will work to locate world-wide experts on specific issues and bring them to Atlantic Canada; to synthesize the science and values underlying important forest policy issues, and articulate values, choices, trade-offs and assumptions; to proactively facilitate two-way communication, via roundtables and media workshops, to promote dialog before issues become public concerns; and to use quantitative, science-based approaches to articulate options and values. Its ultimate goal is to develop effective means to identify impending issues, and to develop public education, public engagement, and proactive methods to avoid future controversies. Steps are already underway to staff the Institute[5]. Clearly, some of the five categories of questions that we posed above would benefit from such expertise being in New Brunswick.

Conclusion

In the three years since the submission of industry's letter to Minister Volpé, forestry in New Brunswick has risen to a level of prominence in the public and professional consciousness that is unprecedented in recent decades. The public voice is louder and stronger, industrial concerns are greater, and the economic vulnerability of the province is clearly evident. The forestry community faces huge challenges to create a healthier forest and forest economy. Success in meeting these challenges will require concerted, coordinated, and constructive efforts of practitioners, researchers, policy-makers from the domains of social, management, and environmental science. We sure live in interesting times!

[5] Details of staffing for the UNB *Canadian Institute of Forest Policy and Communications* are provided in a full-page ad in the July-August 2004 issue of The Forestry Chronicle (Vol. 80, No. 4, p.450).

FOREST MANAGEMENT IN A PUBLIC TRUST

David Coon

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Half of New Brunswick's forests are found on Crown land. These lands and resources are held in trust by the provincial government.

Land in New Brunswick was never ceded to the Crown by the three First Nations which still reside within the province today. Negotiations between the federal government, the province and First Nations are anticipated to address aboriginal title. Courts have also affirmed both aboriginal and treaty rights to harvest resources from Crown lands for personal use and to earn a moderate livelihood – rights which are entrenched on Canada's constitution. Thus Crown lands and forests are held in trust for First Nations with the responsibility resting on the Crown (the provincial government) to negotiate access and management arrangements which accommodate these rights.

Canadian common law holds that these forest commons represent a public trust for all generations to be stewarded by governments without diminishing their inherent value, and that this conveys public trust rights to all citizens. In this context, Crown land and its resources are a public trust to be managed for public benefit for today and in perpetuity without diminishing their inherent value.

The Government of New Brunswick does not hold these lands, waters and resources as property, but rather serves as their trustee.

In this context, one would expect an elaborate system for ensuring that access and management of the Crown land and forests reflected the trust relationships between the provincial government, First Nations and the citizens of New Brunswick. It does not.

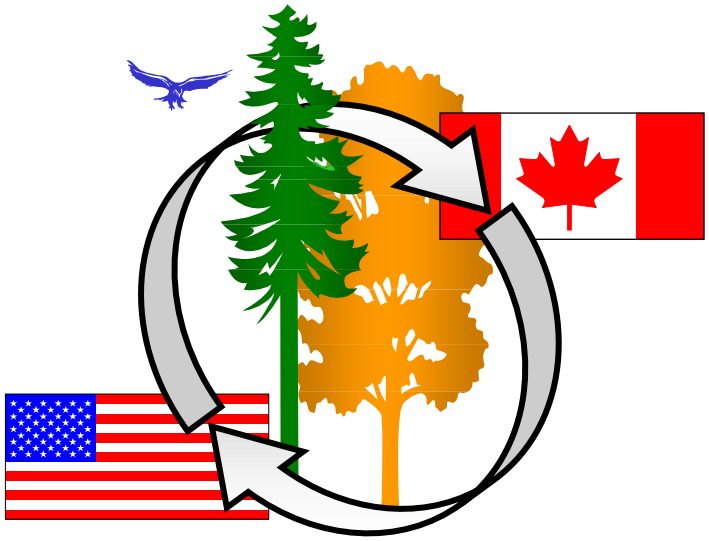
In 1982, the Crown Lands and Forests Act conveyed management responsibilities for, and exclusive access to, its forest resources to companies owning mills in New Brunswick. In light of aboriginal rights and the treaty relationships between the Crown and First Nations, the courts have found that aboriginal people are not subject to the Crown Lands and Forests Act.

While no case has yet been brought before the courts to determine whether the Crown Lands and Forests Act infringes on the public trust rights of citizens, there is widespread discontent with current tenure arrangements and the direction of management. Nor has there been any legal determination of how common law public trust rights mesh with aboriginal rights to allow for rural livelihoods to be sustained through access to public resources.

A Select Committee of the Provincial Legislature recently released a series of recommendations concerning the governance and management of Crown lands and respecting the allocation of resources and distribution of the benefits. Their report followed on public hearings held throughout New Brunswick. If implemented, these measures for the governance and management would better reflect the public trust nature of the Crown lands and forests.

However, a full accommodation of aboriginal rights and treaties, coupled with a recognition of aboriginal title will necessitate more fundamental changes to the current system of tenure and management. This has the potential to significantly increase public benefits from, and enhance stewardship of New Brunswick's forest commons.

ORAL PRESENTATIONS



FIRE DANGER MONITORING IN A NORTHERN BOREAL FOREST REGION USING RADARSAT-1 IMAGERY

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The goal of our study was to evaluate the potential use of RADARSAT-1 images to assess daily variations in dead-fuel moisture over a northern boreal forest area, as parameterized by the Canadian Forest Fire Weather Index (FWI) codes and indexes. The study area was located in the south-central region of Canada's Northwest Territories and was comprised of three main land cover classes (i.e., forested, burned forest and bare soil areas). Nineteen RADARSAT-1 images were acquired over the study area in June 2000 and August 2002, and their backscatter was compared to weather data and to the FWI System components. In both cases, the influences of incident angle and land cover were considered. Radar backscatter was related to relative humidity and rainfall and strong relationships were observed with the FWI System codes and indexes, particularly in the case of the Duff Moisture Code (DMC), Drought Code (DC), Build-Up Index (BUI) and FWI itself. The best regression models were obtained using a stepwise regression procedure in which radar backscatter from areas with minimal vegetation cover (i.e., burned forest and fireguard) was used as independent variables. Limitations and possible improvements of the study are also presented.

HAND-HELD GPS RECEIVERS FOR FORESTRY APPLICATIONS: A CASE STUDY

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Forest management relies more and more on GIS-based planning and decision-support systems. Hand-held GPS receivers are widely used for setting up, upgrading, and updating of required spatial data. To date, standard receivers give horizontal accuracy of 5-10 m under forestry canopy which is sufficient for many applications. Nevertheless, in some cases higher accuracy is needed even under forest canopy for accurate mapping of property boundaries and any power lines or pipes, special management zones such as deer wintering areas and rare biotopes.

This study tested a hand-held GPS receiver (Trimble Geo Explorer XT) under forestry and open land conditions. The receiver claims sub-meter accuracy under open-land conditions. It was the intent of the study to explore the accuracy under forest canopy conditions.

In total, three sample plots were set up: one in a hardwood stand, one in a softwood stand, and one under open-land conditions. The general set up was a square of 50 side length and marked point locations at the corners and at every 10 m intervals along the sides. In the stands, crown closure was measured by spherical densitometer. “Real” coordinates of the marked points were measured using a high precision GPS with a horizontal accuracy of +/- 3 cm. In the open sample plot, this GPS receiver was directly located over the marked points. For the sample plots located in the stands, point measurements on adjacent roads (open conditions for high accuracy) were used. These points were used to orientate an electronic total station to measure the coordinates of the test side points located inside the stands.

After trial set-up all the points were measured with the Geo Explorer XT receiver. In total, three open-land measurements (each 20 point measurements) proved the sub-meter accuracy of the device by having an average absolute distance of 0.76 m, 0.78 m, and 0.81 m between the measured and the “real” coordinates. For the two series in the softwood with an average canopy closure of 84 % the average absolute distance between Geo Explorer XT coordinates and “real” coordinates was 1.22 m and 1.58 m respectively. In the hardwood stand with an average canopy closure of 83 % the results of two series of Geo Explorer XT measurements show 1.25 m and 1.47 m as average absolute distance to the “real” coordinates. Later in the fall a measurement without foliage showed 1.10 m as average absolute distance. The results demonstrate the capacity of this receiver for highly accurate measurements even under forest canopy.

FROM FOREST COMMUNITIES TO COMMUNITY FORESTS? AN EXPLORATION OF THE COMMUNITY FORESTRY CONCEPT IN THE ACADIAN FOREST

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This study interrogates the community forestry concept – in terms of its history and applications - in the Acadian Forest. Rapid, and arguably radical, changes are taking place in the relationship between communities, industries, and governance of the working forests of this eastern North American region. The central questions behind this research are: What is the potential for community forestry in the industrially-dominated, and internally colonized, communities of the Acadian Forest? and How do the developing projects in this region speak to and modify community forestry as we know it? Through an ethnographic study of three different developments within the Acadian Forest – the Maine Master Logger Certification program, the tenant forest farming experiments of the Bas St-Laurent Model Forest, and the birth of the International Loggers' Association – this research incorporates a particular focus on forest workers' perspectives on the long-term viability and social justice aspects of the programs and organizations developing around the drive to sustain a unique culture as well as the resources that have supported and shaped it.

MAKING FOREST POLICY: PERCEPTIONS OF FORESTERS AND NEW BRUNSWICK'S JAAKKO POYRY REPORT

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Limited fibre supplies are of concern to the forest industry, provincial government departments, and special interest groups, to name a few. Foresters are employed by all three of these stakeholders. This paper examines the role of forest policy actors in making public policy. The Brooks and Miljan's (2004) multifaceted framework will be used to assess the foresters' role in the current policy debate regarding softwood fibre supplies related to the Jaakko Poyry report (2002). The conclusions help map out a range of possible roles for (senior) forester policy actors from each of the three stakeholders.

EXTERNAL KNOT CHARACTERISTICS IN BLACK SPRUCE FROM THREE INITIAL SPACINGS

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The objective of this paper is to present a model that will predict the size, location and frequency of knots for black spruce trees. A knot is defined as the portion of a branch contained within the tree stem. For the purposes of this study, a minimum knot size of 0.5 cm is used to coincide with current visual lumber grading rules. Many tree growth models1,2 and branch growth models3,4 have been developed, but their utility in predicting locations and sizes of individual branches or knots is often limited and little work has been published for black spruce. The Ontario Ministry of Natural Resources (OMNR) established two spacing trials near Thunder Bay in 1950 using black spruce, white spruce and red pine. The objective of the trials was to determine the effect of initial spacing on tree size (height, diameter and volume) over time. Blocks were established at spacings of 1.8m, 2.7m and 3.6m for all species. OMNR has permitted destructive sampling of trees within the Stanley trial for the purpose of wood quality research. In 1998, Forintek Canada Corporation harvested 139 trees from the Stanley trial to assess the impact of initial spacing on black spruce lumber grade yield and strength properties5. Knot characteristics were not considered at that time, so this paper is a continuation of that research. A total of 18 trees were harvested from the Stanley trial (7 @1.8m, 6 @ 2.7m and 3 @ 3.6m). Five parameters (vertical location, horizontal diameter, vertical diameter, stem intersection angle and horizontal projection angle) were measured for each branch stub on each tree. Knot size and knot frequency will be modelled using tree diameter at breast height, tree height, whorl location, whorl length, depth in crown and initial spacing. Whorl location is the one parameter that could not be measured directly as black spruce does not have well defined whorls. However, a method for interpreting branch size changes with respect to vertical location is being developed that will provide an estimate of whorl location.

PREDICTING SITE OCCUPANCY OF FOREST BIRDS USING AIR-PHOTO-DERIVED FOREST INVENTORY DATA

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1. Concerns about declines in forest biodiversity underscore the need for accurate estimates of the distribution and abundance of organisms' at large scales and at resolutions that are fine enough to be appropriate for management. This paper addresses two major objectives: (i) to determine whether the resolution of typical air photo-derived forest inventory (using geographic information systems [GIS]) is sufficient for the accurate prediction of site occupancy by forest birds. We compared prediction success of habitat models using air photo variables to models with variables derived from finer resolution, ground-sampled vegetation plots. (ii) To determine whether landscape structure is an important factor in predicting bird distribution in forest-dominated landscapes. Models were tested locally (in the Greater Fundy Ecosystem [GFE], New Brunswick, Canada) using cross-validation, and regionally using independent, geographically-discrete data (from Riley Brook [RB], New Brunswick, Canada).
2. For 62% of species examined, landscape variables were significant predictors of forest bird site occupancy even after statistically controlling for stand-level variability. However, broad spatial extents were less important than local factors in describing forest bird occurrence. Stand type and structure seem to supersede landscape structure in the process of habitat selection by forest birds.
3. In the GFE, 76% (16/21) of air photo, and 81% (17/21) of ground plot models were accurate enough to be of practical utility (auc>0.7). When applied to RB, both model types performed effectively for 55% (11/20) of the species examined. We did not detect an overall difference in prediction success between air photo and ground plot models in either study area. We conclude that remotely-sensed air photo data are as effective as fine resolution vegetation data for predicting site occupancy for the majority of species in this study. Models will be of use to forest managers who are interested in mapping species distributions under various timber harvest scenarios, and to protected areas planners attempting to optimize reserve function.

CARBON SEQUESTRATION RESEARCH IN NEW BRUNSWICK: THE ROLE OF FLUXNET-CANADA IN NEW BRUNSWICK

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There is considerable debate as to whether unmanaged forest ecosystems constitute a net source or a net sink of CO2. The rationale is that mature forests may be in equilibrium with the atmosphere, at which point the forest may release as much CO2 as it absorbs. Furthermore, some or all of the C that is already stored as part of the wood in trees may be returned to the atmosphere following major disturbances, such as forest fires, major insect and disease outbreaks, and blow-down events as the unsalvaged trees undergo decomposition. Forest soils store equally large amounts of C, which may contribute to elevating atmospheric-CO2 concentrations with its release with the gradual warming of the soil following site disturbance and with anticipated atmospheric warming.

Managed, fast-growing forests can be used to enhance C sequestration. In managed forests, wood is regularly extracted from the forests and turned into wood products such as lumber, which generally has turn-over rates which are considerably longer than typical stand rotations. The extracted wood fibre is normally used to manufacture wood products that replace building materials (e.g., steel, concrete) that consume more energy and generate more GHG's to manufacture. Silvicultural methods designed to accelerate timber production are expected to increase the overall C sequestration capability of commercial forests.

Past natural disturbance and forest management activities have left many parts of Canada, including the Atlantic Maritime region, with young, second-growth forests which act as major net C sinks. For example, Nexfor Fraser Papers, Inc. of northwest New Brunswick began its softwood plantation and pre-commercial thinning programs in 1970. Since then, 45 000 ha have been converted into forest plantations and more than 60 000 ha of natural forest stands have been thinned to enhance timber production and at the same time the C storage potential of the land.

Many countries have put in action major research initiatives aimed at examining the role that major forest ecosystems play in the global C cycle. For instance, in Canada in order to address questions of C-sequestration function at the ecosystem level, a country-wide network of flux stations (Fluxnet-Canada) dedicated to measuring GHG exchanges over undisturbed and disturbed forest and peatland ecosystems in southern Canada has recently been created with funding from the Natural Sciences and Engineering Council of Canada, Canadian Foundation of Climate and Atmospheric Sciences, and BIOCAP Canada Foundation.

Fluxnet-Canada addresses several major issues relevant to the terrestrial C cycle in Canada, namely it (1) provides a national level database linking multiple years of 30-minute net ecosystem productivity data and associated meteorological measurements to biometric measurements of total ecosystem C stocks, (2) puts in place much needed infrastructure and technical expertise in Canada to conduct environmental-ecosystem monitoring of commercial forests and peatland systems in Canada, (3) provides new insights into the effects of silvicultural

and land use practices on C and water exchange, (4) acts as an important catalyst for the development of regional and national assessments of climate change and land use impacts on ecological processes and resource outputs in Canada, (5) generates data necessary to develop land use and forest management plans to augment C sequestration and forest resource outputs in many regions of Canada, and (6) provides data necessary to develop trans-regional policies on land use and forest management to address C sequestration and GHG-abatement needs under the Kyoto Protocol on Climate Change.

TRANSITION FROM STAND INITIATION TO STEM EXCLUSION: DEVELOPMENT OF MIXED CONIFER STANDS REGENERATED USING SHELTERWOOD SILVICULTURE

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Two variants of uniform shelterwood are included in a long-term study at the Penobscot Experimental Forest (PEF) in Maine. The experiment was established between 1952 and 1957 in mature stands dominated by a mix of conifers, including eastern hemlock, balsam fir, red spruce, northern white-cedar, and eastern white pine. There are two replicates of two-stage shelterwood (SW2) with < 5 m^2/ha residual unmerchantable trees > 11.4 cm dbh left after the final overstory harvest (FOH), and three-stage shelterwood (SW3) with no trees larger than about 5 cm dbh left. Arrangement of the replicates put one of each treatment on two different areas of the PEF. On one of the areas there were substantially more fir than spruce seed trees (dbh > 15 cm) at the start of the experiment, while at the other there were more spruce than fir. After the most recent inventories, it has been about 35 years since FOH in SW2 and < 30 in SW3.

Regeneration was abundant after the first cut in both treatments, ranging from 2,750 to 10,500 fir and spruce seedlings and saplings/ha, with fir-to-spruce ratios between 6:1 and 27:1. Harvesting operations destroyed < 50% of the seedlings and saplings in both treatments and mortality associated with FOH stabilized at < 5% within 10 years. Stand initiation differed between treatments but not sites. Fir and spruce seedlings continued to establish in SW2 for 20 years after FOH, while in SW3 relatively few became established after 10 years.

Substantial sapling ingrowth (dbh > 1.3 cm) began 15 years after FOH and continued for about 10 years in both treatments. Substantial merchantable ingrowth (dbh > 11.4 cm) began 20-25 years after FOH. At one site it peaked prior to the most recent inventory for both fir and spruce in SW2 and for fir in SW3, while at the other site it is still increasing. Fir mortality reached 10% 30-35 years after FOH in SW2, and was < 10% at the most recent inventory in SW3. Spruce mortality has not reached 5% in either treatment. Both treatments now equal or exceed the total basal area at the beginning of the experiment, albeit with much smaller mean diameters.

Our findings indicate that site characteristics, initial stand attributes, and treatment prescription all affected stand initiation and development. The influence of site on stand productivity was most evident with merchantable ingrowth differing more between areas than treatments. Site factors and/or previous stand composition also had a greater effect than treatment on species composition of the regenerating cohort. Unrelated to either site or treatment, higher fir mortality suggests a long-term shift toward increased spruce composition, despite the initially greater density of fir. The effect of treatment was most evident in duration of stand initiation. The transition to stem exclusion took longer in SW2 than SW3 because the residual trees reduced productivity of the new cohort, a conclusion supported by the fact that BA of the two treatments is equal even though the FOH was 7 years earlier in SW2 than SW3.

A SPATIAL ANALYSIS OF WILDLIFE-VEHICLE COLLISIONS IN MAINE

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Because wildlife-vehicle collisions pose a joint threat to animals and humans, the analysis and management of these events is of interest to a variety of natural resource management agencies, researchers, and individuals. In response to concerns related to ecological and human health, a range of collision management strategies are applied to reduce the incidence of these events. The variation in management strategies likely reflects variation in policy and management objectives, policy and management resources, ecosystems, and transportation networks. Moreover, the diversity in approaches may simply reflect variation in background knowledge of and data describing wildlife-collisions. The purpose of this research is to extend both the knowledge of and data resources describing wildlife-vehicle collisions in Maine. Our spatial analysis of wildlife-vehicle collisions in Maine strives to improve the visualization and assessment of spatial patterns in collision events and to delineate the relative influence of possible drivers of wildlife-vehicle collisions. Of particular interest are the impacts of drivers such as adjacent land uses and land cover, traffic volume, vehicle speed, roadway features, wildlife population, human population, and mitigation tools such as signs. Our analysis combines ecological and economic statistical and analysis tools and makes use of a variety of GIS data resources.

CAN WE SOLVE OPERATIONAL PLANNING PROBLEMS USING LINEAR INTEGER PROGRAMMING?

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New advances in MIP software allow us to solve more complex and larger optimization models of forest operations problems. Still, as more elements are added to the models, they strain the capacity of the solver and the patience of the decision-maker. Moreover, we should not ignore the costs of collecting data, which is a significant expense borne by the user rather than the researcher. In order to answer the question "what should be included in the model", we test the impact of including various planning elements in the model, and quantify their influence on objective function elements and on solution quality.

COMPARING MAINE'S ECOLOGICAL RESERVES WITH MANAGED FORESTS: INITIAL MONITORING RESULTS

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Since 2000 Maine has established over 80,000 acres of Ecological Reserves for the purposes of protecting biodiversity and serving as benchmarks for comparison to the state's managed forests. The Reserves include many of Maine's best examples of alpine meadows, lakes and streams, and old growth forests. In 2002, an *Ecological Reserve Monitoring Plan* was developed to guide data collection at the landscape, stand, and species levels, with monitoring systems closely mirroring U.S. Forest Service Forest Inventory and Analysis (FIA) methods. Nine Reserves have been monitored to date: three each in 2002, 2003, and 2004. Natural communities have been mapped, over 200 permanent plots have been established, and many rare species have been located or re-verified.

Data collected on the Reserves is already beginning to answer important questions about how forest structure and processes differ between Reserves and the rest of Maine's forests. Although nearly all the Reserves had historically been managed for timber production, the initial data analysis indicates that Ecological Reserves appear to have higher basal areas, more large trees (live and dead) and more coarse woody debris than the "average acre" of Maine woods, according to Maine Forest Service data. These measures are quantified in this presentation. Data such as these, coupled with information on well-studied old growth areas like Big Reed Forest, will ultimately yield a better picture of how forests managed by nature compare with forests managed by humans.

HARDWOOD TREE PLANTATIONS IN INDIANA: ESTABLISHMENT SUCCESS IN RELATION TO SILVICULTURAL PRACTICES, MOTIVATIONS TO AFFOREST, & OWNERSHIP CHARACTERISTICS

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Increasing numbers of private landowners are choosing to afforest marginal agricultural land throughout much of the Central Hardwood Forest Region. Establishment success of plantations on private land in Indiana is quite variable. Mortality and poor seedling form are often attributed to competing vegetation and animal browse. While specific silvicultural practices are known to mitigate the effects of these pressures, few studies have addressed how the management behaviors of nonindustrial private landowners translate into plantation establishment success.

Given the resources used to produce seedlings and to support programs that encourage landowners to plant trees, this study sought to explore how plantation establishment success relates to landowners' reasons for planting trees, their ownership characteristics, and the types of silvicultural practices they employ. The objectives of this research were to (i) examine landowner motivations for establishing hardwood plantations in Indiana between 1997 and 2001, (ii) characterize these landowners according to the values they hold for their land, (iii) describe the silvicultural practices employed within these plantations, (iv) quantify plantation establishment success (defined by seedling survival and vigor), and (v) relate these motivations, ownership characteristics, and silvicultural practices to overall plantation establishment success.

All Indiana Department of Natural Resources nursery orders for at least 300 seedlings of one of the three most abundantly sold hardwood species were obtained. From the approximately 2000 orders that met these criteria, 200 were randomly selected. Motivations to afforest and ownership characteristics were assessed through a statewide telephone survey (n = 92) and each landowner provided silvicultural histories for their planting. Field data were collected from 87 plantations to determine seedling survival, vigor, and abundance of surrounding vegetation.

Most (68%) of the land on which trees had been planted was previously used for crop production. Landowners valued their land as a place of residence, for the privacy it provided, and as a legacy for the future. Correspondingly, they planted trees for future generations, to provide food and habitat for wildlife, and to conserve the natural environment.

Seedling survival was highest on sites treated with herbicide prior to planting and that had been planted mechanically. Sites planted by a professional forester, planted mechanically, and those with herbicide applied subsequent to planting had a higher percentage of trees deemed free-to-grow. Subsequent herbicide application did not reduce cover or height of competing vegetation; however, when used in conjunction with mechanical site preparation, overall cover and height of herbaceous vegetation was reduced.

Many landowners engaged in the silvicultural practices necessary to ensure plantation establishment success: 74.7% used a professional forester to plant trees, 87.4% planted trees mechanically, and 87.4% applied herbicide subsequent to planting. Improvements in plantation establishment success will be gained through increasing the number of landowners that engage in the appropriate silvicultural practices.

HOW TREES AGE: RESEARCH ON MECHANISMS CONTROLLING AGE-RELATED TRENDS IN PRODUCTIVITY OF RED SPRUCE

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Trees undergo predictable changes with age. These are usually most dramatic during the early part of a tree's lifespan (seedling to early reproductive maturity), but age-related change may occur at slower rates throughout a tree's life. Some of these changes have been linked to age-related decline in production efficiency. This aspect of age-related change is of particular interest due to shifts in forest management practices towards uneven-aged silviculture and longer rotations. In addition, these trends are important to understanding the role of forests in the global carbon cycle and for the advancement of process-based growth models.

Our research group has been studying these phenomena in conifers for over a decade with red spruce as our model species. Our work has focused on: (1) identifying age-related trends in morphology and physiology, (2) using manipulative experiments to identify potential pathways regulating these changes, and (3) elucidating the relationship between age-related changes at the individual tree level and declines in productivity. As trees age, their increase in size covers several orders of magnitude, greatly complicating understanding the mechanisms underlying age-related trends. This complexity increases when size-related differences in external environments are considered. We have attempted to overcome these obstacles with manipulative grafting experiments. Our earlier attempts were common-rootstock experiments, where scions of various ages were grafted to juvenile rootstock. More recently we have initiated reciprocal-grafting studies, where scions are 'exchanged' between understock of various ages. These approaches have powerful potential to separate the effects of age from those of size, and to identify the pathways through which age-related trends in morphology and physiology are regulated.

Common-rootstock studies showed that scions from old donors grafted onto juvenile understock retained 'marker' characteristics, such as greater needle width, as well as physiological attributes that are related to declining productivity. This suggested a genetic basis, either controlled by an intrinsic 'program', analogous to aging in annual plants and animals, or the induction of genetic change by factors related to size/complexity or external environment. Our recent reciprocal-grafting experiments point to complex interactions of intrinsic genetic programs and influences or inductive cues that are extrinsic to meristems.

RELATIONSHIPS BETWEEN LEAF AREA INDEX, RELATIVE DENSITY AND STRUCTURE IN EVEN-AGED *ABIES BALSAMEA – PICEA RUBENS* STANDS IN MAINE

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Relationships between leaf area index (LAI), relative density (RD) and stand structure are examined for even-aged stands of *Abies balsamea* (L.) Mill. and *Picea rubens* Sarg. in Maine. The Cooperative Forestry Research Unit Commercial Thinning Network sites, split by history of PCT, were used to test conformance to a hypothesized model of production (LAI) over stocking (RD). Three patterns were suggested over increasing RD; 1) increasing LAI, 2) constant LAI and 3) decreasing LAI. Pre- and post-commercial thinning measurements were used to assess changes in structure by thinning method. Multivariate ordination suggested young, precommercially thinned, high site index *A. balsamea* stands be analyzed separate from older, unspaced, lower site index *P. rubens* stands. A positive linear relationship was found for *A. balsamea* between LAI and RD over the range of measured data (LAI range 3.4 – 10.2, RD range 0.23 – 0.62). *P. rubens* stands in this study also exhibit a linear LAI – RD relationship (LAI range 4.4-8.4, RD range 0.53 – 0.87). Crown abrasion may partially explain lower LAIs in older *P. rubens* stands. Post-thinning stand structure was affected by type and intensity of thinning and reductions in LAI and RD varied as expected. Low thinning resulted in higher proportions of LAI/RD when compared to dominant and crown thinning. Commercial thinnings in PCT stands (guided solely by RD reduction) resulted in similar structures for both reduction intensities.

SAMPLING FOR COARSE WOODY MATERIAL: WHAT WORKS IN NORTHEASTERN FORESTS?

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Coarse woody material (CWM; also called coarse woody debris) plays a variety of important roles in forest ecosystems. However, its abundance can be difficult to measure. First, we briefly review traditional and novel methods, including sampling with fixed area plots, line intersect sampling, transect and point relascope sampling, and perpendicular distance sampling. Then, we compare and contrast results obtained in Acadian mixed softwood stands, northern hardwoods, and oak-pine woodlands. When it is desirable to estimate both volume per unit area, and number of pieces per unit area, point relascope sampling can be the most efficient choice (in terms of time required to achieve a specified confidence level on the results). However, the choice of angle (similar to the choice of BAF in prism sampling of standing trees) is critical, and an inappropriate choice can lead to substantial bias in field implementation. When volume per unit area (or closely related quantities such as carbon or biomass) is the sole variable of interest, then perpendicular distance sampling is clearly the most efficient, often requiring less than 20% of the time required for line intersect sampling to give comparable confidence limits. We conclude with practical recommendations for CWM inventory in northern forest conditions.

CHANGES IN THE STAND TYPE AND LANDSCAPE CHARACTERISTICS WITH 80 YEARS OF INTENSIVE FOREST MANAGEMENT IN NORTHERN NEW BRUNSWICK, CANADA (1946-2027)

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Historical landscape patterns and changes by harvesting and silviculture from 1946 to 2002 and projected from 2002 to 2027 were evaluated for a 189,000 ha landbase in northwestern New Brunswick, Canada. Detailed cruise data obtained from 1944-47 and a full set of 1944-45 aerial photography permitted the creation of a GIS forest inventory circa mid-1940s. We compared changes in landscape stand type composition, age class distribution, and patch characteristics (area, size, density, edge, shape, and core area) from 1946 to 2002, and to 2027, based on the company's spatial management plan. The total area dominated by softwood remained relatively constant, at 40% in 1946 and 42% in 2002; it was projected to increase to 51% by 2027. However, mixed hardwood-softwood dominated area decreased from 28 to 18% from 1946 to 2002, and was projected to be 17% in 2027. Hardwood dominated area increased from 10 to 25% from 1946 to 2002, and was projected to be 24% in 2027; softwood-cedar dominated area increased from 9 to 15% from 1946 to 2002, was projected to decrease to 8% by 2027. The forest became considerably younger, with 86% > 70 years old in 1946 versus 44% in 2002, and was projected to be 41% in 2027. An increase of area harvested, with average harvest patches < 100 ha over the past 56-years and protection against spruce budworm (*Choristoneura fumiferana* (Clem.)) outbreaks and fire has resulted in the 2002 landbase having smaller mean and median patch sizes and less variation in patch sizes than in 1946. This trend was projected to continue, with the exception of the projected creation of nine patches > 1000 ha in 2027, of which eight were softwood plantations. Stand type dynamics, both in harvested and non-harvested areas, was surprising. Few of the 1946 stand types remained static by 2002, with 42% of MW shifting to SW as a result of harvesting and 35% of MW shifting to HW as a result of both harvesting and spruce budworm defoliation of the 1950's and 1970's.

RED SPRUCE AND BALSAM FIR GROWTH OVER 50 YEARS FOLLOWING DIAMETER-LIMIT CUTTINGS IN THE PROVINCE OF QUEBEC, CANADA

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During the first half of the 20th century, several observation areas were established in Quebec's commercial forest. The purpose of these areas was to provide long-term monitoring after cutting. The results obtained from two forest types dominated by red spruce and balsam fir and located in the Mauricie National Park and the Mont-Tremblant National Park, Québec, Canada are presented. Pre-harvest compositions and diameter distributions were first compared with post-harvest conditions after 50 years. Basal area growth was modeled using a whole stand approach. Finally, diameter growth of individual stems was analyzed with increment cores. The results were all studied with the assumption that the management objective was to restore some old-growth attributes in post-harvest stands, especially red spruce proportions, which tend to decrease. In the red spruce-balsam fir-yellow birch forest type, it appears clear that red spruce saplings are unable to ensure the resilience of the species because of their low density and inability to successfully compete with balsam fir. Consequently, partial cuttings of low intensity (35% removal) focusing on balsam fir removal should first be used. In the red spruce-balsam fir forest type, red spruce saplings are more abundant and grow faster than balsam fir saplings. Therefore, partial cuttings of higher intensity (50% removal) could meet the management goal.

INFLUENCE OF FOREST PRACTICES ON STAND-SCALE HABITAT SELECTION OF LYNX IN NORTHERN MAINE

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Canada lynx (*Lynx canadensis*) occur across much of the northern United States and Canada, but little is known about lynx-habitat relationships in eastern North America. Results of the few habitat studies conducted on lynx throughout their North American range have been extrapolated to areas with potentially unique ecologies, including differences in climate, prey abundance, predator-prey communities, and rates of forest succession. Data on lynx-habitat relationships is lacking for eastern North America; Maine supports the only verified population of lynx east of Minnesota in the United States. Lynx have recently been provincially listed as an endangered species in Nova Scotia, and are of increasing management interest throughout eastern Canada. Lynx are considered specialists on snowshoe hare (*Lepus americanus*), and habitat use by lynx is closely associated with density of snowshoe hares. It is important to determine the direct and indirect effects of silvicultural practices on habitat choice by wide ranging species that depend on hares, such as lynx. Within the Acadian forest, hares are closely associated with regenerating stands with an abundant coniferous understory. Silvicultural practices that create early-successional stages may increase densities of snowshoe hares and associated foraging opportunities for lynx. However, habitat use by lynx may be associated with more than just access to snowshoe hares, but with overstory and understory features related to protection from predation. Partial harvesting may reduce habitat quality for lynx because partially harvested stands had the lowest densities of snowshoe hares during winter among all overstory types (including regenerating clearcut, coniferous, deciduous, and mixedwood stands) sampled in northcentral Maine. Partial harvesting is commonly practiced in Maine and eastern Canada, but it is unknown how lynx respond to the forest structure and reduced density of hares in these stands. Thus, we evaluated the stand-scale effects of forest practices, including partial harvesting and clearcutting, on lynx in northern Maine. We evaluated habitat selection at the scale of the forest stand by comparing the distance traveled by lynx in each overstory type to the percent of those overstory types within the home range of each lynx. We snowtracked six radiocollared lynx (3 females, 3 males) for 65 km January - March, 2002 and 2003. We utilized continuous GPS sampling to track lynx and recorded overstory type along the lynx trails. We will present data on habitat selection for early regeneration (<14' tree height), mid-regeneration (14-24' tree height), partially harvested stands (1-12 years old), and mature second-growth stands (deciduous, coniferous, and mixedwood stands).

DOES GROWTH AND SURVIVAL DETERMINE THE SHADE TOLERANCE OF SUGAR MAPLE AND YELLOW BIRCH AT THEIR JUVENILE STAGE?

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The regeneration of sugar maple (*Acer saccharum* Marsh) is generally abundant while that of yellow birch (*Betula alleghaniensis* Britton) is often more limited. This difference is usually explained according to their contrasting shade tolerance with sugar maple considered as a shade-tolerant species and yellow birch as a mid-tolerant species. Recently, two trades-offs based on response to variation in light availability have been put forward to explain shade tolerance: growth / survival and growth rate / size of individual.

The objectives of this study were to (i) compare the growth response of sugar maple and yellow birch to a gradient of light availability and size of individuals; (ii) discriminate between the individuals of dead and alive sugar maple and yellow birch as a function of size, growth rate and light availability; (iii) establish relationships between the competitive status, growth rates, etiolation on one hand, and the probability of mortality on the other hand.

No interspecific difference in growth and survival was observed. No difference in size, growth rate and light availability level distinguished alive individuals from dead ones, sugar maple from yellow birch. The competitive status, growth rates and etiolation explained poorly the probability of mortality for each species.

In our study, we were not able to apply these two conceptual models, which suggest that the variation of growth and survival to light availability does not seem to explain the different shade tolerance and regeneration pattern of sugar maple and yellow birch.

MECHANICAL PERFORMANCE OF LAGSCREWBOLTED TIMBER JOINTS

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To facilitate the manufacture of timber joints and increase the reliability, Professor Kohei Komatsu of Kyoto University, Japan, developed a new type of mechanical fastener, registered as 'lagscrewbolt (LSB)'. The term LSB was coined because it functions as both lag screw and bolt. The outer part of this fastener has the same appearance as that of a lag screw and the inside part of top shank is the same as that of a nut for installation of a bolt, Figure 1. LSBs are being used in manufacturing of moment-resisting timber joints in Glulam structures in Japan. Understanding mechanical performance of lagscrewbolted timber joints (LSBTJs) is the precondition in the design of Glulam structures. The proposed research was aimed at studying the load-slip characteristics of LSBTJs subjected to short-term and cyclic loading parallel to grain.

The dimension and appearance of an LSB were given in Figure 1. Glulam was made of Douglas-fir laminates. LSBs were screwed into Glulam parallel to grain, constituting LSBTJs, Figure 2. There were three types of LSBTJ specimens, each of which had two groups, a 'control' and a 'fatigue'. A specimen was aligned concentrically and held by loading blocks using two bolts, Figure 2. Short-term tension tests had a loading rate of 14 mm/min. A triangular waveform was used in fatigue tests. The peak load employed was 0.95 of the short-term ultimate pull-out load (F_{ult}). The valley load was set to $0.1F_{ult}$. The loading frequency was 0.1Hz.

Some findings are: (1) Embedment depth has a nonlinear influence on low-cycle fatigue and short-term behavior of LSBTJs; (2) Cyclic creep slip is a good damage index; and (3) Fracture morphology between short-term and cyclic loading is different.

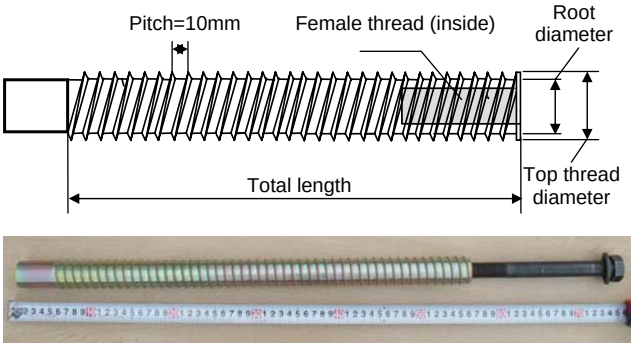

Figure 1 Lagscrewbolt: geometry(top) and appearance (bottom)

Figure 2 Experimental set-up

AN OVERVIEW OF THE NOVA SCOTIA SAWS MODEL

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Nova Scotia has used the Strategic Analysis of Wood Supply (SAWS) to examine strategic issues associated with the provincial wood supply over a period of more than 20 years. During this time the model has changed considerably in its focus and capability. This paper traces some of that evolution and discusses the strengths and weakness of the present version.

A NEW STOCHASTIC DYNAMIC PROGRAMMING APPROACH FOR STAND MANAGEMENT

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This paper reports on computational results with a new stochastic dynamic programming approach to the even aged stand management problem. Our approach is easily able to deal with the four state variables (diameter, basal area, height, treatment type) necessary for reasonable growth models. Uncertainty in prices and regeneration success are reported in this work but the approach is general. Using concepts of neuro-dynamic programming, we discuss the extension to multi-species stands with the corresponding increase in problem dimension.

SAWTIMBER PRODUCTION WITH THINNING IN STRATIFIED, MIXED-SPECIES, EVEN-AGED NORTHERN HARDWOODS

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Exploitative cutting and farmland abandonment throughout the late 1800's and early 1900's influenced today's complex of mixed-species, even-aged hardwood stands across the Allegheny Plateau from northwestern Pennsylvania through central New York. As these stands mature, fast-growing, shade-intolerant species such as black cherry (*Prunus serotina* Ehrh.) frequently emerge above the slower-growing, shade-tolerant species to form distinct strata. Conventional thinning guidelines aimed at increasing high-quality sawtimber production frequently do not directly account for vertical canopy structure which may lead to overthinning in the upper stratum and a concomitant reduction in sawtimber production. We studied strata effects on sawtimber thinning response in Allegheny hardwoods of varied species composition and associated degrees of stratification in 12, 0.1-acre, 65- to 70-year-old, unthinned plots in northwestern Pennsylvania. All trees 1-inch and greater at breast height were inventoried for height, diameter, and crown characteristics in each plot. Cluster analysis was used to identify strata in each plot. Individual plots were thinned using 13 simulated combinations of relative density and structural manipulations. One thinning treatment used a conventional approach, while the others represented different intensities of thinning with sensitivity to strata. Plots were projected by 5-year increments for 15 years using a computer program (SILVAH). Board-foot volume production and medial diameter of the merchantable class (MDM) were compared among thinning trials for each plot. Three out of the 12 plots were identified to have significant board-foot volume and/or MDM increases when thinned with sensitivity to strata as compared to conventional thinning techniques. All 12 plots combined previous to thinning showed no significant sensitivity to thinning with or without concern for strata. We conclude that some even-aged Allegheny hardwood stands are spatially variable, both vertically and horizontally, in degree of stratification due to species composition. Foresters are reminded to adjust for distinctly stratified areas by leaving a higher residual upper stratum density when marking to foster sawtimber production.

HEAT AND MASS TRANSFER CHARACTERISTICS OF RED MAPLE UNDER MICROWAVE HEATING

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This paper presents the temperature and moisture content characteristics of Red Maple under microwave heating. Wood samples of different initial moisture content, thickness and length were dried and compared for drying rate. The moisture content distribution along thickness and length also studied. The experiments showed the thickness is important in power absorbing efficiency, and drying rate. The absorbing efficiency will increase, and then tends to constant when board thickness increases. The drying rate of thinner board was higher because of higher power density when same power input was used. But it decreased when board was very thin. The board temperature could be controlled to reach constant value at lower or middle microwave power levels of 600W to 1000W even though the moisture content is below FSP. Moisture difference was important in thickness, 5% (46mm thick board), but only 3% in length direction (800mm long board).

DIAMETER-LIMIT CUTTING AND SILVICULTURE: A COMPARISON OF SIMULATED TREATMENTS IN EVEN-AGED NORTHERN HARDWOOD STANDS IN MAINE

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Exploitive cutting practices, such as high-grading and diameter-limit cutting, are common throughout the northeastern United States. Residual stand conditions resulting from such practices often vary according to the frequency and intensity of harvests. Diameter-limit cuts repeated frequently with low diameter thresholds are more likely to degrade stands than infrequent removals with larger thresholds. The effects of these exploitive practices will also vary according to the initial age structure and species composition of the stand. In theory, uneven-aged stands are less adversely affected than even-aged stands because entire age classes, comprised of variable genetic qualities, may remain in a stand following a harvest. In contrast, exploitive harvests conducted in even-aged stands typically result in removal of the best growing stock from the upper canopy stratum.

The primary focus of exploitive cutting practices is on extracting timber. Unlike silvicultural treatments, they do not attempt to deliberately regenerate an age class or tend residual trees. These practices are popular because, by removing the largest and most valuable trees, landowners and/or loggers generate immediate and relatively high financial returns. However, studies have shown that the benefits of repeated diameter-limit cutting are often limited to the initial harvests. Short-term benefits are offset by long-term ecological and economical costs. Adverse effects of these practices may include residual stands characterized by poor quality and low vigor trees, less commercially valuable species, and variable stocking and crown cover. Although the negative effects of diameter-limit cutting and high-grading have been documented, research addressing rehabilitation options is scant.

The purpose of this study is to identify silvicultural strategies for managing northern hardwood stands following diameter-limit cuttings. Data have been obtained from four well-stocked even-aged northern hardwood stands in Maine. Silvicultural and exploitive treatments will be modeled over a 50-100-year period using the NE-TWIGS variant of the Forest Vegetation Simulator (USDA Forest Service). These treatments will include shelterwood, crown thinning, single-entry diameter-limit cut, and multiple-entry diameter-limit cut. A financial analysis pertaining to timber harvests and residual stand conditions will be compared across treatments and sites, and sustainability of composition, structure and production will be evaluated. This research will enable us to identify forest practices that allow sustainable, economically viable management of a stand type that is common in the state.

SAPLING RECRUITMENT AND GROWTH DYNAMICS IN MULTI-AGED NORTHERN CONIFER STANDS: A 25-YEAR STUDY

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It has long been recognized that sustainable multi-aged management relies upon defining and attaining specific stand structural goals. These goals are typically defined in terms of residual basal area, maximum diameter, and number of trees per size class. Most assessments of multi-aged stands focus on these attributes, i.e. the structure and growth of the merchantable classes. However, the amount, species, growth and mortality of the sapling classes have important implications for long-term sustainability.

The USDA Forest Service Northeastern Research Station established a long-term silvicultural experiment on the Penobscot Experimental Forest in Maine in 1952. Treatments are replicated at the stand level and include selection cutting on 5-, 10-, and 20-year cycles (SC05, SC10, and SC20, respectively) as well as modified (MDL) and fixed (FDL) diameter-limit cutting at 20-year intervals. A subsample of trees 1.3 cm and larger in diameter at breast height have been numbered and followed individually since 1975, with measurements taken before and after treatment and at 5-year intervals between treatments.

Preliminary analysis of sapling ingrowth data from 1975 to the present revealed high within-treatment variability. The amount of ingrowth recorded in a single inventory varied temporally within treatments by as much as ten-fold, and spatially (between replicates) by two-fold. Values ranged from as low as 269 stems/ha over a five-year inventory period in one of the SC05 stands, to 4739 stems/ha in one of the SC20 stands. The mean rate of ingrowth over the measurement period differed only for SC05 (133 stems/ha/yr) and S20 (595 stems/ha/yr).

A comprehensive analysis of the dynamics of ingrowth in the PEF multi-aged stands will be reported, and the implications for structural and compositional sustainability will be discussed. These data will provide a unique long-term perspective on the amount and species of sapling ingrowth and sapling growth and mortality in northern conifer stands.

THE EFFECTS OF ECONOMIC PROSPERITY ON ENVIRONMENTAL HEALTH: AN HISTORICAL GDP VS. BIRD POPULATION ANALYSIS IN CANADA

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This paper investigates the relationship between bird populations as indicators of environmental health, and economic growth using a pooled data set across nine Canadian provinces over the 1968-2002 period. Two models are tested – a basic model relating GDP per capita to bird populations, and an extended model relating GDP per capita, human population, and environmental conditions to bird populations. The models are run individually for five bird population habitat types including woodland, scrubland, urban, wetland, and grassland birds. Findings are mixed among both models and bird habitat types. The basic model finds support for a U-shaped relationship between GDP per capita and the first three habitat types. The extended model, on the other hand, finds either no relationship (in the case of the first three habitat types) or a monotonic relationship (in the case of the latter two habitat types) between GDP per capita and bird populations. Additionally, the extended model results indicate that a positive relationship exists between human population and bird populations, and that a negative relationship exists between environmental conditions and bird populations for most habitat types. Thus, there is evidence that supports the notion that economic prosperity is good for some environments in Canada.

MODELING FOREST SUCCESSION IN BALSAM FIR-RED SPRUCE-YELLOW BIRCH MIXEDWOOD ECOSYSTEMS USING THE ZELIG MODEL

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The mechanisms of succession are still poorly understood for most forest ecosystems. Gap models are very useful for better understanding the mechanisms of change and predicting the patterns of succession in forest ecosystems. Considerable research has been devoted in recent years to the development and calibration of various gap models. However, as there are few historical data for forest ecosystems, the validation of gap models has been more problematic. The objective of the present study was to calibrate and validate the ZELIG model for balsam fir-red spruce-yellow birch mixedwood ecosystems in southern Quebec. Historical data obtained from an experimental design of permanent sample plots established in 1936 were used to compare the results of the simulations with reality. Several reasons justified the selection of ZELIG for the present study. ZELIG integrates in simple terms the main ecophysiological mechanisms of tree growth and stand development. Also, it remains relatively general for application for different forest types and is adapted for complex stand structures, such as uneven-aged mixed stands. The validation of ZELIG was performed using data from undisturbed and disturbed sites that were subject to two levels of partial cuttings.

OPTIMIZING THE DIAMETER STRUCTURE OF BOREAL SPRUCE-FIR STANDS MANAGED UNDER THE SELECTION SILVICULTURAL SYSTEM IN A PERSPECTIVE OF ECOSYSTEM MANAGEMENT

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The stand dynamics of boreal forest of eastern Quebec and Labrador is characterized by long fire cycles (ca. 300-500 years) and by small-scale partial disturbances, which explains the high frequency of stands of irregular structure in the landscape. Current forest practices, based on clearcutting with protection of advanced regeneration, seems inadequate to maintain irregular old-growth forests in a perspective of ecosystem management inspired by natural disturbance regimes (Bergeron *et al*. 1999).

In many aspects, the selection silvicultural system seems an acceptable compromise to conciliate wood production and the protection of the essential ecological attributes of old-growth, irregular boreal stands. The prescription of selection cutting is often defined in terms of residual diameter structure, which should permit a sustainable harvest from one rotation to another (Nyland 2001). However there in no single “ideal” structure: it’s rather an optimal solution between the management objectives, regional growth and mortality rates of trees, and financial and ecological constraints (Buongiorno and Gilless 2003). The objective of the paper is (a) to present the optimization model used to estimated the “best” diameter structure of stable selection spruce/fir stand, and (b) to compare several scenarios in terms of yield, harvest costs and ecological attributes of old-growth forest (i.e. structure diversity and production of woody debris).

USING THE STAND PRODUCT OPTIMIZATION TOOL FOR MERCHANDIZING STANDING TREES

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For forest managers and researchers alike, the capability to accurately merchandize and appraise the financial value of standing trees is vital. For forest managers this information is critical to making decisions such as whether or when to treat or harvest a stand. For researchers comparing the merits of silviculture strategies, accurate financial values are essential for determining the best strategy.

The Stand Product Optimization Tool (SPOT), developed by the Cooperative Forestry Research Unit at the University of Maine, calculates the most profitable way to merchandize stands based on user input cost, value, and merchantability specifications, and generates a report detailing financial values and quantities of products by product classes. In addition to enabling one to financially appraise the value of standing trees SPOT provides data necessary to optimally merchandize stems by determining the best bucking specifications and the mills to which products should be sent.

SPOT resides in a Microsoft® Excel workbook containing six spreadsheets and several macros written in Microsoft® Visual Basic. Users input a tree list containing five variables including tree species, the tree diameter at breast height (DBH, in.), and tree height (ft.). In addition to the tree list, users must input merchantability specifications including the mill name, product name (i.e. pulp, sawlog, OSB, etc.); mill-delivered value expressed either in cords, boardfeet (International 1/4-inch log rule), or weight (ton); merchantability standards including minimum top diameter (in.), minimum length (ft.), length increment (ft.), and maximum length (ft.). Users also input the stump height (ft.), the log trim for each product (ft), the trucking cost for each mill ($/ton) and the total cost to harvest, yard and load the products ($/ton).

SPOT computes data for a single tree in the tree list and reduces the number of possible products that the tree can be divided into based on the product specifications and the tree's species and size. With the possible combinations of products greatly reduced, SPOT computationally bucks the tree into all the remaining products and selects the suite of products that results in the highest gross value (mill delivered value minus trucking costs). Summing the optimal gross value for each tree, subtracting the harvest, yarding and loading costs, and expressing the value on a per stand basis determines the optimal yield value for the stand.

After the optimization process is complete SPOT generates a product report that lists the mills to which the harvested material should be sent, estimates for the expected weight or volume and value of each product, and the estimated trucking costs. It also contains stand statistics such as the volume, basal area, quadratic mean diameter and height, the number of merchantable and unmerchantable stems, and the total number of pieces cut.

PRINCIPAL FINDINGS OF THE FIRST FULL ANNUAL INVENTORY OF MAINE

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In 1999, the Maine Forest Service (MFS) and USDA Forest Service's Forest Inventory and Analysis (FIA) program implemented a new annual system for inventory and monitoring Maine's forests. A salient feature of the new inventory process is a nearly threefold improvement in timeliness, as full inventories are completed every five years. The 2003 results allow a look at the first full set of annual inventory data over a decade since the extreme spruce-budworm outbreak of the 1980's. The effects of the budworm epidemic are clearly still affecting the composition, structure, and distribution of Maine's forested ecosystems. The area of forest land in Maine has remained stable since the middle of the last century. Although relatively small acreages of forest land are converted to other land uses in Maine, land that converts often removes highly valued forests, such as white pine. Maine's forests are beginning to show increases in inventory volume in some areas. The spatial distribution of sapling-size spruce and fir across the state reveals a general abundance of regeneration, foretelling waves of merchantable wood over the next 15 years. The full suite of FIA indicators is discussed in relation to Maine's forest condition to gain insight into prospective future trends.

HIGH-RESOLUTION WATERTABLE AND SOIL DRAINAGE MAPPING: A DECISIVE STEP TOWARDS BETTER FOREST MANAGEMENT PLANNING

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Until now, forest management and operations planners had no tools to systematically locate wet soils across forested and non-forested landscapes with reasonable geo-spatial certainty, and with operationally sufficient resolution. This lack has – traditionally – meant that the size and magnitude of problems that are connected with operating on wet ground would only be revealed in detail at the time of operation. This, therefore, has limited the planning of operations, and has called for frequent on-the-ground ad-hoc alterations of road and trail layout, harvesting plan, scarification plan, time of operations, etc. In general, operating on drainage-challenged soils with little prior knowledge of wet locations, and at the wrong time of year, leaves the wet ground messy, leads to deep and unsightly ruts, discourages forest recovery on wet areas, interferes with the implementation of best forest management practices, reduces operational and economic efficiencies, and raises un-needed controversies, internal and external. We embarked on a project to map soils subject to high water tables, by fusing several geo-spatial data layers from provincial databases, including the digital terrain maps (DTM). In so doing, we produced maps that not only display all already mapped streams, water bodies and wetlands, but also all ephemeral flow channels that flow into these. We then overlay these features on top of the DTM, and produce a single 3-dimensional water table surface that connects all lakes, ponds, streams, ephemerals, and wetlands. The resulting difference between the actual elevation at any point and that particular surface produces the depth-to-water-table map, at the high water mark. Areas with water tables at or less than 10 cm from the soil surface would be considered poorly drained, or flooded. Areas where the water table comes to within 1 m from the surface would be considered moderately well drained. Usage of these maps is expanding. Examples refer to:

- road and access-trail layout and related cost-cutting measures;
- considering details in harvest blocking and locating, designing, and managing retention islands;
- defining wetlands, feeder streams, and wetland bufferzones;
- narrowing species suitability for planting, based on enduring soil moisture features within cut-clocks;
- estimating on-road and off-road trafficability, according to weather;
- using the depth-to-water table map as a means to further improve on ecological site classification, and to generate better classification of land features based on aerial photography and satellite images;
- Locating vernal pools; confirming blow-down severity on soils that are mapped wet.

LEAF AREA ESTIMATION FOR *ABIES BALSAMEA* AND *PICEA RUBENS* IN MANAGED STANDS IN MAINE

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Forest stand structure is a function of many natural, ecological and anthropogenic processes. Currently, most growth models are empirically based on the assumption that wood growth is a function of the amount of wood present. Models based on leaf area may better reflect growth dynamics (e.g. differentiation) within the stand, while others assume all trees of similar size have a similar growth rate. A geographically broad leaf area estimation model is necessary to use leaf area as a growth predictor for Maine. The objectives of this study were (1) to build a tree-level leaf area prediction model and compare it to previously published sapwood and non-sapwood based models, (2) to test model performance across stand variables and geographic locations throughout Maine and (3) to use tree leaf area to predict stand growth.

Using data from 89 trees of even-aged stands across Maine, we present a model for both *Picea rubens* Sarg. and *Abies balsamea* (L.) Mill. that predicts leaf area from basal area and modified crown ratio. This model outperformed published sapwood models and several other non-sapwood models. It performed slightly better for the more regularly crowned fir than for the spruce used in this study, but is consistent from one site to another of the same species.

TRIAD FOREST MANAGEMENT: FOREST ZONING IN NORTHWESTERN NEW BRUNSWICK

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A case study of triad forest management was conducted on the J.D. Irving, Ltd. Black Brook District in northwestern New Brunswick, Canada. This 190,000 ha privately-owned landbase includes some of the most intensively managed forest in Canada.

Triad forest management involves forest reserves and intensively managed stands embedded within a landscape managed by alternative silvicultural systems patterned after natural disturbance regimes (Seymour and Hunter 1992). The main objective of this project was to analyze the potential for triad forest management on the Black Brook District. Computer modeling and scenario planning analysis was used to quantify trade-offs in timber and non-timber values through a combination of intensive, extensive, and reserve management zones. Eighty-year aspatial scenarios were run in sixteen 5-year periods, which varied the area of each zone in 5% steps from the current landbase allocation of 5% reserves, 39% intensive, and 56% extensive. The overall range evaluated was 0-15% reserves, 39-85% intensive, and 15-61% extensive management areas.

Computer simulation and scenario planning were used to determine the role of forest zoning (triad management) on timber and non-timber values. A total of 64 scenarios, covering area in reserves of 0-22,000 ha, intensive management of 69,000-112,000 ha, and extensive management (natural regeneration) of 0-113,000 ha were analyzed using Woodstock, a forest planning linear optimization model. When intensive management area was held at 69,000 ha, area contained in older condition (>120 years) was 9,000-28,000 ha by year 80 when area in reserves was 0-28,000 ha. As well, projected softwood sustainable yield varied between 2.4-2.7 million m^3 in the first six periods with matching reserve levels. Conversely, with reserves at 9,500, old forest condition remained constant at 12,000 ha and projected softwood yield was 2.5-2.6 million $m^3$when intensive management areas were 69,000-112,000 ha.

Seymour, R.S. and M.L. Hunter, Jr. 1992. New forestry in eastern spruce-fir forests: principles and applications to Maine. Maine Agric. Exp. Sta., University of Maine, Misc. Publ. 716.

REPRODUCTIVE AND GENETIC CHARACTERISTICS OF RARE, DISJUNCT PITCH PINE POPULATIONS AT THE NORTHERN LIMITS OF ITS RANGE IN CANADA

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Pitch pine, *Pinus rigida* Mill., is a rare species in Canada, existing as a disjunct population in the St. Lawrence River Valley in eastern Ontario and as two northern outlier stands in southern Quebec along Canada's southern border with the United States. Reproductive and genetic characteristics of these small, scattered stands were investigated to develop a foundation for management and restoration in the event of a northward range expansion under anticipated climate warming. Seed yields and seed quality appeared to be comparable to other eastern conifers, and to pitch pine at the center of its geographic range. For seed and seedling growth traits, most of the variation was attributable to differences among trees within stands and, to a lesser extent, among stands within a population. The population effect was non-significant. For reproductive traits, such as numbers of filled and empty seeds per cone, reproductive efficiency, and inbreeding estimates, high levels of variation (ranging from 26 to 33%) were found among stands, suggesting that stand structural features, such as stand size and tree density within stands, play an important role in pollination environment and overall reproductive success. Estimates of genetic diversity at 32 allozyme gene loci indicate that these small, isolated stands have maintained high levels of genetic diversity compared to populations at the center of the geographic range in the United States, and also relative to other widely dispersed eastern conifers. Such comparatively high levels of genetic diversity suggest that Canada's extant pitch pine population may represent a remnant of a much wider distribution during warmer climates of the present interglacial period, rather than a population expanding its range northward. The relatively high levels of viable seed production and genetic diversity in native pitch pine populations indicate that Canadian populations may be suitable seed sources for species restoration and expansion in Canada. Representative samples of these native Canadian populations have been established at 12 locations in New Brunswick, Prince Edward Island, and Nova Scotia to assess potential environmental limitations to the introduction of pitch pine in the Maritime Provinces. The pitch pine seed sources established in these tests have shown excellent growth and survival compared with native pines such as red pine (*Pinus resinosa*) and jack pine (*P. banksiana*) and should be considered favourably for industrial wood supply and ecological restoration in eastern Canada.

PREDICTING SLOW DRYING FIRE WEATHER INDEX FUEL MOISTURE CODES WITH NOAA-AVHRR IMAGES IN CANADA'S NORTHERN BOREAL FORESTS

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In Canada fire danger predicted by the Fire Weather Index, produced from point-source weather records, is limited spatially. This study investigated optical and thermal-infrared remote sensing as a potential tool for assessing fuel moisture conditions at finer spatial scales. Between 1993 and 1999, 10-day composite NOAA-AVHRR satellite images and weather station data from the boreal forests of a 250,000km^2 portion of northern Alberta and the southern Northwest Territories, Canada, were used to model two slow drying Fire Weather Index fuel moisture codes (Duff Moisture Code and Drought Code).

Duff Moisture Code, Drought Code, and spectral variables were significantly influenced by temporal variability (between years, seasons, and periods) and spatial variability (between broad forest cover types, elevations, and latitudes). On a yearly and seasonal basis, Duff Moisture Code and Drought Code models were stronger in spring (mean adjusted $R^2 = 0.19$ and 0.39) than in summer (mean adjusted $R^2 = 0.10$ and 0.14), fall (mean adjusted $R^2 = 0.12$ and 0.12), or the entire season (mean adjusted $R^2 = 0.08$ and 0.09). By categorizing spring data spatially and temporally, models did not improve significantly, with only slight improvements in root mean squared errors.

Drought Code was mapped from spectral models based on data from the spring of 1995, categorized by broad forest cover type. These maps showed that Drought Code was underestimated once values exceeded about 150 in over half of the study area because of weak predictions by the open coniferous broad forest cover type model. An examination of a fire which burned in the spring of 1995 showed that in closed coniferous portions of the burned area, Drought Code was predicted as high by the spectral model and moderate by weather station interpolation.

While 10-day composite NOAA-AVHRR optical and thermal-infrared image based models were capable of explaining about 30% of the variability when predicting Duff Moisture Code and Drought Code in spring, no single generalized model was developed. This study was able to identify and incorporate temporal and spatial factors into modeling slow changing fuel moisture conditions in Canada's boreal forests, but was not able to fully describe them using NOAA-AVHRR images.

SOLVING STAND HARVESTING ADJACENCY PROBLEMS USING EXACT MATHEMATICAL PROGRAMMING MODELS

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We present a new linear integer programming formulation of adjacency constraints for the Area Restriction Model (ARM). These constraints are small in number and are a strong model for the stand-centered adjacency problem. We describe constraint development, including strengthening and lifting, to improve the basic formulation. The model does not prohibit all adjacency violations, but computations show they are few in number. Using example forests ranging from 750 to over 6000 polygons, optimization problems were solved in very short computational time.

CONCEPTUAL MODEL OF DISTURBANCE AND HERBACEOUS LAYER RESPONSE IN FORESTS

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Most work on disturbance in North American forests has focused on the tree canopy and woody understory with little consideration of the herbaceous layer. I propose a revised conceptual model of natural disturbance in North American forests to improve our ability to predict herbaceous-layer response. Disturbance severity is quantified on three separate axes: percent of tree canopy removed, percent of understory vegetation removed, and percent of forest floor and soil removed or disrupted. Several common natural disturbance types in forests are evaluated in terms of their relative position within this 3-dimensional model. Eight factors which control herbaceous-layer response and species regeneration mechanisms are linked to the three axes. Depending on the position of a particular disturbance type on the three axes, different response factors and regeneration mechanisms predominate. For example, landslides and severe erosion lie at the upper end of all three axes. Following these extreme disturbances, factors related to substrate condition and propagule availability largely controls vegetation response and widely dispersed seed is the predominant regeneration mechanism. The disturbance severity model provides a framework for evaluating impacts of both natural and anthropogenic disturbances on the herbaceous layer. The model can be applied to forest harvesting disturbances to predict impacts.

HOW DID QUÉBEC ACHIEVE ZERO HERBICIDE IN FORESTRY?

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Chemical herbicides demonstrated their effectiveness in controlling competing vegetation. However, with the public's increasing concerns over the potential environmental effects of these products, it was necessary to develop alternative solutions to control vegetation. Furthermore, a move to integrated vegetation management strategies is encouraged in the context of forest certification. This means finding not only technically efficient methods, but those that are compatible with social considerations. In 1994, the Québec government committed itself to end the use of chemical herbicides in Québec forests in its Stratégie de protection des forêts (Forest Protection Strategy). In 2001 it succeeded in reaching the objective. The Strategy favoured a suite of alternative solutions to herbicides in order to ensure the establishment and growth of plantations. We will present the results of research that was carried out to evaluate the effectiveness of the proposed alternative solutions, and to elaborate on application procedures. Research was able to define an integrated control model without herbicides for forest vegetation, which is adapted to the ecological characteristics of reforestation sites. The Québec experience shows that integrated control of vegetation, centred on early reforestation, use of tall planting stock (35 to 45 cm in height) and intensive mechanical release, bring plants to the free-to-grow stage without the use of herbicides on most sites. This strategy, which uses mechanical treatments only where and when they are needed, is part of a sustainable development perspective used to maintain the long-term biodiversity and productivity of forest ecosystems.

ALTERNATIVE HARVEST DESIGNS TO AVOID ECOLOGICAL DAMAGE CAUSED BY FUTURE ENERGY SCARCITY

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A silviculture design is presented that provides growing conditions for the full Acadian species assemblage. Permanent 'no travel' strips, representing a minimum of 20% of the stand, contribute 'old-growth like' structure, and harbour at least 10% of the dominants and codominants of each species as 'full cycle' trees which are marked never to be cut. Less than 20% of the total stand canopy is removed at each harvest entry. Entries into neighboring strips are at least 20 years apart with a harvest return interval of at least 80 years. This silviculture is certifiable by any and all schemes in existence.

Conventional timber markets may collapse in the fossil energy scarce future that will unfold during the next rotation, and forests may be more valued for the biomass energy they contain than for the conventional timber that they can produce. A return to large scale clearfellings, with little regard for maintaining the diverse and adaptable Acadian forest species assemblage, is a possibility.

In view of the conditions of energy scarcity that are expected to develop, Silvicultural investments in site preparation, planting, chemical competitor vegetation control, thinning, crown release and pruning to produce specific forest products may not be justified.

INFLUENCE OF INTENSIVE FOREST MANAGEMENT ON THE HABITAT, BEHAVIOR AND POPULATION DYNAMICS OF AMERICAN MARTEN IN NORTHWESTERN NEW-BRUNSWICK – PRELIMINARY RESULTS –

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In western Canada and United States and as well as in Newfoundland, martens are known to prefer late-successional coniferous stands where they find a large amount of coarse woody debris (CWD) and many large snags. However, recent studies in northern Maine and southwestern Québec concluded that martens could find a suitable habitat in a larger variety of stands. In most stand types >12 meters in height found in those areas, dead wood structures appear to occur above threshold at which theses habitat features are limiting for martens. Nevertheless, the situation may be different in intensively managed stands like conifer plantations. Indeed, repeated thinning operations may lower abundance of dead wood structures under threshold required for martens. The objective of our study is therefore to determine how the relative scarcity of dead wood structures in plantations affects the habitat preference and population dynamics of American Marten in an intensively managed landscape.

The study began in fall 2001 and is currently conducted in the Black Brook district of the J.D. Irving Ltd company, located in northwestern New-Brunswick. Three areas of 25-49 km² are studied, on which plantations cover a proportion varying from 28-57% of the surface area. The age of the plantations differs in each area, ranging from <10 year-old to 30-40 year-old. The various stand types in the study areas were surveyed to describe the characteristics of the habitat. Marten population density and age structure are estimated by capturing and marking animals during fall. Movements and habitat preference are studied by radiotracking martens. Habitat surveys indicate that all plantations are very poor in dead wood structures. Nonetheless, plantations aged >20 year-old provide an excellent tree cover (mean crown closure >50% and mean tree height > 9 m). Marten population densities (0.6-1.0 marten/km²) measured during fall 2001-2003 in the study area covered by plantations aged 30-40 year-old seem similar to densities reported in unmanaged and protected landscapes in eastern Canada and United States. However, population densities seem lower in the study areas covered by plantations aged 20-30 year-old (0.4-0.7 marten/km²) and by plantations aged <10 year-old (<0.3 marten/km²). Age structure includes a large proportion (>70%) of young individuals (≤2 year-old) and seems representative to the age structure of a population living in an industrial forest. Within their home range, martens seem to avoid plantations aged <20 year-old. The home range of martens also contains a smaller proportion of plantations aged <20 year-old than the surrounding landscape. Martens seem to use plantations aged >20 year-old, which contain almost no dead wood structures, at a similar degree than naturally-regenerated stands, which contain a large amount of snags and CWD. In our study areas, martens seem to select their habitat based on the presence of a dense tree cover rather than based on the abundance of dead wood structures. We will continue to gather data on the behavior and population dynamics of martens up to December 2005 in order to confirm the preliminary results obtained until now.

VEGETATION DYNAMICS FOLLOWING THE BAXTER PARK FIRE OF 1977

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A series of interacting disturbance events occurred in Baxter State Park in Maine offering an excellent opportunity to study long-term changes in vegetation following a fire in the Acadian spruce-fir ecosystem. In July of 1977, 1439 hectares in and adjacent to Baxter State Park experienced a severe forest fire. Much of the fire burned areas that were blown down in a 1974 windstorm; some of those areas were salvaged prior to the fire, while others were not. In 1978, Sandra Hansen set up plots to represent these various stand conditions and measured vegetation composition and structure one year after the fire. This study re-visited those plots in 2003 and documented the current vegetation structure to improve our understanding of post-disturbance forest development which showed little pattern. Pre-fire disturbances influenced the post-fire regeneration process. Variation among plots with the same disturbance history increased with the time since the fire and provided evidence for theories of multiple pathway development. Vegetative development since 1978 has diverged on a plot level.

FAILURE CHARACTERISTICS OF BOLTED LAMINATED STRAND LUMBER CONNECTIONS

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A concern for improved utilization of the wood supply and sustainability of forest resources has compelled the forest products industry to develop innovative alternative wood products. These manufactured products, known generically and collectively as engineered wood products (EWP), used under-utilized wood species and undersized stems in processes that reduce the raw wood into smaller pieces, then bonds and re-forms them into structural wood products. One such product is Laminated Strand Lumber (LSL), trade name TimberStrand®. LSL is a structural composite lumber (SCL) product manufactured by Trus Joist, a Weyerhaeuser Business. This product is formed from sliced wood strands that are aligned parallel with the longitudinal direction of the structural member and bonded together with an isocyanate-based adhesive. Bolted connections are a commonly specified type of mechanical fasteners in structural wood design construction in North America. Although current design codes provide design guidance for sawn lumber and Glued Laminated Timber (glulam), there is limited information provided for proprietary wood composite products such as LSL. This study examines failure characteristics of LSL and solid wood at bolted connections under static load conditions and specifically focuses on identification and characterization of failure mechanisms for single and multiple-bolt connections. The multiple-bolt configuration patterns include two bolts in a single row, two rows of a single bolt, and two rows of two bolts. Loading is applied to the LSL or solid wood (central member) in a double shear arrangement, with 44 mm (1-3/4″) x 89 mm (3-3/4″) LSL or solid wood used as the main member and 32 mm (1-1/4″) thick GE Lexan® (a high strength transparent polycarbonate) used as side members. Use of the GE Lexan® facilitates observation of the physical failure processes and allows image recording of the effects of LSL strand cross-lamination.

A COMPARISON OF AMPHIBIAN ABUNDANCE IN HARVEST GAPS AND NATURAL CANOPY GAPS IN A NORTHEASTERN FOREST

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Amphibians that inhabit upland forests are in constant contact with the forest floor, relying on moist conditions for respiration. Timber harvesting can have a negative effect on amphibian populations by altering forest floor microhabitats. We tested the hypothesis that creating small-scale canopy gaps modeled after natural disturbance patterns may retain adequate habitat structure for amphibians, thus facilitating the maintenance of amphibian diversity and abundance in managed forests. From spring – fall of 2002 and 2003, we used pitfalls with drift fences to sample 2,930 and 9,060 amphibians, respectively, in 22 large harvested gaps, 22 small harvested gaps, 19 natural canopy gaps, and 36 closed-canopy forest plots located in the Penobscot Experimental Forest of central Maine. Location within large-harvested gaps (north vs. south aspect, gap center vs. edge) did not influence capture rates for *Ambystoma maculatum, Notophthalmus viridescens, Plethodon cinereus, Rana catesbeiana, or Rana sylvatica*, but higher capture rates at gap edges than gap centers were detected for *Rana clamitans*. Responses among gap types (large harvested, small harvested, and natural) varied by species and age-class. Metamorphs (young of the year) had relatively lower capture rates in large harvested gaps for *A. maculatum, R. catesbeiana, R. clamitans, and R. sylvatica*. In some cases (*R. clamitans* juveniles, *R. sylvatica* juvenile-adults and metamorphs), capture rates in small harvested gaps were similar to natural gaps. We did not detect statistically significant differences among gap types for *N. viridescens*, *Rana palustris*, juvenile-adult *A. maculatum* or *P. cinereus*, although for juvenile-adult *A. maculatum*, we caught relatively fewer individuals in all gap types than in closed-canopy areas. We also explored relationships between the size of down woody material and its use by *P. cinereus*, a terrestrial salamander, in harvest-created gaps and closed-canopy forest. Log searches ($N = 231$) for *P. cinereus* indicate that the probability of detecting a salamander increases as log diameter increases in harvest-created gaps, whereas in closed–canopy forest, the probability is both higher and constant across log size. These results suggest that harvested gaps, especially small gaps, provide habitat analogous to natural gaps for some species, but not all.

THE STATUS OF MATURE AND OVERMATURE SOFTWOOD FORESTS IN NEW BRUNSWICK, CANADA: IS THERE A WIDESPREAD DECLINE?

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Projections of forest productivity and growth are essential for forest management planning and decision-making, yet little is known regarding the timing, magnitude and causes of stand growth decline, and their resulting ecological consequences. Data from a permanent sample plot (PSP) network in New Brunswick, Canada, were analyzed to evaluate the extent of decline of coniferous stands and determine causes of tree mortality.

The growth and development of 650 mature and overmature PSPs (~50,000 trees) between 1987 and 2000 were analyzed. Plots were subdivided into classes based on Ecoregion and stand type (species group and maturity), and characterized by pattern of volume development: *decreasing*, *fluctuating*, *stable*, or *increasing* volume over time. A third of the plots fell into the *decreasing* category: 33% of 209 balsam fir (*Abies balsamea*) and 26% of 350 spruce (*Picea* spp.) PSPs. A further 23% of balsam fir and 24% of spruce PSPs were categorized as *fluctuating* or *stable*, which left ~50% in the *increasing* growth phase of stand development.

Periodic annual increment (PAI) was negative (-0.9 m^3/ha/yr) for balsam fir plots and marginally positive (0.4 m^3/ha/yr) for spruce plots. Declining balsam fir plots exhibited double the negative PAI of their spruce counterparts (-6 and -3 m^3/ha/yr, respectively). Differences also occurred between Ecoregions (-2 to -7 m^3/ha/yr). Mortality ranged widely among the four volume development classes (1.3 to 11.5 m^3/ha/yr), while growth of surviving trees remained relatively stable (3.4 to 4.9 m^3/ha/yr). Therefore, decline was caused by increased mortality rather than by reduced growth rates. Dead trees were classified into nine cause of death categories, which were wind, insect, and disease related. Wind was the biggest cause of tree mortality, accounting for approximately 50% of dead trees in BFSP and SPBF plots.

WHEN TO PERFORM MECHANICAL RELEASE TREATMENTS IN SPRUCE PLANTATIONS? A STUDY COVERING RANGE OF ECOLOGICAL CONDITIONS IN QUÉBEC

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In Québec, only mechanical treatments are authorized to release conifer plantations from competing species. However, we need to minimize the need for repeated treatments on high-competition sites, which could be achieved with an integrated vegetation management approach. The Québec strategy is based on use of large seedling stock outplanted the spring immediately following a final harvest, in order to take advantage of a low competition level which prevails before competing vegetation establishment. A network of 14 experimental sites, that cover a range of ecological conditions, was established to test the hypothesis that time since planting (number of years) before applying a release treatment is a significant variable to explain conifer seedling growth. Our objective is to determine the optimal delay before performing a mechanical release which could minimize the impact of vegetation re-growth after cutting and thus lessen the need for a second treatment. Preliminary results after eight growing seasons confirm the importance of release treatments over a range of ecological conditions. Carrying mechanical release 3, 4 or 5 years after planting large seedlings did not affect seedling size reached 8 years after planting, over the range of conditions tested.

EFFECTS OF WHITE-TAILED DEER BROWSING PRESSURE ON THE REGENERATION OF BALSAM FIR STANDS

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White-tailed deer (*Odocoileus virginianus*) have expanded their range and populations have increased in Eastern forests in recent decades. Selective foraging affects the growth and survival of many plant species, thus modifying patterns of relative abundance and vegetation dynamics. In forests, sustained heavy browsing reduces plant cover and diversity, and redirects succession as to shift overstory composition. On Anticosti Island, Québec, negative impacts of introduced deer on the vegetation have been reported and include the eradication of most deciduous shrub species and the conversion of balsam fir (*Abies balsamea*) stands to white spruce (*Picea glauca*) stands. A management initiative integrating the harvest of balsam fir stands, the erection of enclosures and the reduction of deer densities through sport hunting has been established to facilitate the regeneration of fir stands. However, the relationship between deer density and forest regeneration is still poorly known. A controlled grazing experiment has been implemented to elucidate the nature of this relationship and to determine deer densities that will allow regeneration of balsam fir stands. The experimental design consists of nine enclosures receiving deer density levels of 0, 7.5 and 15 deer/km² and three cut blocks with natural densities ranging from 26 to 53 deer/km². Preliminary results suggest a threshold between 15 and 26 deer/km² above which forests shifts to a different state.

LONG-TERM STAND DEVELOPMENT AND FINANCIAL RETURNS FOLLOWING HERBICIDE AND PRECOMMERCIAL THINNING TREATMENTS IN THE ACADIAN FOREST

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The Austin Pond Study is one of the oldest studies in North America documenting the long-term effect of herbicides and precommercial thinning (PCT) on the development of spruce-fir stands. Maxwell McCormack established the study in 1977 to compare 12 aerially applied herbicide treatments (glyphosate, triclopyr, and phenoxys) plus an untreated check on a 7-year-old naturally regenerated stand. In 1986 (age 16 years), the original 28 plots were divided in half and one of the halves precommercially thinned to about 700 trees/A. The resulting treatment array represents all combinations of early thinning and competition release practices typically used in spruce-fir stands of the region.

In 1999 (22 years after herbicide application and 13 years after PCT), we relocated all original plots, installed four 0.02-ha sample plots in each half (PCT and no PCT) of the herbicide treated plots, and measured tree species, DBH, and height. The treatments were compared and the plot information used to project stand development to the end of the rotation. Financial analysis was used to determine returns from investments in herbicide and PCT treatments.

Although total wood volumes (with hardwoods included) were not increased by herbicide or PCT treatments 22 and 13 years after treatment, respectively, the proportion of wood volume in softwood (balsam fir and red spruce) at 29 years was increased substantially by herbicide and PCT treatments. Among the treatments, softwood composition was 74% in herbicide-only plots, 88% in PCT-only plots, and 92% in herbicide + PCT plots, while the untreated control plots had only 23% of the volume in softwood. The influence of herbicide and PCT treatments on the merchantable volume of softwoods was compared using several standards. Using the lowest standard (i.e., using the smallest merchantable top diameters), softwood volume was increased by 171% in herbicide-only plots relative to untreated plots. When including only the newer herbicides (glyphosate and triclopyr), merchantable softwood volume increased 264% above untreated plots. The effect of herbicides was enhanced if the stands were later subjected to PCT, and herbicide application enhanced the later effectiveness of PCT. When herbicides and PCT were used in combination, merchantable softwood volume was 411% greater and total financial value more than two-fold higher than the untreated controls at 29 years.

Future stand development of all plots was projected using the FVS-TWIGS model and the rotation-long financial returns from herbicide and PCT treatments calculated. The net present value (NPV) using a 4% discount rate at stand age of 50 years was $627 /A for the glyphosate and triclopyr herbicide treatments, $541 /A for the phenoxy herbicide treatments, and $414 /A for the untreated control. The NPV for PCT alone was $360 /A. Herbicide + PCT treatments had NPVs around $290 /A. Mean internal rates of return were about 8% for herbicide treatment alone, 6.1% for PCT alone, and 5.8% for herbicide + PCT.

Complete results from this work can be found in a 2003 University of Maine M.S. thesis by R.H. Daggett.

THE LS INDEX: A RAPID ASSESSMENT TECHNIQUE FOR IDENTIFYING LATE-SUCCESSIONAL AND OLD GROWTH FOREST

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Late successional (LS) forests are an under appreciated forest age class that is rapidly disappearing from the northeastern US. In other temperate regions this age class may be critical for maintaining 100s of non-charismatic species. Managing for LS forest will require easy and rapid methods for identifying LS stands that are high in ecological value. To build such an index we identified and evaluated candidate LS indicators from the literature. In 2003 we collected forest structure and species data from different age classes including old growth forest for northern hardwoods and upland spruce-fir forest in western, eastern, and northern Maine. Multivariate analysis identified a limited number of non-redundant indicators with which to build the LS index. For northern hardwoods the prototype LS index is based on the density of big trees (>=40 cm DBH) and density of trees with *Collema* spp. (epiphytic macrolichens). For upland spruce-fir forest the prototype LS index is based on the density of big trees (>=40 cm DBH) and density of trees with long (>=15cm long) *Usnea* spp. (epiphytic macrolichens). The index takes about 20 minutes to apply and distinguishes LS stands from other age classes.

IS THE PAST A USEFUL TEMPLATE FOR FOREST MANAGEMENT?

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"Natural disturbance regimes", "historic range of variation", and "pre-European-settlement vegetation patterns" all refer to the development of goals for forest management based on vegetative patterns that existed prior to European settlement. During the last decade the concept has gained widespread approval and been extensively proposed as a template for future forest management in North America. The appeal of the concept lies in the theory that if pre-European conditions supported native flora and fauna in the past, forest management that promotes development and maintenance of those same conditions should allow native species to persist into the future.

While the "natural disturbance regime" concept is alluring on a theoretical level, there are several obstacles that make practical implementation difficult and potentially flawed. These obstacles to implementation range from disagreement or uncertainty about what vegetation conditions existed prior to pre-European settlement to natural and anthropogenic climate dynamics making the "historic range of variation" an obsolete target to large-scale patterns that would be impossible or counter productive to mimic to high costs for human communities and species that have benefited from current post-European settlement dynamics.

These types of obstacles arise when considering how to mange the forests of Maine within their "historic range of variation". The southern portion of the Maine was extensively cleared for agriculture and the rest of the state has experienced multiple harvests of varying intensity over the last two centuries, leaving few, examples of pre-European settlement forest. Further complicating the effort, historical records are prone to sometimes conflicting and always subjective interpretation. Longer-term records from paleoecology studies suggest that spruce only became a dominant tree species across Maine during the last millenium. The "little ice age" a dramatic period of cooling recorded in the northern hemisphere ended in the mid 19th century. Does the spruce dominance recorded in early accounts of Maine forests represent the "historic range of variation" or is it just an archaic reflection of vegetation dynamics during a colder climatic period? In Maine, as in every region, humans and other species respond to changes in vegetative pattern. Some species have benefited from past human manipulations and others have not. Adjusting management to fall within an "historic range" will negatively impact certain human communities and species while benefiting others. How do we weigh the importance of one group of species or human communities compared to another?

The obstacles associated with the practical implementation of the "historic range of variation" do not make understanding past patterns of vegetative dynamics any less important. Increasing our knowledge about past trends and responses is essential to understanding implications of historic manipulations and predicting responses to future actions. We should use this knowledge to make forest management decisions that purposefully cultivate desired attributes rather than aimlessly mimic past conditions.

ARE THERE MIXED FOREST SPECIALISTS? THE CASE OF THE BLACKBURNIAN WARBLER

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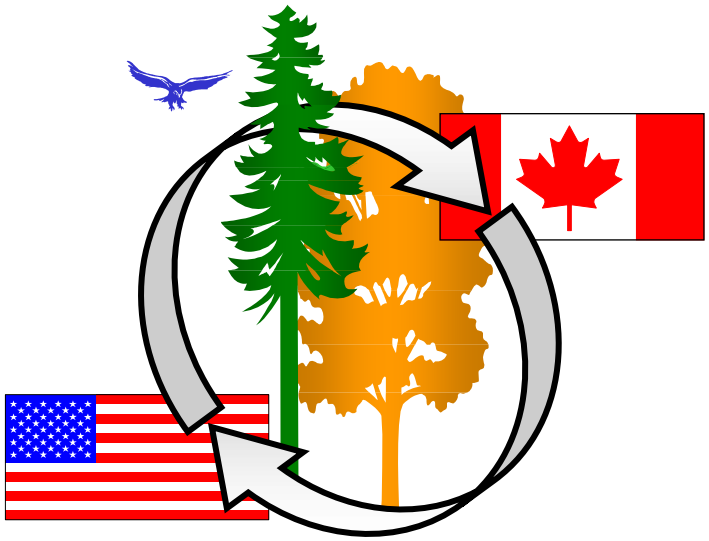
Determining the importance of mixed forests to species diversity has become an important aspect of forest ecology and management. However the response of avian communities to conifer-deciduous gradients is still poorly understood. We examined habitat use by Blackburnian Warblers (*Dendroica fusca*) at two spatial scales and across a spectrum of forest cover types using spot mapping, point counts, and behavioral observations. Blackburnian Warbler abundance was highest in mature forest. We detected no difference in abundance among cover types recognized by the provincial forest inventory (deciduous, coniferous, and mixed forest). However, at finer resolutions, the species was more likely to occur in stands containing a combination of both deciduous and conifer trees. Territory locations were positively associated with deciduous tree height, conifer live crown width, and mature tree density. At the individual tree scale, Blackburnian Warblers were more likely to select mature conifer and deciduous trees for foraging and singing than immature conifers, but did not show preference for any tree species. The mixed forest association exhibited by this species may be due to the tendency for this forest type to be characterized by a tall, large-volume canopy rather than non-structural attributes

Field studies are underway to determine effects on stand structure and dead tree dynamics.

POSTER PRESENTATIONS



AN AGE-RELATED COMPARISON OF DIURNAL PHOTOSYNTHETIC TRENDS IN RED SPRUCE (*PICEA RUBENS)*

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As some tree species age, a decline in photosynthesis is often associated with a decline in growth efficiency of forest stands. In addition, conifers undergo many morphological changes with age, such as the onset of flowering and cone production, a decrease in lateral and height growth and the production of shorter, thicker needles. While these growth characteristics are well documented, less is understood about the physiological changes that trees undergo as they age.

Previous research has shown that for some conifer species instantaneous rates of photosynthesis are lower in older trees than in juvenile trees, possibly indicating an inherently lower capacity of older trees to photosynthesize. Previous studies with ponderosa pine (*Pinus ponderosa*) and lodgepole pine (*Pinus contorta*) demonstrated that while early morning photosynthetic rates were similar regardless of tree age, these rates diverged throughout the course of the day. Our research focuses on the diurnal photosynthetic trends characteristic of different age classes of red spruce (*Picea rubens*), in order to reveal whether total carbon assimilation (A_{max}) is lower in old trees or if it is an effect of the time of day when measurements are performed.

Research was conducted at the Penobscot Experimental Forest (PEF) in Bradley, ME during the summer of 2004. Ten trees in each age class, juvenile (7-12 years), mid-age (60-75 years) and old (120-150 years), located within the same stand were investigated. Photosynthetic rates were measured on fully expanded, previous year foliage in the top third of the canopy. Measurements were made using a LICOR 6400 gas exchange system at ambient CO_2, saturating irradiance (2000 µmol) and a leaf temperature between 22°-25°C.

Our results show that photosynthetic rates of juvenile trees were consistently higher than rates of older trees throughout the entire day. Photosynthetic trends among the different age classes of red spruce do not diverge during the course of the day. We are currently investigating whether these differences in photosynthetic rates are due to a lower investment in the photosynthetic apparatus in older trees, inherently higher rates of carbon assimilation in younger trees or other factors.

PATTERNS OF TREE REGENERATION IN LEAVE PATCHES

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Leave patches, or "tree islands," that are left during harvesting operations may function as sources of natural tree regeneration in the surrounding cutblock. The goal of this project is to assess the species composition and distribution of tree regeneration within and surrounding tree islands. The major focus of this project is on effects of the island edge on tree regeneration in the first year after harvest. We found that our edges consisted of two zones: 1) the outer edge (0-3m into the cutblock) composed mostly of trembling aspen, red maple, and pin cherry, and 2) the inner edge (0-10m into the island) containing a combination of shade-intolerant regenerating species (trembling aspen, red maple) and shade-tolerant residual species (balsam fir, alder, spruce).

A FOREST IN CONFLICT: THE PROPOSAL FOR A 3.2 MILLION ACRE NATIONAL PARK AND PRESERVE IN MAINE'S WORKING FOREST

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The proposal of a Maine Woods National Park and Preserve in the mostly industrial forestland of northern Maine has caused many debates. Questions about traditional uses of the north woods, issues of access and economic impact, are at the heart of the conflict.

In March of 2003, Maine Governor John Baldacci announced the Fall 2003 Blaine House Conference on Natural Resource Industries. It was a gathering of experts from the fishing, farming, forestry, aquaculture and tourism & recreation industries in Maine. They discussed challenges they face, contributing factors to those challenges, creative plans for sustaining them, and Maine's natural resource-based economy. The conference steering committee of 39 members was surveyed in the summer of 2003 regarding the proposed national park and issues surrounding the debate. The purpose of the survey was to examine diverse forest values, bring greater perspective to this issue, and inform further research.

The survey respondents believed there could be a "common ground" solution for Maine, especially in light of the decline of the timber industry and the rising value of outdoor recreation and tourism. They categorized the park proposal as an important natural resource policy issue. It is for that reason that this survey has led to further research designed to examine the proposal in the context of diverse values of the forest, as well as the array of conservation strategies for northern Maine.

SOIL TEMPERATURE AND MOISTURE CONDITIONS IN AN ASPEN, JACK PINE, AND BLACK SPRUCE FOREST STAND IN NORTHERN SASKATCHEWAN (BOREAS)

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The Forest Hydrology Model ForHyM was used to simulate daily mean soil temperature and soil moisture conditions for the aspen, jack pine, and black spruce sites of the BOREAS project, from 1997 to 2004. This model uses daily weather (air temperature, and precipitation), rudimentary site descriptors (soil depth, texture, organic matter content, forest cover type, and sensor data and metadata (depth of sensor locations, time of measurement, etc.) as input. Temperature and soil measurements were taken at several depths, down to 1 m from the top of the forest floor, below the moss layer when present. Model calculations and measurements were generally in good agreement with one another, in spite of major differences in canopy (deciduous versus coniferous canopy structures; major differences in leaf area), ground cover type (moss, lichens/herbaceous, herbaceous) and soil texture. Disagreements could mostly be traced to differences in modeled versus observed snowpack depth, and these differences, in turn, could be related to occasional difficulties in snow versus rain assignments for particular precipitation events. Temperature simulations and measurements were generally closer to one another (often within 0.5 C, at any depth) than soil moisture measurements and simulations. For the latter, two probes placed at same depth but at different locations within the stand followed similar trends but at different moisture levels. Part of the metadata protocol should specify the actual soil profile conditions in the immediate vicinity of the probes. This study shows that ForHyM, originally calibrated for forest conditions in Atlantic Canada, and southern parts of Quebec and Ontario, can also be successfully applied to boreal forest conditions, where the climate is considerably dryer, and colder.

EFFECT OF THERMAL TREATMENT ON SELECTED PROPERTIES OF ORIENTED STRANDBOARD

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Some of the concerns in using wood composite panels are their poor dimensional stability, susceptibility to attacks by insects and fungi and low water resistance. One method that could be employed to improve these properties is to modify the board by heat treatment, which is now commercially applied in solid wood.

Heat treatment experiments of commercial OSB samples were done in a pyrolysis reactor equipped with five (5) thermocouples, located in different areas of the reactor. The samples were placed inside a stainless steel basket. Temperatures ranging from 150 to 220º C were used. The mechanical properties of the boards as well as their thickness swell were evaluated following the Canadian Standard Association's method for OSB (CSA 0437-93). Results showed that MOR was significantly affected with heat treatment. MOE and IB was relatively constant even at higher temperature (220ºC). A thickness of 2% was observed in samples treated at 220ºC. This is significantly lower than the untreated sample which had a thickness swell of 15%.

The color developed on the samples was also observed. Results showed that heating the sample up to 220ºC gave dark brown color which is not acceptable to the consumers. By visual inspection, there is no significant difference on the surface color of those treated at 180 and 200ºC. At these temperatures, the surface color of OSB samples is acceptable. Thermogravimetric Analysis was performed to determine the thermal stability of heat-treated samples. The ground samples were heated at 10ºC per minute from 30ºC to 580ºC. Results showed that at 40 minutes heating time (around 365 ºC), weight percent remaining in OSB treated at 220 ºC was around 30%, while for the rest of the treated OSB samples, the weight percent remaining was 4 – 7 %. This result shows that sample treated at higher temperature was more thermally stable compared to those treated at lower temperature.

REGENERATION STRATEGIES OF JAPANESE BARBERRY (*BERBERIS THUNBERGII* DC) IN COASTAL FORESTS OF MAINE

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Invasive exotic plant species have been shown to threaten biodiversity, habitat quality, and ecosystem functions, as well as agricultural and silvicultural economics via loss of revenue and high costs of invasive control programs. Invasion into intact closed-canopy forest ecosystems is less common than in open (e.g. grassland) habitats. However, one invasive species that has successfully invaded forests is the introduced ornamental shrub Japanese barberry (*Berberis thunbergii* DC.) in the family Berberidaceae. Japanese barberry was introduced over 125 years ago and is becoming a major threat to native systems, but relatively little has been published about the basic biology or ecology of the species. Gaps in knowledge include shortages of published information about regeneration dynamics and seedbanks. This study addresses the questions: (1) What is the density and origin of regenerating Japanese barberry and other species before and after removal of the Japanese barberry overstory? (2) Does a portion of Japanese barberry seeds remain viable for at least a year under natural conditions? (3) Do varying temperature and moisture regimes affect the germination success of seeds with and without the presence of Japanese barberry fruit pulp?

These questions will be addressed by two separate studies. The first study encompasses questions 1 and 2 and consists of a field study and greenhouse study. Monhegan Island, ME, and Wells Research Reserve in Wells, ME, have been chosen for study sites due to high levels of barberry invasion. A continuous stand of Japanese barberry will be delineated at each site, and transects will be cut through each stand to allow access to sample plots. A maximum of thirty 1m radius plots will be cleared and sampled on Monhegan Island in late summer 2004 before the current year's fruits ripen. Measurements will include percent cover of Japanese barberry, percent overstory shade, Japanese barberry regeneration counts, and the presence of other species. A pair of soil samples (14cm x 14cm x 10cm) will be collected from one half of each plot. One soil sample will be placed in a greenhouse setting, and Japanese barberry seedlings will be counted as they emerge. The other soil sample in each pair will be kept in cold storage over the winter and will be processed using the same methods in spring 2005. One soil sample in up to 30 additional sample plots will be collected in spring 2005 on Monhegan Island and from another 30 plots on the Wells Research Reserve. The undisturbed halves of all sample plots will be sampled in late summer 2005 to gather additional regeneration data for Japanese barberry and other species.

Study Two consists of collecting ripe fruits from the two sites and germination of intact fruits, extracted seeds, and commercially collected control seeds in growth chambers. Replicates of twenty five control seeds and twenty five extracted seeds will be incubated in growth chambers to identify the optimum temperature and moisture regimes for germination.. An additional twenty five seeds in berries will be used in each replicate to evaluate the influence of the fruit pulp on germination.

MAPPING CRITICAL LOADS AND EXCEEDANCES FOR EASTERN CANADA

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This poster informs about mapping process and latest maps depicting pattern of critical soil acidification loads and related exceedances across eastern Canada. Two approaches have been used: one that assigns the critical soil acidification parameters to the attribute files of existing ecological land classification data layers, and one that examines well-studied sites, such as those of the Acid Rain National Early Warning System (ARNEWS). The maps show that areas impacted by historical acid deposition are mostly located in southern Ontario, Southern Quebec, and Nova Scotia, in areas where the rate of soil weathering is slow on account of weather-resistant soil substrates. On uplands, forests would be most affected. Forests on these locations have shown decline symptoms that appear to be correlated with the extent of the local soil acidification exceedance, as calculated.

CONSIDERING HETEROSCEDASTICITY AND REPEATED MEASUREMENTS IN FOREST GROWTH MODELING

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Modeling forest growth from permanent sample plots involves two major statistical issues: heteroscedasticity and repeated measurements that are unequally spaced most of the time. With this kind of data, the traditional ordinary least squares (OLS) provide biased estimates of both model and parameter variances. For simultaneously taking account of both issues, a general variance-covariance structure of a nonlinear growth model is proposed by merging a variance function, namely a power-of-the-mean function, with a spatial power function. The first allows variance modeling as a function of the expected predicted values. The second makes it possible to assess the correlation between two equally or unequally spaced measurements. The merge took the form of a variance-covariance matrix involving three parameters. The model was derived using data from permanent sample plots located in the Mauricie National Park, Québec, Canada. Compared to the OLS method, the variances of the parameter estimates tended to decrease. Moreover, the method provided unbiased confidence intervals for the predicted values. Consequently, the proposed variance-covariance structure represents an answer to the increasing need for error analysis for forest growth prediction.

DISTURBANCE HISTORY OF OLD-GROWTH RED SPRUCE STANDS IN NORTHERN MAINE: LINKING TREE-RING AND STEM-MAPPED DATA

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The aim of this study was to reconstruct the detailed history of natural disturbance for three old-growth, mid-elevation red spruce stands in northern Maine. By linking dendroecological methods and stem-mapped data, we estimated the actual area encompassed by particular disturbance events, as well as their frequency and location within stands.

We conducted the work in the Big Reed Forest Reserve, which at *ca.* 2000 hectares is thought to be the largest remaining contiguous tract of old-growth forest in New England. Unlike many small, isolated old-growth stands that may not be representative of the surrounding landscape, the Reserve supports forest communities, soils, elevation ranges, and topographic settings typical of northern Maine. Thus, it affords a unique glimpse of forest structure, composition, and processes that represent what forests of this region might have been like in the absence of disturbances associated with European settlement and subsequent development.

Three 50-by-50 m spruce-forest plots from a larger study were selected for intensive sampling here. The X and Y coordinates were recorded for all living and dead trees (individuals ≥ 10 cm diameter at breast height [dbh]) and saplings (individuals ≥ 2 m in height but < 10 cm dbh) within each plot. For each living tree we recorded dbh, total height, height to base of the live crown, crown class (dominant, co-dominant, intermediate, and overtopped), and stratum. To determine canopy projection area for each tree, we measured the horizontal distance from bole center to the canopy drip line in four cardinal directions.

We found no evidence of stand-replacing disturbance in these three spruce stands. The disturbance dynamic appears to have two components: pulses of moderate-severity disturbances caused by host-specific disturbance agents (i.e. spruce budworm, spruce bark beetle) interposed upon a background of scattered small-scale canopy gaps, presumably from wind damage. Consequently, rates of disturbance fluctuated considerably over time; however, they rarely exceeded 35% of canopy area lost per decade. The overall mean decadal disturbance rate was 10.1%. Gap areas, even during peak decades of disturbance, were apparently too small or too densely occupied by advance spruce regeneration to admit shade-intolerant species, although at times they did admit mid-tolerant species. Spruce trees clearly benefit from relatively small canopy gaps scattered in space and time: 80.6 % of trees showed one or more releases before canopy accession. Thus, this pattern of disturbance maintains red spruce dominance of the canopy. Reconstructed gap areas reveal that, following budworm outbreaks, gaps were both larger and more numerous. Gap areas thus calculated were generally smaller (median 25.3 m^2, mean 46.7 m^2) than those from other *Picea* forests. Several measures of canopy structure provided strong supporting evidence for historical disturbance patterns revealed by dendroecological methods.

RELATIONSHIPS BETWEEN POTENTIAL ROOTING DEPTH, TREE GROWTH, AND WHITE PINE (*PINUS STROBUS* L.) DECLINE IN SOUTHERN MAINE

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White Pine Decline is characterized by thinning of the crown and mortality (26% of basal area) in pole-size stands in southern Maine. Most dead trees had their last year of growth in 1996 or 1997. Recent studies have demonstrated that the drought of 1995 incited the decline, and that potential rooting depth of less than 30 cm is a key predisposing factor. White pine rooting depths can be limited by plow pans, high water table, shallow bedrock, or lithological discontinuities (fine texture soils overlaying coarse texture soils). Many white pines regenerated on potentially rooting restricted sandy soils after extensive farm abandonment in southern Maine.

This study estimated the occurrence and distribution of white pine stands in southern Maine (York and southern Oxford counties) that are at risk to White Pine Decline due to shallow rooting depths. Digitized soil maps were overlaid with satellite cover types to indicate potential areas where white pine is growing on soil types that may have a restrictive layer. Based on this map, 39 sample sites were established in 2003 using a random selection of locations. White pine growth and productivity, as well as potential rooting depth, were measured in 4 subplots at each location. Twenty-three locations were found to have potential rooting restrictions that predispose white pine to decline incited by drought, but only eight locations had restrictions that were less than 30 cm deep, an indication of sites at high risk to White Pine Decline. Analysis of variance showed relationships between restricted rooting and growth inhibition for diameter breast height (DBH) and sapwood area. A 20% reduction in DBH ($P = 0.032$) and a 33% reduction in sapwood area ($P= 0.057$) were observed in ca. 60 yr old trees next to soil pits showing rooting barriers within 50 cm of the surface.

Soil analysis verified the field observations detecting presence of significant soil textural changes ($P <0.001$) from loamy sand (81.6% sand) in the B-horizon to coarse sand (90% sand) in the C-horizon. White pine roots were rarely found (8 of 36 soil pits) below these textural changes. The conclusions of this study show that soils at risk to White Pine Decline are widely scattered across the area but can reduce diameter growth of individual white pine that grow with the localized restrictions. Stand densities should be kept low to reduce the likelihood of the onset of White Pine Decline.

REGENERATION OF NORTHERN WHITE-CEDAR FOLLOWING SILVICULTURAL TREATMENT: A LONG-TERM STUDY

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Northern white-cedar (*Thuja occidentalis* L.) is found on many different types of sites, both in pure stands and in mixture with other species. Common associates include spruce (*Picea* species), balsam fir (*Abies balsamea* (L.) Mill.), and yellow birch (*Betula alleghaniensis* Britton). Unfortunately, the circumstances leading to the successful recruitment of northern white-cedar are poorly understood. Some studies suggest that regeneration is associated with small natural disturbances such as blowdown. However, silvicultural treatments imitating nature have had varying degrees of success with regard to northern white-cedar regeneration. Browsing has been identified as the main factor limiting establishment and sapling development in many regions, but some areas do not regenerate successfully even when fenced.

Concerns about sustainable forest management have motivated researchers to study the relationships between silvicultural treatments and northern white-cedar regeneration. Experiments have been planned on lowland areas in the Gaspé Peninsula, Eastern Québec and on mesic sites in the Outaouais region, Western Québec. Though these new experiments will enable us to better identify the conditions associated with successful regeneration, they will only provide a short-term perspective. Medium-term data will be provided by a retrospective study of partial cuts conducted 15-20 years ago. Fortunately, researchers at the Penobscot Experimental Forest in Maine have been collecting data on northern white-cedar regeneration and growth for over 50 years. The PEF experiment includes 10 replicated silvicultural treatments. These data will be analyzed in order to determine if there are relationships between treatment and northern white-cedar regeneration, and the findings will be used to develop treatments for the Gaspé Peninsula experiment. Further analysis will be conducted in order to examine the interactions of treatment and site type on cedar regeneration and tree response to partial cutting.

The results of this study will provide us with a better understanding of northern white-cedar regeneration mechanisms, and will help us to identify silvicultural regimes that promote cedar establishment and growth.

IDENTIFICATION OF ECTOMYCORRHIZAL FUNGI FORMING SYMBIOTIC ASSOCIATION WITH AMERICAN CHESTNUT AND THEIR UTILIZATION IN RESTORATION EFFORTS

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The American chestnut, once the 3rd most dominant tree in Eastern US forests, has been almost eliminated by the invasive fungus *Cryphonectria parasitica.* However, extensive research efforts during the last two decades have given much hope for restoring this giant tree to its natural range. A tree breeding program initiated by the American Chestnut Foundation appears very close to establishing a blight-resistant American chestnut. Another research effort, focused on the "hypovirulence" phenomenon and application of genetic engineering technology, has also shown great potential in combating the blight fungus. Overall, these technologies show promise for restoration of the American chestnut.

Mycorrhizal fungi may play a vital role in tree restoration efforts. These fungi are often essential for the survival of trees by supporting growth under a variety of subnormal soil and other stress conditions. Systematic studies to identify species that form functional symbiotic interactions with chestnut tree roots and their utility in chestnut restoration efforts have not been carried out. Our goal is to introduce blight-resistant chestnut trees to the Southeastern forests affected by nearly a century of coal mining.

We tested in our laboratory 10 species of ectomycorrhizal fungi (*Amanita rubescens, Boletus subtomentosus, Cenococcum geophilum, Laccaria bicolor, Laccaria laccata, Paxillus involutus, Pisolithus tinctorius, Suillus americanus, Suillus luteus, Rhizopogon rubescens*) for their ability to form mycorrhizal interactions with American chestnut roots. The experiment was conducted under semi sterile conditions. American chestnut seeds (Virginia) were allowed to germinate in a sterile environment (500 ml medium containing milled peat, vermiculite and Perlite in equal proportions + 0.005 part dolomitic limestone). After seedlings had developed secondary roots, they were inoculated with the fungal mycelium and planted in pots and moved to a greenhouse. Inoculation was repeated after 2 week and 4 week periods. Three months after the last inoculation, seedling roots were examined under a dissecting microscope for the presence of ectomycorrhiza. The identified mycorrhizal tissues were also subjected to transmission electron microscopic analysis to further characterize the type of interaction. Out of the 10 species tested, 5 formed ectomycorrhiza (*A. rubescens, C. geophilum, L. bicolor, L. laccata, P. tinctorius*) as determined by the presence of mantle and Hartig net. Fungi from these tissues were reisolated and confirmed to be the species used for inoculation.

In addition to the five described above, we found two other fungal species which were different from the ones used in the test. Apparently, these were either contaminants or were resident in the seeds before they germinated. Since morphological analyses could not identify these species, we used the restriction fragment length polymorphism (RFLP) method to characterize them. The RFLP analyses indicated that one of the unknowns belonged to the order *Tomentella*. However, the identity of the other unknown could not be determined by this analysis. Efficacy characterization of these fungi in supporting growth and survival of chestnut seedlings on mined field sites is being carried out.

ECOLOGY AND SILVICULTURE OF NORTHERN WHITE-CEDAR

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Northern white-cedar (*Thuja occidentalis* L.) is an important ecological and economic component of northern forest ecosystems throughout northern New England and eastern Canada. In addition to its commodity value as shingles, posts, boat-building lumber, and mulch, it is an important source of winter forage and habitat for white-tailed deer (*Odocoileus virginianus*). Despite its utility and value, there has been little research on the ecology and management of this species. Most studies of cedar have been conducted in the Lake States, where forest type, soil condition, climate, and disturbance history vary greatly from the forests of the Northeast. We have a limited ability to predict cedar growth in northeastern forests, especially in response to silvicultural treatments, and know little about its regeneration and early development.

Though foresters generally associate higher stem quality in cedar with upland seepage forests, these ideas have not been substantiated through data in any meaningful way. Cedar is often a minor component of mixed-species stands and is harvested opportunistically in the course of managing for more dominant species. Foresters interested in managing for cedar are handicapped by a lack of knowledge of cedar silviculture. Recruitment into sapling and pole stages is often problematic, and managers have expressed concern about the sustainability of the cedar resource. Further research into cedar ecology and response to silviculture is critical for sustainable management.

We propose to: 1) develop methods to predict stand- and tree-level growth of northern white-cedar in response to silvicultural treatment and site quality; 2) estimate rotation ages needed to attain various diameters; and 3) quantify sapling recruitment and growth patterns during early stand development. These objectives will be accomplished by conducting stem analysis on cedar trees in managed upland and wetland stands in central and northern Maine, and from a Maibec Industries millyard in Quebec, in order to assess age – size relationships and growth rates. These data will be supplemented by those collected on the USDA Forest Service silviculture experiment on the Penobscot Experimental Forest in central Maine, and in old-growth stands in the 5000-acre Big Reed Reserve in northern Maine.

We anticipate this study will provide data needed to improve our understanding of northern white-cedar ecology, and to develop effective management guidelines for cedar in the mixed-species northern forest.

PROPOSED STUDIES FOR INVESTIGATING THE ONSET OF RADIAL GROWTH REDUCTION CAUSED BY BALSAM WOOLLY ADELGID DAMAGE ON BALSAM FIR IN RELATION TO CLIMATE USING DENDROECOLOGICAL METHODS

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Balsam woolly adelgid (BWA) (*Adelges piceae)* was first identified in Maine in 1908 and by 1947 had been found across the lower half of the state. By 1951 isolated patches of infestation had been found as far north as Westmanland in northern Aroostook County. Infestations in coastal areas of Maine have been chronic, while further inland damage has been sporadic and widely scattered. Within the last decade increased damage has been reported in interior portions of the state with the worst damage in central Hancock and Washington Counties.

We will test the hypothesis that reductions in radial growth of BWA infested balsam fir (*Abies balsamea*) in central Hancock and Washington counties have been initiated within the last decade and are associated with distinct weather patterns such as warm winters and/or drought. We will also confirm whether damage severity varies with soil drainage class and other stand parameters.

Circular, 0.08 hectare (1/5 acre) study plots will be established in the area east of the Penobscot River where recent reports of BWA damage have originated on land owned by International Paper (IP). Thirty plots, stratified by climate region and soil drainage class, will be established on sites capable of commercial production of balsam fir. Several site and tree measurements will be recorded on each plot and increment cores will be taken from at least 12 host and 12 non-host trees. Measurements will be taken as described in the Forest Inventory and Analysis Field Guide (USDA Forest Service 2003)

Chronologies will be developed from the increment cores for balsam fir and non-host species. These chronologies will be cross-dated, standardized, and compared with each other to remove stand-wide effects on growth patterns in an attempt to single out BWA effects on balsam fir. This examination will show whether reduction in radial growth of adelgid-infested fir is a recent event. The onset of growth decline will be compared with climate records to evaluate relationships between minimum temperatures, drought (as indicated by precipitation and stream flow), and BWA signals in fir chronologies. Relationships between soil drainage class, other stand parameters, and severity of BWA symptoms will be quantified using multivariate analytical techniques. The study's results will indicate if climate can explain the recent increase in BWA damage in Hancock and Washington Counties and how severity of BWA damage varies by drainage class and with radial growth reductions at DBH.

Reference:

USDA Forest Service. 2003. Forest inventory and analysis national core field guide, volume 1: field data collection procedures for phase 2 plots, version 1.7. USDA, For. Serv.-WO. Internal report.

INFLUENCE OF TEMPERATURE, MOISTURE REGIME, FOREST CANOPY, PREDATION, HERBACEOUS COMPETITION, AND SOWING DATE ON GERMINATION, EMERGENCE, AND EARLY SURVIVAL OF NATIVE AND NON-NATIVE TREE SPECIES IN THE ACADIAN FOREST

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The Acadian forest forms the transition zone between the eastern temperate and boreal forests. With the possibility of a changing climate, it will be important to predict how increasing temperatures and changing patterns of precipitation may influence the distribution of important native and exotic tree species. Although climate may act to limit the geographic distribution of a tree species at any of several points during its lifecycle, the influence of temperature and moisture on the sensitive early life stages may be particularly important. In addition, understanding how other factors such as seed predation, herbivory, plant competition, and season of dispersal can influence whether a seed is able to germinate, emerge, and survive can help determine the relative importance of climate on these life stages.

The objectives of our study are to: 1) examine the effects of different temperature and moisture regimes on the germination success of important native Acadian tree species and exotic tree species; 2) quantify the effects of seed predation, herbaceous competition, overstory, and sowing date on the emergence and first-year survival of important native Acadian tree species and exotic tree species; and 3) determine if silviculture can be used to mitigate possible negative effects of climate change on soil temperature and moisture to encourage the germination and establishment of desired Acadian forest species. These objectives are being accomplished using both growth chamber and field studies.

The growth chamber study is examining patterns of germination for nine tree species representing boreal (balsam fir, trembling aspen, white birch), temperate (eastern white pine, red maple, red spruce), and exotic (hybrid larch, Norway maple, Norway spruce) species under three temperature and three moisture regimes in a factorial design. Moisture levels in the germination media were controlled using polyethylene glycol solutions of 0, -.75 and -1.5 MPa to simulate wet, moderate, and dry conditions, respectively. Temperature regimes included the 30-yr average for Bangor, Maine from 1971-2000 [June high (23.5°C) and low (11.8ºC)], and plus and minus 7.5ºC from this baseline. This experiment provided control over temperature and moisture conditions, as well as observation of timing of germination not generally possible in the field.

The field study includes seed from the same nine tree species in a 2^4 factorial design and is examining the influence of: 1) sowing date (fall vs. spring), 2) overstory canopy (overstory vs. no overstory), 3) vertebrate predator protection (cage vs. no cage), and 4) herbaceous plant competition (grass vs. no grass) on emergence and early survival. Emergence and mortality, and the cause of mortality, were tracked weekly during the first growing season in 2004. General patterns of soil temperature and moisture under each treatment also were monitored.

USDA FOREST SERVICE RESEARCH ON THE PENOBSCOT EXPERIMENTAL FOREST: 50-YEAR UPDATE

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The Penobscot Experimental Forest (PEF) is located in Bradley and Eddington in east-central Maine. The forest was established in 1950 when a number of industrial landowners purchased the land to be used for forest management research by the USDA Forest Service, Northeastern Forest Experiment Station (now Northeastern Research Station). A long-term research program was established on the site, and continues today through a memorandum of agreement with the current forest owner, the University of Maine.

The most extensive research project on the PEF is the 600-acre silviculture experiment initiated by the Forest Service in 1952. This replicated study of forest response to silvicultural treatment and exploitative cutting includes selection cutting on 5-, 10-, and 20-year cycles, two- and three-stage shelterwood, irregular shelterwood, thinning studies, fixed and flexible diameter-limit cutting, commercial clearcut, and an untreated control. All stands in the experiment have a permanent plot network on which regeneration, ground cover, stumps, snags, and live trees > 0.5 inch dbh are numbered and measured before and after every harvest, and at approximately 5-year intervals between harvests.

Research on the PEF has been an important source of information about advance regeneration, seed viability, feasibility of regeneration methods, precommercial thinning, effects of exploitative harvests, sustainability of stand structure and composition, habitat suitability, and leaf area relationships. The experiment recently passed the half-century mark, and overall results through 40 years have been published (see Sendak et al. 2003). The Forest Service is committed to continuing the research on the PEF, and is in the final stages of developing and approving a revised study plan for the experiment.

Sendak, P.E, J.C. Brissette, and R.M. Frank. 2003. Silviculture affects composition, growth, and yield in mixed northern conifers: 40-year results from the Penobscot Experimental Forest. Can. J. For. Res. 33:2116-2128.

THE EFFECTS OF ALTERNATIVE DIAMETER-LIMIT CUTTING TREATMENTS: SOME FINDINGS FROM A LONG-TERM NORTHERN CONIFER EXPERIMENT

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Partial harvests in which only large and valuable trees are removed have long been common in the United States and Canada. These types of cuttings often have degrading effects on residual stand condition, though there is little data on the topic. Fortunately, modified (MDL) and fixed (FDL) diameter-limit and commercial clearcutting (CC, i.e. unregulated harvest), as well as the uneven-aged silvicultural system of selection (SC), have been applied by the USDA Forest Service on the Penobscot Experimental Forest (PEF) in Maine for over 50 years.

Preliminary results from the PEF study suggest that the degree of degradation, and thus potential for future management, are affected by both the removal criteria and the number of previous harvests. Pre-treatment comparisons of volume, percent cull, and percent spruce species revealed no significant differences, and treatment differences were not great following a single harvest. Though there were no treatment differences in mortality or harvested volume over the measurement period (which included three cuts each in MDL, FDL and SC, and two cuts in CC), volume at the end of the period was higher in the MDL and SC than CC and FDL. Differentiation of the treatments into these two groups is supported by the species data, which showed more spruce in the MDL and SC than CC and FDL. Stand quality expressed as percent cull was only different between the SC and FDL treatments.

Though more complete analysis is needed to fully understand the effects of these treatments, our preliminary results suggest that structural effects of the diameter-limit treatments are not distinguishable from selection after a single entry. However, multiple entries resulted in quantifiable differences, with less volume and a lower proportion of spruce in FDL and CC stands. Stands repeatedly cut with FDL were also differentiated from SC stands by stand quality (expressed as percent cull). Modified diameter-limit cut stands were similar in structure, composition, and quality to SC stands, even after repeated entries. These findings suggest important differences in the diameter-limit cutting variants, and will be of use to managers and landowners who are faced with decisions about partial cutting alternatives.

DYNAMICS OF TREE GROWTH AND COMPOSITION FOLLOWING PARTIAL CUTTING IN AN OAK – PINE FOREST IN MAINE

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The Holt Research Forest in Maine is an early 1900s origin even-aged second-growth forest. Common tree species include eastern white pine, red maple, and red oak in mixture with other softwoods and hardwoods. In 1987 ten 1-ha blocks on the forest were partially harvested to initiate a long-term study of ecosystem response to silvicultural treatment. Since that time, data from treated blocks and untreated controls have been used to assess changes in stand structure (density and volume), species composition, growth, mortality, and snag dynamics.

Objectives of the treatment were to increase structural diversity, regenerate a new cohort, and improve stand quality, growth, and composition. White pine and red oak were favored, as were good form yellow and paper birch, red spruce, and eastern hemlock. Grey birch, mature balsam fir, poor vigor red spruce, and trees > 50 cm dbh (primarily white pine "wolf" trees) were removed. These objectives, and the low-impact partial harvesting applied, are consistent with the objectives and forest management preferences of small landowners in the region.

There were no pre-treatment structural or compositional differences between harvest and control blocks (for species > 5% of BA). Inventory data collected post-treatment indicated fewer trees and less volume in the harvest blocks, as would be expected. Total stem density no longer differed between treatments nine years after harvest, apparently due to the combined effects of higher ingrowth in the harvest blocks and higher mortality in the control. Volume remained lower in the harvest than control blocks. Species composition did not differ between treatments, either immediately or one decade after harvest, despite attempts to improve composition. Net growth was also not differentiated by treatment, with the exception of higher medium – large sawtimber growth in the control due to greater stocking in those classes.

Post-harvest inventory revealed that the harvest blocks had fewer snags, despite no pre-harvest difference in snag density between treatment areas. Though the number of snags increased in both the harvest and control blocks over the next decade, greater snag recruitment (a function of mortality) occurred in the control. Partial cutting thus decreased both the number of snags in the residual stand and the rate of snag formation, resulting in increasing between-treatment differences in snag density over time.

EVALUATION OF STRESS CALCULATION ON I-JOIST WITH WEB HOLE BY ONE POINT LOAD FAILURE TEST: STUDY ON FAILURE BEHAVIORS OF WOOD I-JOIST WITH WEB HOLE

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This paper summarizes the preliminary testing of wood I-joist with web hole. Two depths of I-joists specimens with circular and square web hole are involved in to get testing max load and critical point, when one point loading occurs. On the other hand, calculating max loads in different specimens are generated by the theory developed on Section 1. By analyzing the results of calculating max load and testing max load, author believes that the theory developed in Section 1 can be used to evaluate the strength of I-joist with web hole, but some factors should be re-considered, such as the effect of hole size, the effect of hole style, and so on. This observations and measurements are intended to aid the development of a calculation procedure for predicting the load-carrying capacity of a wood I-joist with a web hole.

MAINE'S COMMERCIAL THINNING RESEARCH NETWORK: A LONG-TERM RESEARCH INSTALLATION DESIGNED TO IMPROVE OUR UNDERSTANDING ABOUT HOW FORESTS RESPOND TO THINNING

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Maine's Commercial Thinning Research Network was established in 2000 to develop a better understanding about stand responses to commercial thinning in the state's forests. Initial efforts by the network are divided into two phases. Phase I developed a set of interim guidelines for commercial thinning through the development of a software product called ThinME. Phase II, representing most of the effort, has involved establishing a statewide network of research sites to address specific questions about commercial thinning. Data from Phase II will help further refine the thinning software developed in Phase I, improve regional growth and yield models related to thinning responses, and address other silvicultural questions of interest. The plot network is currently focused on answering two key questions about commercial thinning in spruce-fir stands across the state: (1) For natural spruce-fir stands that have not received pre-commercial thinning (PCT), what is the influence of (a) method of commercial thinning and (b) residual density on subsequent stand response? (2) For natural spruce-fir stands that have received previous PCT, what is the influence of (a) timing of first commercial thinning entry and (b) residual density on subsequent stand response?

Twelve study sites have been established across the state of Maine. Six sites have previously received PCT and range in age from 25 to 40 years old. The other six sites have never received PCT and range from 40 to 70 years old. At each site, seven 0.37 ha (61 m x 61 m) treatment plots have been established. Commercial thinning treatments in stands that have not received PCT include a factorial combination of thinning method (low, crown, or dominant) and level of relative density reduction (33 percent or 50 percent). Commercial thinning treatments in stands that have received PCT include a factorial combination of timing of first commercial thinning (now, delay 5 yrs, or delay 10 yrs) and level of relative density reduction (33 percent or 50 percent). The thinning treatments, which used single-grip harvesters and forwarder trails spaced 30.5 m apart, were applied from fall 2000 through fall 2002. Four 0.02-ha (15.2 m x 13.3 m) measurement plots were placed at the center of each treatment plot. All plots have been measured before and after thinning. Regular post-treatment measurements are being collected from permanent tagged trees. Measurements include species, DBH, tree location, total height, and height to live crown.

UNDERSTORY HEIGHT GROWTH DYNAMICS IN UNEVEN-AGED, MIXED-SPECIES NORTHERN CONIFER STANDS

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Managing uneven-aged, mixed-species stands requires balancing the need for high leaf area allocation in the overstory where it is most efficient with the need for sufficient growth of younger cohorts in the understory. To help forest managers make informed decisions to maintain this balance, the understory growth dynamics of northern conifer species in stands managed under uneven-aged silvicultural systems were studied. Sapling height growth of *Picea rubens* Sarg., *Abies balsamea* (L.) Mill, and *Tsuga canadensis* (L.) Carr. was modeled as a function of overstory canopy openness (gap fraction) using regression analysis. Research was conducted in four uneven-aged northern conifer stands on the Penobscot Experimental Forest in eastern Maine; two replicates each of selection cutting on five and ten-year cycles. Gap fraction estimates were obtained directly above 167 sample trees between 0.5-6.0 m in height, using a LI-COR LAI-2000 plant canopy analyzer. These estimates were tested in several model forms with initial tree height to predict sapling height growth. Regression modeling demonstrated that sapling height growth of all three species followed monotonically increasing patterns with respect to decreasing canopy closure. The gains in advancement through the understory were progressively reduced as higher levels of canopy openness were obtained. However the monotonically increasing nature of the best fit models makes it difficult to suggest any particular overstory density goal for balancing efficient overstory leaf area allocation and sufficient sapling height growth.

BIOLOGICAL CONTROL OF OUTBREAKING POPULATIONS OF THE BALSAM FIR SAWFLY WITH ITS BACULOVIRUS

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Recent increases in the area devoted to intensive forest management in North America have been accompanied by changes in the levels of defoliation attributable to some insects previously viewed as secondary pests. For example, the intensity and duration of balsam fir sawfly (*Neodiprion abietis* [Harris]) outbreaks have recently increased in managed balsam fir (*Abies balsamea* [L.] Mill) forests in western Newfoundland and Cape Breton. A baculovirus (*Neab*NPV) is responsible for the collapse of balsam fir sawfly populations in natural conditions and may provide an efficacious yet environmentally-friendly tactic to suppress epidemic populations of this insect. No method is currently available to suppress epidemic populations of this forest insect.

This study examines the effects of aerial applications of *Neab*NPV on populations of its host. To determine the optimal strategy for biocontrol, applications were directed against increasing, peaking and declining populations. From 2000–2002, *Neab*NPV, partially purified from isolate that originated from the same area, was applied in a 20% aqueous solution of molasses on seven blocks supporting high-density populations of the balsam fir sawfly. Applications were carried out using Cessna 188 'Ag Truck' airplanes equipped with four, underwing Micronaire AU 4000 atomizers. Densities, frass production and levels of *Neab*NPV infection of field populations of balsam fir sawfly were monitored in the year subsequent to application, in addition to the pre- and post-application sampling.

Results indicate that balsam fir sawfly densities were distinctly lower in the generation following an aerial application of *Neab*NPV, but only when treatments were directed against increasing or peaking populations. When directed against declining populations, *Neab*NPV applications apparently did not influence the natural collapse of outbreaks. Although the artificial introduction of *Neab*NPV did not consistently affect densities of the treated generation, it had an effect on host biology in the weeks following the treatment as levels of *Neab*NPV infection increased and frass production (concomitantly larval feeding) decreased in treated areas.

Thus, this study suggests that *Neab*NPV may provide an efficacious tactic to suppress increasing or peaking population outbreaks of the balsam fir sawfly through the use of aerial applications of NeabNPV at rates as low as 1×10^9 polyhedral inclusion bodies per hectare

INNOVATIVE FASTENER FOR ENGINEERED WOOD PRODUCT CONNECTIONS

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Engineered Wood Product (EWP) is a class of materials used as an alternate engineering material to solid wood. Because EWP are manufactured they can be created to have superior mechanical and physical properties, including high resistance to fracture (splitting). Controllable attributed make it possible to create structural connections in EWP that are mechanically very efficient, and by implication that are highly cost effective. The University of New Brunswick project "Design Methods for Connections in Engineered Wood Products" funded by Natural Resources Canada aims to provide knowledge and tools for efficient design of EWP connections. The sub-study reported here is concerned with using small diameter hollow metal tube fasteners in a type of EWP known as Laminated Strand Lumber (LSL). Using small diameter hollow tube fasteners means that the fasteners are slender and will yield and buckle in the cross-section if overloaded. This produces a highly ductile connection response which is very desirable under anti-seismic or anti-hurricane design conditions. The authors are investigating appropriate selections of fastener material (type of metal), outside diameter, wall thickness and surface texture. Connected structural members of solid wood can split even when slender tube fasteners are employed because solid wood has low fracture toughness. This reflects the highly aligned nature of longitudinal cells, leading to fracture planes that lie parallel to grain. By contrast LSL has high fracture toughness that reflects that strands are deliberately not perfectly aligned, are overlapped and are bonded with synthetic adhesives. High fracturing resistance (resistance to splitting) means that fasteners can be tightly grouped. This minimizes the footprints connections have on structural members. The authors are investigating effects that footprint related parameters like fastener spacing have on connection strength and stiffness. Tools for this are experimental investigations aided by numerical modeling that uses the finite element approximation technique.

Although the work discussed here is in relatively early stages it is already apparent that use of an innovative slender metal tube type fastener in LSL produces highly efficient connections. It is anticipated that the same will be true for connections in other EWP.

INTEGRATING CARBON SEQUESTRATION OBJECTIVES INTO FOREST MANAGEMENT PLANNING

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This poster presents the development of a modeling framework that integrates forest carbon (C) dynamics with empirical growth and yield models currently in use by forest managers at Canadian Forces Base (CFB) Gagetown. Temporal C dynamics are built upon work by Diaz-Balteiro and Romero (2003) in which the C content of forest stands is based on a single conversion factor from merchantable volume to C. The conversion factor is a non-species-specific merchantable volume-to-C content multiplier of 0.2. We replace this assumption by using species-specific, age-dependant C yields. C yields account for both C increments and depletions in the standing forest generated with a multiple-cohort forest C dynamics model, CO_2Fix (Masera et al. 2002). Projections of optimized C-sequestration in standing forests, wood products and associated harvesting schedules were generated over a planning horizon of 80 years using an empirical growth and yield model (Woodstock by Remsoft). Linear programming technique of goal programming is used to minimize the inevitable loss of revenue associated with managing the forest for C (longer rotation age, less intensive harvesting). The effects of clearcutting, partial cutting and pre-commercial thinning and the C balance of the forested landscape were also simulated. Spatially, soil C content is generalized in an artificial neural network (ANN) that is digitally applied to the digital elevation model (DEM) of the landbase. Input variables to the ANN are the topography calculated from the DEM; forest cover type based on aerial photography; C content of a selection of soils on site and calculated depth to water table.

FOREST ROAD NETWORK PLANNING FOR THE UNB FORESTS LANDS

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The strategic forest plan for the UNB Forest Lands identifies four major management goals: Teaching, research, financial responsibility and public profile. A forest road network which supports these goals would satisfy the following objectives:

- provide access to selected educational blocks
- provide access to all harvesting stands,
- minimize road construction costs by reusing some existing roads,
- reduce impact on watercourses and the land by reducing the number of stream crossings and road density.

To locate future harvest stands (and the educational blocks), a medium-term (20 years) tactical forest plan was created using Mixed Integer Linear Programming. This spatial harvest schedule satisfied the teaching and financial responsibility goals.

In a second step, a systematic and later on an improved road network was designed. The systematic road network was designed using an equally spaced grid and did not account for existing roads in the forest. This was created as an assessment tool for comparing with the improved road design, which used both the systematic approach and heuristics to design the future network.

The improved road network reduced the total road density in the UNB woodlot from 46 m/ha to 15 m/ha and reduced the average skidding distance in Noonan from 176 to 108 m. Total road construction over lifespan of the project was 12.2 km.

Access to targeted educational stands was provided by the improved road design. The general concept of connecting access roads to loops enables easy navigation of busses with student groups without having to turn on a dead-end road.

In a third step, the harvest schedule was re-optimized to smooth road construction activities over time, and hence to meet road construction budgets and reduce the NPV of road construction.

SCREENING FOR GENETIC RESISTANCE AND PROPAGATING BEECH BARK DISEASE-FREE AMERICAN BEECH (*FAGUS GRANDIFOLIA*)

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American beech is an important tree species in eastern North America that has been severely affected by beech bark disease (BBD), a complex disease that involves the interaction of a scale insect (*Cryptococcus fagisuga* Lind.) and a *Nectria* fungus. While many trees have been killed, some show resistance to the disease. Resistance is believed to be of genetic origin and this gives an opportunity to propagate disease-free trees, introduce them to natural forests and increase resistance levels. The purpose of this project is to use vegetative propagation on mature American beech trees that appear resistant to BBD and test if the resistance is due to genetic factors. Three propagation techniques are being applied: micropropagation of buds, root sprouts and epicormic roots from branches and grafting. Due to the difficulty of propagating this species in the past, a pilot study was carried out in 2003 to determine the feasibility of different propagation methods. It was determined that grafting success was low (30%) and was related to the rootstock diameter. Contamination of *in vitro* cultured buds was high for some genotypes (more than 50% for 45% of the genotypes) and rooting of plantlets was low (less than 25%). Cuttings of root sprouts and shoots induced from branches were unsuccessful and epicormic shoots induced from branches were not vigorous and didn't survive *in vitro*. The grafted material is currently being tested for resistance by inoculating the scale insect on the bark of the seedlings.

CROWN DIMENSIONS OF FOUR NORTHERN HARDWOOD SPECIES IN DEVELOPING EVEN-AGED STANDS: THE INFLUENCE OF SHADE TOLERANCE ON GROWING SPACE OCCUPANCY

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Differences between tree species in their requirements for growing space have generally been inferred by indirect methods. Direct measurement of tree crowns in single-storied stands provides a more reliable comparison of crown occupancy by contrasting tree species. We made detailed measurements of the crowns of upper-canopy trees in three young even-aged northern hardwood stands (ages 19, 24, and 29 yrs) in the Adirondack Mountains of New York State. Two measures of growing space occupancy, crown projection area (CPA) and crown surface area (CSA), were calculated for 30 trees of each of four species that represent a wide range of shade tolerance. On average, over the 10-yr chronosequence, CPA increased by 52% ($P<0.001$) and CSA increased by 61% ($P<0.001$). The average CPA and CSA for less shade-tolerant white ash (*Fraxinus americana* L.) and yellow birch (*Betula alleghaniensis* Britton) was about 30% higher than for more shade-tolerant sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.) ($P<0.001$). Analysis of covariance revealed differences among species for CPA ($P=0.004$) but not CSA ($P=0.17$), after controlling for differences in tree size and local crowding. This finding was related to the fact that sugar maple crowns were significantly narrower, yet also tended to be longer than for the other species. Stem increment was related to occupied growing space (CPA & CSA) and shade tolerance ($P<0.01$ for both measures), noting that the shade-intolerants produced ~40% more basal area growth per unit crown area. During early stand development growth rates commonly associated with shade tolerance characteristics provided the best explanation for differences in growing space occupancy among these species.

LONG-TERM EFFECTS OF HARVEST INTENSITY ON SOIL O HORIZON THICKNESS IN SPRUCE-FIR STANDS IN MAINE

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The spruce – fir forests of northern Maine are characterized by shallow-rooted trees, with most of the available nutrients derived from decomposing organic matter in the O horizon. This horizon acts as a protective barrier that prevents erosion of the mineral soil and minimizes desiccation. These attributes make it imperative that the integrity of the O horizon be maintained, in order to minimize disruptions in nutrient cycling that can impair soil fertility and site productivity. Silvicultural treatments result in disturbances that can alter the forest floor microenvironment and are capable of eliciting changes in soil physical characteristics. We are conducting analyses of O horizon depth to quantify the relationship between harvest intensity and thickness of the organic horizon. O horizon depth measurements were made 30 years after harvest in eight stands representing two replicates each of four treatments: 0%, 30%, 50%, and 80% volume removed. This study will improve our understanding of the long-term impacts of harvesting, and our ability to manage spruce – fir forests more sustainably.

DOCUMENTING THE ECOLOGICAL EFFECTS OF NEW SILVICULTURAL SYSTEMS IN MAINE'S ACADIAN FOREST

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The Forest Ecosystem Research Program (FERP) was initiated in 1993 on the Penobscot Experiment Forest in Bradley, ME. Using current information about natural disturbance regimes in the Acadian Ecoregion, an expanding-gap silvicultural system with permanent reserve trees was developed. Based loosely on the German "Femelschlag" system, the treatment prescriptions include: a) 20% canopy removal on a 10-year cutting cycle (creating 0.2 ha openings) with 10% of the basal area remaining in permanent reserve trees, and b) 10% canopy removal level on a 10-year cutting cycle (creating 0.1 ha openings) with 30% of the basal area remaining in permanent reserve trees. Changes in baseline data, including measurements of overstory trees, tree regeneration, understory vegetation, snags and downed woody material, are being monitored on a periodic basis. The large size of FERP plots has been designed to facilitate interdisciplinary investigations and include projects: 1) establishing the relationship between light intensity and the diversity of herbaceous vegetation in harvest and natural gaps; 2) determining the influence of natural and harvest gaps on forest amphibians; 3) describing the influence of both gaps and DWD distribution on forest insects, specifically parasitic wasps and click beetles; 4) quantifying the nutrient content of DWD; and 5) modeling the effects of harvesting on vertical and horizontal forest structure.

SILVICULTURAL TREATMENT AFFECTS COMPOSITION, GROWTH, AND YIELD IN MIXED NORTHERN CONIFERS IN MAINE

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A long-term experiment on the Penobscot Experimental Forest in Maine, U.S.A. was designed to provide information on the best silvicultural practices for managing stands of mixed northern conifers. We evaluate growth and yield and changes in species composition, quality, and structure during the first 40 years of the experiment. Replicated treatments include the selection system, uniform shelterwood, unregulated harvesting, and diameter-limit cutting. The new cohort established under three-stage shelterwood was subsequently left untreated or precommercially thinned. Between-treatment differences in net volume growth were not statistically significant, though gross volume growth differed significantly for managed v. unmanaged, selection v. shelterwood, and shelterwood v. diameter-limit treatments. The three-stage shelterwood treatment with precommercial thinning 10 years following final overstory removal resulted in good control of hardwoods and hemlock, and a large increase in spruce and fir. The selection system on a 5-year cutting cycle resulted in increased hemlock, spruce, and fir, with a decrease in hardwood species. If the primary goal were production, even-aged management would most likely be preferred. We recommend two-stage shelterwood as applied in this experiment with some modification to improve species composition and stand quality. Stand quality, measured here as the proportion of cull tree volume, and species composition were influenced by treatment.

SMALL FOREST CATCHMENT AND STREAM RESEARCH: FIELD MEASUREMENTS AND MODEL

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The stream and water table hydrology of forest ridges was examined by small catchment monitoring and modeling, pre- and post harvest, at several locations: Northwestern New Brunswick (Gounamitz Lake), Northern New Brunswick (Island lake), and near Sackville Nova Scotia (Pockwock Lake and Five-Mile Lake). Hourly monitoring parameters for the streams in Nova Scotia included with stream discharge, temperature, electrical conductivity, pH and dissolved oxygen. Monitoring parameters for the water table in New Brunswick included water table fluctuations and temperature. Wells were used to monitor water table fluctuations just above catchment specific seepage zones. Post-harvest water tables all increased above control wells, but during the growing season only. Well temperatures also increased post-harvest, by as much as 2 C, depending on well location, and general flow path of groundwater above the wells. Water-table fluctuations were all synchronized across each cluster of wells, and closely followed the pattern of modeled amounts of gravitational water in the soil. Well temperatures were further synchronized with water-table fluctuations, year-round, and actual well temperatures were related to depth of measured and calculated water table: the greater this depth, the lower and the more constant the temperature. Stream temperatures either closely followed the calculated soil temperature pattern within the riparian zone, as determined for the forest floor and the top soil below, or were somewhat cooler and more delayed, in keeping with water that would seep into the stream from further below. Stream electrical conductivity and acidity were strongly synchronized with stream discharge, in a predictable manner.

INFLUENCE OF SILVICULTURAL INTENSITY AND COMPOSITIONAL OBJECTIVES ON THE PRODUCTIVITY OF REGENERATING FOREST STANDS IN MAINE

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Millions of acres of northern Maine's Acadian forest are in a relatively young condition following clearcut harvesting. Although natural hardwood and softwood regeneration can be abundant, the species composition of this regeneration is often not what landowner's desire. Tremendous opportunity exists to improve the composition, quality, and growth rates of these stands while they are in an early successional stage. Many landowners question whether it is better to start over, or to work with what is there and make the best of it?

The intensity of silvicultural treatments and compositional objectives set by forest managers largely determine the long-term outcome of stand development. Silvicultural intensity is determined by the degree of investment in vegetation management, artificial regeneration, and thinning. Compositional objectives determine whether particular species of conifers, hardwoods, or a mixture of conifer and hardwood species are desired in the final stand.

In 2004, we established a long-term study on the Penobscot Experimental Forest near Bradley, Maine that seeks to: (1) quantify the growth and development of early successional stands to varying intensities of silvicultural intervention and compositional objectives, (2) document ecophysiological mechanisms affecting the dynamics and productivity of young forest stands, and (3) compare the energy requirements and financial returns associated with early intervention in young stands.

The study site is an 8-yr-old naturally regenerated stand of aspen and red maple with an understory of balsam fir and red spruce. A 3 x 3 factorial design plus an untreated control (10 treatments) is being used. The treatments include three levels of silvicultural intensity (low, medium, high) and three compositional objectives (conifer, mixedwood, hardwood). Levels of silvicultural intensity are defined by the degree of control over (1) species colonization (tree planting), (2) relative species performance (control of competing vegetation), and (3) spacing among desired trees (thinning). A stratified, random experimental design with 4 replications is being used. Treatment plots are 30 m x 30 m (0.09 ha) in size and include a nested 20 m x 20 m (0.04 ha) measurement plot. Tree species planted in the medium and high intensity treatments include improved white spruce and four clones of hybrid poplar (D51, DN10, DN71, and NM4).

All crop trees (natural and planted) were selected or planted in summer 2004. Initial height, diameter, crown length and radius, and health condition of all trees also were measured. The amount of energy input from human labor, petroleum, and herbicides needed to establish each of the 10 treatments is being measured.

THE COOPERATIVE FORESTRY RESEARCH UNIT: A PARTNERSHIP BETWEEN MAINE'S FOREST MANAGERS AND THE UNIVERSITY OF MAINE SINCE 1975

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Maine's large forestland owners have long recognized the need to support a strong research effort as part of their managing Maine's forests. In 1975, a small group of visionary forest industry leaders and representatives of the University of Maine formed the Cooperative Forestry Research Unit (CFRU). It is now one of the oldest industry / university forest research cooperatives in the United States, and continues to serve as a model of joint leadership and cooperation between Maine's largest industry and the University of Maine.

The CFRU is composed of about 24 private and public forestland management organizations from across the state that guide and support research on key forest management issues facing Maine's forest landowners and managers (www.umaine.edu/cfru/). The mission of the CFRU is to *"conduct applied scientific research that contributes to the sustainable management of Maine's forests for desired products, services, and conditions."* The CFRU has been generously supported for 29 years through the voluntary financial and in-kind contributions of its members.

During that time, the CFRU has researched and solved a number of crucial issues facing Maine's forest managers. In recent years, the CFRU also has become the primary research and development effort supporting third-party forest certification in the state. CFRU research has had two primary objectives: 1) develop information and tools to improve the efficiency and productivity of forest management and 2) provide science-based information about the ecological effects of forestry practices.

Research focusing on the ecological effects of forestry practices has allowed the CFRU to provide scientific information that has been instrumental in helping the forest industry meet the requirements of certification by the Sustainable Forestry Initiative and Forest Stewardship Council. In addition, this research has provided key information for policy makers addressing a number of important forestry issues in Maine and elsewhere. Current CFRU research continues this tradition with a focus on improving silviculture in the Maine forest and improving our understanding about the influence of forest management on wildlife habitat and conservation of biodiversity.

In addition, CFRU-sponsored research on The University of Maine campus has provided scores of undergraduate students, graduate students, and faculty in forestry and wildlife with the opportunity to learn about and help solve some of the most important problems facing forest managers in the state. This investment has provided a wealth of expertise that has been drawn upon by forestry organizations, government agencies, and the public when information and advice was needed about key sustainable forestry issues. The CFRU has had a positive and lasting influence on the forestry culture at The University of Maine by providing a direct link between the university and the people managing Maine's forestland.

ELEMENTARY SILVICULTURE: PRESENTING FOREST SCIENCE TO CHILDREN THROUGH THE NSF'S GK-12 FELLOWSHIP

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The National Science Foundation's GK-12 Fellowship Program provides a link between science education at the graduate and primary/secondary school levels. The program grants 12 fellowships to University of Maine graduate students in a variety of science or math departments. Fellows each work with 3-4 local teachers in grades 3-12 to design and implement demonstrations, laboratory projects, and field trips. Fellows use their areas of expertise to demonstrate the scientific method, the use of specialized equipment, and the fun and excitement of science. This program, and others like it (there are 73 similar programs at other universities in the U.S.), provide an excellent opportunity for forestry education. The future of Maine's forests depends on an informed and scientifically literate public. As an NSF fellow, I will be able to work with schoolchildren to create an awareness of the importance and complexity of forest ecosystems. I plan to accomplish this by focusing on four main themes throughout the school year: diversity, growth, competition and change. I hope that my participation in this program will both facilitate science education and inspire young students to pursue careers in science.

ENERGY BUDGET ABOVE A BALSAM FIR FOREST IN MARITIME NEW BRUNSWICK

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The poster describes (1) the seasonal trends in Bowen Ratios (β), (2) energy closure, and (3) relationships between energy closure and mean meteorological variables (e.g., air temperature, relative humidity) measured from a 20-m meteorological tower installed in a predominantly balsam fir forest in west-central New Brunswick, ~130-km northwest of the City of Fredericton. Blocks of data spanning several days to weeks are taken from the annual period starting from August, 2003 to July, 2004. The energy balance equation used in the analysis, i.e., $R_n = \lambda E + H + G + H_b + H_l$, requires input measurements of net radiation (R_n), latent and sensible heat fluxes (i.e., λE, H), heat conduction through the soil (G), and heat storage in the boles of the trees (H_b) and leaves (H_l). Results from this research shows that the Bowen Ratio (defined as $\beta = H/\lambda E$) during daytime in September 2003 varied from 0.3 to 4.5. Among the various energy components, λE averaged to 48.95 W m^{-2} (or J s^{-1} m^{-2}), with values ranging from -50 to 280 W m^{-2}. Sensible heat flux (H) averaged to about 27.48 W m^{-2}, with values ranging from -35 to 250 W m^{-2}. The soil heat flux (G) averaged to 8.3 W m^{-2}. The storage terms together including that for the boles, leaves, and trunk space air contributed nominally to the overall energy budget of the stand (~3.8 W m^{-2}; or about 0.8% of R_n at its maximum mid-day value). The energy closure was within 77% for September 2003, of which λE contributed to 67% of this level and H, 31%. Energy closure increased from 30% at sunrise to 95%, mid-day.

MODELING CARBON DYNAMICS AS RELATED TO NUTRIENT CYCLING AND FOREST MANAGEMENT

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As the climate is expected to get warmer, one can reasonably expect that soils become drier, and – as a result - forest productivity and nutrient cycling rates should decrease, while soil organic matter decomposition rates should continue to increase. However, changes of nutrient cycling and organic matter decomposition rate will likely depend on site-specific matters as affected by forest type and by local soil conditions. A forest nutrient cycling and biomass model (ForNBM) was developed to simulate these changes, for the purpose of assessing the overall sustainability of forest C sequestration and nutrient availability, as these would change in the context of local climate change and weather conditions, at the forest stand scale.

With ForNBM, we simulate the processes of carbon assimilation and nutrient (N, S, Ca, Mg, K) cycling dynamics as affected by forest harvesting, thinning and forest disturbances. The simulations are further used as input to project change in forest mensurational conditions over time, as expressed in terms of dominant tree height, basal area, and stem density.

This model has a hydrology module, a nutrient cycling module, a C cycling (biomass growth) module, and a mensurational stand dynamics module.

The hydrology module is used to simulate all major heat and water retention and flows within the forest stand, year-round, according to local weather records for air temperature and precipitation, and by specifying forest cover type, leaf area, vegetative conditions on the ground, depth of forest floor and rooting zone, and soil texture. As such, the model simulates snowpack depth, snowmelt, rate of water infiltration and percolation through the soils.

The C cycling module simulates: net photosynthesis production, allocation of the same to foliage, wood, and roots, litter production from foliage, wood, and roots, litter accumulation and decomposition on and in the mineral soil.

The Nutrient cycling sub-model simulates nutrient availabilities, nutrient uptake and nutrient requirements, soil acidification, and soil mineral weathering based on atmosphere deposition, and biomass –related nutrient requirements of the growing forest stand.

The growth and yield module relates forest biomass growth to dominant tree-height growth, basal area and stem density. The linkage is based on predicting changes in the site as affected by systematic changes in soil moisture, soil temperature and nutrient availability.