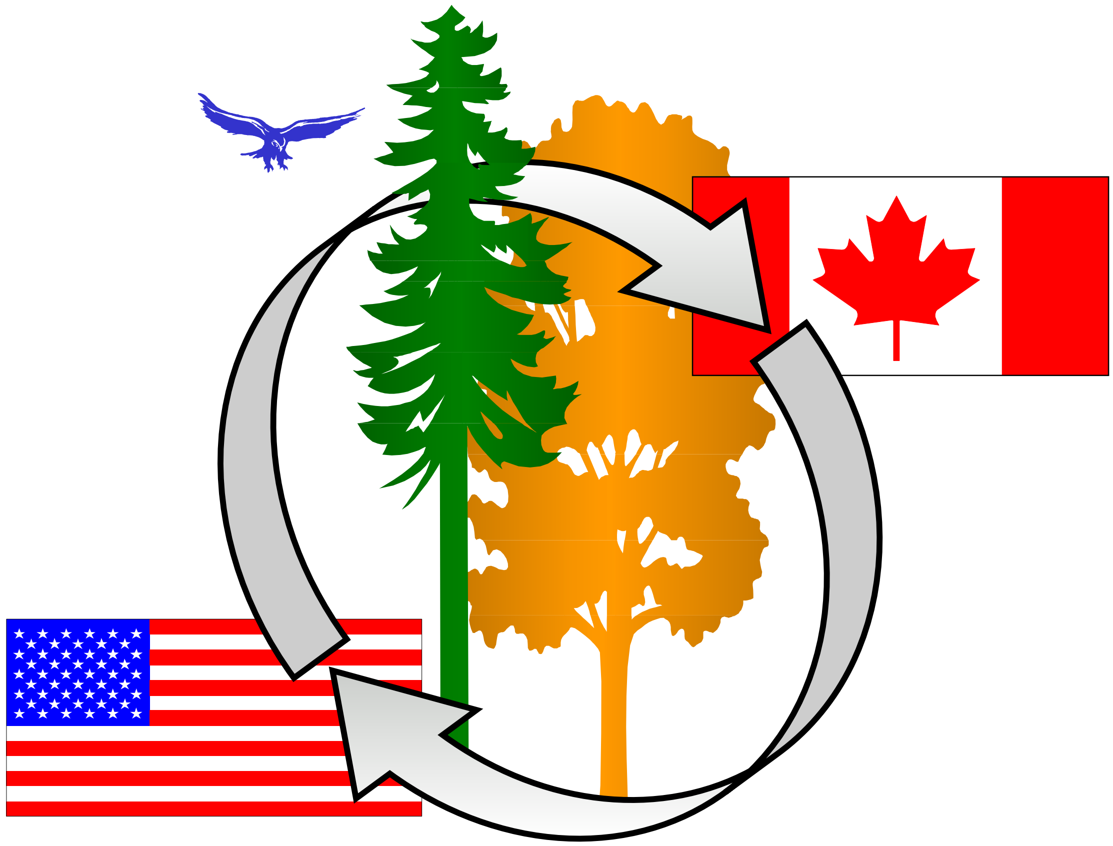

Eastern CANUSA Forest Science Conference

October 19 – 20, 2002
University of Maine
Orono, Maine

Conference Proceedings

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Compiler:

Robert G. Wagner

Hosted by:

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

And

University of New Brunswick
Faculty of Forestry and Environmental Management

INTRODUCTION

Welcome to the first 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.

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

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THE ACADIAN FOREST: A BORDERLANDS LEGACY

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The Acadian forest covers an immense territory running from western New York and southern New England to the eastern shores of Quebec and the Maritime Provinces. The region can best be understood as a borderlands construct, in which the ecological, economic, and cultural commonalities outweigh differences across the international boundary. These commonalities are more apparent in some areas than in others. Ownership patterns in the Acadian forest, for instance, are amazingly diverse, ranging from Crown lands in the Maritimes to private, million-acre woodlands in Maine, with woodlots, national forests, trust lands, conservation easements, and wilderness preserves in between. Still, in other ways the forest shares important characteristics across these several states and provinces. First, the Acadian forest is dynamic. In prehistoric times, it responded to wide swings in climate and other natural conditions, and more recently it has been shaped and reshaped by cultural and economic transformations like changing wood markets, agricultural decline, and a growing appreciation for the spiritual and recreational significance of wilderness landscapes. Second, the Acadian forest is proximate to some of the most urbanized sections of North America, and this has great economic and political significance. Third, this forest has a history of global connections, despite to its regionalistic and localistic political culture. The Acadian forest has always played an important role in our global economy, and today we are becoming aware of the important role it plays in our global ecology. But in a region characterized by cultural insularity, particularly in New England and the Maritimes, we wear this global burden uneasily. Finally, the Acadian forest has been an index of our quality of life and a cultural icon at least since the beginnings of the Romantic era and the advent of tourism in the mid-nineteenth century. For this reason, it is a natural feature with immense cultural significance for those who live in or near it.

The economic history of the Acadian forest supports this borderlands construct. From its heyday as a logging district to the rise of the pulp and paper industry, the Acadian forest has shared common characteristics. These include strong competitive advantages in lumber production based on adaptations to climate and topography, remarkably static technologies, vigorous markets easily accessible by sea, and low requirements for infrastructure investments. But at the same time, work in the Acadian forest was subject to high risks, both for capital and human life, due to its labor intensity, to its dependency on propitious weather conditions, to the sharp cyclical production swings characteristic of wood-products production, and to the industry's long-term economic inflexibility.

The Acadian forest began losing its competitive advantage as a logging district in the 1870s, when lumber producers moved westward and southward across North America. After 1907 per-capita lumber use remained static all across the continent, and production in the Acadian forest went into an absolute decline, reviving only after the Great Depression. Because this was part of a broader downward trend in the rural economy of the East, producers and government agencies had few options for reversing trends in the logging industry. But into this vacuum stepped the pulp and paper industry, first in New England and New York in the 1880s, and then in the

Maritime Provinces after the turn of the century. While this industry brought capital and value-added production to the Acadian forest, it also brought some of the same structural weakness that had become apparent during the waning years of the dimension lumber industry.

Today, pulp and paper producers face problems similar to those lumber producers faced in the first decades of the twentieth century. There are several options before those who live in the region, including experiments with new wood uses, new forms of tourism and eco-tourism, and proposals for wider wilderness management in the Acadian forest. Each of these poses a unique challenge that sets the Acadian forest apart from forests to the west or south, and together they unify the borderlands region, as we continue to define issues in international terms, share ideas across the border, and express concerns that transcend national identities.

ECONOMIC AND CULTURAL IMPORTANCE OF THE FORESTS TO THE PEOPLE OF THE REGION

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Introduction

We all share a feeling that the forest is important, or we wouldn't be here. We feel that way for various reasons, some of them in conflict with one another. Many communities feel this way: on the road into Berlin, New Hampshire the sign says, "The city that trees built". At the main city park in Bangor, a tall statue of Paul Bunyan greets the visitor. I've been asked to comment on the forest's economic and cultural importance, and am groping for some things to say that haven't been said before. Of course this is not so easy. I will open with brief remarks on seven key forest values, note some differences within the region, and then review some key challenges.

Seven Forest Values

A useful approach is to build a story around the seven forest values (Table 1). The forest is clearly a key element in the *culture and sense of place* of this region. The fact that the forest dominates the landscape is obvious but not the real point here. It dominates lifestyles, perceptions about the world, the community's interactions with people who visit and those from elsewhere who care about these forests. A key culture/sense of place variable is Native rights… now bubbling briskly in several local areas.

Table 1. Forest Values
Culture; sense of place
Biodiversity
Habitat
Source of raw material
Economic sector & community
Real estate
Recreational resource

The importance of the forests as *habitat* for wildlife and fish and a *biodiversity* resources is incontestable. What is at issue, rather, is what this means for ownership and management.

As a source of raw material, an *economic sector and community base*, the forest shares with the entire resource sector a decidedly mixed record. Most obviously, across the entire region, agriculture, fisheries, and forests have been cyclically unstable and have supplied a shrinking level of employment for several generations, depending on sector and place. In some towns, paper mills actually increased employment until the late 1960's or 1970's, and with few exceptions, job levels have since fallen due to rapid mechanization. This is superficially called "decline" (often by those with a special interest in using that term), but in more instances than not, falling job counts have been accompanied by rising production. In most instances, remaining jobs are better paid and safer than ever before. In the case of the paper business, they far outrank all but a few of the alternative blue-collar opportunities for pay, fringes, and stability.

The paper industry has generated a number of critical, though little noticed, social contributions (Irland n.d.). First, it has created a reservoir of important skills useful to other industries. A "downsized" paperworker has far more opportunities in life than a laid off shoe shop worker. The prosperity has enabled many people in remote communities to enjoy a middle class lifestyle, to send generations of young people to college, and to see a bit of the world. Some of these workers have become leaders – at this writing a Maine paperworker, after serving as a legislative leader, is running for a seat in the US Congress. Surely these patterns are similar across the entire region.

Important cross border family, business, and social connections predate the expansion of the lumber business and the paper industry in this region, but these have been sustained and amplified greatly by the day to day contacts involved in cross border business. Every day, thousands of visits, family events, phone calls, and business deals -- in both directions -- testify to an ongoing cultural unity, bilingual in many places, that distinguishes this region.

These forest values are the same across the region, the mix varies, and the degree of public concern about each individual value varies.

Clearly the forest is important as *real estate* across the region, even thought private ownership is limited in the more northerly areas. The forest as a *recreational resource* has two dimensions. First, it is a recreational backyard for local residents, whose patterns of use are well established and important to them. The forest and its waters are also a recreational resource for visitors "from away", who often have different favorite ways of using the forest. When these groups collide, as they often do, politicians face endless contention and bitterness over how to manage the conflicts.

Interest groups and journalists sometimes depict conflicts between these values as good versus evil – but mostly they are competing goods. In my opinion, it is not true to say that any one of these forest values is the most important, that all others must wither in its shade. Rather, all of them are important, if only to different groups. All of them will be increasingly important to society in the future.

How Does the Forest Vary Within Region?

Ownership

The obvious difference within the region is the varying role of public ownership (Table 2). This is almost a cliché. Yet its significance can be overrated, given the institutional history and philosophies of management on these lands.

Table 2. Regional Forest Ownership and Economy

State/Province	Population MM	Total Land Acres	Total Forest Acres	Govt. Owned Percent	Output $MM $US	Employment
Quebec	7.4	380.6	207.2	89	14.21	109,300
New Brunswick	0.7	18.0	15.1	49	2.94	18,300
Nova Scotia	0.9	13.1	9.6	31	1.26	11,900
New York	18.2	30.2	18.6	22	7.8	65,800
Vermont	0.6	5.9	4.6	16	0.9	7,300
New Hampshire	1.2	5.7	5	22	1.3	9,600
Maine	1.2	19.8	17.7	6	5	27,600
Total	30.2	473.3	277.8	N/A	33.41	249,800

Sources: Canada: State of Canada's Forests, 2001-2002.

US: USDA FS, Gen Tech REpt NC-219

US population: 1998, Statistical Abstract of the United States.

$C converted to US at 70 cents.

Multinational private ownership is common across this region, and an array of new ownership institutions is emerging. A situation that once exemplified stability is now changing rapidly and in ways few of us fully understand. The last decade has seen more change in this respect, on the US side, than the previous century did. As to freehold timberland, Canada has not been immune to change. It is worth wondering for a moment whether some of the other changes now being seen in New England (easements for example), will spread northward.

A key trend is the changing meaning of ownership – new and complicated forms are emerging. I was recently asked to predict (guess?) the future of the public/private ownership split in Maine. On thinking about it a moment, I realized that this is almost a meaningless question – I had never looked at it quite that way before.

Forest industry
A statistical description of the industry's variations around the region would be vast and of little interest to this audience. Basically, the industry is based on large scale commodity production to the North, and moving south, this shifts away from commodities toward specialties. The degree of vertical integration within the industry also decreases from north to South. Interestingly, a large proportion of the region's value added industry is concentrated in metropolitan areas where the firms can be close to their customers. For this reason, those firms are as likely to use wood from elsewhere as from the Northwoods. Being close to ports gives some firms an advantage in being able to use low-cost imports, while it poses significant competitive threats to the high volume commodity producers for the same reason.

This region is one of the culture hearths of the lumber and paper industries in North America. As a result, it wrestles daily with problems reflecting its mature condition and legacy of mills located according to the economic and locational forces of a bygone time. Changing technologies, new market demands, new sources of international competition, and competing raw materials are driving an unprecedented degree of competitive pressure on the mills, landowners, and loggers of this region. The financial stress on all parties is palpable, and there is no quick solution. Market participants at all levels are price-takers on an international or continental market. Even the largest corporate behemoths in this industry cannot dictate prices to their customers. Look at the bifold closet doors in any Big Box home center. They are probably made with wood from Chile. A recent news item says that 60% of the product shown at last spring's High Point furniture show was imported. Experts expect that share to rise.

All of this is occurring against a backdrop of North American and Global industry restructuring that includes a number of ominous signs. Conflicts over log and lumber trade have resulted in an unprecedentedly high US tariff on Canadian softwood lumber. There is little hope for security of the policy environment in this critical market as this essay is being written. This situation was not sought by anyone, and may result from a combination of miscalculations and stubbornness in the wrong places at the wrong times. A failure to resolve this on terms satisfactory to Canada spells doom for many sawmills and their communities on the northern fringes of the eastern Canadian forest. This is the specific intent of the industry group pushing the tariffs…though they would phrase the matter somewhat more delicately.

United States papermaking capacity fell last year for the first time on record; it is said that there is not one new greenfield virgin pulp mill on the drawing boards anyplace in the US today. This probably applies equally to eastern Canada. The North American industry is beset by many difficult challenges, not least of which is the current exchange rate situation. Industry re-structuring is one force behind a major re-structuring of private forest ownership in the entire United States. New kinds of forest owners, dividing of former empires into large chunks of investor-owned lands, selloff of development rights through conservation easements, all of these are disquieting in a region accustomed in the past to a remarkable stability in the players and in landowning patterns. A new future is being created before our very eyes -- the dealmakers doing all of this don't fully understand all the long-term implications. Nor do I.

Economies

Resource dependence and its modalities are clearly changing. People dancing on the graves of paper mills are missing some important things, as I suggest above. Yet change will occur. There are no iron rice bowls anymore. The future for timber dependent communities is uncertain. It has not yet been demonstrated that tourism, value, or a rising, footloose service economy can fully replace what is being lost.

Social demands on the forest

Social demands are not that different across this region, though their political expression, and the mix of values undoubtedly does. Residents of this region consume wood products of all kinds at a high rate. Measured in tons, the Eastern Canadian provinces are undoubtedly net exporters, while New England and New York are net importers on a large scale. Still, many products not available in this region (tropical hardwoods, softwood plywood) are imported.

Demands for biodiversity protection and all of the nontimber forest values emerge from our sprawling suburbs every day. More ominously, many of these demands are seeking not merely accommodation, but exclusive primacy. Political polarization escalates.

What Are the Key Challenges?

The list of challenges is long. It is hard to condense it: the key fact IS that the list is long, and the stakeholders numerous. Many of the stakeholders perceive no incentives to compromise with others. For some, "the perfect is the enemy of the good": they chronically oppose improvements that do not go far enough. With such a long list, and such uncompromising political actors, the biggest challenge I see is *maintaining a roughly stable policy environment* for long-term forest ownership, forest management, and forest industry investment. Without such an environment, the future for many forest-based communities is dim.

Many of the issues involve competing demands by fairly large groups of people: such conflicts over recreational uses, ranging from Allagash access to cross country ski trails to controlling spread of invasive aquatics and exotic forest insects and whether to re-introduce the grey wolf. Other issues include how best to retain a semblance of wildness in "the wildlands," how new management priorities should be applied in Crown and Public lands, whether Maine should have a large National Park, how to ensure long-term timber sustained yield in a market economy, and whether current and likely intensive management practices are likely to compromise significant elements of the region's heritage of biodiversity. In significant parts of this bioregion, unresolved Native rights remain a significant source of uncertainty and social tension.

A day may come when another spruce budworm outbreak will unleash its fury across this region. When it does, it will be in a forest much changed from that of the 1970's and 80's. Governments and land managers will face it with a different array of tools. It is far from certain that that array will include chemical pesticides.

So the key challenge, dominating them all, will be finding ways to manage political conflict and retain a more or less stable policy environment. The region does not get a very good report card on this at present. Not all interests share this objective, and it is not something that is ever achieved. Yet it must remain an aspiration. Stability cannot mean rigidity and attempts to freeze an idealized past. Yet changes must proceed in an orderly manner, with due respect for legitimate property rights. As this proceeds, all of the forest values noted here will be more important.

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TIMBERLAND INVESTMENT IN THE NORTHEASTERN U.S. AND EASTERN CANADA: HOW DOES THE NORTHERN FOREST STACK UP RELATIVE TO OTHER TIMBER-PRODUCING REGIONS?

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Introduction

Timberland ownership by financial investors has grown rapidly during the past decade in the United States and, to a lesser degree, Canada. More than $10 billion of timberland properties in North America are now held directly by pension plans, endowments, and other institutions. Another $10 billion of timberland is held by publicly traded timber-focused companies such as Plum Creek and TimberWest.

A share of this investment capital has flowed to timberlands in the northern forest region. Several of the major timberland investment advisory firms--including Hancock Timber Resource Group, Wagner Forest Management, and GMO Renewable Resources--have made acquisitions in the northern New England states. Plum Creek became a major owner of timberland in Maine when it acquired the former Scott Paper lands from Sappi.

Despite these recent investments, many financial investors view timberlands in the northern forest with disfavor relative to timberlands in other major timber-producing regions of the world. The poor standing of northern forests among financial investors is often based on misperceptions rather than reality. A discussion of these misperceptions provides a useful framework for understanding the current and future role of the region’s timberlands in the global timber economy.

Financial Investor Misperceptions of the Northern Forest

Three common misperceptions hinder the flow of capital from financial investors to timberlands in the northern forest.

- Slow timber growth translates directly into relatively low rates of return for timberland ownership,
- The forest products industry is exiting the region, thus weakening markets for timber and timberland, and
- Risks for timber production from environmental regulation in the region are relatively high.

Let’s take a closer look at each in turn.

Slow Timber Growth Depresses Timberland Returns in the Northern Forest

Timber in the northern forest does indeed grow more slowly than plantations of southern pine in the U.S. South, Douglas-fir in coastal British Columbia and the U.S. Pacific Northwest, radiata pine in New Zealand and Australia, and eucalyptus in Brazil. However, this relatively slow pace of timber growth does not dictate that northern forests are expected to produce low rates of return.

Most participants in timberland markets are pretty smart. They recognize that some properties are capable of producing more timber than other properties, and price those differences into timberland values. Variation among properties in expected return levels is a function of differences in investment risks rather than productivity. Investment risks depend on factors such as the depth and diversity of timber markets, the predictability of timber harvest volumes, and the liquidity of timberland properties. If expected returns from fast-growing plantations are relatively high, it is because participants in timberland markets perceive those investments to be relatively risky.

In fact, properties with relatively low rates of timber productivity can be priced to generate relatively high returns. In the northern forest region, the common benchmark for comparing timberland values across space and time is the transaction price expressed as a percentage of the immediate harvest value of the standing timber inventory on the property. Timberlands typically trade in a range of 50 to 75 percent of immediate harvest value. A timberland property that transacts for 50 percent of immediate harvest value will have a relative high expected return. That same property, however, will have a relatively low expected return if it transacts at 75 percent of standing timber value.

In short, expected returns depend on how timberland properties are priced, not on how fast the trees grow.

Interestingly, over the past five years, timberlands in northern New England and northern New York have generated higher annual rates of return (13 percent) than timberland properties in either the U.S. South (8 percent) or the U.S. Pacific Northwest (4 percent).

It deserves mention, however, that the relatively low intensity of forest management in the northeastern U.S. and eastern Canada--a consequence in part of the relatively slow growth of the region's timber--limits the capacity of financial investors to deploy capital to take advantage of advances in tree-growing technology. This truly does disadvantage timberlands in the northern forest relative to other regions.

The Forest Products Industry is Retreating from the Northern Forest

To be sure, there has been a substantial shift of timberland ownership in Maine from traditional forest products industry owners to financial investors and conservation interests. However, this phenomenon is not unique to the northern forest. Industrial ownership of timberland has also declined in the U.S. South and U.S. West.

Table 1. Net movement of timberland acres in the United States by ownership category, 1999-2001

	Financial Investors	Forest Products Industry	Conservation Interests	Other
Northeast	+1,560,025	-1,486,060	+447,397	0
South	+3,873,154	-3,927,253	+255,2240	-732,301
Pacific Northwest	+620,000	-309,000	0	0

There have also been several high-profile closures of pulp and paper manufacturing facilities in the region. Again, this is not unique to the northern forest. Older, high-cost plants have been closed in other regions as well. Resource Information Systems, Inc. (RISI) estimates that pulp capacity fell between 2000 2002 by 4 percent in the U.S. Northeast, 3 percent in the U.S. South, and 2 percent in the U.S. West.

Importantly, RISI projects that pulp capacity in the U.S. Northeast will increase over the next 15 years, albeit slowly at about 0.5 percent per year. Similar slow rates of capacity expansion are projected for other North American regions.

The bulk of net revenues--more than three-quarters--from a typical timberland property in the northeastern U.S. and eastern Canada derives from sawtimber rather than pulpwood sales. Lumber manufacturing is far less capital intensive than pulp and paper production, and the sawmilling industry is relatively fragmented. The region's lumber producing capacity is therefore likely to closely track regional sawlog supply and production.

The northern forest is currently experiencing the same shifts in timberland ownership and the same stressful economic conditions in wood products manufacturing as other timber-producing regions. Over time, however, there will continue to be more than sufficient demand for the region's timber production.

Environmental Risks to Timber Production are Relatively High in the Northern Forest

Financial investors are keenly aware of recent ballot initiatives in Maine to ban clearcutting and restrict rates of timber harvest. They also hear calls from environmental interests for the creation of a massive Great North Woods National Park and the cessation of timber production within it. This leads many such investors to conclude that environmental risks--the chance that additional forest practice rules will add substantial costs to timber production, or, in the extreme case, that timber production will be banned--are relatively high in the region.

Again, this is largely a misperception. Environmental risks in the north woods are reduced greatly by the natural regeneration and selective harvesting that is commonly practiced in the region.

Furthermore, the relatively low per-acre price of northern forest timberland creates opportunities for environmental interests to exert control over the management of large areas through the purchase of easements, or in some cases, full fee ownership. This allows timberland owners to monetize more of the environmental values on their properties than they can in other regions.

THE CHANGING ROLE OF PROTECTED AREAS IN FOREST MANAGEMENT

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Introduction

The dominant theme of land management over the last 30 years has been the emergence of something called ecosystem management (Grumbine, 1994). This concept has been applied to lands of all types, and certainly forests. Modern forestry is struggling to come to grips with this concept and understand what it implies for Northern American forests. For the century prior to the rise of ecosystem management, single purpose forestry was the dominant way of seeing the landscape. That view of a forested landscape probably reached its apex when large tracts of public lands were turned over to private forest companies with the main goal being the production of fiber to maximize economic value.

Part of the solution set conceived for an ecosystem approach to forest management is to have a representative network of protected areas as part of each forest landscape. From a reverse perspective, protected area managers see compatible forest management as the solution to their approach to ecosystem management. Despite this seeming agreement of mutual need for each other, forestry and protected area professional still have an uneasy alliance. There are misunderstandings on both sides and certainly some degree of mistrust.

From a protected area perspective, ecosystem management was discussed as early as 1932, with the Ecological Society of America's Committee for the Study of Plant and Animal Communities. Committee members recognized that a comprehensive system of sanctuaries in the United States must protect ecosystems as well as particular species, represent a wide range of ecosystem types, manage for ecological fluctuations (i.e., natural disturbances), and employ a core reserve and buffer approach. The committee also discussed the need for inter-agency cooperation and public education to make the approach successful. These components remain as foundations for the more recent approaches toward ecosystem management. More recently, Agee and Johnson (1988) and Woodley et al. (1993) published edited books on ecosystem management in protected areas. The modern approach to ecosystem management was pioneered in Yellowstone National Park and the Greater Yellowstone Ecosystem has been the subject of much literature and debate (Keiter and Boyce, 1991).

So the thinking on the role of protected areas was established early and the Ecological Society's committee's report remains relevant today. This paper examines trends in North American protected area and their connection with an ecosystem approach to forestry.

The Role of Protected Areas

Protected areas are generally described as having a range of values, including aesthetic, recreational, economic, scientific and ecological. This paper does dot deal with the aesthetic value of protected areas, except to point out the majority of citizens in North America visit protected areas. Protected areas are where the majority of our increasingly urban dwelling populations connect to wild nature. The economic value of protected areas is very difficult to calculate. However, even using traditional economics, the value of protected areas as tourism sites often exceeds the value of forests on a hectare per year basis. In Canada and the United States, national parks are one of the chief reasons that international visitors come to the country and a key source of revenue. Using non-traditional economics, the value of conserving protected areas for their ecological services is very high. Robert Constanza calculated the value of ecological services from "wild nature" was calculated as providing 100 to 1 annual return on investment.

Closer to the realm of forest management, protected areas are often touted as reserves of biodiversity. The United Nations Convention on Biological Diversity points to international agreement on this position in article 8 of the convention titled *In-situ* Conservation:

Each Contracting Party shall, as far as possible and as appropriate:

(a) Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;

(b) Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity;

It is perhaps now obvious that efforts to conserve the earth's biodiversity are fundamental to us all. Over 6 billion humans have transformed somewhere between 39-50% of the Earth's land surface to agriculture and urban development. We have increased atmospheric CO2 concentration by 30% in the last century and we use more than half of the accessible surface fresh water. Over 50% of terrestrial nitrogen fixation is caused by human activity (use of nitrogen fertilizer, planting of nitrogen-fixing crops, release of reactive nitrogen from fossil fuels into the atmosphere). On many islands and even parts of North America, more than half of plant species have been introduced by man. Approximately 20% of bird species have become extinct in the past 200 years, almost all of them because of human activity. Protected areas are viewed as a way of trying to manage against the forces causes dramatic ecosystem change and biodiversity loss.

Current Trends in Protected Areas in North America

There are a number of trends in protected areas systems that are directly relevant to forest management:

A Growing System

As conservation measures, protected areas have been growing in importance for over a century. But in the past three decades, North America's protected areas have undergone many changes, highlighted by rapid and continued growth. In 1970 there were about 800 North American protected areas that could be classified by the International Conservation Union (IUCN) in their class I-IV system. By 1980, protected area numbers grew to 1,300, and currently are above 2,800 units. The total area of protected areas has increased to some 300 million hectares, covering about 15 percent of the continent's land area (IUCN 1998). In the last three decades, Canada's protected area has tripled. In 1980 alone, the US parks system doubled in size with the enactment of the Alaska National Interest Lands Act (McCloskey 1995). About half of the protected area in Canada takes the form of national and provincial parks. In contrast, most of Mexico's protected areas (72 percent of the total area) are designated as biosphere reserves, all of which have permanent residents and considerable levels of resource extraction. In the United States, nationally protected areas are divided among national wilderness preserves, national wildlife refuges, national parks, and biosphere reserves.

Protected area figures are often misleading as they tend to be inflated. The World Conservation Union's most inclusive categories 5 and 6 have led to a major increase in reported protected area. These categories include biosphere reserves, wildlife management areas, and landscape management systems where there are high levels of both recreational and commercial extraction. Totally protected areas (World Conservation Union categories I–III) are those in which extractive activities are prohibited. These areas account for only 5.7 percent of North America's landmass. Thus despite major increases in the number of protected areas, they have had relatively little impact on the area allocated for forestry. This is due to their relatively small footprint (5.7%) and their tendency to be located in areas not useful for forestry (see below).

Paper Parks

Despite the apparent growth in numbers of protected areas, mere designation does not always mean the areas are protected. The phenomenon of "paper parks" is worldwide, and occurs even in North America. The term "paper parks" refers to areas that are designated as protected but there is no meaningful management in place to ensure their protection. Even in North America, there is enormous variety in the levels of protection afforded to areas designated as protected. Even in many of the IUCN Class I-III protected areas in North America, where designation has occurred, there is no infrastructure or staff to manage the parks. In these parks there is little or no control over tourism, hunting and trapping is unregulated and process like fire are suppressed rather than managed as an ecological process. It is questionable whether such areas meet the full role of being protected areas.

The phenomenon of paper parks has implications for forestry. If protected areas are part of an ecosystem-based approach to the management of protected areas, then is appears obvious that these areas must be well managed and there must be some monitoring system in place to record ecosystem condition.

Protecting rock and ice

The central tenant behind most protected area systems is that they protect representative examples of the full range of ecosystem types. This can be done at a range of ecological scales, with the most commonly selected being ecozones to ecoregions. In reality, the vast majority of protected areas are located in lands that were of little value for other purposes, including forestry. In Canada, for example, there are no class 1 agricultural lands found in protected areas. Canada's first and most famous national park, Banff is 50% rock and ice. This pattern also holds for the United States. In Idaho, a gap analysis showed that only 0.1 % of best agricultural lands were in protected areas. Biodiversity follows productivity. The most productive lands have the highest levels of species richness. In Canada, it is estimated that over 70% of all threatened or endangered terrestrial species reside in the 1% of potentially arable land that has not been converted to agriculture. If protected areas were designed to conserve biodiversity, basic ecological theory would predict that they must represent the full range of ecosystems, including those with high productivity. If protected areas are to compliment forestry by being reserves of biodiversity and ecological benchmarks, they must be represent the range of productivity classes and ecological types found on the landscape.

Increasing Use – Especially the Backcountry

There is a lack of precise information regarding the use of protected areas, because methods have constantly changed or been interrupted (Eagles *et al*., 2000). Despite the lack of rigor in much of the visitor use information, the majority of indicators point to growing use of protected areas and many such areas at capacity use. While many parks had overall use levels flatten in the 1990's, there are still increases in backcountry use.

The U.S. Fish and Wildlife Service (USFWS, 2001) reported that more than 34 million Americans fished, 13 million hunted and 66 million observed wildlife last year. These recreationists spent more than $108 billion pursuing their activities, for 1.1 percent of the gross domestic product in 2001. In Canada, the most popular adventure travel operators in 1993, were those providing trail riding, canoeing, nature observation, snow-mobiling and whale watching, respectively (Tourism Canada, 1995). On the east coast, 45 % residents of the Atlantic provinces visit a national park in a given year.

While the U.S. population increased by 18.7% between 1987 and 1994, recreation visits to the National Park System (NPS) increased by 30% (American Recreation Coalition, 1996). This overall trend flattened from 1986 to 1996, when the NPS has reported an overall decline in visitor-days (Cordell and Super, 2000). With only one true National Park in the northeastern region (Acadia National Park) recreation visitor-days per acre have substantially increased (Cordell *et al*., 1999b) over the entire period.

The greatest increase is in protected area use was all focused on the backcountry, including canoeing. (Cordell and Super, 2000), backcountry overnight use and backcountry day use Roggenbuck and colleagues (1994). In many protected areas backcountry areas are at capacity resulting in increased pressure on public lands managed for forestry. This is especially relevant in the National Forests of the United States where recreational use has often become more important than forest harvest.

More Active Management

A final trend in protected area management relevant to forestry is that protected areas are being actively managed. The history of protected area management has been dominated by the notion that these areas should be managed with little or no human influence. While this remains true, it is increasingly apparent that there is often a need to intervene to maintain ecological integrity. The need for active management stems from such causes as large numbers of visitors, control of invasive species, ecosystem restoration of historical land uses and management of fire. Restoring wildfire is a particular challenge, but it is being done successfully in many areas. In order to restore fire, Banff and Prince Albert National Parks have used selection forestry techniques to create thinned stands that act as fire breaks around townsites or on park borders. Gwaii Hannas National Park has been successful in eradicating non-native populations of rats and raccoons from some islands. Wardens at Pt. Pelee National Park, because predators are absent, regularly cull its population of white-tailed deer to ensure that levels of herbivory do not impact plant species richness. Increasingly protected area managers and foresters are faced with similar types of problems and use similar tools.

What Can Protected Areas Do For Forestry?

Protected areas can compliment forest management in many ways. Within the broader landscape, protected areas are focal points for outdoor recreation, thus easing any conflict between forestry and recreation. If well designed, protected areas can act as reserves of biodiversity, allowing repopulation of surrounding areas.

A frequently overlooked role for protected is as benchmarks for understanding forest management. All management decisions, including those of forestry, are a choice between desired future conditions. Adaptive management is a process of using management plans in the same sense as scientific hypothesis. In both cases, future predictions are made and tested. The main job of foresters is to use science to make predictions on the outcomes of management interventions. For example, foresters predict that if they do a 2-pass selection harvest in red spruce stands, the advance regeneration will result in another red spruce stand of equal genetic heterozygosity. That is a prediction only. Testing that prediction requires an experimental design with a treatment and a control. In order to have a proper experiment in forest management, a control treatment (benchmark) is essential. For many issues in forest management, large tracts of unharvested land (protected areas) are essential to understand the effect of management actions. This is basic experimental design. Examples of hypothesis that need protected areas for testing are 1) Breeding Bird Diversity is limited by forest harvest or 2) Harvesting can emulate natural disturbance regimes. Testing either hypothesis requires large representative areas where forestry does not occur.

A forth value of protected areas for forestry is the spin off value ecosystem management experiments in protected areas. For example, lets examine the benefits from fire management. Protected area managers have taken the lead in fire management techniques that are not based on full suppression. These include the use of prescribed fire, development of forested fire breaks using stand thinning and landscape based fire control methods. Such fire management strategies have applicability on forested lands and are being adopted by foresters. Forest management and protected area have much in common. They both deal with stand type and age distributions across the landscape. The use of techniques to manage fire on the landscape is one example where management solutions can be transferred.

What Can Forestry Do For Protected Areas?

There are certainly many problems if protected areas are expected to conserve biodiversity, allow recreation activities and be benchmark research areas. The foremost problem is that most protected areas were never designed with these goals in mind or, if they were, new ecological understandings have sometimes invalidated the design. In most cases protected areas are too small to protect viable populations of all species (especially large-range demanding species) and account for the range of ecological dynamics (including regional scale insect epidemics and large fire regimes). It is well established that small, isolated parks lose species, based on the principles of island biogeography (Newmark, 1985).

The minimum size of core representative areas is difficult to establish. Minimum reserve size is a function of isolation, disturbance type, latitude and species present. Noss and Coperider have suggested that, for the continental USA isolated core areas less that 400,000 ha will require active management in perpetuity. Similarly Nudds has suggested that the minimum reserve area for southern Canada be 500,000 ha. The confidence intervals on these estimates are very large. Whatever the exact size of theoretical core representative areas, the large majority of existing protected areas are too small to accommodate all species and processes. This does not mean they are of no value. Rather it implies that protected areas need to have the most compatible adjacent land uses in order to be effective. For forested protected areas, clearly the most compatible land use is ecosystem-based forestry. It can be argued that forest protected areas are best surrounded by lands managed for long term forestry.

Conclusions

There are many answered questions about managing complex ecosystems. These answered questions apply equally to the management practices of forestry and protected areas. Increasingly there is a common understanding that, on a landscape basis, forestry and protected areas are excellent partners. They can be complimentary in the goals of conserving biodiversity on the landscape, allowing for large-scale ecological processes to occur and allowing the public to recreate and connect to the natural world. Thus it follows that protected area professionals should advocate for lands to be set aside for long-term sustainable forestry. Conversely forestry professionals should advocate for networked systems of large, representative protected areas that are well managed as core reserves and ecological benchmarks. Like it or not forestry and protected areas need each other.

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EVOLVING FOREST PRACTICES IN THE NORTHEASTERN US AND CANADA: THE TEST OF SOCIAL ACCEPTABILITY

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Introduction

The new orientations taken by forest policies in both Canada and the United-States during the past decade, especially the place given to the philosophy of ecosystem management, are producing a new generation of forest practices. Ecosystem management has been defined as an ecological approach to natural resource management to assure productive, healthy ecosystems by blending social, economic, physical and biological needs and values. Some forest certification programs, especially the ones supported by the Forest Stewardship Council, are also promoting this approach.

To translate the concept of ecosystem management into forest practices, the principle of emulating natural disturbances has become the main driver in developing silvicultural strategies. As explained by Hunter & Seymour (1999): "We believe that the central axiom of ecological forestry is that the manipulation of a forest ecosystem should work within the limits established by natural disturbance prior to extensive human alteration of the landscape. The key assumption here is that native species evolved under these circumstances, and thus that maintaining a full range of similar condition under management offers the best assurance against losses of biodiversity."

Emulation of natural disturbances is influencing forest practices in two ways. At the stand level, naturalistic silvicultural systems are being developed in ways to maintain structural complexity and protect biological legacies. At the landscape level, harvest patterns are designed to emulate stand patterns created by natural disturbances.

Implementation of these strategies is relatively new. Their overall sustainability has yet to be established: Are these practices ecologically viable? Are they economically feasible? Are they socially acceptable? We will focus our attention on one aspect: the social acceptability of ecosystem management strategies in the Northeast when people view their related practices directly in the woods.

Ecosystem Management Strategies in the Northeast

For discussion purposes, four main ecosystem management strategies can be considered in development in the Northeast, emulating one of three major disturbance regimes: 1) partial cutting systems for gap phase ecosystems, 2) mosaic patch cutting strategies for the spruce budworm disturbance regimes, 3) aggregate cutting strategies for fire dominated disturbance regimes, 4) the triad strategy.

Because of the high precipitations in several eastern forest regions, fires are infrequent allowing the development of late successional forests with gap replacement dynamics. The Northern hardwoods of New England and the Acadian red spruce-balsam fir ecosystems are examples of the northeastern rain forest. A diversification of partial cutting silvicultural systems to create multi-cohort stands, are being developed for such forests based on natural regeneration. Forestry practised in Algonquin Provincial Park in Ontario (Corbett 2001) and by the Seven Islands Land Company in Maine illustrates this approach.

In the colder climates of the eastern rain forest, balsam fir becomes a dominant component of the landscape. Stand replacing mortality related to spruce budworm outbreaks and windthrow becomes the main natural disturbance factor. This creates a mosaic dominated by medium sized (1-100 ha) evenaged stands. In Quebec, for example, mosaic patch cutting management systems using careful logging methods, are being developed for the eastern boreal fir forest (Bélanger 2001).

Large areas of more western forest regions are characterized by large-scale forest fire regimes (Perera et al. 2000, Bergeron et al. 2002). To emulate disturbance patterns in fire driven forest regions, aggregated clearcutting strategies associated with green tree retention silvicultural systems are being developed. This approach is now the official policy in Ontario's boreal forest.

As for plantation forestry, it is still trying to find its niche in an ecosystem management context. The landscape triad concept, initially proposed for Maine's northern forest by Hunter & Seymour (1992), is having some influence on the way people are finding a place for plantations in the Northeast. The principle consists of practising a "balanced forestry", represented by a triad of high-yield plantations and ecological reserves embedded in a matrix of ecological forestry.

Now, what is the potential social acceptability of these different management strategies?

A Framework to Predict Problems of Social Acceptability

Recent advances in the study of people's appreciation of landscapes and their perception of forest sustainability provide an interesting framework to predict social acceptability of forest practices. It is based on the fundamental fact that people tend to judge forest practices by how they look. Such judgements, however, are not just based on the aesthetic appeal of a forest after intervention. The visual environment is the filter through which people encounter and evaluate environmental quality. Their perception is based on visual cues (Table 1). Visual degradation is generally equated to unsound practices while practices that look good are judged positively (Sheppard & Harshaw 2001). Consequently, landscapes that appear neat and cared for are more likely to be deemed acceptable. This is the concept of visible stewardship proposed by Sheppard.

On a similar basis, it is possible to address the question of visual preferences in our society by recognising what Hull et al.(2000) call aesthetic ideals. For discussion purposes, four general groups can be distinguished in relation to their landscape preferences. 1) The romantic group idealizes what seems to be untouched landscapes. 2) The well-tended preference group appreciates landscapes that show an image of care and good management. 3) Following the ecological aesthetic, people should appreciate management practices that produce conditions similar to those produced by ecological processes. 4) Finally, the aboriginal group preferences are influenced by their relation to the land, particularly by "Mother Earth's" power to provide for their hunting, trapping and fishing activities.

Table 1. Criteria of visible forest stewardship

Criteria of acceptability	Visible cues
Perceived naturalness	Signs of artificialisation
Perceived environmental protection	Signs of site degradation
Perceived sustainability	Levels of disturbance at a human scale (1-10 km^2)
	Signs of wood squandering
Perceived appropriateness for preferred activity	
Recreation	Visual quality
Hunting-trapping	Good hunting-trapping habitat

Acceptability Problems and Successes in the Northeast

The performance of the four ecosystem management strategies on the basis of criteria of visual acceptability (Table 2) are quit e different. As can be expected, partial cutting strategies perform well on all criteria while aggregate cutting fail on every mark. In a nutshell, partial cutting is easily perceived as maintaining the forest environment while large clearcuts do not leave much signs of visual sustainability. Strategies based on dispersed patch cutting seem acceptable as long as people can see landscapes where forests dominate disturbed areas (Paquet & Bélanger 1997).

When we compare the acceptability of the same management strategies to the different landscape preference groups (Table 3), partial cutting strategies receive almost unanimous support while aggregate cutting receive general disapproval except for the ecological group (and still then). For the mosaic strategy, the romantic group could pose some opposition while being acceptable for the other groups. Finally the triad poses the problem of the acceptability of its plantation component that affects the naturalness of the managed forest.

Case examples illustrate this evaluation. In Algonquin Park, though some groups want complete abolishment of cutting due to the protection status of the territory, forest practices based on partial cutting are not the object of much public debate. Consensus on forest practices seems to be achieved in this delicate situation.

On the other hand, though Ontario's ecosystem management strategy has the support of the population, its Guide for Natural Disturbance Pattern Emulation is drawing important criticism. Several groups contend that emulation of large fires is just an excuse for increasing the amount of cutting rather than curtailing cutting (McNicol & Baker 2002). As for First Nations, fire is often considered a disaster, especially if it affects a considerable proportion of a family trapline. Using it as a reference for harvesting, represents a difficult sell.

Table 2. Visual acceptability of four developing management strategies in the Northeast

Visible acceptability criteria	Management strategy: Partial cutting	Mosaic patch cutting	Triad	Aggregate cutting
Naturalness	Yes	Somewhat	No/yes	No
Perceived environmental degradation	Low risks	Moderate risks	Moderate risks	High risks
Perceived sustainability	Yes: Permanent forest cover	Yes: Human scale disturbance	Yes: Human scale disturbance	No: Catastrophic disturbance
Perceived suitability for recreation	High	Moderate to high	Moderate	None
Perceived suitability for wildlife of interest	No impact or small improvement	Improvement	Improvement and impacts	Large impact

Several groups see the Forest Mosaic Strategy in Quebec as a reasonable compromise between clearcut silvicultural systems and providing landscapes where multiple use is still possible (Bélanger 2001). This is the case, for example, for some communities of the Innu First Nation in Quebec (Morel & Bélanger 1998). However, good and credible explanations are needed to convince people than can be categorized as part of the Romantic group.

As for the triad approach, its plantation component remains an object of debate especially since plantations are often associated with the use of pesticides. To illustrate the point, the FSC certification system, will not certify plantations created by the conversion of natural forest since 1994. Irving's problems with the certification of its Black Brook Forest in northern New Brunswick illustrates the continuing contentiousness of plantations for the public in the Northeast even while globally respecting sustainable forestry criteria.

Table 3. Social acceptability of four developing management strategies in the Northeast

	Management strategy			
Landscape preference group	**Partial cutting**	**Mosaic patch cutting**	**Triad**	**Aggregate cutting**
Romantic	Yes	Generally no without information	No	No
Well tended	Yes	Yes	Yes	No
Ecological	Yes	Yes	No/Yes	Yes/No
Aboriginal (boreal)	Yes	Yes	No	No
Overall acceptability	Always yes	Generally yes	Debatable	Clearly no

Conclusion

Large advances have been made during the past decade to develop management strategies that will win the general support of the population. However two major stumbling blocks are and will remain the object of controversy. Plantation forestry and the practices related to it do not correspond to what people generally expect when going in the woods: natural forests. On the other hand, forest ecologists and managers will have to be very imaginative if they ever want to get any support for aggregate clearcutting. They are going to be confronted with the fact that most of the population in the Northeast lives in forest regions characterized by gap replacement ecosystems, and consequently, partial cutting systems will become the reference people will know as good forestry. And as suggested by Terry C. Daniel (In Sheppard & Harshaw 2001), it is unlikely that providing ecological knowledge will bring any substantial change to people's aesthetic preferences.

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ORAL PRESENTATIONS

CHARACTERIZING THE EFFECTS OF FOREST GAPS ON PARASITIC HYMENOPTERA

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Forest gaps contribute to habitat heterogeneity and are thought generally to contribute to overall biodiversity. Gaps can provide habitat for flowering plants and the beneficial insects that depend on them. We conducted a survey seeking to characterize gap effects on parasitic Hymenoptera communities (Parasitica). Adults of the Parasitica have been reported to feed on nectar while searching for prey for their offspring. The study was conducted in three small gaps (900-1000m^2), three large gaps (1900-2100m^2) and a large clearcut as a contrast. Yellow pan-traps and malaise traps were used to estimate relative abundance of the wasps. Traps were placed along a north-south transect to investigate possible edge and shading effects. Samples were taken weekly throughout the summer of 2002. North-south and east-west band transects were also conducted to identify flowering plant species present and floral density within and surrounding the gaps. Temperature and relative humidity measurements were taken within gaps and into the adjacent forests to monitor microclimate differences. Trapped Parasitica were counted and sorted into morphologically distinct taxa. Preliminary results indicate that the abundance of the Parasitica was greater at gap edges and into the surrounding forest than within the gap. Both the abundance of flowering plants and Parasitica was greater in the large clearcut than it was the smaller gaps, indicating that the smaller gaps may not provide habitat of comparable quality to a clearcuts.

"WORKING TOO CLOSE TO THE STUMP": RURAL POVERTY, ENVIRONMENTAL JUSTICE AND FOREST MANAGEMENT IN MAINE AND EASTERN CANADA

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Recent attempts to define a socio-ecological region known as the "Northern Forest" in concert with a variety of conflicts surrounding potential major land-use changes in the North Maine Woods have made necessary a reconsideration of the human-ecological analytical frameworks available to scholars, policy-makers, industry leaders, and community and labor organizations for discussing and negotiating the future of the Northeast region. A flurry of publications and redefinitions of organizations surrounding issues of change in the forest industry, land ownership, and political organization of rural communities provides evidence of a struggle to define culture, community, forest values and justice for natural resource dependent rural areas of the U.S. and Canada. Concurrently, scholarly debates about the promises and pitfalls of breaking down the constructed geographical binary of "First World" and "Third World" raise questions about environmental justice failures inherent in the various political-economic arrangements of extractive regions within industrialized nations.

Consequently, attention has been drawn to the need to rethink a number of analytical stand-bys including: assumed links between rural poverty and natural resource dependence, concepts of community management of resources versus regulation by government and industry, and a call to redefine forest dependencies and values on the basis of geographical scale. Environmental histories and issues of class and regional inequalities in political power have also surfaced as important variables in these discourses. However, a focus on place, culture, and the significance of the international border that runs through this ecological region has failed to crystallize in these debates. Some important questions that might be addressed concerning the interplay between resources, people and governments by broadening the scope of the discussion to include these themes are: What happens when there are two governments regulating a resource region and industry? What is the significance of the large Francophone ethnic minority in the "Northern Forest" who have a particular history as both colonizing and colonized and who have a unique role in the ecological history of the Northeast region? What are the varying impacts of the political-economic and cultural changes facing the "Northern Forest" region on communities at risk for rural gentrification or subsumption under the proposed national park versus communities that are marginal to this speculative zone of development?

In this paper, I focus on comparing the rationales behind the forest product industry in northern Maine and the innovative Canadian Model Forest tenant forest farms in Québec and New Brunswick. I argue that the geographical sub-field of Political Ecology - with its foci on the historical role of economics and colonialism, science, language and discourse, ideology, gender, property systems and the everyday politics of the community and the household in shaping human relationships with nature – offers the most comprehensive conceptual framework for planning in the international Northern forest.

IMPROVING THE PALLET BENDING STRENGTH BY ALTERNATIVE DESIGN

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Pallets are widely used to store and handle goods. An estimated of 411 millions new pallets were manufactured in 1995 in the United States alone. These frames are often subjected to bending and impact load.

In service, there are two types of pallet support systems, a racking system and stacked (or floor supported). Under the racking system there are two support modes: a) racked across the stringers, b) racked across the deck-boards. Each type of support mode dictates the bending either of the stringer or of the deck boards

The stringers through the conventional pallet design consist of a lumber, which provide the clearance for the transport facility through the notching portion and the bending resistance perform by the remained wood section. Through out the previous experiment it was observed that the rupture initiated at the corner of the notch. In a majority of cases it started at the center corner of the notch and propagated toward the center. It was concluded that due to the load concentration at the notch corner, the shear force governs the failure. Consequently the premature failure occurs before reaching the stringer bending resistance. A new design has been proposed to have a built-up stringer. Each components of the built-up stringer would carry the majority of the bending, shear and providing the clearance individually up to their maximum capacity. Through the proposed design, the stringer would have three components: part A, fastener and part B. Component A, to resist the bending force and component B, to provide the clearance required by the transportation system. These components are from selected wooden species and are fasten together with a metal fastener (nail). The metal fastener would be subjected to the shear force.

The advantage would be approaching the maximum strength of each component and consequently increasing the load bearing capacity of the pallet. Through the preliminary test, the pallet with built-up stringer showed 50% increase compare to the conventional pallet. This comparison took place by matching the raw material for both type of pallet and the uniform load was applied up to the ultimate failure.

TERMINAL HARVESTING IN NORTHERN NEW ENGLAND

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Forests provide important raw materials to the citizens of northern New England (Maine, New Hampshire, and Vermont). One of the most important raw materials in the world is round-wood. Wood fiber is an important product by itself, as well as being part of many different products; from firewood as a fuel, to paper and cellophane products, to luxury items such as wooden dashboards in cars, or elegant furniture. Since wood products are so important, much emphasis has been placed on growing trees efficiently as well as the processing of round wood into other products. However, little research has emphasized wood supply from the loggers' point-of-view in northern New England. If a sudden decrease in wood supply from terminal harvesting (the last time a parcel is harvested, forever removing the parcel from timber production) were to occur, a decrease in wood supply would be inevitable.

The logging industry is one of the largest industries of northern New England (Maine, New Hampshire, and Vermont). This industrial community fuels much of the economy in these states, as well as other states, and even parts of Canada. One successful way of getting to know the logging population of this region is by studying them through a survey. A comprehensive survey was conducted in 2001, aimed at surveying as many logging professionals working in Maine, New Hampshire, and Vermont as possible.

In this study, the extent of terminal harvests will be quantified using GIS techniques, from existing data, responses from the survey instrument, as well as Landsat 7 Thematic Mapper classified images. Relationships between sociodemographic information about loggers and economic/financial practices and outlooks will be presented. Relationships between types of logging operations (mechanized, traditional, etc.), harvested wood lot sizes, and number of wood lots per year will also be studied and presented.

IMPROVEMENT CUTTING IN DEGRADED NORTHERN HARDWOODS: RESULTS OF A 30-YEAR REPLICATED FIELD EXPERIMENT IN UPSTATE NEW YORK

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For many reasons, degraded hardwoods stands have become abundant in eastern North America. These degraded stands provide a difficult challenge because of the small amount of acceptable growing stock (AGS) present. As a result, many of these forests require significant financial and temporal investments in order to produce high quality timber. Forest resource professionals are just realizing these challenges and are considering a full range of silvicultural alternatives to rehabilitate degraded stands. Stand improvement treatments (formerly timber stand improvement or TSI) may best rehabilitate these forests by minimizing investments and shifting the balance from unacceptable to acceptable growing stock in a timely manner.

Initiated in 1970, this study is an ongoing evaluation of a series of experimental stand improvement cuts, conducted in a degraded northern hardwoods stand, growing on various site conditions. This study attempts to understand stand improvement effects on species composition, structure, and quality of northern hardwoods stands growing in Upstate New York.

Four stand improvement cuts were applied to the degraded stand, which started with 65% of the original basal area in unacceptable growing stock (UGS). The four treatments left 90 sq ft per acre basal area residual, approximately two-thirds of which was UGS, 60 sq ft of residuals, half of which was UGS, 30 sq ft of residuals, all of which was AGS, and 0 sq ft of basal area -- effectively a clearcut. Site effects were incorporated into the experiment by using a randomized block design. Four 4-acre blocks were established along a catena that included complexes of moderately-well and somewhat poorly drained soils. Each block was divided into four 1-acre experimental units. In 2000, overstory trees were measured for dbh by species. In 2002, all trees $\geq$ 1-inch dbh were classed as acceptable or unacceptable growing stock, and all sawtimber trees were graded using U.S. Forest Service protocol. Stocking charts were used to portray stands before, immediately after, and 30 years after treatment.

Prior to the cuttings, relative stand density was 62%, which may be attributable to the combination of a 1950s hurricane, beech bark disease, and the preponderance of cull trees -- of the original stand's basal area, 36% was cull. After 30 years of growth, all of the treatments have developed near-A-line densities. Intensity of the cut was positively related to increases in stand quality and the proportion of desirable species. Removing as much of the UGS as possible, including saplings and pole-sized trees that may not be merchantable, is an important aspect of stand improvement. In some forests, full rehabilitation may not be possible unless the stands are regenerated. Stand improvement in degraded woodlots is important to the future of our forests. If measures are not taken to improve conditions, opportunities will be lost.

MANAGEMENT OF UNDERSTORY AMERICAN BEECH BY TWO MECHANICAL CONTROL METHODS

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In the northeastern United States and eastern Canada, American beech (*Fagus grandifolia* Ehrh.), is one of the primary inhibitors to regeneration of desirable hardwoods. The lasting effects of beech bark disease, intense browsing of valued species by deer, and the failure to properly manage these affected forests has led to poor regeneration of desirable species of higher commercial value. Research at the Huntington Wildlife Forest in New York and the Allegheny National Forest in Pennsylvania has already demonstrated the effectiveness of herbicide treatments to control small beech in conjunction with carefully planned silvicultural prescriptions. This study investigated the effectiveness of one manual method as an alternative to chemical methods for controlling understory American beech in northern hardwood stands. This method was compared to two techniques of herbicide control of undesired beech stems. Investigations considered time of treatment, stump age and size, and site quality.

Four study sites were established within the Adirondack Mountain region and the Southern Tier region of New York State. Treatments were conducted by cutting understory hardwoods < 5.5 in. dbh with a brush saw. Cutting was conducted in 100 sq ft plots at two-week intervals from April through October during 2000 to test for response throughout the growing season. Observations made in the summer of 2001 indicate felling treatments in July and August minimized stump sprout production. Sprouting increased with increasing stump diameter, up to 8 in. and decreased with increasing stump height, up to 2 ft. Eighty three percent of sprouts initiated from the callus tissue, an indication of low sprout survival as the stump decays. This is supported by data collected on plots treated in mid-summer of 1997 and 1998, where number of sprouts declined by three and four growing seasons after the felling treatment.

Cut-stump and basal-spray applications of herbicides to beech stems successfully minimized sprouting. Application of Garlon 4, Accord, and Chopper were each successful in minimizing stump sprouting when applied as a cut-stump treatment. Garlon 4 and Chopper were also effective when applied as basal spray treatments. Upon initial evaluation one growing season following treatment, the herbicide applications proved more effective than felling treatments in controlling sprouting.

Choosing the optimal time for felling will help to reduce the degree of stump sprouting and minimize subsequent growth. However, stump sprout evaluation must be conducted for several years to confirm if sprouting is minimized by mid-summer treatments, whether further sprouting will occur, and if initial sprouts will decline with time. Likewise, I suggest continued monitoring of the regeneration plots to evaluate relative rate of development by both beech and non-beech species, thus, determining if felling of understory beech leads to regeneration of more desirable species. In addition, cost effectiveness between treatments must be calculated by time-motion studies to determine financial feasibility of felling treatments.

IMPLEMENTING AN INTERNATIONAL FOREST COMMUNITY CLASSIFICATION IN THE NORTHERN APPALACHIAN-ACADIAN REGION

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Progress on developing a taxonomic forest classification to describe the diversity of ecological forest communities in the Northern Appalachian-Acadian region will be outlined. The classification is designed to synthesize existing state and provincial forest community data into a common system, employing standards consistent with the International Classification of Ecological Communities. The result will be a systematic framework for applying ecological knowledge of northeastern forests to monitoring, research, and management. This initiative marks the first effort to correlate jurisdictional forest classification data across provincial and international borders. The Northern Appalachian-Acadian forest classification will enable inter-regional and inter-national forest assessment and foster cross-border understanding and cooperation.

A MODEL FOR ASSESSING LUMBER RECOVERY AND QUALITY OVER TIME

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The objective of this study is to describe a method to predict lumber recovery and lumber quality in black spruce (*Picea mariana* [Mill.] B.S.P.) plantations at various points in time. This study is part of a larger initiative to expand stand density management diagrams (SDMD) to include predictions of product quality and product volume.

The Ontario Ministry of Natural Resources (OMNR) established spacing trials in 1950 near Thunder Bay. Forintek Canada Corp. (Forintek) conducted an intensive study of the black spruce plantations in 1998. In total, 139 trees were selected from four spacings (2.7 x 2.7 m, 2.2 x 2.2 m, 2.0 x 2.0 and 1.8 x 1.8 m) to cover merchantable DBH classes in each spacing. The raw data from x-ray densitometry measured by Forintek was used for this project and has been subsequently organized into a database.

Density profiles from pith to bark were created at all positions for each tree using average ring density. A stepwise regression was performed on each profile to obtain the change point that defines the juvenile- to mature-wood boundary. A weighted average for the coefficient of regression values was used to determine the best change point in each case. The juvenile boundary for each tree and each elevation was analyzed with respect to stand density but the results were not statistically significant. This information can be used to establish a juvenile core for the entire tree.

Each tree was re-created 20 years back in time at 5-year intervals using the cambial age and ring width information. A sawmill simulation program called Optitek, developed by Forintek, will allow the prediction of lumber recovery at five different time periods (1998, 1993, 1988, 1983 and 1978). The output will allow for determination of product distribution, lumber volume and lumber recovery factor with respect to time period and stand density. The output of Optitek also includes a description of the location of each piece of lumber in each tree by a standard coordinate system. By combining this information to the previously defined juvenile core, selected measures of lumber quality in each piece of lumber can be estimated and analyzed with respect to stand and tree characteristics.

DIFFERENTIAL GROWTH RESPONSES IN MATURE EASTERN WHITE PINE FOLLOWING PARTIAL CUTTING TREATMENTS

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Eastern white pine (*Pinus strobus* L.) was the most important commercial tree species that initiated the start of the lumber industry in Canada and the northeastern United States in the 1700s. The importance of the pine harvest diminished steadily after 1900 due to a number of factors, including overharvesting, lack of adequate reforestation in terms of both quantity and quality, and conversion of forested lands to other uses.

Given the historically poor success rate of regenerating quality white pine stands following clear cutting, recent emphasis has been to manage white pine under the uniform shelterwood system. This system involves the partial removal of the overstory trees, resulting in a residual stand with trees having varying degrees of neighboring competition. Knowledge of the growth response of residual white pine to partial cutting is important to forest managers who are attempting to accelerate forest succession in natural mixed species stands through the removal of the non-pine component in the hopes of converting them to white pine cover-types.

The study site was the Cartier Lake Silvicultural Area within the Petawawa Research Forest (PRF), Chalk River, Ontario. Stiell (1984) previously used the site to assess stand-level responses to improvement cuts. The site contained predominantly multi-cohort, mixedwood stands with a wide range of density and species composition. Portions of the mixedwood stands were partially cut in the fall of 1971 to varying levels of residual basal area. Stiell (1984) laid out a 2x3 factorial design with two levels of cutting treatment (control and treated) and three levels of average pine basal area (6.9, 11.5 and 16.1 $m^2\ ha^{-1}$) within the study area. Trees were selected in 1995 for detailed stem analysis in order to measure yearly growth response over the 23-year post-cutting period. Trees were chosen from within each of the six treatments and stratified into three dominance classes to investigate the variation in tree response due to canopy position.

Trees from all crown classes showed significantly ($p<0.0001$) greater rates of diameter, basal area and volume growth following release. Only intermediate trees responded with increased height growth. Plasticity in growth form was evident. Intermediate trees exhibited significantly ($p<0.0001$) different crown and stem form among crown classes in the control treatment, and different ($p<0.0001$) crown form relative to the release treatment. Crown size, which was positively correlated with volume increment, improved as a result of competition release and was inversely correlated ($p<0.0001$) with levels of local neighborhood competition. Vertical distribution of bole area increment in all crown classes was altered in the release treatment. Bole area increment in released trees increased progressively from tree apex to base of the stem for the first 15 years after partial cutting, eventually resulting in significant ($p<0.0001$) changes in stem form. Control trees showed relatively constant area increment below the crown with no significant change in stem form.

Stiell, W. 1984. For. Chron. 60:3-9.

SHELTERWOOD CUTTING METHOD IN A CONIFEROUS STAND IN NW NEW BRUNSWICK: 5-YEAR RESULTS OF REGENERATION AND RESIDUAL STAND

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In Canada, most coniferous stands are harvested by the clearcutting method. Nevertheless, this method has been strongly criticized for its negative impacts on the environment. Moreover, this method, when applied on large areas, is not suitable for obtaining an adequate natural regeneration, thereby requiring seedlings plantation. For these reasons, the Canadian public is urging industries and governments to develop alternative harvest methods that would respect the environment, maintain the biodiversity and promote a desirable natural regeneration. For Eastern Canada, very little information is available concerning alternatives to clearcutting. A research project was developed in New Brunswick to validate the shelterwood method in a fir-spruce stand.

Installed in NW New Brunswick in July 1995, this experimental design has various objectives: 1) to evaluate the efficiency of shelterwood cutting in promoting a natural regeneration of desired species in a specific bio-climatic context; 2) to determine the effect of the cut intensity on the regeneration process; 3) to test the influence of soil scarification on the regeneration composition and 4) the quantify the incidence of the shelterwood cut on the residual trees growth.

Five years after the cut, the regeneration structure shows, without soil scarification, very clear trends: the cut intensity favored density and height growth of fir and spruce seedlings. Height growth was higher for fir compared to spruce. Two years after soil scarification, spruce seedlings number was strongly promoted by cut intensity: 69 323 seedlings/ha for heavy cut compared to 28 750 seedlings/ha for the control). The highest cut intensity (40 %) negatively affected (- 75 %) the balsam fir seedling density; the fir/spruce regeneration ratio is completely inverted (62 %/37 % for the control and 37 %/62% for the highest cut intensity). 5-year diameter increment on residual trees was the highest in the heavy cut (3,21 cm) followed by the light cut (3,00 cm) and the control (2,26 cm).

These results show that in our bio-climatic conditions, the shelterwood method associated with soil scarification could be used with success in the eastern Canadian environment to regenerate spruce-fir stands.

PREDICTING UNDERSTORY AMERICAN BEECH DEVELOPMENT AFTER PARTIAL CUTTING IN UNEVEN-AGED NORTHERN HARDWOODS

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American beech (*Fagus grandifolia* Ehrh.) has diminished in commercial value since the spread of beech bark disease through the northeastern portion of North America. Yet, it often remains a dominant component in the understory of many northern hardwood stands, interfering with the development of more desirable species such as sugar maple (*Acer saccharum* Marsh.). Due to the cost of site preparation, it is useful for managers to know whether a new cohort will likely become beech-dominated after a cutting treatment. We developed a contingency table to determine the probability of changes in understory beech importance after a partial cutting in uneven-aged stands.

The importance of beech as an understory component was assessed using a Species Index Value (SIV), which measures the proportion of stems, weighted by height, for each species on a milacre plot. We used a five by five contingency table to assess the transition of beech importance after cutting, with classes labeled as Absent (SIV = 0), Low (0.01 – 0.25), Medium (0.26 – 0.50), High (0.51 - 0.75), and Very High (0.76 – 1.0). We calculated the proportion of plots shifting in beech importance for each pre-cut SIV class to determine the probability of change after treatment.

The contingency table provides a tool for evaluating the probability of beech dominance on a plot-level basis, and for estimating the overall change in the degree of beech development across a stand. The probability of beech development on a plot is dependent on the pre-cut status of that plot and is determined by the cell values in the rows for each SIV class. Plots where pre-cut beech is Absent or Very High are not likely to change after treatment, with approximately 70% and 80% of plots remaining in their respective classes. For the middle pre-cut classes, beech SIV is more likely to increase after treatment, with 38% and 40% of plots in the Medium and High classes moving to the next highest SIV class. In many cases, a stand inventory will contain plots with a variety of pre-cut conditions. To determine the likely development across all the plots, one simply multiplies the number of plots in each pre-cut SIV class by the appropriate probabilities. Then, to assess the stand-level changes, one sums up the number of plots in each post-cut column.

Unlike traditional techniques for evaluating the need for site preparation, the contingency table allows managers with different objectives to set their own tolerance levels for beech. The table can then be used to determine whether beech will likely increase past the tolerance level.

NONINDUSTRIAL PRIVATE FOREST LANDOWNERS OF THE NORTHERN FOREST

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The fate of the forested regions of Maine, Vermont, New Hampshire, and northern New York (the Northern Forest) is largely controlled by public and private organizations and individuals. The largest group of landowners in the region is nonindustrial private forest (NIPF) landowners – the private individuals and organizations who own between 1 and 5,000 acres of forest land. An estimated half million NIPF landowners in the region collectively control 51 percent of the 27 million acres of forest. In addition to NIPF owners, forest-industry companies, other large private landowners, and federal and state government agencies control 10 million, 3 million, and 2 ½ million acres, respectively.

The general characteristics and attitudes of NIPF landowners periodically are assessed through a survey conducted by the USDA Forest Service. The total area of forestland owned by NIPF owners in the Northern Forest decreased between 1994 and 2002, while the number of NIPF ownerships increased. Consequently, the average area owned decreased by half, from 61 acres in 1994 to 31 acres in 2002.

The current landowners own their land for a variety of reasons, but the dominant reason is the land is a part of their primary residence and they enjoy the privacy and beauty that the forest provides. While forest management and the income generated from timber sales is not the most important reason for owning forests for most of the region's NIPF owners, most have experience with harvesting forest products. This bodes well for the preservation of working forestlands. But only 8 percent of the landowners have written management plans and only half of the land is owned by someone who has consulted a professional forester or land manager. Consequently, the quality of the stewardship is questionable.

The future of the NIPF land in the Northern Forest may prove to be very dynamic. Nearly a quarter of the land is owned by people who intend to sell, give away, subdivide, or convert part or all of their forestland in the next 5 years. Most of the region's landowners contemplate no or minimal management activities on their land, so many of the harvesting activities that occur may be ill planned. Landowners express some serious concerns, such as property taxes, their ability to pass their land on to their heirs, and misuse of their land by trespassers. They also are concerned about the potential of natural damage by insects and diseases, wind and/or ice storms, and fire.

MEASURES OF MAINE COMMUNITY DEPENDENCE ON THE FOREST SECTOR

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The forestry sector is an important contributor to the economic base for communities throughout Maine. Concentration of employment in forestry and primary wood products manufacturing industries is considerably greater in Maine than the national average (Maine State Planning Office 2001). Methods to measure the degree to which Maine communities depend on the forestry industry underscore the importance of the forest sector to Maine's economy. Commonly-used measures of dependency (the Forest Reliance Index (FRI) and Location Quotients) and of diversity (Shannon-Weaver (1949) Index) were calculated at the county level using secondary employment data.

We correlated socio-economic indicators of community well-being with dependency measures to examine social and economic factors that may be associated with dependency. A geographic examination of our results helped detect spatial trends in forest sector dependency.

The Forest Reliance Index showed the most variation between counties as well as a general geographic trend of decreasing forest reliance moving from the northern and rim counties towards the southern and coastal counties. Location Quotients did not indicate as much distinction between counties as the FRI, but a similar geographic trend was apparent in county Location Quotients. Shannon-Weaver Index values demonstrated the least variation between counties and did not suggest any geographical trend in economic diversity. Generally, socio-economic indicators relating to income, poverty status, unemployment and education showed the strongest correlation to dependency measures. Results from the analysis suggest that measures of dependency, rather than diversity, are more helpful in distinguishing between levels of forest industry reliance at the county level. Geographic trends suggest Maine counties in the central and western part of the state and those that border Canada tend to be more dependent on the forest industry than counties in the southern and coastal region.

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LONG-TERM EFFECT OF HERBICIDES AND PRECOMMERCIAL THINNING ON THE COMPOSITION AND STRUCTURE OF MAINE SPRUCE-FIR STANDS

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The Austin Pond Study is one of the longest running studies in North America documenting the effect of herbicides and precommercial thinning (PCT) on the development of northern spruce-fir stands. The original 1977 study included 12 aerially applied herbicide treatments plus an untreated check and a control. In 1986, the original 28 plots were divided in half and one of the halves PCT'd to about 700 TPA. In 1999, we relocated all plots from the original study and installed four 1/20-acre sample plots in each half (PCT and no PCT) of the original 28 herbicide treatment plots. Species, height, and DBH were recorded for tree species in 1999, and species and cover recorded for all herbaceous and shrub vegetation in 2000.

Glyphosate and triclopyr herbicides had a large influence on long-term species composition; with fir and spruce comprising 56% more of total volume in the herbicide treated plots than in the untreated control ($p < 0.001$). Quaking aspen (*Populus tremuloides*), red maple (*Acer rubrum*), and other hardwoods dominate the volume of the Control only. PCT also had a strong influence on species composition, producing a similar domination by spruce and fir as a result of cutting the hardwoods during thinning. In addition, PCT reduced total volume ($p < 0.001$) compared to non-PCT plots. The combined effect of herbicide treatment + PCT produced stands nearly completely dominated by fir and spruce.

PCT had a reverse effect on merchantability, with greater merchantable volumes (10 cm top) in the herbicide + PCT treatments than with the herbicide only treatments ($p < 0.001$). The exception was control + PCT, where merchantable volume was still reduced (despite being composed mostly of fir and spruce) relative to the untreated control and similar to the herbicide only treatments ($p < 0.001$). Therefore, herbicide treatment appeared to be required for spruce and fir to take full advantage of later PCT.

The influence of herbicide and PCT on both species composition and merchantable volume produced substantial differences in financial value among the treated stands at 29 years. Triclopyr + PCT had the highest financial value followed by Glyphosate + PCT and the Control only. The effect of the early herbicide treatments on stumpage value is indicated by a larger value of fir and spruce in the Triclopyr only and Glyphosate only treatments than in the Control only. However, this increase in fir and spruce composition produced by the herbicide treatments did not offset the value of the hardwoods that remained in the stand. PCT alone increased did not increase stand values above the Control only, but did produce nearly double the value of the spruce-fir component compared to the Control only.

As part of this analysis, growth and yield projections of stand conditions through the end of the rotation are being used to determine long-term financial returns from herbicide and PCT treatments in Maine spruce-fir stands.

THE LAND-USE HISTORY AND STAND DYNAMICS OF MONHEGAN ISLAND

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Some of the coastal islands of Maine are experiencing heavy mortality of their white spruce (*Picea glauca*) forests. Depending on what island you're standing on, most of the mortality is being caused by the spruce bark beetle, hemlock looper, eastern dwarf mistletoe or windthrow. On Monhegan Island, eastern dwarf mistletoe (*Arceuthobium pussilum*) is the cause of extensive mortality of the white spruce stands. However, the red spruce (*Picea rubens*) stands are relatively unaffected by the mistletoe. Why are the pest vulnerable, white spruce stands susceptible to the mistletoe? Are these stands natural or a consequence of land-use history? The effects of land-use history on the modern vegetation is well documented for certain areas. A general pattern of land clearance, extensive agriculture, and abandonment is consistent from site to site. On Monhegan Island, this same pattern of land-use history holds true. Previous studies have also shown that the reforestation of abandoned fields can be quite different from the vegetation of pre-settlement forests. The hypothesis for Monhegan Island is that white spruce is dominant on old fields and red spruce is dominant on historically forested sites. To test this hypothesis, land use will be documented using old maps, land deeds, the 1870 agricultural census, pollen records, aerial photos, early 1900's photographs, and personal communications. The vegetation will then be sampled from 1/50 ha plots randomly located within strata that have been developed from three maps depicting forest cover: 1873, 1922, and current USGS. Information will collected for trees ≥ 10 cm dbh, herbs and shrubs, and tree regeneration < 2 m in height. The data will be analyzed using ordination techniques. In summary, the coastal islands are suffering high mortality in the white spruce forests. This leads to the implication that the pest-susceptible white spruce forests are a consequence of European settlement and are not natural.

KOREAN PINE-BROADLEAF FORESTS OF THE RUSSIAN FAR EAST: TOWARD A SILVICULTURAL COMPARISON WITH WHITE PINE ANALOGS IN EASTERN NORTH AMERICA

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The pine-broadleaf forest formations of eastern North America and the Russian Far East share an intriguing set of similarities and differences that suggests strong potential for comparative research on the stand dynamics and silviculture of mixed, uneven-aged forests.

Regional precedents define Korean pine-broadleaf stands as those in which Korean pine (*Pinus koraiensis*), a long-lived, moderately shade-tolerant five-needle pine, comprises at least 20% of the canopy by tree volume. They are typically found between 42° and 46° N. lat. on Russia's eastern (Pacific) seaboard at elevations ranging from 500 to 1500 meters. *Fraxinus, Quercus, Betula, Acer, Tilia, Ulmus,* and *Carpinus* are among the most commonly associated deciduous genera, of which multiple cohorts have been observed to establish, mature and die beneath a single pine cohort. *Picea* and *Abies* are often found in the understory of older stands as well. While these and other characteristics share much in common with the white pine-broadleaf forests of eastern North America, important differences include the fact that the southern Russian Far East was not glaciated during the last ice age (11,000 years ago), and that a large proportion of forests in the Russian Far East remain in a primary condition. In an initial effort to compare growth dynamics in the two forest types, we calibrated the NE-TWIGS individual-tree diameter growth model, which was designed for the northeastern U.S., to permanent plot observations recorded in seven stands over 8-30 years in Ussuriyskiy State Nature Reserve (Primorskiy *krai*). The results of comparing the growth rates predicted by the calibrated model to some of those observed in the permanent plots are given in Table 1.

Table 1. Model Calibration Results

Species	n	R^2	Predicted growth and rank[a]	Observed growth and rank[a]	Error[b]
Pinus koraiensis	255	0.386	0.0998: 3	0.0853: 3	17.01%
Acer mono	227	0.200	0.0685; 6	0.0580; 6	18.18%
Acer	54	0.407	0.0826; 4	0.0730; 4	13.17%
Tilia amurensis	82	0.180	0.0816; 5	0.0640; 5	27.50%
Abies nephrolepis	67	0.262	0.1376; 1	0.1201; 2	14.57%
Abies holophylla	48	0.569	0.1357; 2	0.1259; 1	7.79%
Total	**733**	**-**	**0.0976**	**0.0837**	**16.52%**

[a]average annual growth (in.); rank of growth rate (1-fastest, 6-slowest); [b]over prediction as a percentage of observed growth

The low R^2, together with borderline results from other validity tests, limit the inferences that can be made from this calibration. However, the model's accurate ranking of growth rates and modest errors suggest that, if larger data sets can be obtained, this approach could be a useful part of a broader basis for comparing stand dynamics across the two forest types.

The results also provide evidence that the conceptual model of NE-TWIGS, presenting diameter growth as a function of tree basal area, site quality, and basal area/acre of larger trees, can be applied beyond the northeastern U.S. forests for which it was initially designed.

ASSESSING VERTEBRATE SPECIES RISK ASSOCIATED WITH INDUSTRIAL FOREST MANAGEMENT

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An important goal for sustainable forest management is the maintenance of healthy populations of indigenous wildlife species. Species risk assessments are an important tool in conserving wildlife populations, as ranking species by risk level allows managers to determine priority with regards to management actions.

A study is currently underway in New Brunswick, Canada, in which risk of extirpation is being assessed for a suite of forest-dependant terrestrial vertebrate species. The study area is the JD Irving, Ltd. Black Brook District; ca. 190,000 ha of industrial freehold that represents some of the most intensively managed forests in Canada. The objectives of the study are to provide a list of species potentially at risk in the study area and to catalogue areas where information is lacking; to examine how changes in landscape disturbance regimes have affected species persistence; and to analyze the effectiveness of our ranking framework for assessing species risk in management planning. Ultimately, this research will result in new information on management actions to improve vertebrate species persistence on industrial forest landscapes.

Species are being ranked by relative risk using a theoretical ranking matrix known as the Species-Sorting Algorithm (SSA) (Reed et al. 2001). The SSA is a categorical classification system that places each species into one of four risk categories based on the results of four ranking variables. The data used are a combination of spatial data (habitat availability, absolute abundance and connectivity) and reproductive output data (from published sources). Habitat use information has come from a variety of sources, including previous work by the New Brunswick Department of Natural Resources and Energy (NBDNRE) and a review of published information. Habitat development stages have been determined based on previous NBDNRE assessments and an analysis of provincial timber databases. In addition, a host of alternate life history, biological, and ecological characteristics have been collected for each of the 157 vertebrate species that are expected to occur on the landscape. Using multivariate statistics, these additional variables were analyzed to find those with greater predictive value than those in the initial ranking matrix. The addition of alternate ranking variables may increase the robustness of the model. The ranking scores for the existing four variables were assessed for possible changes based on a sensitivity analysis of the model (i.e. how much do we have to change the scores for the ranking variables before risk classification changes?).

The established ranking matrix will also be used to compare species risk across alternate landscapes. Landscapes that will be used to assess the biotic integrity of forest management activities include: 1) the 1946, pre-intensive management forest, derived from interpretation and digitizing of a set of 1946 aerial photos; 2) the present forest; 3) a hypothetical current forest based upon simulation of natural (but no anthropogenic) disturbances applied to the 1946 forest; and 4) the projected forest in year 2027, based upon actions planned under the current 25-year management plan.

EFFECTS OF PRECOMMERCIAL THINNING ON SMALL MAMMALS IN NORTHERN MAINE

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Silviculture is the dominant land-use practice in Maine and currently about 4% of the timberland is in high production silviculture, which includes precommercial thinning (PCT), plantations, and herbicide release. Greater than 146,000 acres of forest have been precommercially thinned in Maine since 1993. Small mammals are an important taxa to examine the effects of intensive forest management because they are both predators of invertebrates and prey for many avian and mammalian carnivores in Maine. In addition, small mammals may assist the revegetation of nonforested areas by dispersing spores of hypogeous fungi present in their feces. Habitat variables describing the structure of mature forest at both the stand scale and microhabitat scale have often been associated with high densities of small mammals. Thus, silvicultural practices that accelerate forest succession and reduce stand rotation, such as PCT, could produce favorable habitat conditions for species of small mammals that prefer the overstory and understory structural characteristics of mature forest. However, there is little relevant scientific evidence for the effects of intensive forest management on wildlife in Maine.

We investigated the effects of PCT, from 1-16 years since thinning, on small mammals and forest structure in seven townships in the commercial forests of northern Maine. We live-trapped small mammals on 24 PCT stands and 13 paired-control stands during June-August 2000 and 2001. During 2000 we captured 280 red-backed voles (*Clethrionomys gapperi*), 70 deer mice (*Peromyscus maniculatus*) and had 211 captures of short-tailed shrews (*Blarina brevicauda*) and masked shrews (*Sorex cinereus*). In 2001, trapping resulted in 320 individual red-backed voles, 277 deer mice and 574 captures of shrews. Additionally, we measured microhabitat characteristics of these stands to compare between PCT and non-PCT stands. Stands treated with PCT supported greater numbers of red-backed voles and shrews and numbers of deer mice were greater in older stands. This work and previous studies conducted in Maine indicate that the numbers of small mammals increase with stand age and that densities fluctuate between years. PCT, at scale of the forest stand, produces habitat with several structural attributes that are similar to mature forest. Therefore, this practice may produce habitat characteristics that enhance populations of red-backed voles and other species found in mid-seral forests.

EFFECTS OF PRECOMMERCIAL THINNING ON ABUNDANCE OF SNOWSHOE HARE IN NORTHERN MAINE

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Maine supports a diverse carnivore community and has the only verified population of Canada lynx (*Lynx canadensis*) east of Montana in the contiguous U.S.A. Understanding habitat relationships of snowshoe hare (*Lepus americanus*) is a prerequisite for evaluating effects of human activities on obligate forest carnivores. Recently, intensive forest management, including precommercial thinning (PCT), has been challenged in relation to indirect effects on Canada lynx; however, little research has been conducted on the effects of PCT on hare beyond four years post-treatment. PCT is a silvicultural technique that decreases stem density and may reduce densities of hare relative to unthinned, regenerating stands. Investigators have consistently related high densities and relative abundances of snowshoe hare to mid-successional habitats with high stem densities of saplings. Thus, a forest practice that decreases the density of regenerating forest stands and promotes rapid growth of crop trees may decrease densities of snowshoe hare.

The objectives of this study were to determine if PCT with brush-saws decreases abundances of snowshoe hare on herbicide treated clearcuts, from 1-11 years post-treatment. During 2000-2002, we investigated the effects of PCT on snowshoe hare, 1-11 years post-treatment, in 6 townships in the commercial forests of northern Maine. We established > 46 km of fecal pellet transects on 17 precommercially thinned stands and on 13 unthinned-control stands. Further, we live-trapped hare on a subset of stands to develop a predictive relationship between densities of pellets and absolute densities of hare at the stand-scale.

Hare pellet densities were linearly related to densities of hare from 0 – 3 hares/ha and to 31,000 pellets/ha/month. Pellet densities were approximately 2 times greater in control stands than stands treated with PCT during leaf-off season (October – April) and nearly 2.5 times greater during leaf-on season (May – September). The effects of thinning continued to reduce hare densities until at least 11 years post-treatment. Although regenerating clearcuts treated with PCT supported lower densities of snowshoe hare relative to unthinned-control stands, the magnitudes of these differences were less than those reported for alternative forest practices, such as partial harvesting. Effects of forestry practices on lynx need to be evaluated at the scale of the landscape to consider alternative forest management practices across the multitude of stands required to support a viable population.

DIAMETER-LIMIT VERSUS SELECTION CUTTING IN NORTHERN CONIFERS

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The northeastern United States has a history of exploitive timber harvesting, characterized by removal of the biggest and/or best trees without concern for residual stand condition. A renewed awareness of the need to preserve management options has refocused attention on the condition and potential of residual stands. However, long-term effects of repeated diameter-limit cuts are largely unknown. The Penobscot Experimental Forest in Maine is the site of a long-term USDA Forest Service experiment on even- and uneven-aged silviculture and exploitive cutting. Treatments, including fixed diameter-limit (FDL) and selection cutting, have been applied for 50 years.

Data suggest that FDL cutting has a degrading effect on stand condition. Relative to selection cutting, FDL removals resulted in diminished stand quality, poor control of residual stocking, and unfavorable shifts in species composition. Though regeneration stocking was similar, regeneration density was significantly less in FDL stands. Short-term volume removals and financial return were higher in FDL stands, but residual value was lower.

Radial growth rates of residual red spruce (*Picea rubens* Sarg.) trees in FDL stands were compared to those of trees in selection stands, using increment cores removed at breast height. Residual trees in the FDL stands were significantly slower growing than those in the selection stands, across all age classes. Even after release (harvesting), trees in the FDL stands had slower radial growth rates and remained smaller than trees released through selection cutting. These findings imply that fixed diameter-limit cutting results in residual stands of slower-growing, smaller, and potentially less valuable trees.

THE INFLUENCE OF INTER- AND INTRA-SPECIFIC COMPETITION ON GROWTH OF WHITE PINE, RED PINE, AND NORWAY SPRUCE

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Allocation of resources and growth patterns of individual trees are influenced by the degree of competitive influence immediately surrounding the tree. This research would examine the effects of inter- and intra-specific competition on the growth of red pine, white pine, and Norway spruce. These stands were all even-aged, and the competition comes from surrounding trees of similar age and from like and different species.

Fifty-nine trees from three sites across New York State were destructively sampled and 20 disks from each tree were removed. Basal area densities for the stands ranged from 110-280 ft^2. The d.b.h., azimuth, distance, and species of all competitors within a fifth-acre plot were recorded. Nested within this plot was a tenth-acre plot in which all competitors were cored. Crown measurements, including height and length of live crown, were also recorded. Two sample branches from each whorl were also measured.

Each disk was digitally scanned, and WinDendro software was used for tree ring analysis. This will allow each tree to be recreated in terms of volume, height, basal area and diameter. A polynomial growth equation was calculated for volume by tree and the relative growth rate equaled the derivative divided by the original equation. The relative growth rate value was averaged over the last fifteen years of life per tree. Surface area was also calculated, and a surface volume index was calculated per tree by dividing the derivative of the volume growth equation by the surface area. This was also averaged over the last fifteen years of each tree's life. The relative growth rate and SVI will be compared by species at varying levels of density, between pure and mixed stands, and at varying sites. The first null hypothesis tested will be that there is no difference at individual tree level in relative growth rate and surface volume index by species when comparing different levels of density between pure and mixed stands. ANOVA will be used to compare growth and to test for an interaction of species, density and composition. Early results from this "in progress" thesis will be presented.

HYDROLOGICAL CHARACTERISTICS AND LANDSCAPE SETTING OF BREEDING POOLS FOR WOOD FROGS AND SPOTTED SALAMANDERS

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Hydroperiod (i.e., water level fluctuations and seasonal drying patterns) has a strong influence on the faunal composition of wetlands. Wood frogs (*Rana sylvatica*) and spotted salamanders (*Ambystoma maculatum*) are thought to rely on seasonal wetlands (vernal pools) for greatest breeding success, but there is little documentation of their reliance on these habitats. Our objective was to identify what site and landscape characteristics are associated with high numbers of breeding individuals. We documented reproductive effort for wood frogs and spotted salamanders by counting egg masses in 21 wetlands in Acadia National Park in 2000 and 2001; for each of the species, we subsequently separated the sites into 3 categories of relative importance based on reproductive effort. We measured several site and landscape variables including water level fluctuations and drying day of all sites in both years. High numbers of wood frog egg masses were associated with six site and landscape variables ($P < 0.05$) that are all typical of seasonal wetlands that consistently dry early to mid-summer. Significant site variables include: primary productivity ($r = -0.59$), presence of an inlet ($r = -0.96$), presence of an outlet ($r = -0.99$), wetlands that contain unfrozen water in winter ($r = -0.94$); significant landscape variables include: sites that are separated from surface waters (Kruskal-Wallis $\chi^2 = 6.12$) and sites that are positioned on upper slopes (Kruskal-Wallis $\chi^2 = 7.21$). In contrast, high numbers of spotted salamander egg masses were associated only with site variables that are indicative of more permanent wetlands ($P < 0.05$); specifically, presence of an inlet ($r = 0.98$), presence of an outlet ($r = 0.99$), and wetlands that contain unfrozen water in winter ($r = 0.98$). Our results show that although wood frogs and spotted salamanders often breed in the same sites (3 of the 21 sites were classified as having high relative importance for both species), the relative order of importance of sites for the 2 species differs ($r_s = -0.16$, $P > 0.05$).

ROOT SYSTEM DEVELOPMENT IN THE NURSERY AFFECTS PERFORMANCE OF CONIFEROUS SEEDLINGS

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It is well known that nursery culture affects morphological and physiological characteristics of the planting stock. Interactions between nursery-related characteristics and those of the forest site are important determinants of the successful establishment and growth of planted trees. This presentation summarizes almost a decade of research on the effects of nursery culture on various aspects of post-planting performance of coniferous seedlings. Although the studies were made in western Canada, the results are applicable to eastern North America.

The strength of anchorage of *Pinus contorta* Dougl. planted from different types of nursery stock and of trees from natural regeneration was tested by pulling with a winch and determining turning moments required for destabilization and uprooting. A range of stock types, site conditions, and tree ages (11-21 years after planting) were included. Trees germinated in peat blocks and planted before the roots emerged from the growing medium were about 1.5 times harder to destabilize (but not to uproot) than those planted from hard-wall container stock. Hence, the lack of modification of root development by nursery culture coupled with wide spacing at planting produced best anchorage in pine. Naturally regenerated pine, if not thinned, was weakly anchored but spacing the stands strengthened the anchorage within a year after treatment. Bareroot pine was anchored equally or stronger (on only one site) than trees originated from hard-wall containers. Chemically pruned stock was more difficult to destabilize (but not to uproot) than non-chemically pruned stock from same-size hard-wall containers. Soil type influenced the anchorage more decisively than nursery culture did.

Seedlings from mechanical (box pruning) and chemical pruning were compared to non-pruned seedlings of similar characteristics (spacing in the nursery and, for the latter, the same container type) for *P. contorta* and *Picea glauca* (Moench) Voss. A series of trials on spruce included laboratory testing of hydraulic properties of root systems, performance and root system development after planting into 64 L boxes, and (also for pine) performance on a field site, as well as on forest sites. Briefly, mechanically pruned stock outperformed the other stock types, especially the non-chemically pruned hard-wall container stock, in virtually all trials. In pine, mechanical pruning almost completely eliminated post-planting root system deformities and stem zigzagging resulting from toppling while these conditions were common in the other stock types. In spruce, root systems were smallest at planting in mechanically pruned seedlings and their hydraulic conductivity (HC) was on average below those of the other stock types. However, 6-8 weeks after planting the HC of the mechanically pruned root systems increased dramatically despite little increase in root numbers, total root length, and surface area while HC changed little or declined in the other stock types even though their root systems considerably increased in size. There were also significant differences in the growth of roots in different soil substrates (organic or mineral) and in colonization by mycorrhizae-forming fungi in different types of spruce planting stock.

EXAMINING THE MACROECONOMIC FACTORS THAT AFFECT CLEARCUTTING IN CANADIAN FORESTS

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The practice of clearcut harvesting in forests has been a source of great controversy over the past few decades. While the economic and ecological effects of clearcutting is often debated, it is clear that this method of harvesting has become the most socially undesirable of all harvesting alternatives. Indeed, recent research in North America has found that the general public associates clearcutting with environmental degradation and would like to see it reduced.

The purpose of this study is not to enter into the clearcutting debate. Rather, the intent is to shed light on the driving forces behind the practice of clearcutting. More specifically, this paper investigates the manner in which various macroeconomic variables affect the annual forest area clearcut in Canada. The analysis is based on historical trends (1975-1999) of clearcut harvesting in five regions of Canada including British Columbia, Quebec, Ontario, the Prairies, and Atlantic Canada. Pooled (cross-section, time-series) regression analysis, using fixed and random-effects specifications, is employed.

Explanatory variables used in this study fall in line with previous academic literature that investigates macroeconomic-environment relationships. Specifically, it is hypothesized that per capita gross domestic product (GDP), population, and technology have significant impacts on annual area clearcut. Since previous empirical studies provide mixed evidence as to the direction of these macroeconomic impacts on other forms of environmental degradation, quadratic functional forms have been specified and tested.

Results of this investigation provide strong evidence that area clearcut tends to exhibit a U-shaped relationship with GDP/capita and population levels, and an inverted U-shaped relationship with technology over the past 25 years in Canada. The first two findings imply that, in a developed country context, higher levels of GDP/capita and population at first cause increased demand/pressure for reduced clearcutting. However, continued income and population growth is eventually associated with less concern (in the case of GDP/capita) and pressure (in the case of population) over clearcutting practices as timber consumption desires and needs become driving forces. Concerning the technology result, the inverted U-shaped relationship may imply that technological change has shifted from enhancing clearcutting practices to enhancing alternative harvesting techniques.

Elasticities have been calculated for the periods 1975, 1987, and 1999. Findings indicate that GDP/capita and population have tended to decrease forest area clearcut in Canada for each of these years. Technological change, on the other hand, has tended to have the opposite effect. Overall, these findings indicate that: (i) income grown has caused Canadians to become more concerned about the practice of clearcutting (albeit to a lesser degree every year); (ii) population growth tends to increase public awareness about the practice of clearcutting (again to a lesser degree every year); and (iii) technological advances have tended to favour the practice of clearcutting (once again to a lesser degree every year).

ASSESSING THE FEASIBILITY AND PROFITABILITY OF CUT-TO-LENGTH HARVESTS IN EASTERN HARDWOODS

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Cut-to-length (CTL) logging applications are becoming more popular in hardwood forests. CTL harvesting causes much less damage to the residual stand than conventional harvesting because logs and trees are not pulled through the stand and trees can be felled directionally. Because delimbing occurs in front of the harvester, limbs and slash are used as a mat upon which the machine travels. As a result, soil disturbance and compaction are minimized. Also, working conditions are safer with CTL versus conventional harvesting, and the CTL harvester holds an important advantage over the rubber-tired system in areas where there is a shortage of woods workers. The greatest disadvantage is that initial investments are higher for CTL harvesting than for the conventional operations that use chainsaws and cable skidders. Using data from our own field time and motion studies on small and large CTL machines operating in New England, Forest Inventory and Analysis (FIA) stand-level plot data from Vermont, New Hampshire, and Maine, and prices for delivered sawlogs and pulpwood for this region, we conducted a profitability assessment for CTL operations in Eastern hardwood forests. The FIA plots selected represent 5,242,142 acres. Of this total, it is profitable to log 4,531,247 (86.4%) and 4,000,986 (76.3%) acres with the small and large CTL systems, respectively. Delay-free results suggest that harvesting can be profitable with small CTL machines at a minimum tree size of 4.7 cubic feet (ft^3), and with large machines at a minimum tree size of 6.6 ft^3. Average tree diameter at breast height (d.b.h.) should be 6.5 and 6.8 inches for small and large CTL machines, respectively. Where a mix of sawlogs and pulpwood is being handled, an average mix of 971.57 ft^3 of sawlogs and 1,140.97 ft^3 of pulpwood is needed for the small machine to be profitable. For the large machine, an average mix of 1,051.09 ft^3 of sawlogs and 1,146.73 ft^3 of pulpwood is required for a profitable operation. Results suggest that a substantial amount of eastern hardwoods can be harvested profitably with CTL technology, and that profitability can be increased substantially if CTL machines are matched to the size of trees harvested. Small CTL should not be used in stands in which the average tree dbh exceeds 14 inches. CTL methods are highly effective in thinning operations to reduce levels of forest fuels. These results should be valuable to loggers, landowners, consultants, and hardwood sawmills and pulp and paper industry in the eastern United States.

USING ANALYSES OF NATURAL AND HUMAN-CAUSED FOREST DISTURBANCE ON THE J.D. IRVING LTD. BLACK BROOK DISTRICT TO INFORM FOREST AND BIODIVERSITY MANAGEMENT

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The concept of using natural disturbance regime as a guide for appropriate forest management has received increasing attention over the last decade. Information on the historic range of variability of natural disturbance can help forest managers to maintain structural and compositional patterns and regional mosaics of forests that are consistent with the natural disturbance regime. Such information can also help to select stand-level silvicultural treatments that are appropriate, given the natural disturbance regime, silvics of species, and stand dynamics. Maintaining regional forest type diversity and applying appropriate stand-level treatments reflect the essence of the coarse filter approach to maintaining biodiversity. The 190,000 ha J.D. Irving Ltd. Black Brook District in NB represents some the most intensively managed forest lands in Canada. Analyses were conducted to facilitate managing for biodiversity and timber management, based on a coarse-filter approach, using Black Brook as a case study. Natural disturbance regimes, primarily spruce budworm (*Choristoneura fumiferana* (Clem.)) and fire, were used to define guidelines for appropriate stand- and forest-level treatments. Scenario planning tools were used to quantitatively analyze forest landscape patterns under managed and natural disturbance conditions. A "pre-management" covertype inventory was established using photointerpretation and digitizing of 1946 aerial photographs for the entire landbase, and historical harvest and silviculture maps were digitized to obtain pre-1982 harvest and silviculture locations. We used modeling to project the current and simulated potential forests under alternative scenarios; analyzed management and disturbance effects on species composition, patch size, and age class distributions; and compared temporal and size distributions of past harvesting and silviculture with those potentially created by natural disturbances. Actual and projected landscapes were then assessed for the risk of extirpation of each vertebrate species, using a species sorting algorithm and spatially explicit landscape data.

BIOCHEMICAL AND PHYSIOLOGICAL MARKERS OF ENVIRONMENTAL STRESS IN FOREST TREES

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Forest trees are constantly exposed to various types of natural and anthropogenic stressors. The negative effects of acidic deposition on soil productivity due to the solubility of Al, leaching of nutrients, and possibly too much nitrogen from atmospheric deposition may take a long time to appear. This issue is of major concern to forestland managers because such processes may impact growth and productivity over large areas. A major long-term goal of our research is to develop a set of early physiological and biochemical markers of stress in trees before the appearance of visual symptoms of stress. The evaluation of apparently healthy trees is essential in developing risk assessment and stress remediation strategies for forest trees prior to the onset of obvious decline.

Our objective is to determine the usefulness of polyamines, particularly putrescine, and amino acids such as arginine, as foliar indicators of stress in visually asymptomatic trees. Specific stressors being investigated with these markers include perturbations in soil chemistry attributed to acidic deposition (nitrogen saturation, nutrient depletion, Al mobilization) and ice storm injury. Previous research from our group established the relationship of putrescine in red spruce foliage with increasing Al and declining nutrients, especially Ca, in forest soil. A correlation between foliar putrescine and high nitrogen deposition in the form of ammonium nitrate was also seen in spruce, pine, maple, yellow birch, and oak trees at Harvard Forest, MA, Hubbard Brook Experimental Forest, NH, and Big Moose and Delaware River Basin, NY, USA. Putrescine has also been used successfully as a marker of stress remediation in sugar maple stands in PA.

Besides the negative effects of acidic deposition on productivity through Al solubilization, there is also an increasing concern about the potential adverse effects of elevated rates of N deposition caused by acidic deposition on water quality and the health of ecosystems. This concern stems from the fact that in 1990, the United States Clean Air Act targeted a 50% reduction in S deposition but only a 10% reduction in N. Although most temperate forests are N limited, continuous deposition of N from the atmosphere can move them towards nitrogen saturation. Nitrogen saturation may have negative impact on growth through major changes in carbon and nitrogen metabolism e.g. sequestration of nitrogen compounds in leaves and lower photosynthetic rates. Preliminary data from our laboratory shows that the amino acid arginine increases several fold in response to high nitrogen input, and could thus be used as a specific marker of excess nitrogen inputs in otherwise nitrogen limited forest soils.

In recent years our ongoing research partnership has expanded to include researchers from several northeastern states, universities, and federal agencies in the US and other countries such as Korea, Japan, and India. The unique feature of this interdisciplinary effort is that this type of physiological research receives added value through the context provided by cooperating ecologists, pathologists, and hydrologists as well as by providing the links between tree function and environmental disturbance.

EFFECTS OF SHELTERWOOD CUTTING ON REGENERATION, WEED CONTROL AND GROWTH OF RESIDUALS IN A FIR-SPRUCE SOFTWOOD STAND: 9-YEAR RESULTS

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The aim of this "pioneer" study is to develop an alternative to clear cutting for mixed conifer stands in Eastern Canada. The shelterwood method is a regeneration cut that allows, through the removal of the old crop in two or more successive fellings, the establishment of a desired natural regeneration. As it provides both seed and protection, the shelterwood method also promotes biodiversity and allows a better weed control by attenuating the light that reaches the understory (alternative to the use of chemicals). The openings created by the partial cuts combined with the scarification of the soil will also encourage the establishment of a spruce regeneration.

The objectives are:

1. Quantify the effect of a shelterwood cut on the density and the development of the regeneration
2. Determine the effect of the shelterwood cut on the weed competition
3. Assess the effect of scarification on the regeneration (in terms of quantity and quality)
4. Establish a relation between seed availability and viable seedlings production
5. Validate the shelterwood method in Eastern Canada

The study area was designed in 1992 in a natural 55-year old fir-spruce stand, in St-Anne (NB), more precisely in the Forêt Expérimentale of the Faculté de Foresterie. It has nine main plots (1600 m²), all established according a randomized complete design with three replicates. The treatment applied was a seeding cut of different intensities: control (0 %), low (-20% of the basal area) and high (-35% of the basal area). To evaluate the regeneration, each plot was subdivided into nine systematically located paired sub-plots. Within each pair, one was randomly assigned to a soil scarification while the other was kept as a control. In 2002, nine screen-bottomed wooden seedtraps (900 cm²) were installed next to each cluster of subplots. Traps content is collected weekly during seedfall from mid-August to December. In each plot, measurements, such as height, annual growth, and root collar diameter, were also taken to assess the vigour of fir seedlings, which were previously classified as tall or average.

A secondary felling will be performed in 2002. Data processing is ongoing. A few preliminary results will be presented.

OLD-GROWTH FORESTS AS RESERVOIRS OF GENETIC DIVERSITY AND REPRODUCTIVE FITNESS

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In response to public concern, the Canadian Forest Service organized a national symposium in 2001 to discuss the issue of old-growth forests from a science perspective. The objectives were to bring together Canadian expertise on old-growth forests : (i) to define old growth within the main forest regions of Canada, (ii) to understand its biological complexities and potential ecological roles, and (iii) to discuss management and restoration experiences and options. Although old-growth forests have been valued primarily as habitat for forest-dependent wildlife, recent research on old-growth forests in eastern Canada suggests that, as tree populations age, they tend to increase in genetic diversity and reproductive fitness. Therefore, old-growth forests may serve as natural reservoirs of genetic diversity and reproductive fitness for the constituent tree species. This has important implications for the dispersal and adaptation of trees across increasingly fragmented forest landscapes subject to anticipated rapid climatic changes and the introduction of new pest and disease problems. The negative relationship detected between average tree height and percent monomorphic loci, and strong positive correlations between tree height and (i) percentage of polymorphic loci, (ii) measures of allelic richness, and (iii) observed heterozygosity, indicate strong relationships between growth performance (a fitness trait) and measures of genetic diversity in red spruce. The negative relationship between height growth and the proportion of rare alleles suggests that these rare alleles may be deleterious to growth performance; whereas latent genetic potential showed a significant and positive relationship with height. Age was not correlated to average stand (population) height but was correlated to seedling progeny height growth. In late-successional species, such as red spruce, age and size (e.g., height and stem diameter) relationships may be strongly influenced by local stand disturbance dynamics that determine light availability, growing space, etc. In larger, older stands, age appeared to provide a good surrogate measure or indicator for genetic diversity and progeny growth performance. However, in smaller, more isolated populations, these age and fitness relationships may be strongly influenced by the effects of inbreeding depression and genetic drift. Old-growth forests can represent superior seed sources, but only if they are of sufficient size and stem density to avoid the deleterious effects of inbreeding and genetic drift. Nevertheless, these older populations of trees may have an important function in maintaining the adaptive potential of tree species. Their conservation and protection should be of wide general interest to the forest sector.

EFFECTS OF THE PLANER KNIFE JOINTING ON THE SECONDARY WOOD MANUFACTURING

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The knife peripheral planer is the most common machine in wood industries served to plane the wood surface. This machine removes single chips from workpiece by the intermittent engagement of knives, mounted on the periphery of a rotating cutter-head. The final step during installation of knives on the cutter-head is the jointing operation. An abrasive stone is passed across a rotating cutter-head and lightly touching all knives. Any knife with longer out extending would be grounded back in order to have a common cutting circle for all knives. Thus each knife will take a chip to equal depth. The jointed land at the cutting edge have a 0 degree clearance angle, but becomes negative due to the workpiece motion as well as to the cutting edge wear. It was presumed that due to the jointing operation the superficial layer of the planed board would be crushed and demolished, which alter its quality and performance at service. Four jointing land widths were considered to evaluate its influence on three species.

The results confirmed that depend on the anatomical feature of the given wood specimens, a wider jointed land would alter the surface quality up to different degree, in terms of the glueline shear strength performance. The effect of the jointing was magnified when the moisture content of the samples were fluctuated.

PROJECTED RESPONSE OF SPRUCE-FIR STANDS TO COMMERCIAL THINNING IN MAINE

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Commercial thinning has been identified as a top silvicultural research priority by public and private landowners in Maine. Since there are few long-term commercial thinning studies for the northeastern United States, commercial thinning data are incomplete for the region. To address this research need, the Cooperative Forestry Research Unit (CFRU) established a Commercial Thinning Research Network in 2001. Growth and development of spruce-fir stands following the application of various commercial thinning prescriptions are being projected on sites across the state of Maine.

Four sites are used in this analysis. A 2 × 3 factorial design with one untreated check was installed on each site using randomized complete block design. Seven 0.92 acre (200 × 200 feet) treatment plots were established at each site with a 0.02-acre measurement plot (100 × 87.12 feet) centered within each treatment plot. Treatment plots had the relative density reduced by 33% or 50% using dominant, crown, or low thinning methods. Species, DBH, and total height were recorded for all tree species within the treatment plot.

Forest Vegetation Simulator (FVS) was used for all stand projections. Species, DBH, total height, and number of stems were used from the stand list file (.slf) generated by FVS and became the basis for all volume calculations. Total and merchantable volumes were generated by a volume code written using SAS. The volume code is based on Honer's volume equations and calculates total volume, pulpwood volume, and sawlog volume based on user defined merchantability standards. In this study, merchantable limits for pulpwood were 4"-2" top and 7.6"-6" top for sawlogs. Stumpage prices from the Maine Forest Service (2000) were used to calculate market values of all harvested wood.

In general, commercial thinning increased the NPV with maximum NPV occurring ten to twenty years from date of thinning. Low thinning treatments and their unthinned controls had similar NPV's making low thinning treatments less profitable over the projection period. Dominant thinning treatments consistently extended the biological rotation age whereas crown and low thinning varied. Dominant and crown thinnings tend to be most profitable over the projection period since thinning revenues for these treatments are usually greatest.

IDENTIFYING PHYSICAL FACTORS IMPORTANT TO MODELING SOIL EROSION VULNERABILITY OF FORESTED AREAS IN MAINE USING THE DELPHI TECHNIQUE

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The Dictionary of Forestry defines the Delphi method as "an iterative technique designed to obtain a consensus among experts concerning the best course of action or what is likely to happen under a specified scenario". It also defines an expert system as "a program that expresses a domain of human expertise as a set of rules". The Delphi method can be viewed as an expert system used to reach consensus among experts on a defined problem. In this study, the technique was used to identify physical factors important to modeling soil erosion vulnerability in Maine forests.

The Delphi method identifies a group of people considered experts in the field of the problem addressed. The experts are then asked to participate in a structured survey where a questionnaire is sent to all participants. Responses from this survey are compiled and sent back to the experts. They then have a chance to modify their original response. This process is continued until consensus is reached, usually in three or four rounds. A strength of the technique is that participants do not know the identity of other participants. This deters more outspoken members of the group from influencing the opinions of others.

Twelve experts were identified and agreed to participate in the process. The experts have completed two rounds and a third round is expected to complete the process. The first round asked participants to envision that they were pre-planning a timber harvest on a site in Maine with no surface water and on a site with surface water. They were then asked to list and rate the seven most important factors that should be considered when evaluating the vulnerability of the forested sites to logging induced erosion. Twenty-five different factors were identified as important to soil erosion vulnerability on sites without surface water and twenty-eight factors were identified for sites with surface water present. The most important factor for either type of site was slope. Top factors for sites without water include soil erodibility, soil moisture, soil drainage and season of harvest. Top factors for sites with surface water include harvest layout, distance to water, soil erodibility, and soil drainage, suggesting the importance of harvest planning for these sites.

HERBACEOUS LAYER COMPOSITION IN A FORESTED WATERSHED: IMPLICATIONS FOR FOREST MANAGEMENT

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Watershed-level vegetation studies provide insights into ecosystem function and provide the basis for designing ecologically based forest management, although few studies have focused on this intermediate scale. Our objective was to examine the variation in species composition in the herbaceous layer within a small forested watershed (ca. 56 ha) in relation to: 1) environmental variables at the individual plot ($5m^2$) scale, and 2) position within the watershed.

The study area is located in southeastern New Brunswick, Canada. Forest cover varied from red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*) stands near the stream to trembling aspen (*Populus tremuloides*), red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), and other hardwoods near the ridgetops. Stands were mature (ca. 90 yrs) at the time of sampling and originated from cutting and/or fire.

A total of 167 circular plots ($5m^2$) were placed 50m apart on transects running from the stream edge upslope to the ridgetops throughout the watershed. Percent cover was estimated for each species in the herbaceous layer (all vascular plants $\leq$ 1m tall). Environmental variables were measured at each plot, including canopy and litter composition (coniferous, deciduous), litter depth, microtopography (pit, mound, flat), topography (slope, aspect, position), litter chemistry (pH, K, Ca, Mg, P, N, C, C/N ratio), and leaf tissue chemistry (K, Ca, Mg, P, N) of false lily-of-the-valley (*Maianthemum canadense*). Detrended correspondence analysis (DCA) was conducted on species cover data to characterize vegetation variation and canonical correspondence analysis (CCA) was used to identify relationships between species composition and environment.

There was complete turnover in species composition along the first DCA axis, owing primarily to the unique composition of one portion of the watershed located in a wet seepage. The ordination separated plots under deciduous canopy from those under coniferous canopy. Plots under deciduous canopy had shallower litter, higher soil pH, and lower soil organic matter than plots under coniferous canopy. CCA indicated that the vegetation pattern was most strongly related to canopy and litter composition. Coniferous stands and species which are common under a coniferous canopy (i.e., *Gaultheria hispidula*, *Coptis trifolia*, and seedlings of *Abies* and *Picea* species) occurred near the stream whereas deciduous stands and species common under a deciduous canopy (i.e., *Pyrola* spp., *Aralia nudicaulis*, *Medeola virginiana*, and *Chimaphila umbellata*) were found on the upper slopes.

The small watershed is a convenient unit for studying vegetation variation among adjacent communities and underlying causal factors. Information at this intermediate scale is needed in forest management planning to identify unique communities and habitats for protection or special treatment. The high degree of variation in herbaceous-layer composition in relation to topography and canopy characteristics, even at the scale of the small watershed, should be taken into account in forest management planning.

EFFECT OF PRECOMMERCIAL THINNING ON BALSAM FIR RESISTANCE TO WINDTHROW

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Balsam fir often regenerates naturally in overstocked stands. Precommercial thinning is a common practice used to reduce stand density and increase diameter growth. This treatment can also be used to promote commercial thinning opportunities through an increase in average diameter at a given age and an increase in resistance to windthrow. The study presented here focuses on the effect of precommercial thinning on root system characteristics and on resistance to uprooting or stem breakage.

Two thinned and two unthinned balsam fir stands were selected at Forêt Montmorency, 75 km north of Quebec City. Five trees in each stand were selected for root system measurements including size, orientation and form of roots with a diameter greater than 2 cm. Ten trees in each stand were selected to relate stem biomass to the critical turning moment for uprooting. Crown characteristics were also measured to translate critical turning moments into critical wind speeds.

Thinning induced a faster response at the root level in comparison with that measured in the stem. However, root response did not occur uniformly. It was greater in the upper part of the root. Both treated and control stands tended to develop T-beam shapes over time. Thinning did not produce an asymmetrical distribution of root cross-sectional area for any of the stands sampled.

The relationship between the critical turning moment for overturning and stem biomass was not influenced by thinning. However, some crown characteristics were modified by the treatment. Simulations of critical wind speeds suggest a modest increase in critical wind speed for precommercially thinned stands.

DEVELOPING METRICS FOR 3-DIMENSIONAL FOREST STAND STRUCTURE: A TEST OF THE STAND COMPLEXITY INDEX HYPOTHESIS

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Over the past 10-15 years technologies have advanced enough to make measurement and analysis of three-dimensional (3D) patterns of forest stand structure feasible. Unfortunately, there still is no unified definition of forest stand structure, let alone an accepted set of metrics to measure it. For example, some authors have included distribution and volumes of coarse woody debris, species composition, and canopy height, as components of forest stand structure. This broad definition, we feel, has lead to some confusion and a general lack of a coherent theories describing stand structural development outside of even-aged stands.

For this presentation, I will define forest stand structure as "the physical arrangement of stems and canopies of living trees within a stand, regardless of species composition." Using this definition, forest stand structure is a subcomponent of forest stand complexity, which includes the other components listed above. Using the narrowed definition, I tested the Zenner (2000. Ecol. Appl., 10: 800-810) Stand Complexity Index (SCI) hypothesis with both simulated data and data from USFS managed stands at the Penobscot Experimental Forest in Bradley, ME.

SCI incorporates spatial pattern of stems along with one (or more) size variables associated with each tree (Figure 1). A higher SCI is supposed to indicate a much more diverse stand structure. Simulations showed that SCI was particularly sensitive to stem density and the size ranges of the component trees. Field data confirmed this observation. Clear-cut plots had consistently higher SCI than control or 5-year selection cuts, even though both control and 5-year selection cuts had "more desirable" structural characteristics.

Even though SCI has proven to be inadequate for capturing 3D structure, it still has potential with some modifications. Work is ongoing to describe the metric's underlying distribution and create a relative SCI that incorporates density and size effects. We feel that future work with structural metrics needs to incorporate both computer and field testing.

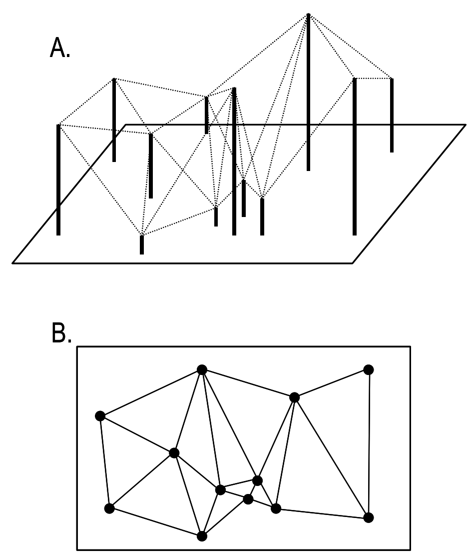

Figure 1. Diagrammatic representation of a 3D triangulated irregular network (TIN) using tree heights as the vertical *z* value on a stem-mapped plot (A) and the corresponding 2D TIN of the same plot (B). The ratio of the sum of surface areas of the TIN in (A) to the TIN in (B) is the SCI (for height in this case).

MOSS DISTRIBUTIONS IN INDUSTRIAL AND OLD-GROWTH FORESTS IN MAINE

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Increased demand for wood has led to rapid removal and fragmentation of old growth forests. The effects of different silvicultural practices on biodiversity are unknown for most taxa. For the past four years we have investigated the effects of forestry practices and forest structure on moss distributions in northern Maine. We surveyed 14 habitat treatments within a 200 km^2 industrial forest, from mature forest through clearcuts. We also evaluated riparian and upland buffer strips because they are common conservation treatments. For comparison, we surveyed forest sites dominated by conifers and by deciduous species within a 2400-ha old-growth forest, that has never been commercially cut. Our objectives for this study were to (1) establish a sampling protocol for mosses in a forested landscape, (2) create a species list for each harvest stage or forest treatment, (3) compare species distributions among managed and old-growth habitats, and (4) identify potential old-growth specialists.

Species presence, abundance, and substrate occupancy were recorded within replicated plots for each habitat treatment. By assessing species-area relationships in plots from 1m^2 to 80 m^2, we found that a 50-m^2 plot was suitable for assessing moss diversity in these habitats. Using this sampling protocol, we then compared species richness and determined moss community composition among the various replicated forest treatments.

Moss species richness differed significantly among harvest treatments and age classes (ANOVA, df = 15; $R^2 = 0.79$, $p < 0.0001$). Old-growth mixed-wood and mature deciduous sites had the greatest mean number of species ($\bar{x}$ = 30 and 29 species respectively) while non-herbicided clearcuts had the lowest ($\bar{x}$ = 13.33 species). Moss community composition differed between the areas sampled in the old-growth forest and all treatments sampled in the industrial forest. In addition, moss community overlap among the industrial forest harvest treatments was limited. Our results include finding significant differences between old-growth forest and mature forest in the industrial sites. This pattern is apparently driven by moss species found only in old-growth forest and by the disturbance-specialist species found in the mature industrial forest. We also found a surprising degree of similarity between clearcut and young plantation sites. Upland buffer strips and intact forest had a similar moss community to one another while riparian buffer strips were missing stream specialists present in their respective interior control plots.

We found that approximately 40% of the species encountered were substrate specialists, with a greater number of these found in the old-growth forest. In addition, moss community composition varied by substrate type, with the tree boles and a combination of coarse woody debris and soil being particularly different from other substrate types.

Understanding the impacts of forestry practices on local biodiversity has become an important issue with increased concern over species loss from fragmented habitats. Our results will be useful for comparing the potential impacts of alternative tree-harvest strategies on the local moss communities.

VEGETATION DIVERSITY IN NATURAL GAPS, HARVESTED GAPS, AND CLOSED CANOPY IN THE ACADIAN FOREST, MAINE

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Minor disturbances creating canopy gaps are characteristic of the Acadian forest type with a 1% frequency rate per year (Runkle 1981). The Forest Ecosystem Research Program (FERP) at the University of Maine is testing an expanding-gap shelterwood silvicultural system that uses a 1% disturbance frequency. Natural disturbances creating canopy gaps are important to the structural and biological diversity of a forest ecosystem, and the regeneration of commercially valuable tree species in forest stands may be dependent on the occurrence of canopy gaps (Seymour et al. 2002).

The objective of this study was to compare vegetation dynamics among and within harvested gaps (from 0.02 to 0.2 ha in size), natural gaps, and under a closed canopy on FERP research plots. We examined the influence of gap characteristics on patterns of vegetation composition, abundance, and diversity. Gap characteristics examined include gap size, canopy openness, gap origin, location within the gap, and pre-harvest composition. On nine treatment plots (each about 10 ha in size), we evaluated 45 harvested gaps, 23 natural gaps, and 23 non-gaps. All vegetation data was collected four growing seasons after harvest. Vegetation was identified to the species and measured by percent cover within $4m^2$ quadrats located every 2 m along a north/south transect within each gap.

Species abundance was 80% greater in gaps than under closed canopy transects ($p < 0.0001$), and abundance was greater in harvested gaps than natural gaps ($p=0.0048$). Species abundance was positively correlated, but weakly, to increasing canopy openness measured by leaf area index ($r^2=0.363$, $p=0.00$). Diversity (as measured by the Shannon-Weiner index) differed among harvested gaps, natural gaps, and closed canopy ($p=0.000$), and species richness (average number of species per gap) differed among all gap types and closed canopy ($p<0.0001$).

Harvested gaps contained 113 more species than natural gaps or closed canopy, and *Rubus* species were the most important of all species present only in harvested gaps. Natural gaps contained 16 species that were not present in harvested gaps or closed canopy, and non-gaps contained four species not present in harvested gaps or natural gaps. Overall, *Abies balsamea*, *Acer rubrum*, *Tsuga canadensis*, and *Aralia nudicaulis* were the four most important species for all gaps and closed canopy. Harvested gaps had the greatest number of regenerating tree stems for all height classes, and closed canopy transects had the least number of tree stems for all height classes, but the average number of stems per hectare was independent of gap origin or closed canopy ($p=0.1516$).

Runkle, J.R. 1981. *Ecology* 62: 1041-1051
Seymour, R.S., White, A.S., and deMaynadier, P.G. 2002. *For Ecol Man*. 155: 357

EFFECT OF AGE ON GROWTH OF RED SPRUCE AND EASTERN HEMLOCK IN MULTI-AGED STANDS

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Well-known patterns in the fundamental relationship between tree-level stemwood volume increment (VINC) and projected leaf area (PLA) are examined and quantified for eastern hemlock (*Tsuga canadensis* (L.) Carr.) and red spruce (*Picea rubens* Sarg.) in managed, mixed-species, multi-aged stands in east-central Maine. Both species follow a sigmoid pattern, suggesting a peak growth efficiency (GE, stemwood volume growth per unit of PLA) in mid- to upper-canopy trees with PLAs of less than half that of the largest trees sampled. Tree age negatively influenced the VINC:PLA relationship in the expected manner: at a given PLA, older trees produce less stemwood than younger ones. The combined effect of leaf area and age is accurately modeled with a Weibull-like function in which the asymptote is an index of tree maturity defined as tree age relative to an estimated maximum for the species.

Though previous studies have independently documented both the sigmoid relationship between VINC and PLA and the negative effect of age, their conclusions have been confounded by the strong correlation between age and mean tree PLA. This study addresses both issues simultaneously, and is the first to demonstrate a decline in GE with age independent from the effect of increasing PLA. The important implication of this work is that the longer trees spend in suppressed understory positions, the less growth efficient they will be when they reach the canopy. This contradicts the long-held belief that tree size serves as well as age when managing multi-aged stands of shade-tolerant species.

FOREST SOIL N DYNAMICS AT A PAIRED WATERSHED EXPERIMENT IN MAINE

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Nitrogen is commonly thought of as the most limiting nutrient to plant growth, yet elevated N deposition can result in N accumulating in excess of biotic demand, a condition known as "N Saturation." Excess N can perturb soil microbial N transformations and may cause initial increases in net N mineralization rates followed by decreases in net N mineralization with concomitant increases in net nitrification. Along with increases in net nitrification and N loss, N saturation is often associated with a loss of forest productivity. Understanding nitrogen dynamics in soil under enhanced N deposition is key to predicting future forest health. We studied forest floor and mineral soils at the Bear Brook Watershed in Maine (BBWM), a paired watershed experiment with one watershed serving as a reference and another treated with $(NH_4)_2SO_4$. We used both lab incubations and *in situ* measurements to evaluate net N mineralization and net nitrification in both watershed soils. Significantly higher net N mineralization and net nitrification rates were observed in the treated watershed by both methods. For example *in situ* net N mineralization was 4.25 mg kg^{-1} day^{-1} in the treated watershed compared to 3.00 mg kg^{-1} day^{-1} in the reference watershed. Soil under differing dominant forest types present in these watersheds resulted in different N cycling rates and different response to long-term N fertilization: hardwoods had higher N mineralization rates in the O horizons, however softwoods had higher rates in the mineral soils. Despite different N cycling rates, influenced by forest cover and treatment, input-output estimates suggested ~80% N retention in treated watershed, despite the long-term N amendments to this watershed, and ~96% N retention in the reference watershed.

EFFECTS OF HARVESTED CANOPY GAPS ON FOREST AMPHIBIANS

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Amphibians, a significant component of forest systems, are often studied in forest ecology and management projects due to characteristics that render them sensitive to disturbance. Amphibians are in constant contact with the forest floor, relying on cool moist habitat for respiration and thus harvesting can have a negative impact on amphibian populations by altering forest floor microhabitats. However, harvests that leave structure, such as down woody material and standing trees, may reduce negative effects of canopy removal on amphibian populations. In the Penobscot Experimental Forest of central Maine, canopy gaps have been created as part of a long-term research project to better understand the ecological effects of canopy removal. Our objectives are 1) to compare relative abundance of forest amphibians among artificial and natural canopy gaps and contiguous, closed-canopy forest, and 2) to compare relative abundance of forest amphibians within artificial and natural canopy gaps to determine if gap aspect influences distribution.

We sampled forest amphibians in 44 harvested gaps, 19 natural gaps, and 36 full-canopy plots using 3-m straight-fence pitfall arrays. Pitfall arrays measure relative rates of surface activity, an indication of how suitable the surface is for foraging and mating. Each sample plot (harvested gap, natural gap, full-canopy) had a pitfall array located 5 m south of the plot center, at center, and 5 m north of the center. Captures from these pitfall arrays were pooled to compare relative amphibian abundance among treatments. Seven natural gaps and 23 harvested gaps had pitfall arrays positioned every 5 m along the entire north-south transect of the gap to study gap aspect. Our results reflect captures caught between 10 May and 26 July 2002 of the first field season.

Three of the 4 species reported to be sensitive to canopy removal, the redback salamander (*Plethodon cinereus*), wood frog (*Rana sylvatica*), and blue-spotted salamander (*Ambystoma laterale*) only accounted for 12.3% of all captures. The fourth sensitive species, spotted salamanders (*Ambystoma maculatum*), green frogs (*Rana clamitans*), and eastern newts (*Notophthalmus viridescens*) accounted for 21%, 33.2%, and 21.4% respectively of all captures. Initial results comparing captures per 100 trap nights for each species indicate that amphibians in gaps are active in numbers similar to those of nearby full-canopy sites. There also appears to be no distinct pattern in amphibian captures between the north and south aspects within gaps. Further sampling during the fall of 2002 and spring and fall of 2003 may clarify possible underlying trends that were not detected thus far.

CURRENT STATUS OF EASTERN WHITE PINE (*Pinus strobus* L.) IN KOUCHIBOUGUAC NATIONAL PARK

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Since generalizations from one region or tree species to another may be misleading in forest management discussions, a research study was initiated by Parks Canada and the Canada Forest Service to determine the status of eastern white pine (*Pinus strobus* L.) in Kouchibouguac National Park. The purpose of this research study was to determine the status of eastern white pine stands in relation to potential regeneration and successional processes. Tree, regeneration, and site measurements were recorded in nine representative stands of eastern white pine. From historical records pertaining to the Acadian Forest Region, observed existing forest patterns from other areas of the Acadian Forest Region, and from the results of this research study, the following was determined:

a) At first the eastern white pine regeneration appears to be satisfactory for the development of future eastern white pine stands in the Kouchibouguac National Park;

b) In reality, the present eastern white pine stands will gradually disappear and the species will become less pronounced on the landscape; and

c) Without the development of silvicultural and /or forest restoration techniques that address the current minimal seedbed conditions, minimal light conditions, and an overabundance of competitors in the understory, the present eastern white pine stands will gradually disappear and the species will become less pronounced on the landscape.

EVIDENCE OF Ca DEPLETION IN FOREST SOILS AT BEAR BROOK WATERSHED IN MAINE (BBWM)

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Deposition of sulfates and nitrates in northeastern North America has resulted in continuing concerns over base cation depletion in forest soils. Increased deposition threatens not only soil productivity and tree health, but also water quality and fauna. The Bear Brook Watershed in Maine (BBWM) is a long-term paired watershed study aimed at examining the effects of atmospheric nitrogen and sulfur deposition on whole ecosystem processes. Since 1989 BBWM has been treated with ~4 X ambient N and ~3 X ambient S. Quantitative soil excavations and analyses indicated differential effects of forest type and soil horizon on base cation depletion. Soil solutions were sampled in the treated and reference watersheds during 2001-2002 using tension lysimeters and ion-exchange resins. The experimental design allowed us to evaluate watershed, forest type and soil horizon influences upon soil solution chemistry. In hardwood stands, soil solution base cation concentrations decreased with depth in the reference watershed but increased with depth in the treated watershed. In contrast, softwood stands in both treated and reference watersheds showed increased base cation concentrations with depth (X 1.3 and 2 increases, respectively). Of the base cations, Ca was dominant and also showed the greatest response to forest type and treatment. Solution Al concentrations were inversely correlated to Ca concentrations.

ROOTING DIFFERENCES BETWEEN RED SPRUCE AND BALSAM FIR

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There are many similarities between red spruce and balsam fir; the term "spruce-fir" is often used as if they were a single species. It is often assumed that spruce and fir have similar root systems. However, results from this study show that their root characteristics are very different in some aspects, including root biomass, root length, root size proportion and root structures.

Forty red spruce and forty balsam fir root systems (roots ≥ 1.0 cm in diameter) were excavated by hand in 30-year-old spruce-fir stands in 8 plots of two sites at the Penobscot Experimental Forest. Half of the plots were located in the stands that were precommercially thinned (PCT) 18 years earlier, and half of them were located in untreated stands. Roots were cut off to a single root section without any branching. Roots were classified into one of four root structure classes according to their structural positions: sinker, oblique, deep and surface roots. Roots in each structure class were further grouped into three different diameter classes: small (1-2 cm), middle (2-5 cm) and large roots (≥ 5 cm). All root sections were measured by biomass (dry weight) and root length.

Above-ground characteristics of red spruce and balsam fir (such as age, DBH, height, above-ground weight and stem ring growth) were shown to be different. Some of those tree characters may not show species differences in Unthinned (UT) stands, but all of them show species differences in PCT stands. PCT treatment generally has a greater influence on balsam fir development than on red spruce development.

For the total root amount, red spruce has less root biomass and root length than balsam fir in PCT stands. In UT stands, no species differences of root biomass were found, but there were differences in root length. For large roots, there were no species differences in biomass and length both in PCT and UT stands. However, the large root proportion of red spruce is significantly higher than that of balsam fir, both for biomass proportion and length proportion. For small and middle size roots, there were significant differences in biomass and length, both in PCT and UT stands. Small root proportion of red spruce is smaller than that of balsam fir, both in biomass proportion and length proportion. Middle size root proportion only shows species differences in length. Surface roots only show species differences in root length in PCT stands. Sinker roots, oblique roots and deep roots show species differences in biomass and length both in PCT and UT stands. Surface root proportion of red spruce is much larger than that of balsam fir, but sinker root, oblique root and deep root proportions of red spruce are much smaller than those of balsam fir. Root radial growth is similar for both species without PCT treatment. However, balsam fir roots respond to PCT treatment to a greater degree than red spruce.

AVIAN RESPONSE TO REMOVAL OF A FOREST DOMINANT: CONSEQUENCES OF HEMLOCK WOOLLY ADELGID INFESTATIONS

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The hemlock woolly adelgid (HWA; *Adelges tsugae Annand*), an introduced aphid-like insect from Japan, poses an important and immediate threat to the health of eastern hemlock (*Tsuga canadensis*). It has spread rapidly to the Northeast, being first reported in Connecticut in 1985 and now dispersed to every town in the state. Hemlock stands support moderate levels of avian diversity, including several species that are largely restricted to hemlock stands in the region. We studied changes in bird species composition associated with the decline and loss of hemlock resulting from chronic HWA infestations.

The study was conducted within a 4900-km^2 region in central Connecticut during the breeding seasons of 2000 and 2001. Bird surveys, using 10-minute, 50-m radius point counts, were conducted at 40 points in 12 hemlock stands varying in HWA infestation and overstory mortality levels. We found that overstory hemlock mortality was highly correlated with avian community composition.

Black-throated green warbler (*Dendroica virens*), Acadian flycatcher (*Empidonax virescens*), blackburnian warbler (*Dendroica fusca*), and hermit thrush (*Catharus guttatus*) were strongly associated with intact hemlock stands that exhibited little or no mortality from HWA. Abundance of eastern wood-pewee (*Contopus virens*), brown-headed cowbird (*Molothrus ater*), tufted titmouse (*Baeolophus bicolor*), white-breasted nuthatch (*Sitta carolinensis*), red-eyed vireo (*Vireo olivaceus*), hooded warbler (*Wilsonia citrina*), and several woodpecker species was highest at points with >60% mortality.

Eastern hemlock has unique structural characteristics that provide important habitat for numerous bird species in the northeastern U.S. As a result, removal of hemlock by HWA has profound effects on avian communities. Our data suggest that numerous species are affected positively or negatively by loss of hemlock due to HWA, and a few species are at risk of range retractions or local extinctions. We need additional studies of avian habitat use in hemlock forests across broader geographic regions, as well as long-term studies of bird productivity over the course of HWA infestation and accruing hemlock mortality.

A MODEL OF A RED OAK USING LINDENMAYER SYSTEMS

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The purpose of this paper is to describe a model of a red oak tree (*Quercus rubra*). This model will capture the architecture of a red oak tree through a mathematical formalism, the Lindenmayer system (L-system). L-systems are based on repeating patterns and recursively reproduces them. In the case of a red oak, the repeating pattern can be seen as the branches being smaller versions of the stem, smaller branches being smaller versions of the branch they are attached to, and so forth. Repeating patterns in a red oak will be identified and simulated with an L-system. Such a repeating pattern is referred to as a L-system module. In each L-system module, parameters such as growth equations and branching angles will be determined. These parameters will need to take on values and will guide how data is to be collected.

BLACK SPRUCE CONE DEPREDATION BY RED SQUIRRELS IN EASTERN NEWFOUNDLAND

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The granivorous Red Squirrel (*Tamiasciurus hudsonicus*) was recently introduced (1960's) to insular Newfoundland and since as spread throughout the island. Concern exists over the impact this species will have on the forest successional patterns because of: 1) its ability to consume seeds of conifer tree species and; 2) the lack of coevolution between trees and red squirrels. Little research as been conducted to date on black spruce (*Picea mariana*) cone depredation in different ages of black spruce trees and the effect that it has on seed output. Also, previous studies examined depredation until late October and we suspected over-winter foraging could be significant.

A 2-year study was initiated to investigate the effects of cone depredation over two varying cone crop years. In 2000 we set up 10-12 prism plot in each tree ageclass (21-40, 41-60, 61-80, 81+). Late August cones were collected before red squirrel harvesting began in, and between, prism plots. Cones were later assessed to determine external and internal characteristics. In late August, late October, and early June from 2000-2002 all trees were viewed with binoculars and depredation rates determined for autumn (late October observations) and overall depredation (June observations).

Black spruce cone crops in year 2000 were much smaller than in 2001. Red squirrels reduced seed output up to 98%. Comparing cone size from cones available in August 2000 to cones remaining in June 2001, cones remaining were significantly smaller ($p < 0.001$). Cone selection and depredation by red squirrels drastically influence seed output and just by counting cones does not give an accurate effect of depredation on seed output.

Autumn 2000 depredation rates ranged from 51 – 84% and depredation rates ranged from 61 - 84% from November 2000 – June 2001. The larger black spruce cone crop of 2001 influenced depredation rates. Fall 2001 depredations rates ranged from 39 - 45%, much smaller than 2000. The same effect was noticed for over-winter depredation rates at 26 – 45%. Overall, red squirrels had a dramatic impact on seed output during low cone crop years due to high predation. General cone selection behaviour in all black spruce tree ages may reduce the regeneration capabilities of this dominant tree species in Newfoundland.

LOCAL AND LANDSCAPE HABITAT USE BY WOODPECKERS IN AN INDUSTRIAL FOREST

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This project is part of a three-year study designed to characterize the habitat of woodpeckers in an industrial forest in northwestern New Brunswick. This talk features data collected during the 2001 breeding season, investigating the influence of local vegetation and landscape context on the presence of four species of woodpeckers: Downy Woodpecker (*Picoides pubescens*), Hairy Woodpecker (*Picoides villosus*), Yellow-bellied Sapsucker (*Sphyrapicus varius*), and Northern Flicker (*Colaptes auratus*).

Models of habitat use may vary depending on the spatial scale under investigation. Therefore, it is important to consider landscape context as well as local vegetation structures when determining habitat use, particularly as forests become more fragmented under intensive management. We determined the effect of local vegetation structures (within 100 m), as well as landscape context (within 500 m and 1000 m) on each species' presence at 73 census points. The landscape context was considered independently of the local vegetation.

Bird counts were conducted using a modified mobbing call method. An area covering over 6000 ha was sampled systematically, using Chickadee mobbing and Barred Owl calls to attract the birds to the census points. The points were separated by at least 600 m, and were visited six times during the breeding season. Vegetation was surveyed at three 10 x 20 m plots within a 100 m radius of each census point. The landscapes were classified into seven coarse patch types by stand age (mature, medium, early, clearcut) and/or composition (hardwood, mixedwood, softwood) using GIS. Logistic regression was used to model local and landscape effects on the presence of each species.

The resulting models underline the importance of taking a multi-scale approach to habitat use modeling. There are significant relationships between local vegetation and the presence of Northern Flickers and Hairy Woodpeckers. At the landscape scale, Flickers have a strong relationship with the 1000 m variables, while the presence of Hairy Woodpeckers is not related to either landscape scale. Downy woodpeckers do not have a significant relationship with local vegetation, but there is a significant relationship with 500 m landscape variables.

These models and their implications for forest management will be discussed in detail.

IS PATCH RETENTION WORKING?

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Patch retention is becoming a common tool for retaining biodiversity in harvested forests of northern Maine. However little known as to whether foresters and loggers are successful at placing retention patches in sites of significant ecological value. We conducted surveys of forest structure and plant species to determine if 2-5 year old retention patches contained greater ecological value than adjacent clearcuts and nearby mature forests. Our study area was central and southern Aroostook County, northern Maine. We used a block design to sample patches in 6 harvest blocks, 6 adjacent clearcuts, and 6 nearby mature forests (controls). Harvest blocks were randomly selected from a pool of 20 harvest blocks. Sample transects were randomly placed in treatments. Treatments were sampled for trees, logs, mosses, vascular plants, and a limited number of lichen species. Retention patches ranged in size from 0.04 to 2 ha. Retention patches had significantly greater tree density, large trees density, large log volume density, large logs density, forest herb species, lichen species, and moss species than clearcuts. Retention patches had similar tree density, large trees density, large log volume density, large logs density, forest herb species, lichen species, and moss species than nearby mature forest. Retention patches contained surveyed elements of biodiversity at levels much greater than clearcuts and comparable to adjacent mature forest.

IMPORTING THE LANDSCAPE MANAGEMENT SYSTEM TO THE NORTHEAST

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Shifting market and social values, evolving scientific understanding, a changing population, and the globalization of trade and transport are continuously reshaping the demands placed on forestland. The uncertainty generated by shifting populations and social values are especially evident in Maine where recent voter referendums have sought to restrict the application of specific forest management techniques. These ongoing changes have forced forest managers to incorporate more, and more complex, objectives into their planning considerations.

To meet these evolving objectives requires detailed planning across large spatial scales and far into the future. While criteria for measuring complex objectives are often defined for large spatial scales the practical implementation of any plans has been, and will continue to be, conducted at the individual stand or management unit. When goals are designated for larger areas (e.g. landscapes, watersheds, or ecosystems), options available for a single stand must be evaluated simultaneously with the goals, status, and options available for all the other stands within the area. This can make the process of landscape or ecosystem management tremendously complicated.

The Landscape Management System (LMS)[1] is one several software tools being developed to facilitate complex forest ecosystem planning. The software system integrates GIS technology, growth and yield models, stand and landscape visualization, and analysis tools to evaluate current and future landscape conditions under a variety of management scenarios. The approach takes advantage of the rich history of research and data collection in forest ecology, mensuration, and silviculture at the stand scale. This accumulated knowledge provides a basis for classifying forest stand conditions and predicting their future development. Individual stand information is then aggregated across larger spatial scales to evaluate the tradeoffs and consequences associated with different management strategies.

LMS was developed in the Pacific Northwest starting in the early 1990's. Importing the approach and tools developed for that region to evaluate management issues in the Northeast represents certain challenges. These include: availability of inventory and site information, scale of management polygons, forest structural stage classifications, and dominance of particular silvicultural systems. None of the exposed challenges are insurmountable and LMS, as both a tool and an approach, should prove useful for comparing consequences of different management approaches across landscapes in the Northeast.

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[1] See http://lms.cfr.washington.edu/lms2/lms.html for more details.

THE EFFECTS OF CLEARCUT HARVEST AND HERBICIDE TREATMENTS ON FLOWERING PLANT AND WINGLESS WASP COMMUNITIES

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While there may be substantial negative impacts of clearcut harvesting and subsequent herbicide applications in northern forests, such practices open forest stands for colonization by flowering plants which may serve as pollen and nectar resources for insects. A survey was conducted of flowering plant and beneficial insect abundances at 20 sites in western Maine representing 6 treatment groups. Treatments included recent (3-5 years) and older (14-15 years) clearcut stands, half of each age group had been treated with herbicides following harvest and half not treated. Two other treatments included 1) plantations which were comparable in age to the older clearcuts and had been treated with herbicides; and 2) mature stands which had not been treated with herbicides and which had closed canopies that were approximately 25 m above the ground. Each treatment had 3 replicates except the older clearcuts which had 4 because of higher variability in the vegetation communities. Line intercept sampling was conducted to estimate floral abundance at two-week intervals throughout the summer and pitfall traps were used to estimate the relative densities of wingless parasitic wasps (Hymenoptera). Herbicide treatments had little or no affect on the abundance of floral resources. Floral abundance was highest in the plantations, followed by recent clearcuts, then older clearcuts and lowest among the more mature stands. The relative abundance of the wingless Parasitica was not correlated with floral abundance early in the season, but was strongly and positively correlated with the floral abundance later in the season. This finding is at odds with the only published study of which we are aware that compared silvicultural treatments in Oregon. That study reported the negative impact of clearcuts on the abundance of a wingless parasitic wasp associated with old growth forests.

GENETIC VARIATION IN WOOD DECAY RESISTANCE OF WHITE SPRUCE (*Picea glauca* (Moench) Voss)

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To better understand the genetic variation of decay resistance in white spruce, three fungi were used for the study of wood decay resistance. Standing-tree decay (*Fomitopsis pinicola*), white-rot (*Tremetes versicolor*), and brown-rot (*Gloeophyllum trabeum*) fungi were studied on heart wood samples in Petri plates. A total of 270 trees from 35 families were harvested in a thinning operation from 36-year-old provenance-progeny trials of white spruce at two locations. The growth of the three fungi were evaluated by their daily grow rates on heartwood samples collected from the thinning material. The narrow-sense heritability for decay resistance on brown-rot, white-rot and standing-tree decay were 0.14, 0.18 and 0.04, and the coefficient of additive genetic variation was 14%, 16% and 15%, respectively. The narrow-sense heritability for heartwood density and mean ring width is 0.24 and 0.08, and the coefficient of additive genetic variation was 1.9% and 5%, respectively. The result revealed considerable phenotypic variations and relatively high coefficient additive genetic variation in decay resistance of heartwood. The effect of environmental factors for tree growth and resistance of standing tree decay accounted for high proportion of unexplained residual variation. The traits and the two progeny tests we studied could promise possibilities for increasing the wood density, and decay resistance of white spruce against fungi through tree improvement.

IMPACT OF STAND DENSITY MANAGEMENT ON PRODUCT QUALITY AND FINANCIAL RETURNS IN THE S-P-F SPECIES

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The potential shortage of large-size sawlogs is emerging as a constraint to the growth and prosperity of the forest industry in eastern Canada. To sustain the sawlog supply, the forest industry in eastern Canada is embracing stand density regulation regimes (e.g., precommercial thinning, commercial thinning) to accelerate the diameter growth of individual trees and to shorten the rotation age for sawlog production. While several studies have shown that the stand density regulation is generally effective in accelerating the diameter growth, no studies have quantified the effects of stand density regulation on end-product quality in Eastern species. Moreover, the economics of these silvicultural regimes has not been evaluated. In recent years, a series of research projects have been initiated by Forintek to evaluate the impact of major stand density regulation regimes on product quality and financial returns in the S-P-F species, the three most important lumber species in eastern Canada. This paper reports on initial spacing (IS) in black spruce, precommercial thinning (PCT) in balsam fir, and commercial thinning (CT) in jack pine.

The three studies show that stand density regulation at any stage (IS, PCT and CT) is effective in accelerating the diameter growth of individual trees in the three species although maximum fibre volume production may not be achieved. With increasing spacing, stem taper, crown size and branch diameter tend to increase, and consequently lumber quality is affected negatively. The magnitude of the negative effect, however, depends on the thinning intensity and species. It appears that lumber quality does not decrease significantly as long as stand density stays over 2,000 trees/ha. Economic analysis indicates that both PCT and CT are economically viable silvicultural regimes for the lumber industry, but a moderate to heavy thinning intensity is needed to achieve a significant increase in average diameter growth to justify the treatment costs. A significant increase in average tree diameter in the thinned stands will lead to a significantly higher lumber value recovery per m^3 of wood. In addition, a larger average tree diameter reduces the logging and lumber manufacturing costs. The initial spacing study shows that a wider initial spacing than traditional 2 x 2 m for black spruce yields higher economic returns if the stands are managed for sawlog production. An initial spacing of 2.7 x 2.7 m may lead to a significant decrease in lumber quality despite its highest benefit/cost ratio.

POSTER PRESENTATIONS

INFLUENCES OF LANDSCAPE PATTERN ON FOREST BIRDS: A SPECIES-CENTERED APPROACH

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Due to the heterogeneous nature of forest mosaics, delineating ‘patches’, ‘edge’ and ‘connectivity’ for use in forest fragmentation studies has been problematic. Most research relies on relatively arbitrary definitions of pattern that may not reflect species’ perception of habitat boundaries. This could result in misleading conclusions about the influences of fragmentation on native wildlife. Our objective was to develop habitat models that can be used to map the distribution of mature forest bird species in a Geographic Information System (GIS). We established 320 point count plots stratified to represent a broad range of cover types and age-classes within the Fundy Model Forest, New Brunswick, Canada. Using stand-level information available in the GIS we developed Resource Selection Functions (RSFs) for two mature forest bird species, Blackburnian Warbler (*Dendroica fusca*) and Ovenbird (*Seurius aurocapillus).* RSFs were derived from optimal logistic regression models that explained the most deviance in the presence/absence of selected species. RSF distribution maps were used to design a sampling strategy for landscape pattern and composition research. This approach reflects the heterogeneous nature of forest habitat more accurately than a dichotomous ‘patch – non-patch’ strategy, and may lead to better predictions about population trends at the landscape scale.

ADAPTIVE RESEARCH: REVISING A LONG-TERM SILVICULTURE EXPERIMENT

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The Penobscot Experimental Forest (PEF) in Maine is the site of a long-term USDA Forest Service experiment in even-, uneven-, and two-aged silviculture. Regeneration methods such as selection cutting on 5-, 10- and 20-year cutting cycles and two- and three-stage shelterwood are being studied, as are a variety of intermediate treatments. Exploitive cuttings such as diameter-limit and commercial clearcut are also included in the experiment.

Each treatment is described in a study plan, and guidelines for application and measurement must be followed. The value of the long-term study rests, in large part, on the appropriateness of the study plan and the scientists' ability to replicate treatments in space and time. The study plan for the PEF silviculture experiment was first approved in the 1950s. Since that time, two formal revisions have been made, each adding additional treatments and measurements, and utilizing data collected to-date to adjust the treatments as necessary. The most recent study plan revision was approved in 1975.

In the > 25 years since that time, new data have enabled us to better understand dynamics of regeneration and tree growth, particularly in the uneven-aged stands. It is thus time for us to revise the plan in a way that simultaneously protects the long-term experiment and allows scientific advances to be made. We are currently in the process of summarizing and analyzing existing data, and using our findings as the basis for changing treatment and measurement protocol. Special attention is being paid to the uneven-aged systems, which utilize inflexible mathematically defined structural goals. We are adjusting these goals in a manner that maintains the integrity of the long-term experiment, yet reflects more reasonable expectations based on improved understanding of stand dynamics.

The study plan revision process is challenging. We are not only working with incomplete data, but must make revisions in a way that makes the most of available resources without jeopardizing the >50 years of effort invested in the study. Though 50 years is a long time for a research program of this magnitude to persist, it represents only about half of an even-aged rotation in northern conifers. We have so far raised more questions than we have answered, and anticipate many years of research in the future.

SUPPLEMENTAL CONTROLLED-RELEASE FERTILIZATION OF CONIFEROUS SEEDLINGS IN THE NURSERY – EFFECTS ON MORPHOLOGY AND FROST HARDENING

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Some forest nurseries in Atlantic Canada grow more than one crop per year. Seedlings are sown in a greenhouse but later moved outdoors freeing up the greenhouses for the next crop. Controlled-release fertilizer, supplemental to fertigation, may help in reaching morphological targets but it may delay frost hardening predisposing crops to frost damage during winter storage. This study examines effects of Nutricote® on the morphology, frost hardening, and winter-storage survival of seedlings of several coniferous species. Nutricote® is a controlled-release fertilizer applied by hand to the surface of the growing medium. The study consists of three separate experiments in which height (HT), dry weight (DW), root collar diameter (RCD), frost hardening (on three dates: 09.10; 23.10; 06.11) were measured, elemental analyses of foliage and growing media were made, and storage survival assessed. All seedlings were grown in Jiffy® pellets; all treatments were replicated four times. Non-fertilized with Nutricote® seedlings were used as controls.

Experiment 1 examined effects of a single pellet (40-day release period) on seedlings of black spruce (*Picea mariana* Mill. (B.S.P.)) (bS), red spruce (*P. rubens* Sarg.) (rS), white spruce (*P. glauca* Moench. Voss) (wS), and eastern white pine (*Pinus strobus* L.) (ewP), all sown in June. Frost hardiness increased with time but the hardening of Nutricote-treated rS and ewP was slower than that of the controls (date x species x fertilizer effect p 0.01). Significant increases in HT, RCD, and DW were only in rS and not in the other species. Fertilizer increased electrical conductivity (EC) of the growing medium and slightly increased its pH but foliar concentrations of nutrients were little affected.

In experiment 2, April-sown bS seedlings were treated with 40-day or 100-day release period pellets applied as a single (1 pellet) or a double doze. Frost hardening was unaffected by any fertilizer type or doze but HT, RCD, and DW were significantly greater in one and two pellet applications (no sign. differences for doze) of 40-day release pellet and by the double doze of 100-day release pellets, compared to the controls. Single 100-day release pellet had no significant effect on morphology. High salinity (high EC) occurred only after the single 100-day release pellet. Growing medium pH increased slightly after Nutricote® application. No striking differences in foliar concentrations of macronutrients were found.

In experiment 3, seedlings of bS sown in April, June, and July were provided with one 40-day release pellet. Positive growth responses were found only in early-sown seedlings. Frost hardening was not significantly affected by fertilizer application. Elemental analyses of foliage showed slight, rarely significant increases in macronutirent concentrations, growing media were affected as in treatments 1 and 2 with greater salt accumulations in early than in later sowing dates/fertilizer applications.

OPTIMAL CANOPY CONDITIONS FOR CARBON GAIN IN SAPLING RED SPRUCE: APPLYING A PROCESS MODEL TO ON-SITE MICROCLIMATE DATA

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It is often suggested that partial shade provides an optimal light environment for growth of juvenile red spruce (*Picea rubens* Sarg.). Hourly time-step data collected by a series of microclimate monitoring stations in stands with various degrees of overstory cover provided us the opportunity to test this adage using a simple process model.

Monitoring stations were in stands managed under clearcut, shelterwood, and selection systems (two replicates of each treatment) in the Penobscot Experimental Forest, Bradley, Maine. At each station, mean hourly air temperature, humidity, sunlight flux, soil temperature, and foliar temperature of an adjacent sapling spruce were recorded. We used a carbon-budget model based on physiological response curves to estimate carbon gain by foliage in the upper crown of sapling red spruce. The model produced an estimate of net photosynthetic carbon gain per m^2 of foliage area for the growing season using functions that predicted potential gross photosynthesis (from light flux data), respiration, and potential inhibition of photosynthesis by temperature (T) and leaf-to-air vapor pressure deficit (VPD) in hourly time-steps. We also ran the model with –5, -2.5, +2.5, and +5 ^{o}C deviations from recorded temperatures to examine the relative carbon gain for spruce in the three stand types under cooler and warmer climate scenarios.

In the selection stands, mean light availability over the growing season was only 16% of that in the clearcuts, and the shelterwoods received about 26%. However, in the clearcuts, light intensity was often above the light saturation point for spruce foliage. In addition, both T and VPD showed roughly twice the inhibitory influence in the clearcuts than the selection stands, with an intermediate effect in the shelterwoods.

Our estimates showed net carbon gain per unit foliage area over the growing season to be roughly equal between the shelterwood and clearcut treatments, and severely light-limited in the selection stands. The results were similar under hypothetical decreased temperature scenarios. However, under the increased temperature runs, inhibition by VPD and T had a far greater effect on carbon gain in the clearcuts than in the shelterwoods. At ambient + 5^{o}C, carbon gain in clearcut and selection treatments was approximately equal, while the shelterwoods showed roughly twice the carbon gain of the other treatments.

VEGETATION OF FORESTED UPLANDS IN THE MASSABESIC EXPERIMENTAL FOREST, SOUTHERN MAINE, U.S.A.

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We summarize a three-year vegetation inventory regarding plant species composition and structure of the forested uplands in the 3600 ac Massabesic Experimental Forest (MEF) in Alfred and Lyman, York County, Maine. The inventory is in preparation for a new series of manipulative experiments in this eastern white pine (*Pinus strobus*) – northern red oak (*Quercus rubra*) ecosystem. The MEF has two separate units that were subdivided for the inventory into ten arbitrary parcels labelled N1-N4, S1-S6, and ranging from 36-1336 ac. A grid of 399 permanent sample points was established at a spacing of 330 ft x 660 ft. Trees larger than 4.5 in diameter at breast height were tallied using variable radius plot sampling with a 10 basal area factor prism. The sample points also served as the center of 0.01 ac plots on which smaller trees and all other vascular plants were inventoried. The most common overstory trees in the MEF were eastern white pine, eastern hemlock (*Tsuga canadensis*), northern red oak, and red maple (*Acer rubrum*). Almost 1200 trees > 18 in dbh were tallied, with up to 19.8 large white pines per ac. This abundance of large trees is unexpected given a major wildfire in 1947, storms in the 1950s, and subsequent salvage harvest. Mortality data suggest that eastern hemlock will increase in the MEF, while white pine and red oak may decline in importance. Regarding tree seedlings between 1 ft tall and 0.5 in dbh, eastern hemlock was most abundant, followed by maples (especially red maple), oaks (northern red and white, *Q. alba*), and white pine. Parcel S3 had the highest density, followed by S4 and N1. Shrub stem density (> 1 ft tall) was greatest for beaked hazelnut (*Corylus cornuta*), followed by three viburnum spp., highbush blueberry (*Vaccinium corymbosum*), and winterberry (*Ilex verticillata*). Shrub stems ac^{-1} was highest in N3, followed by S1 and N2. The most common herb was starflower (*Trientalis borealis*), found in > 60 percent of plots in each unit. Other common herbs and shrubs were low sweet blueberry (*V. angustifolium*), Canada mayflower (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*), and a sedge (*Carex lucorum*). Meander transects 307 ft long between plots provided a more comprehensive plant list, including about 500 taxa. Native plant communities appear to be intact, as we rarely encountered invasive, exotic plants, even in the wetter areas. A Geographic Information System of the MEF was developed to include data from the inventory, forest type, soils, fire history, topography, roads, and streams. Distribution of large trees, plantations, species of special interest, and many other features can be mapped easily with the GIS.

RELATIVE FLAMMABILITY OF INVASIVE EXOTIC AND NATIVE PLANTS OF THE NORTHEASTERN U.S.

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In the Northeast, invasive exotic plants might have different fuel characteristics than the native species they sometimes displace. We seek to improve efficacy of prescribed fire for land managers, and assessment of fire hazards to homeowners and business-owners. Risk of wildfire could be greater in the wildland-urban interface if invasive plants are dense and have higher flammability than their native counterparts. Conversely, a fire-prone ecosystem that has been invaded by weedy exotic plants might have a less-frequent fire return interval and lower severity, with consequences for fire-dependent rare species, e.g., at the Albany Pine Bush Preserve where the Karner Blue butterfly depends on a native lupine of pitch pine woodlands.

For the Joint Fire Science Program, Boise, ID we are modifying BEHAVE fuel models to better represent conditions in the Northeast. As a part of this, we sampled flammability of plants not tested before by using a cone calorimeter to quantify effective heat of combustion (HOC) as a measure of heat content in oven-dried leaves and twigs. We compared 14 invasives, 12 of which are exotic, to 13 native species which might be displaced in disturbed habitats. Based on three replicates per species and two fluxes for oven-dried material, we found a range from 6-17 MJ/kg, which is overall lower than for green and dry plant fuels from California and Colorado. At the upper end, *Alnus incana* (speckled alder), *Solidago rugosa* (rough-stemmed goldenrod), and *Populus tremuloides* (trembling aspen) have a higher heat content, while *Vitis* sp. (native grape) and an invasive exotic shrub, *Frangula alnus* (European alder-buckthorn) have lower heat content than most plants we tested. Two troublesome invasive herbs, *Fallopia japonica* (Japanese knotweed) and *Microstegium vimineum* (Japanese stiltgrass), were similar in their relatively low heat content. Three native herbs had higher heat content on average than three invasive herbs.

The implications are that (1) use of fire to control undesirable vegetation can be more effective if a species-by-species approach is taken to meet management objectives in a particular stand; (2) flammability also involves leaf surface to volume ratio and moisture content, and these should be quantified to improve the inputs in modeling fire behavior; and (3) comparison of data such as these with relative flammability data from other regions will increase our understanding of fuels and relative flammability in the Northeast.

NEW BRUNSWICK TRIAD CASE STUDY: IMPLEMENT HARVESTING INSPIRED BY NATURAL DISTURBANCE

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The concept of using natural disturbance regimes as a guide for appropriate forest management has received increasing attention over the past decade. The TRIAD approach to forest management proposes reserves and plantations, embedded within a landscape managed by alternative silvicultural systems that mimic the natural disturbance regimes that predominate across a landscape. Intensively managed forest (plantations, thinned stands), extensively managed forest (naturally regenerated, perhaps longer rotation), and protected areas, (unmanaged areas, meant to sustain values that could be otherwise be lost) should co-exist on the landscape.

Located in north-western New Brunswick, the Black Brook District is privately-owned by J.D. Irving Ltd. 190,000 hectares in size, it represents one of the most intensively managed forests in Canada. Over 60,000 hectares of the landbase is comprised of plantations. Another 49,000 hectares consists of tolerant hardwood stands, which are being managed for high quality veneer and sawlogs by selection and patch-cut systems. A network of scientific reserves totalling more than 7,000 hectares has been established in cooperation with the World Wildlife Fund. The scientific reserves are divided into two types: core reserves and adaptive management areas. These areas provide benchmark forest conditions to which the managed forest could be compared, as well as in which areas to conduct experimental harvesting inspired by natural disturbance will be implemented. The spectrum management objectives on this landbase, from intensive to extensive, make it a well-suited candidate for research on TRIAD based management strategies.

Harvesting methods inspired by natural disturbance will be developed and applied to 2,600 hectares of adaptive management areas in the Black Brook District. Treatments will be defined based on stand type, predominant natural disturbance agent, and stand structure resulting after disturbance. The agents of natural disturbance considered to be of greatest importance in the area are spruce budworm (*Choristoneura fumiferana* (Clemens)) and gap dynamics. Assessments and comparisons of stand composition, vertical and horizontal structure of tolerant hardwood, mixedwood, and spruce-fir stands will be made between the core reserves, adaptive management areas as well as selected treatments in the working forest.

Based on a characterization of the forest at each of the established plots, and the landscape type to which it belongs: (core reserve, adaptive management area or the working forest), one of 12 treatments will be assigned. Twenty sample plots will be established in each treatment, giving 12 x 20 = 240 plots. Six of the treatments will be those developed to emulate natural disturbance in the adaptive management areas, 3 will be the typical treatments currently being used in the working forest, while the remaining will be either untreated control areas (core reserves).

IMPACT OF RESIDUAL TREES ON HARDWOOD STAND GROWTH AND YIELD FOLLOWING CLEARCUTTING

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Residual trees and snags are often left following clearcutting - sometimes purposely and sometimes inadvertently. Irrespective of the reason, an important question is what is the impact of residuals on future stand volume? To begin to answer this question, a 30 year old tolerant hardwood stand in western New Brunswick that had been clear-cut and precommercially thinned at age 15 was examined. Results indicate that the relationship between residual tree density and stand volume is convex in shape. Between 250 and 500 residual trees/ha, stand volume is lowest. Residual trees suppress crop tree growth but are in insufficient number to compensate for the volume reduction. At less than 125 residual trees/ha and more than 600 residual trees/ha, stand volume is highest. Residual trees do not restrict crop tree growth at low densities and at high densities, residual trees compensate for the low crop tree volumes they induce because a sufficient number are present. These results are tentative and more samples are needed to confirm the relationship between residual tree density and stand yield. In addition, a longer term perspective is required and the impacts of residual tree size and species need to be determined.

A CROSS-CULTURAL STUDY OF OCCUPATIONAL CHOICE AND PRESTIGE AMONG LOGGERS

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Two distinct populations of loggers work in Maine's border counties of Quebec: Maine resident and Quebec resident woods workers. This study compared the sense of occupational choice and prestige held by these workers, as well as their sociodemographic attributes. Significant differences in age, education, and logging experience were found between these two populations. In addition, Maine resident loggers were found to exhibit less resignation to woods work than their Quebec counterparts. However, Quebec resident loggers indicated that their profession was held in higher esteem among the public than did loggers from Maine. Results have implications for logging labor supply and labor recruitment efforts in a region heavily dependent on the forest products industry.

CAUSES AND COSTS OF UNUSED LOGGING CAPACITY AMONG LOGGERS IN NORTHERN NEW ENGLAND

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Recent attention has focused on the costs of unused logging capacity. Indeed, the Wood Supply Research Institute (WSRI), a partnership of logger associations and wood consuming mills, established funding for research to investigate the phenomenon in Maine and twelve southern states – the first study funded by WSRI. Focus groups, a mail survey, and weekly logger productivity reports were used to identify the causes and costs associated with idle logging capacity in Maine. The study was also extended to loggers in the two other northern New England states, New Hampshire and Vermont, as well as to loggers in the Province of Quebec who work in Maine.

SHOVEL LOGGING IN A DEFERMENT HARVEST: SOIL BULK DENSITY AND RESIDUAL STAND EFFECTS

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Shovel logging, a ground-based, non-tractive yarding method that uses an excavator fixed with a grapple instead of a bucket, offers the potential to yard felled wood with less impact to forest soils than conventional rubber-tired skidding methods. The results of this study indicated that, although neither conventional nor shovel logging methods can be recommended over the other based solely on short-term impacts to soil bulk density, shovel logging resulted in significantly less surface soil disturbance. In addition, shovel logging eliminated the need for primary skid trail construction, identified as a potential source of particulate matter that may contribute to nonpoint source pollution. In addition, there was (a) no difference between treatments (skidder vs. shovel) in the average amount of bole damage per tree, and (b) no relationship between treatment and the frequency of severe bole damage

GROUND SKIDDING AND HARVESTED STAND ATTRIBUTES IN APPALACHIAN HARDWOOD STANDS

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A statewide logging-in-progress study was conducted in West Virginia to examine the associations among several ground skidding and harvested stand attributes. There was a strong positive association between skidding distance and cycle time, and a significant negative relationship between the percent of trees removed in the stand and total cycle time. The number of residual trees per acre and number of trees per acre in the preharvest stand were not significant in explaining total skidding cycle time. In addition, the number of trees and volume skidded per cycle were positively associated with cycle time, as was the number of bunching moves. Results suggested that differences in operator behavior may be more important in explaining the size of payloads per cycle than, for example, the size of the skidder used.

USE OF 1946 AERIAL PHOTOGRAPHS TO CHARACTERIZE FOREST CHANGE IN NORTHWESTERN NEW BRUNSWICK

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Over the past 2 decades, a strong movement towards ecosystem-based management and conservation of biodiversity has developed. This movement has spawned the 'natural disturbance paradigm', which states that if disturbances shape the composition and dynamics of vegetative communities, and if the character of vegetative communities defines biodiversity, then forest management strategies that are guided by an understanding of natural disturbance processes will maintain forests attributes that conserve biodiversity.

In order to 'design with nature', a forest manager must have knowledge in two general, but important, areas. A forest manager must understand the spatial and temporal patterns of both regional natural disturbances and anthropogenic disturbances. J.D. Irving Ltd.'s 190,000 ha, Sustainable Forestry Initiative (SFI) Certified Black Brook District in northwestern New Brunswick will provide the case study area for this unique project. This landbase ranks among Canada's most intensively managed forested landbases and contains over 60,000ha of plantations.

This study is unique in having historical 1946 aerial photography that covers the entire landbase, which has been used to develop a historical GIS-based forest inventory. This 'snapshot' in time was analyzed to determine reference conditions for forest characteristics prior to intensive forest management. Aerial photographs were interpreted based on species composition and development stage, and summarized by vegetation community within an ecodistrict, based on New Brunswick's Ecological Land Classification System. The data were analyzed to determine changes in overstory species composition, patch size, age class structure and connectivity since 1946. This 'temporal snapshot' of the past forest condition will provide a reference for comparison with current and future forest structure.

SPATIAL AND TEMPORAL PATTERNS OF NATURAL DISTURBANCE IN OLD-GROWTH FORESTS OF NORTHERN MAINE

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Natural disturbances such as fire, insect outbreaks, and windstorms strongly influence the structure, function, and species composition of forest communities. Ecologically-based management of our remaining old-growth, as well as our more common secondary forests, requires an understanding of the natural disturbances that have historically shaped and regenerated these forests. Region-specific estimates of the extent, frequency, and resulting structure of natural disturbances are now being used to design and manage nature reserves and to develop sustainable silvicultural prescriptions. The detailed history of disturbances can best be detected in old-growth forests, whose tree rings contain a relatively long record of growth releases, suppressions, and tree establishment that can be linked to disturbance events. We are conducting this work in The Nature Conservancy's Big Reed Forest Reserve (northern Piscataquis County, Maine), which at nearly 2000 ha is one of the largest tracts of old-growth forest in the region.

By linking dendrochronology with spatial pattern analyses, we will determine the historical type, extent, and frequency of natural disturbances throughout the Reserve and test the following working hypotheses: 1) disturbance type and extent differ among forest community types, and 2) disturbance events registered on individual plots are synchronized at some scale throughout the Reserve. We have established thirty-eight plots (30 m by 50 m) in a stratified (by forest community type) random manner, which will allow us to make statistical inferences at the scale of the entire Reserve. Using the data derived from increment cores, we will construct a disturbance chronology for each plot. Given the replication of plots within each community type, we can determine if chronologies differ between communities. And by knowing both the dates of past disturbance and the geographic location of plots, we can test for synchronicity of disturbance events across plots. The scale at which disturbances are synchronized will provide an estimate of the geographical extent of past disturbances.

Preliminary results – based on tree ages alone – indicate that none of the thirty-eight plots show single-cohort age structures, suggesting that large-scale, stand-replacing disturbances have not occurred within the historical period covered by the tree-ring record. Age structures, however, are quite variable among plots and may reflect a variety of disturbance histories.

WHITE PINE (*Pinus strobus*) DECLINE AND MORTALITY ASSOCIATED WITH SHALLOW ROOTING-DEPTH POTENTIAL

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Throughout southern Maine there was a noticeable decline and mortality of white pine (*Pinus strobus*) from 1997 through 2000 in dense pole-size stands. The decline was widespread, scattered, and happened simultaneously indicating that it was incited by an abiotic stress. Because only isolated stands showed decline and mortality, site factors likely predisposed trees to injury. Site factors are likely related to the widespread field abandonment that took place throughout southern and central Maine, and led to establishment of pure white pine stands in many areas. These stands are more likely to occur on sites with soil limitations, such as plow plans and lithological discontinuities, that cause roots to spread more horizontally. The first hypothesis is that potential shallow rooting depth of white pine predisposed the species to water stress and that only the white pine on drought sensitive sites, e.g shallow rooting depth, suffered mortality. The second hypothesis follows that the inciting factor was a drought event occurring prior to 1997-2000, the period of white pine mortality.

Paired sites, consisting of a high and low mortality site, were evaluated in nine locations located south of 45.1° N latitude in the towns of Wells, Lebanon, Hollis, Limington, Casco, Nobleboro, Massabesic, New Gloucester and Oxford. Tree species, crown class, crown condition, and diameter at breast height (DBH) were recorded at each stand. Two cores were removed from each dominant and codominant white pine, including dead trees, for dendrochronological analysis. Potential rooting depth was measured in each site. Crossdating of cores was used to calculate the percentage of dead trees with the last growth ring in a given calendar year. Stream flow and precipitation measurements were used as indicators of water status in surrounding watersheds. Paired t-tests were used to evaluate differences in basal area, stems/ha, and potential rooting depth on high and low mortality sites. Standard t-tests were calculated by location for differences in DBH, age, and number of years of decline of white pine between high and low mortality sites and between dead and surviving white pine on high mortality sites.

High mortality sites had rooting depth potentials (24.6 cm) that were significantly less than low mortality sites (44.8 cm) at all 9 locations. White pine on high mortality sites were significantly younger (49 yr) than low mortality sites (78 yr). High mortality sites also had significantly more stems/ha of white pine (495 stems/ha) than low mortality sites (273 stems/ha). Trees that died had smaller DBH (20.8 cm) than those that survived (26.5 cm). We conclude that shallow rooting depth and high stem density predisposed trees to mortality induced by drought stress. Climate data suggest that a drought in 1995 was the inciting factor for the decline. Most predisposed trees died from 1995 to 1998 with peak mortalities in 1996 (30 %) and 1997 (34 %).

WATER TEMPERATURE CHANGES IN SMALL HEADWATER STREAMS BEFORE AND AFTER HARVESTING

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We studied water temperature gradients along 500-m reaches of 15 small headwater streams both before (2001) and after (2002) harvesting in western Maine. Each stream was assigned to one of 5 different treatments: (1) clearcut with no buffer, (2) clearcut with 11m buffer, (3) clearcut with 23m buffer, (4) extensive partial cut, and (5) control (no harvesting). Streams typically drained areas of less than 161 ha (400 ac). Automatic water temperature probes were deployed at 100-m intervals in each stream reach. The middle 300 m of each stream was subjected to harvest, thus leaving a 100-m fully forested section upstream, and a 100 m fully forested section downstream.

In the pre-treatment year (2001), temperature gradients were found to be extremely dynamic. Water temperature often alternately increased and decreased along the 500-m study reach of each stream as a result of underground and overground (e.g., tributaries, springs) inputs. Typical downstream warming was highly modified by natural inflows. Data from the post-harvest year (2002) have only recently been retrieved and will be presented in the poster.

Canopy closure over the stream changed very little after harvest for all treatments except the "no buffer" treatment (Fig. 1). Therefore, we expect to see little change in water temperature after the harvest, except for the "clearcut, no buffer" treatment. A post-harvest assessment showed there was virtually no breach of the stream channel by harvesting equipment, even in the "no buffer" streams.

At the time of this abstract, we have summarized data for one stream in the "no buffer" treatment (Fig. 2). The data show a distinct increase in water temperature in the harvest zone in 2002 (post harvest), even though average daily air temperature during the summer was slightly lower in 2002. The 7-day moving average water temperature did not comprise the thermal tolerance of the brook trout, a key species of concern in headwater streams.

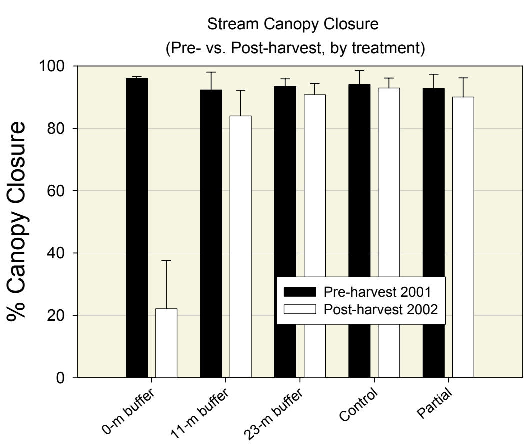

Fig. 1. Mean change in percent canopy cover over streams in the 5 different treatments.

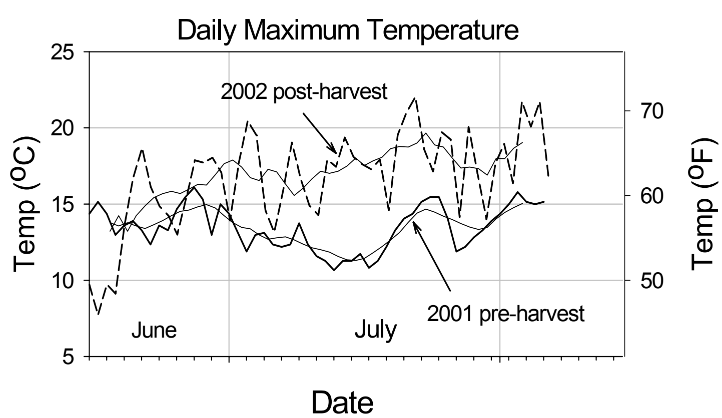

Fig. 2. Daily maximum water temperature trace for one "no-buffer" stream in 2001 (pre-harvest) and 2002 (post-harvest) year. Light lines represent 7-day moving averages for each year.

RELATIONAL DATABASE OF DOWN DEAD WOOD SAMPLED IN MAINE, NEW HAMPSHIRE, AND VERMONT

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Down Dead Wood (DDW) provides an important role in carbon and nutrient cycling, carbon sequestration and wildfire behavior, among others. This report makes available to the scientific community the sampled DDW data on the Forest Inventory and Analysis (FIA) plots of Maine, New Hampshire and Vermont since 1994. The sampled data was obtained based on Line Intersect Sampling (LIS) of two orthogonal transects in fixed-radius plots. DDW was tallied when intersected by the line intersect plane as well as any pile data in the plot to difficult to tally the individual pieces.

The data is presented in a system independent form, intended for a MySQL database management system. This includes definitions of MySQL table schemas and tab delimited attribute values. The DDW database is composed of nine tables or entities: CARBON_CONVERSION, COMBINED_PIECE, COMBINED_PILE, COMBINED_PLOTCON, COUNTY_CODES, DECAY_CONVERSION, LANDUSE_CODES, SPECIES_CODES, and STATE_CODES.

The main source of data is contained within the three tables, COMBINED_PIECE, COMBINED_PILE, and COMBINED_PLOTCON. These tables hold all the DDW and plot data from Maine, New Hampshire and Vermont combined. The COMBINED_PIECE table holds all the data resulting from tallied DDW pieces at each plot. The COMBINED_PILE table holds all the data resulting from the DDW piles located at each plot. And the COMBINED_PLOTCON table holds all the data required to further describe the plot conditions. The CARBON_CONVERSION and DECAY_CONVERSION tables hold the conversion factors for calculating the biomass and carbon content from the cubic foot volume of the DDW. The COUNTY_CODES, LANDUSE_CODES, SPECIES_CODES, and STATE_CODES tables are primarily used for associating codes with actual names.

SIMULATING THE CHARACTERISTICS OF A FOREST LANDSCAPE DISTURBED BY SPRUCE BUDWORM OUTBREAKS

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The natural disturbance paradigm suggests that if human disturbance more closely resembles historical natural disturbances, timber resource needs and protection of biodiversity can be reconciled. Moreover, with an increased understanding of natural disturbances, management actions might be altered to reduce the impact of disturbances on future management conditions.

We have obtained a reference forest condition for a forest management unit in northwestern New Brunswick from the interpretation of 1946 aerial photography. Spruce budworm (*Choristoneura fumiferana* Clem.) defoliation and insecticide spraying information have been digitized for the period from 1946 to the present, spanning two outbreaks in that region. We have used this information to determine a defoliation sequence for each stand in the forest in the absence of spray protection, and simulated the development of different combinations of stand type and defoliation sequence using a defoliation-sensitive stand table projection model, STAMAN. Stand species composition, diameter distribution, density, and volume have been forecast. These attributes have been used to tabulate several landscape indicators.

At the stand level, relative compositions shifted towards higher percentages of hardwood, non-susceptible softwoods, and less susceptible spruce during the forecast period. Survival favoured dominant trees, while production of coarse woody debris increased by up to 20 m^3/ha. Spruce-fir volumes declined by 30-45% during the second, more severe defoliation sequence. Spray protection reduced these declines by more than half. Across the landscape, pure fir forest was eliminated, and replaced by mixedwood forest.

Intended improvements include refinement of ingrowth and succession processes, and incorporation of better reference stand conditions for the 1946 forest.

PREDICTING HABITAT SUPPLY FOR AMERICAN MARTEN USING MEASURES OF LANDSCAPE COMPOSITION AND CONFIGURATION

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American marten (*Martes americana*) are the most area-sensitive, forest specialized mammal inhabiting northern Maine. We developed models to predict habitat supply for marten in Maine using 124 adult marten home ranges and 98 simulated, unoccupied home ranges in a commercially managed landscape. Year-specific habitat maps were generated from Landsat Thematic Mapper satellite imagery; habitat extent, patch and edge characteristics, and six fragmentation metrics were calculated for occupied ranges and for simulated ranges that were placed in areas not occupied by resident, radio-collared marten. The information-theoretic approach was used to rank 30 *a priori* logistic regression models developed to identify the habitat characteristics and landscape metrics that determine occupancy versus non-occupancy by resident adult marten and to predict the distribution of marten home ranges across the landscape. Predictions of occupancy and non-occupancy were tested against reserved field data (n = 127 occupied and 41 unoccupied home ranges not used in the model building process) to evaluate each model's predictive capability. The top ranked model included four variables (the proportion of suitable habitat, patch density, patch size variability, and the interaction of patch variability and density), and correctly predicted 70% of our model build data and 72% and 100% of our independent data sets. The proportion of a home range-sized area in suitable habitat was the most important single variable determining whether space would be occupied or unoccupied by a resident marten. However, our highest-ranked models also included at least three variables measuring landscape configuration and shape, indicating that some landscape metrics are additive to the effects of habitat extent in determining patterns of spatial occupancy by marten. Our top-ranked model was used with range-wide maps for Maine based on 1993 and 2000 satellite imagery to predict habitat supply across the state, and to estimate change in habitat supply and marten density, 1993-2000. Change in amount of habitat between 1993 and 2000 was minor; the estimated number of marten home ranges that could be supported by available habitat (i.e., habitat supply) decreased by 3%. Estimated habitat supply would support 5,561 males and 8,800 females (total 14,361 resident marten) in 1993 and 5,778 males and 8,197 females (13,975 resident marten) in 2000. Habitat supply for males increased (+ 4%), whereas habitat supply for females decreased (- 7%), 1993-2000. Spatial arrangement of habitat affects males and females differently because males utilize larger home ranges; females require suitable habitat that is concentrated within smaller areas. Our results indicate that both extent and fragmentation of habitat are important determinants of habitat supply for marten and that landscape-scale planning will be necessary to conserve marten in areas where human use reduces habitat extent and increases fragmentation.

ROAD INFORMATION SYSTEM FOR THE UNIVERSITY OF NEW BRUNSWICK FOREST LAND

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The University of New Brunswick (UNB) has over 3600 acres of forestland in 2 distinct locales within a 25-minute drive from the main UNB Campus. This proximity accounts for the attractiveness of the forestland for multipurpose use and so it is managed to fulfill four main strategic values: Teaching, Research, Financial Responsibility and Profile. To both serve such a variety of functions and achieve the goals associated with its management an efficient road network is needed.

Due to change of many physical conditions, like the new Trans-Canada Highway, throughout the forestland, area losses and deterioration of the roads themselves, the functionality of the road network was noticeably degraded. To improve the effectiveness of the current road network and to keep up with steadily increasing future demands a comprehensive database, the Road Information System (RIS) has been established. Using GPS in combination with a data dictionary, geometric and attribute data of the existing road net, the right of way, the drainage system and the actual usage of each road were captured for this information system in summer 2002.

This poster illustrates the general structure of the RIS. It also shows first results of the analysis of the road network including the actual quality of the roads and the alignment of the different road types. As key variables for the quantitative evaluation of the network: road density, road spacing, the accessible area and the average skidding distance are calculated by the usage of geographic information system technology (GIS).

For teaching/research, recreation and the operational function of the forestland the needs concerning roads are identified and combined for the future access planning. By nature there is a difference in the needs for recreational roads, operational roads and others and those different needs are easily taken into account using the RIS and GIS. Each road type has characteristics, which are accounted for and are built into the decision matrix for long-term planning and use. So from the relatively high existing road density only the future needed roads are selected and upgraded.

The RIS is a beneficial tool to forest management in terms of road network planning and adapting to the multi purpose use. The information system also helps to monitor the permanent road maintenance tasks. Additional data concerning road quality (e.g. bearing capacity) can easily be added which increases the functionality to monitor usage and refine the calculation of road upgrading costs.

MODIFIED DIAMETER-LIMIT CUTTING: SILVICULTURE OR EXPLOITATION?

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Though the selection system has a long history of use in Europe and America, it is rarely rigorously applied due to the perceived complexities of developing structural goals and marking timber in a way that simultaneously removes mature trees, tends immature growing stock, regenerates a new age class, and controls residual structure. Instead, removal-driven methods of harvesting such as diameter-limit cutting are often applied.

It has been established that diameter-limit removals in which a fixed diameter limit is used degrade residual stand condition in terms of potential volume and value production (see work by Nyland and others, and Kenefic et al. in this publication). However, a modified diameter-limit approach, in which size thresholds for tree removals are flexible, has been suggested as a less exploitive alternative to fixed diameter-limit cutting.

The USDA Forest Service's long-term silviculture experiment on the Penobscot Experimental Forest in Maine includes the selection system on a 20-year cycle (S20) as well as fixed (FDL) and modified (MDL) diameter-limit cutting. In the MDL treatment, trees above the diameter limits may be retained for seed or wind protection, and trees below the diameter limits may be harvested to capture mortality. Unmerchantable trees and those of undesirable species are retained.

Preliminary analysis of data from the first 50 years of the experiment suggest that stands which were cut using modified (flexible) diameter limits were better stocked and had greater volume and value than those in which fixed diameter limits were used. Additionally, after three entries, it appeared that the MDL stands would continue to be operable under existing cutting rules on a 20-year cycle. Undesirable species, quality, and stocking suggested that the FDL stands would take longer to regrow the volume previously cut.

Though the structure and composition of the MDL stands was far superior to that of the FDL, there were clear differences between the S20 and MDL. Most notably, the proportion of poor quality trees was higher in the MDL than in the S20, and a lack of attention to spacing (thinning) and regeneration were apparent in the stand structure and mortality data.

It is not surprising that these differences exist, since MDL is removal-driven. Silviculture, by definition, is "controlling the establishment, growth, composition, health, and quality of forests and woodlands" (Helms, 1998). Though modified diameter-limit removals make limited concessions toward residual stand quality and regeneration establishment, the cut is applied without regard for future growth, composition, or health. It is thus, by definition, not silviculture. The degree of degradation that occurs following such cuts is highly variable.

USDA FOREST SERVICE RESEARCH ON THE PENOBSCOT EXPERIMENTAL FOREST

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In 1950 a number of pulp and paper and land-holding companies purchased land in the towns of Bradley and Eddington, Maine. This land was leased to the USDA Forest Service, Northeastern Research Station to be used for a long-term experiment in silviculture of northern conifers. Since that time, a dozen silvicultural treatments have been applied in a 560-acre study. Each treatment is replicated at the stand level, with an extensive permanent plot network. Growth and regeneration data are collected before and after every harvest and at 5-year intervals between harvests.

The Forest Service experiment on the PEF encompasses even-, two-, and uneven-aged silvicultural systems. Regeneration methods include selection cutting on 5-, 10-, and 20-year cutting cycles, shelterwood with two- and three-stage overstory removals, and shelterwood with retention. Exploitive harvesting practices, such as fixed and flexible diameter-limit cutting and commercial clearcutting, are also included in the study. Additionally, cooperators have conducted many short-term studies of ecosystem function and wildlife-habitat relationships within the long-term research area.

Forest Service research on the PEF has been an important source of information about advance regeneration, seed viability, feasibility of regeneration methods, leaf area relationships, effects of exploitive harvests, sustainability of stand structure and composition, habitat suitability, and precommercial thinning. The experiment recently passed the half-century mark, and continues today under a memorandum of agreement with the University of Maine, which has owned the forest since 1994. The Forest Service is committed to continuing the research on the PEF, and is in the process of developing and approving a revised study plan for the experiment.

EFFICIENT STAND-LEVEL INVENTORY PREDICTIONS USING MULTIPLE IMPUTATION MODELS

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A New Brunswick, and many other forest jurisdictions, forest-level inventory is carried out using two-staged sampling. Forests are stratified into stand or cover types based on aerial photography and a ground inventory is carried out. All plots falling in a particular strata are then used to estimate average stand tables. These data are then used as inputs into the long-term forest management planning process. In many situations, these strata averages also get used at the annual operational planning level. Aspatial strata averages are assigned to stands and used to determine blocks, harvest systems, transportation needs, and mill flows. If variability within a stratum is large, then these averages will not be very representative of any particular stand. On the other hand, operational cruises are an added cost and, as a result, are not extensively carried out.

An alternative approach is to use multiple imputation to select a subsample of plots from the ground inventory that better represents a particular stand. Multiple imputation requires a large detail set and a smaller subset of data. The large data set represents the complete information and the smaller data set represents an incomplete data set. The incomplete data is used to select a subsample of data from the complete set to use to estimate the missing data.

In the forest inventory context, every stand has a cover type called from the aerial photography. The cover type can serve as one element within the incomplete data set. The key is to identify which additional variables are needed to enable accurate predictions from multiple imputation. A variety of field variables including, basal area/ha, species composition, average dbh, average height, etc. are used to identify which variables would need to be measured in the field via a "operational" cruise. The goal is to identify the minimum set of data needed to accurately predict stand tables based on a subsample of plots from the second-stage ground inventory.

FACTORS ASSOCIATED WITH THE LOCAL EXTIRPATION OF A DISTURBANCE-DEPENDANT BIRD

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Birds requiring periodic disturbance to maintain suitable habitat include some of the most threatened vertebrate taxa in North America. Although previous studies demonstrate that some bird species are restricted to particular seral stages, few studies include analyses of potential mechanisms for these patterns. To investigate the factors restricting these species to early seres, we studied a disturbance-dependant bird, the Chestnut-sided Warbler (*Dendroica pensylvanica*) from 1994-2001 in two regenerating clearcuts 8 and 12 ha in size on the White Mountain National Forest.

We individually marked Chestnut-sided Warblers with color bands, and monitored number of territories as well as all reproductive activity throughout each nesting season. In addition, we measured habitat characteristics at Chestnut-sided Nest sites and random points within territories over the entire study, and assessed arthropod food abundance at both sites from 1994 to 1998.

We monitored 133 Chestnut-sided Warbler territories over the study period. Numbers of territories were significantly related to time at both sites ($p < 0.05$), and by the end of the study, both populations were virtually extirpated. We found 112 Chestnut-sided Warbler nests over the study period. Survival rates of Chestnut-sided Warbler nests declined significantly ($p < 0.05$) over successional time at one site but not at the other. There was no trend in the proportion of pairs fledging young over time at either site ($p > 0.05$). Food abundance differed significantly among years at both sites ($p < 0.05$); however, we did not observe a directional change that might have accounted for the declines in numbers of Chestnut-sided Warblers we observed. Vegetation at random sites increased from 1.5 to 5 m in height over the study period. In contrast, the height of the vegetation at nest sites did not change over the course of the study. The proportion of random sample points with vegetation height in height classes usable as nesting habitat by Chestnut-sided Warblers (1-2 m) decreased significantly over the course of the study ($p < 0.05$).

Because we did not observe any consistent relationship between the numbers of territories at our sites and nest predation, the proportion of pairs fledging young, or food abundance, we conclude these factors are not responsible for the change in territory numbers at our sites. In contrast, CSWA appears to have a narrow tolerance of nesting conditions, and the availability of nest sites has clearly decreased. Thus, our study indicates that the declines over time in numbers of territories we observed are most likely attributable to declines in availability of suitable nest-sites for this highly stereotyped species.

A SIGHTING PROBABILITY ASSESSMENT OF A DOUBLE COUNT AERIAL SURVEY TECHNIQUE FOR WHITE-TAILED DEER (*Odocoileus virginianus*) IN NEW BRUNSWICK, CANADA

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For widely dispersed animal populations, aerial surveys are the only practical approach for censusing large areas and difficult terrain efficiently. With the double-count technique, two observers independently search the area of interest from a helicopter at a fixed speed and fixed height above ground. These observations are used to make a corrected density estimate of the population surveyed. The major limitation of aerial surveys is that they are negatively biased, with observers routinely missing 25-50% of the animals in a survey block. Incomplete counts during aerial surveys are a result of observers missing animals that should have been seen or observers missing animals because they are blocked from view. This results in sighting probabilities that are much less than 1.0 for the observers.

Aerial surveys have been difficult to conduct in Canada due to the closed canopy of the boreal forest. In 1992, Francois Potvin developed a double count aerial survey technique in Quebec for estimating numbers of white-tailed deer (*Odocoileus virginianus*) in large tracts of boreal forest. A potential source of error with the Potvin technique is the assumption that sighting probabilities are constant for the length of the survey line flown. This project examined the effect of cover type and group size on sighting probabilities for the Potvin double count aerial survey technique. Observers counted deer decoys placed on survey lines in the University of New Brunswick Woodlot in Fredericton, New Brunswick using the Potvin double count aerial survey technique during January and February of 2002. Three group sizes and three broad cover types were used to test the assumption of constant sighting probability. Results from this study indicate the Potvin double count technique calculates sighting probabilities which are 30% greater than actual sighting probabilities, and that cover type has a significant impact on the number of deer seen by observers.

MULTITEMPORAL IKONOS AND LANDSAT ETM+ SATELLITE DATA USE IN DETERMINING FOREST REGENERATION STAND CONDITIONS

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The ability to monitor large areas of regenerating forests cost-effectively is an important goal of both industrial and non-industrial forest landowners. Information about the structure and composition of the regenerating forest is needed to determine future silvicultural prescriptions. Use of satellite data to assist in this process may prove to be very beneficial. Satellites such as Landsat provide digital coverage of large areas on a regular basis and at a relatively low cost, which allows monitoring of large forest tracts or scattered parcels.

In this study Ikonos (4 meter, multispectral) data was acquired to map an area in northern Maine. During 2001, two seasons of imagery were collected, the first during May before hardwood leaves had begun to appear and during June after the hardwood leaf out. Digital change detection methods were employed to map areas of hardwood and softwood. In addition to the multitemporal aspect of the imagery used, the high spatial resolution of this sensor captures more homogeneous pixels with less spectral mixing among ground cover types, which happens to a greater degree when pixel size is increased. This spectral homogeneity allows for more distinct mapping of the forest regeneration conditions on the ground.

Landsat ETM+ data represents coarser spatial resolution but provides a wider range of recorded spectral wavelengths. For this study, several seasons of Landsat ETM+ data were acquired during the same year as the Ikonos. In previous studies, the use of vegetation indices have been shown to be effective in detecting small changes in forest vegetation characteristics. By using the seasonal imagery, indices such as the normalized difference vegetation index (NDVI) and the normalized difference moisture index (NDMI) can be derived and combined with multispectral data to assist in quantifying regeneration stand conditions such as softwood density and competition from hardwood species.

This poster provides examples of Landsat ETM+ and Ikonos imagery collected throughout the year to determine which combination of vegetation indices, and spectral bands enhance the identification of regeneration composition and particularly softwood density. One technique being evaluated employed linear regression, where the Ikonos based softwood map provided the dependent variable and the Landsat bands and indices were the independent variables in predicting the softwood density for Landsat 30-meter pixels.

TRIAD APPROACH TO FOREST MANAGEMENT: LAND USE ZONING IN NORTHERN NEW BRUNSWICK

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A TRIAD case study will be conducted on the J.D. Irving Ltd. Black Brook District in northwestern New Brunswick. This 190,000 ha privately-owned landbase includes some of the most intensively managed forest in Canada, with more than 60,000 ha of plantations, and 49,000 ha of tolerant hardwood managed for high quality veneer and sawlogs. In addition to the timber extraction areas, more than 7000 ha of scientific reserve areas have been created. J.D. Irving Ltd. has committed to implement 2600 ha of adaptive management treatments, within the adaptive management reserves, inspired by natural disturbance. These will be based upon spruce budworm (*Choristoneura fumiferana* Clem.) and gap replacement.

The main objective of this project is to evaluate a TRIAD management system in J.D. Irving's Black Brook district. This analysis will attempt to quantify trade-offs in timber and non-timber values through a combination of intensive, extensive, and reserve areas. We will also develop alternative silviculture techniques based upon natural disturbance regimes. These techniques will be implemented as harvest prescriptions in adaptive management areas and quantify changes in stand structure following harvest.

We will begin this project by first characterizing the forest in terms of species composition, age class, and patch size distribution. A historical snapshot has been provided by interpretation of 1946 air photos of the landbase. This information will be used to provide characterization of the forest in which there had been little human intervention. This will allow for a starting point to begin our analysis of forest management strategies. These strategies will incorporate various amounts of forest area zoned to intensive or extensive management regimes, or forest reserves. Depending on the scale of resolution, the possible number of combinations for dividing forest area into extensive, intensive, and forest reserves can get very large. As an example, for an interval scale of 20%, there are 21 unique possible aspatial combinations for the three forest zones. This number will increase even further with the addition of spatial and temporal possibilities. At some point in this matrix of forest management scenarios lies the forest of today and a future forest projected by the current twenty-five year management plan.

A suite of indicators will be developed relating to timber production, wildlife and fine filter biodiversity elements. These will be used to assist in the analysis of the management scenarios using a forest estate model (Woodstock/Stanley). This information will allow forest management planners to have a visual perspective of where their forest lies and what other options are available to them. This will allow for forest managers, concerned with the maintenance of biodiversity objectives, to make more informed landscape level decisions.

LEAF AREA MODELS FOR AND LEAF AREA TRENDS IN *Pinus strobus* L. IN MAINE

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Leaf area (LA) estimation models for *Pinus strobus* L. were developed, tested, and compared in distinct structural environments in the Penobscot River valley of central Maine. Test plots were located within an even-aged stand containing four thinning treatments (in order of most dense to least): unthinned dense control, unthinned control, B-line, and crop tree. Litter trap collections over the past ten years provided an appropriate reference for which to compare LA models within each treatment. Seven stand-level models were developed and compared. Two models utilized sapwood area as a predictor variable, while the remaining five models were variations of the "Valentine" model (Valentine et al., 1994). Graphical analysis of average LA per hectare displayed consistent model bias among treatments except in the unthinned dense treatment. Lack of model fit within unthinned dense plots may be a factor of higher sapwood taper in the stem resulting from dense stand structure. Additionally, sapwood model estimates and litterfall estimates agreed except for the crop tree treatment, where an unusually high trap value from the 2002 collection may be overestimating LA and thus, artificially raising the average litterfall reference line. While the Valentine model continues to be a promising tool for non-destructive leaf area mensuration, recent adjustments to the model improve, but do not perfect this technique. Our data suggest that stand structure may play an important role in model appropriateness especially in dense stands.

Valentine, H. T. et al. 1994. For. Sci. 40:576-585.

FACTORS AFFECTING BMP COMPLIANCE IN MAINE: A SURVEY OF FORESTERS AND LOGGERS

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The passage of the Federal Water Pollution Control Act Amendments in 1972 has many implications for the forest industry. These amendments set goals to improve water quality throughout the nation from both point and non-point sources of pollution. Each state is required to develop methods to control sources of pollution. The Environmental Protection Agency uses the concept of "Best Management Practices" (BMPs) to promote erosion control from activities such as forestry. Compliance with BMPs in forestry is dependent on many factors including the type of BMP, site of application, and those responsible for applying BMPs. The goal of this survey was to identify factors that influence BMP compliance rates in Maine from the perspective of Maine foresters and loggers.

The survey was conducted by mail using the total design method. A cover letter and survey were sent to all licensed Maine foresters residing in Maine and New Hampshire, with repeat mailings for non-respondents. Similar methodologies were used to survey loggers in the state of Maine. Questions were designed to clarify respondent's opinions about the effectiveness of BMPs and factors affecting BMP compliance rates. One section of the survey asked categorical questions and another section asked respondents to rank a given list of possible reasons for non-compliance. Possible reasons included "BMPs are too costly", "lack of landowner knowledge", "lack of landowner concern", "lack of logger knowledge", "lack of logger concern", and "lack of forester concern".

Ninety-five percent of the foresters indicated that BMPs were at least "usually" effective in controlling sedimentation, while eighty-five percent of the loggers indicated that BMPs were at least "usually" effective in controlling sedimentation. Both foresters and loggers rated "lack of logger concern" to be a top reason for non-compliance of BMPs. However, more loggers than foresters ranked "BMPs are too costly" as a reason for non-compliance. This suggests an economic burden on loggers to implement BMPs. Other factors indicated by both loggers and foresters as influential in BMP compliance were "lack of landowner concern" and "lack of landowner knowledge". Increased BMP training for landowners and research on cost sharing of implementing BMPs may be helpful in improving BMP compliance rates in the state of Maine.

CROP TREE GROWTH TWENTY-FIVE YEARS AFTER PRECOMMERCIAL THINNING IN A NORTHERN CONIFER STAND

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Growth characteristics of selected *Picea rubens* Sarg. (red spruce) and *Abies balsamea* (L.) Mill. (balsam fir) crop trees were studied in a northern conifer forest to determine the effects of precommercial thinning (PCT) 25 years after initial treatment. The research was conducted in an area of the Penobscot Experimental Forest (PEF) in Bradley, Maine where there is an ongoing study on the effects of different PCT regimes on species composition and growth and yield of selected crop trees. The initial experiment is four different PCT treatments and two levels of fertilization with four replications of each combination. Four of the 2.4 x 2.4 m (8 x 8 ft) plots and five of the control plots (no PCT) from the initial study were utilized. A total of 80 crop trees were measured: 21 balsam fir unspaced, 20 balsam fir spaced, 16 red spruce unspaced, and 23 red spruce spaced. Upper stem diameters and heights were measured from the stump to crown base on all 80 crop trees and branch diameters were measured between 1.0 - 2.0 meters above breast height (bh). In addition, diameter at breast height (dbh) and total height (THT) were recorded for all crop trees.

Two measures of growth efficiency (GE, growth per unit of growing space) were examined: stemwood increment (dm^3) per unit of projected leaf area (m^2) and stemwood increment (dm^3) per unit of crown projection area (m^2). Stem form differences were evaluated by comparing stem taper across species and treatments. The number of branches, average branch size, and percent knot volume of each crop tree were compared between spaced and unspaced crop trees.

GE did not differ between spaced and unspaced plots, although PLA and CPA per tree were larger in the spaced plots. Overall, balsam fir was more growth efficient than red spruce. There were no differences in average PLA between the two species, but red spruce had a larger CPA than balsam fir. Volume, crown length (CL), % knot volume, average branch size, and the number of branches were all significantly larger for crop trees in the spaced plots than in the unspaced. Crop tree stem taper was greater in the spaced plots and the height/diameter (H/D) ratio was lower. Red spruce THT did not differ between treatments, but balsam fir crop trees had significantly taller trees in the spaced plots compared to the unspaced.

DISTURBANCE REGIMES IN MIXEDWOOD STANDS FROM DIFFERENT TOPOGRAPHIC SETTINGS

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Old-growth forest landscapes provide important sites from which natural disturbance patterns in different forest types and landscape settings may be described and applied to a variety of management issues. We used the radial growth patterns and ages of canopy trees sampled in the 2000-ha Big Reed Forest Reserve in northern Maine to reconstruct stand-level disturbance patterns and investigate the effects of topographic position on disturbance regimes. During 1999 and 2000 a total of eight sites at BRFR were selected for sampling; four each were located in softwood stands and softwood-dominated mixedwood stands. Two stands within each forest cover type were located on slopes with a northwest aspect, while the other stands were chosen from areas with no significant slope. Rectangular plots of 0.5 ha in size were established in each stand and divided into 10-m x 10-m grids. Dbh, species, and crown position were recorded and increment cores were extracted at a height of 1.4-m from all living trees≥ 10-cm dbh in each plot. Following standard core preparation, annual ring widths were measured to the nearest 0.01 mm on a Velmex measuring system and cross-dated using marker years and the COFECHA program.

For the current presentation of preliminary results, we analyzed two mixedwood stands, MWA and MWLA located in slope and lowland positions, respectively. The MWLA and MWA stands are comparable in total basal area, 26.4 m2/ha and 24.1 m^2/ha, respectively. Both stands are equally dominated by red spruce (*Picea rubens* Sarg.) associated with significant amounts of sugar maple (*Acer saccharum* Marsh.), American beech (*Fagus grandifolia* Ehrh.), and yeloow birch (*Betual alleghaniensis* Britt.). The composition of lowland MWLA stand is more diverse than MWA, including several tree species not recorded in MWA. Balsam fir (*Abies balsamea* (L.) Mill.), while present in both stands, is three times as abundant in MWLA as in MWA.

Stand age structures, releases (i.e., 100% increase in radial growth over the previous 10 year period and lasting for 10 years), and patterns indicative of gap origin (i.e., an initial 5-year rate in excess of an absolute value) were used to reconstruct the disturbance history of each stand. The combined percentage of trees of gap origin and those exhibiting release were used to approximate area disturbed for each decade between 1800 and 1980 and generate disturbance chronologies.

The age structures of the two stands are generally similar, although MWA possesses a greater component of trees >100 years in age than MWLA. Major periods of establishment breast height recruitment occurred in the mid-1800s and 1920's-1930's in both slope and lowland stands. Stands in both sites also showed minor peaks in the establishment or around1800, possibly representing stand initiation. The approximate disturbance chronologies calculated for the stands support the age-structure data. Levels of disturbance ranged from 2%-42% per decade between 1850-1980, with the highest rates in the mid-1800's and the 1920's-1940's. The average annual rates of disturbance are remarkably similar for the mixedwood stands from both topographic positions (1.46% and 1.50%) and comparable to other values calculated in northern Maine.

FOREST CHANGE AND FRAGMENTATION COMPARISONS USING TERRA MODIS AND LANDSAT ETM+ IMAGERY

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The Terra satellite platform contains the Moderate Resolution Imaging Spectrometer (MODIS) which holds promise to become an important data source for land cover characterization and monitoring at regional and global levels. Although this study addresses forest cover assessments in Guatemala's tropical forests using multi-scale satellite imagery, it has implications for performing similar regional assessments of temperate and boreal forest environments.

The research questions we are attempting to address in this preliminary study are: 1)

Can MODIS 250 m resolution imagery detect annual forest clearing? 2) Can MODIS be employed to characterize forest fragmentation to assist in forest monitoring and biodiversity assessments along the Mesoamerican Biological Corridor in Central America and Mexico?

The poster includes qualitative comparisons of change detection images and maps derived from MODIS and Landsat ETM+ multi-temporal and multi-spectral data. Preliminary findings indicate that the coarse resolution MODIS imagery can detect large forest clearing (i.e., those associated with pasture land use conversion), however small clearings (<10-15 hectares) associated with subsistence slash and burn agriculture are not effectively resolved using MODIS data alone.

Further research into the combined use of MODIS and Landsat to derive sub-pixel information (e.g. forest density changes) from MODIS may improve the capabilities of coarse, spatial resolution data for regional forest assessments.

RGB-NDMI: A SIMPLE, ACCURATE AND EFFICIENT FOREST CHANGE DETECTION METHOD USING TIME-SERIES LANDSAT SATELLITE IMAGERY

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Change detection and forest monitoring are among the most important contributions of satellite remote sensing to sustainable forest management. Researchers at the Maine Image Analysis Laboratory (MIAL) have developed a simple, logical, and accurate method to detect and map annual forest changes across large landscapes. The method, originally called RGB-NDVI, has been successfully tested in northern Maine and Central American forest environments. A revised method, RGB-NDMI, will be presented using examples from study sites in northern Maine and a recent application in the southern U.S. to map live plantations and annual pine mortality caused by Southern Pine Beetle attack.

The normalized difference vegetation index (NDVI) has been shown to be correlated to green biomass, leaf area index, forest canopy closure among other vegetation parameters. It is one of the most popular vegetation monitoring tools applied in remote sensing of forests. The NDVI utilizes the visible red wavelengths (approx. 0.6 – 0.7 microns) where most of the energy is absorbed by vegetation for chlorophyll production and the reflected infrared wavelengths (0.7 – 0.9 microns) that reflect most of the energy due to leaf structure. The normalized difference moisture index (NDMI) is a similar vegetation index however the shortwave or middle infrared reflected waveband replaces the red wavelength. The middle infrared waveband has absorption properties correlated with water content in vegetation and soils. Dense vegetation canopies have the highest NDVI and NDMI and non-vegetated targets (urban, water, bareground) have values approaching zero.

Most image processing software packages can produce a color composite image using 3 Landsat images, each coupled with red (R), green (G) or blue (B) in the computer display device. We apply this approach to change detection to produce a multi-date color composite NDVI (or NDMI) image by coupling each date with R, G, B in chronological sequence. In a working forest environment such as the industrial forest of northern Maine, both harvest (biomass decreases) and regrowth (biomass increases) can be observed over the time sequence represented by the vegetation index dates. Clearcuts can be distinguished from partial cuts with good accuracy.

When large landscapes and/or multiple ownerships are involved, multi-temporal satellite imagery may be an appropriate and cost-effective tool (compared to aerial photography) to monitor annual forest change using either visual or digital analysis methods.

FERP: DESIGNING AND UNDERSTANDING SILVICULTURAL SYSTEMS FOR THE FUTURE

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The Forest Ecosystem Research Program (FERP) was initiated in 1995 on the Penobscot Experiment Forest in Bradley, ME, as a collaborative effort between the University of Maine and the U.S. Forest Service. The focus of FERP has been understanding the ecological relationships within the Acadian forest as harvested using two versions of an expanding gap silvicultural system, which is loosely based on the famous German "Femelschlag" system and incorporates many aspects of ecological forestry. Differences between pre-harvest, baseline data collected in 1995-1997 and post-harvest data collected in 1998-2000 are being used to compare this system with forest structure developed by both natural tree-fall gaps and by more traditional harvesting regimes of this region (i.e., selection cutting). Current areas of investigation include: 1) the relationship between light intensity and herbaceous cover for various species, both in man-made and natural gaps; 2) the effects of harvesting on type and decay of downed woody debris (DWM); and 3) the spatial distribution of DWM within harvested gaps and the surrounding matrix. New studies are investigating how the characteristics of canopy gaps and DWM influence understory vegetation communities, arthropod communities, and amphibian populations. Details about FERP can be found on the web at: http://www.umaine.edu/fes/Wagner/FERP/default.html.

LEAVE PATCHES AS REFUGIA FOR VASCULAR PLANTS IN HARVEST BLOCKS

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Leave patches or "tree islands" that are left in harvest blocks appear to function as refugia for some of the sensitive species of the herbaceous layer and the structural elements upon which they depend for habitat. However, we do not know the critical characteristics that these tree islands must have to insure that these species survive and successfully reproduce. We are assessing the influence of size and edge aspect on ground temperature, light, humidity, and herbaceous layer species composition as a function of distance from the island edge. The goal of this multi-year project is to assess the functionality of tree islands of varying sizes as plant refugia and sources of critical elements of stand structure.

The objectives of the project are: 1) to characterize microclimate, herbaceous layer vegetation, environment, and stand structure on islands identified in 2002 before and after harvesting, 2) to examine the distribution of island sizes and the amount and severity of blowdown with respect to edge aspect in pre-existing islands, and 3) to determine the minimum island size required for the existence of core habitat unaffected by edge.

Two islands of each size class, 1.0 ha, 0.5 ha, and 0.25 ha were delineated and permanent plots were sampled before and after harvesting in 2001 and 2002. Transects were laid in north, south, east and west directions from the island center to 25 extending 50 m into the adjacent cut block. In the 1.0 ha islands, sets of 1 m^2 quadrats were placed according to the island edge, inside and outside of the island with additional plots placed in the center. Transects in the 0.5 ha and 0.25 ha islands contained single 1 m^2 quadrats at intervals in relation to the edge. Data collected in the quadrats were the percent cover of vascular plants, substrate (leaf litter, fine and coarse woody debris, scat, cones, mineral soil, humus, bark, dead and live trunks, stumps, live roots, and rocks), canopy cover (hardwood, softwood and open), and microtopography (level, pit, and mound). Data collected in 5 m^2 stand structure plots were the size, species, and percent live crown for trees >7 cm DBH, saplings and shrubs (<7 cm DBH) by species and number of stems, and coarse woody debris by length, DBH top and bottom, decay class, and species (where possible). We used dataloggers placed with a subset of plots, in addition to two controls, before and after harvest to record temperature, relative humidity, sunlight, and rainfall. We examined the size of twenty-six islands established before 2001, along with blowdown (the number of trees $\geq$5cm DBH that had been blown down since harvest by species, DBH, length, compass bearing of the fallen bole, the quadrant in which it was located, and whether the tree was uprooted, leaning, snapped or uprooted/leaning).

Our current work indicates that most existing islands are relatively small (<0.25 ha) and are subject to blowdown along their edges. These preliminary results also suggest that some additional wind protection should be provided in the southwest quadrant of tree islands, e.g. by leaving a buffer of wind-firm, smaller trees. The baseline data we have collected this year will allow us to make more detailed recommendations based on future analysis of vegetation and environment response to this year's harvest.

OCCUPATIONAL CHOICE AMONG LOGGERS IN MAINE'S NORTHERN FOREST AND SOUTHERN COUNTIES

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As a political entity created by the US Congress, the Northern Forest does not represent a distinct ecological or economic region, and, as such, distinctions between the 28 so-called Northern Forest counties and neighboring counties in the region can be somewhat artificial. Aspects of Maine's Northern Forest logging community were examined in order to develop baseline information on loggers' occupational choice, and to detect trends, if any, by comparing our work with an earlier study of the state's loggers. Moreover, as a way of understanding whether loggers in Maine's Northern Forest have a sense of occupational choice that is distinct from loggers in the rest of the state, our study compares responses of loggers who work in Maine's Northern Forest counties and the state's southern counties. A sequence of multiple survey mailings – a cover letter and survey, followed by a reminder postcard, and finally a second cover letter and survey – were sent to 2,870 Maine loggers.

Compared with a previous study of northern Maine's logging community conducted in 1968 by the Public Affairs Research Center, Maine's loggers today are older, better educated, and reported more years of logging experience. Statistically significant differences were found between these two groups in their logging experience, with Northern Forest loggers reporting approximately 2.5 more years of logging experience than loggers from southern Maine counties. Northern Forest loggers also reported significantly more generations preceding them in logging than were reported by loggers from the state's southern counties. Results also suggested a greater sense of resignation to logging as an occupation among Northern Forest loggers vs. loggers who work in the state's southern counties. A majority of loggers in both regions of the state sensed that the general public viewed loggers as unskilled and did not respect the work that loggers do. However, a majority of loggers in both regions agreed that logging was respected within their own communities. In addition, 72 percent of Northern Forest loggers and 60 percent of southern county loggers in Maine said that they would not encourage a son or daughter to be a logger.

Overall, results of our study suggested that, although aspects of a cohesive occupational community may exist among Maine loggers across the state's Northern Forest and southern counties, there are significant differences in their reasons for logging that may have implications for logging labor recruitment in the Northern Forest region. Implications for the future may include a continued decline in the availability of individuals who are willing to participate in a skilled domestic logging workforce, particularly in Maine's Northern Forest.

DECLINE OF BALSAM FIR AND ITS RELATION TO NATURAL DISTURBANCE AND ABIOTIC FACTORS IN NEW BRUNSWICK: THE ROLE OF INDIRECT EFFECTS.

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Spruce budworm (*Choristoneura fumiferana* Clem.) is North America's most damaging forest insect, which principally attacks balsam fir (*Abies balsamea* (L.) Mill.) and spruce (*Picea* spp.), affecting balsam fir regeneration and survival. Spruce budworm outbreaks typically last 5-15 years and can result in the death of whole stands, and increased mortality rates for up to 10 years after the outbreak.

Literature indicates that spruce budworm-caused balsam fir mortality is influenced by stand characteristics and site conditions, but most datasets are limited both spatially and temporally. We have addressed this shortcoming by integrating existing data collected over the last thirty years from 2636 permanent sample plots (PSP) in New Brunswick, which encompass over 227,000 trees.

The aim is to investigate the hypothesis that present balsam fir decline is due to the indirect effect of past cumulative defoliation-related stress. Individual tree growth and mortality data from the PSPs and tree/stand/site characteristics were analysed using Arc/Info to determine their relationships with balsam fir decline, and compared to maps of past annual defoliation levels from 1950-2000.

From 1987-95, even though spruce budworm populations were generally at low levels, 28% of 676 PSPs in mature and over mature fir-spruce stands exhibited net volume decline where mortality exceeded the growth of surviving trees. Although not statistically significant declining stands were exposed to higher mean and maximum cumulative defoliation over the last spruce budworm cycle.

COOPERATIVE FORESTRY RESEARCH UNIT

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The Cooperative Forestry Research Unit (CFRU) was founded in 1975 and is one of the oldest industry / university forest research cooperatives in the United States. 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 is composed of about 25 private and public forestland management organizations from across the state that guide and support research through annual financial and in-kind contributions.

Over the years, the CFRU has solved a number of key problems facing Maine's forest managers. Today it continues to serve as a model of joint leadership and cooperation between Maine's largest industry and the University of Maine. CFRU scientists are working to solve the most important problems in managing Maine's forests. Current CFRU research projects include:

- Maine Commercial Thinning Research Network – *Bob Wagner and Bob Seymour*
- Effect of precommercial thinning on snowshoe hare – *Dan Harrison*
- Influence of forest practices on habitat selection by lynx in northern Maine – *Dan Harrison*
- A habitat supply assessment for marten – *Dan Harrison*
- Effect of buffer and filter strips on water quality and aquatic biodiversity – *John Hagan*
- Austin Pond: Long-term effects of herbicide application and precommercial thinning on the development of a young spruce-fir forest – *Bob Wagner*
- Patch retention as a tool for maintaining biodiversity in a northeastern industrial forest – *John Hagan*
- Factors affecting the regeneration and early growth of balsam fir and red spruce – *Mike Greenwood*
- Role of interfering plants in hardwood regeneration: literature review – *Ralph Nyland*
- Indicators for maintaining biodiversity in managed forests – *John Hagan*
- Northern hardwood growth and yield model – *Tim McGrath*

In addition, the CFRU is a leader in organizing field tours, conferences, and training sessions to help forest managers across the state keep up with the latest results from forest research. Details about the CFRU can be found on the web at: http://www.umaine.edu/cfru/.

MAINE'S COMMERCIAL THINNING RESEARCH NETWORK

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Members of the University of Maine's Cooperative Forestry Research Unit (CFRU) have identified a better understanding about commercial thinning and resulting growth & yield responses as their top research priority for 2000-2005. As a result, the CFRU established a Commercial Thinning Research Network in 2000. Initial efforts by the network were divided into two phases. Phase I developed a set of interim commercial thinning guidelines that have been packaged in a computer program called ThinME. Phase II has established research sites that address the most pressing questions about commercial thinning in Maine's forests.

Phase II is focused on designing, installing, and maintaining a statewide network of commercial thinning research plots. Data from this network will help further refine the thinning guide developed in Phase I, improve growth and yield models related to thinning responses, and address other silvicultural questions of interest.

Initial efforts have been directed at establishing research installations in spruce-fir stands across the state to answer two key questions:

1. For natural spruce-fir stands that have never received precommercial thinning (PCT), what is the influence of (a) method of 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 on CFRU member lands across the state of Maine. Six sites have been previously PCT'd and are approximately 25-40 years old. The other six sites have never received PCT and range from 40-70 years old. At each site, seven 0.92-acre (200 ft. x 200 ft.) 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% or 50%). 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% or 50%). The thinning treatments use single-grip harvesters and were applied to all sites from fall 2000 through fall 2002.

Four 0.05-acre (50.0 x 43.6 ft.) measurement plots are placed at the center of each treatment plot. All plots have been measured immediately before and after thinning. Periodic post-treatment measurements are being taken on permanent tagged trees. Measurements include species, dbh, tree location, total height, and height to live crown.

EFFECTS OF FERTILIZATION ON GROWTH INCREMENT AND WOOD PHYSICAL-MECHANICAL PROPERTIES OF YOUNG SLASH PINE

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The trial stand of 2m x 2m spacing for slash pine was on yellow-red soil in the Fengshushan Forest Farm of Jiangxi Provence of China in 1991. Soil properties were: pH4.5~5.0 effective nitrogen (N) 149.8 $mg.kg^{-1}$ effective phosphorous (P) 3.23 $mg. kg^{-1}$ effective potassium 47.93$mg.kg^{-1}$. This soil lacked phosphorous and potassium, but had abundance of nitrogen (N). Eleven sorts of fertilization treatments (P_1, P_2, P_3, N, K_1, K_2, NP_2, P_1K_1, P_2K_1, NP_2K_1 and Control) were compared in a randomized block design. Nitrogen, potassium (K), and phosphorous fertilizer were applied successively from 1992 and 1994. The basal diameter or DBH, height of each tree was determined in the winter of each year. Measurements of soil properties were conducted every year. Effects of fertilization on tree growth and wood physical-mechanic properties were studied in March 1998. Variance analyses showed that there were significant effects of fertilization on tree growth of slash pine and latewood percent, wood basic density and compression parallel to the grain of wood (CP), modulus of elasticity (MOE) and modulus of rupture (MOR) for slash pine.

Nitrogen fertilizer had negative effects on slash pine growth. Basal diameter, height, and volume index of trees treated with Nitrogen decreased 2.2%~14.2%, 2.2%, 12.7%, and 22.1%~22.7% respectively, compared with control trees. Volume of K fertilized trees was smaller than unfertilized trees. P alone and P combined with N or K, and combined N-P-K increased growth of slash pine. Basal diameter, height, and volume index increment increased 8.8%~30.1%, 7.7%~35.8%, 23.3%~134.4% in order.

Significant differences in shrinkage percent of tangential, radial, axial (AL), volume of wood at air-dried condition and ratio (T/R) of tangential to radial shrinkage were not found among eleven treatments at 0.05 level. But the AL and T/R of wood from trees fertilized with P, N-P were smaller than those from unfertilized trees and AL of wood from trees treated with only Nitrogenous or potash fertilizer were than that unfertilized trees. P, N-P, N-K, and N-P-K enhanced latewood percent, basic density, CP, MOR and MOE compared with physical-mechanical properties of wood from unfertilized trees. Increasing percents of wood properties above were positively correlated with the amount of P fertilizer treated per hm^2.

Growth increments of tree height, diameter at breast height, and tree volume in stands treated with fertilizers were positively related with latewood percent, wood basic density, CP, MOR and MOE, respectively. Both latewood percent and wood basic density were separately correlated with CP, MOR and MOE in all treated trees. In trial stand of slash pine, wood physical-mechanic properties from dominated trees were best compared with those from suppressed trees, and intermediate trees. Wood properties from intermediate trees were greater than those from suppressed trees in the same stand.