Restoring the Acadian Forest

A Guide to Forest Stewardship for Woodlot Owners in the Maritimes

by Jamie Simpson

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Restoring the Acadian Forest:

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FOREWORD

Like many Maritimers, I have had a connection with the forest from an early age. I spent much of my childhood in the forest with friends – building shelters, climbing trees, hunting, fishing and camping. Later, I developed an interest in how we use the woods. I got a chainsaw, and David Thompson, one of the woodlot owners profiled in this book, showed me how to use it. He gave me an appreciation for selecting certain trees to cut over others, using harvesting to improve the quality of his woodlot. He showed me an alternative to the indiscriminate clearcutting taking place on many nearby woodlots.

I took time to visit other woodlot owners, and they broadened my understanding of forests and forestry – people like Marc Spence and Gary Schneider (also profiled in this book) and Merv Wilkinson of Vancouver Island. I took part-time jobs thinning and harvesting trees, and I gained an appreciation for the work involved in making a living in the woods. My awareness of the Acadian Forest grew as I took courses in ecology at Acadia University. My understanding of forest management expanded as I completed a Master of Science in Forestry degree at the University of New Brunswick.

I bought my own woodlot and began an adventure of exploration and discovery. While wandering its eighty-odd acres, I found evidence of past owners – broad piles and low walls of stones painstakingly picked from ploughed fields, the last remains of a wood-rail fence, a couple of rusted spring-tooth harrows, a rotting sled with rusted metal runners – all slowly disappearing as the forest grew again. Beyond the old farmland, I found evidence of small clearcuts, areas which contained dense, even-aged growth of balsam fir, hardly bigger than six inches across at 40 years of age and already starting to expire. Luckily, from a forest restoration perspective, shade-tolerant, long-lived red spruce trees were scattered within these stands of dying balsam fir, ready to take the place of the short-lived fir. I also found the stumps from more recent harvesting. Large red spruce and yellow birch trees had been cut in what is known as high-grade harvesting when a previous owner had cut and sold some of the more valuable trees.

Much as I would like to have those big trees still standing, I am content to work with what is left. I have thinned around the trees which I would expect to see in mature Acadian Forest and that have good growth potential. I favoured red spruce, yellow birch, white ash and sugar maple trees over the abundant balsam fir. Low quality hardwood trees became my yearly firewood, giving the better-formed trees more room to grow. I cut a few big tamarack trees and had them milled into lumber to make repairs to the old farmhouse I bought with the land. I replaced floorboards that had been worn from a full inch to a quarter of an inch in some places from generations of boot traffic. Looking back a few generations helps to put the present and future into perspective. With time and sensible management, a degraded woodlot can grow into a diverse and valuable piece of the Acadian Forest.

ACKNOWLEDGEMENTS

The idea for this book started with DeLancey (Lance) Bishop, a Nova Scotia woodlot owner, farmer and part-time wood harvesting contractor who is passionate about the plight and potential of the Acadian Forest. He realized that there was no comprehensive resource available for woodlot owners who wish to learn about the Acadian Forest and ways to restore its ecological and economic value. He and a dozen or so other woodlot owners came together under the name of the North Mountain Old Forest Society and, among other endeavours, raised the funds necessary to begin researching and writing this book.

Lance and I have been friends since we studied biology together at Acadia University. Later, I worked with Lance in the woods, cutting trees for private land owners and trying to put our ideas about good forestry into practice. A couple of years ago, Lance told me about his idea for this book, and soon a committee was formed to put the idea into action. Soren Bondrup-Nielsen, our academic

Rochelle Owen

Marina Myra and Lance Bishop

advisor at Acadia University, was on the committee, along with fellow Acadia graduate Sean Basquill, forest technician Will Martin and writer Flora Cordis Johnson. The committee worked hard to set the book in motion and chart its course.

The editing skills provided by Alison Hughes were essential; her patience and dedication helped to see this project completed. Contributing authors, researchers and editors are Flora Cordis Johnson, Bob Bancroft, George Fullerton, Lillian Harris, Lance Bishop, Karen DeWolfe and Gary Schneider.

Graphic design is by Elaine Doyle; front and back cover design is by Kelly Davis. Huge thanks to these two people for ensuring this project saw the light of day.

Thanks go to those who gave their time to provide me with resource materials, answer questions and review sections of the book for technical accuracy. These people include Peter Salonius, Canadian Forest Service; Vince Zelazny, New Brunswick Department of Natural Resources; Soren Bondrup-Nielsen, Acadia University; Judy Loo, Canadian Forest Service; Kevin Keys, Nova Scotia Department of Natural Resources; Tony Pesklevits, graduate student, Dalhousie University; Alex Mosseler, Canadian Forest Service; Taumey Mahandrappa, Canadian Forest Service; David Palmer, YSC Marketing Board, NB; Marney Isaac, graduate student, University of Toronto; Ken Hardie, NB Federation of Woodlot Owners; Bob Bancroft, wildlife biologist; Art Lynds, Nova Scotia Department of Natural Resources. Their inclusion does not mean they have reviewed the entire content of this book, so any remaining inaccuracies must be attributed to me.

The woodlot owners who are profiled in Chapter 5 gave time from their busy days to show me their woodlots and explain how they care for them. They have put into practice ideas that are presented in this book, working with the forest to promote ecological health and economic value. Their dedication to the Acadian Forest is rarely recognized, and society is indebted to these woodlot owners and others like them for the benefits their woodlots provide beyond the bounds of their properties: clear air, clean water, wildlife habitat and a beautiful landscape. May they inspire others to look a little more closely at the forest to see what it has to offer, and to work with the forest to encourage its natural bounty and diversity.

These folks are Gig Keirstead and Denise Howlett, Kingston Peninsula, NB; Susan Tyler and Clark Phillips, near Sussex, NB; brothers Marc and Mike Spence, Baie Verte, NB; Bob Bancroft and Alice Reed, Pomquet, NS; Bill Freedman, Halifax, NS; Dave Thompson, Elmsville, NB; Gary Schneider, Orwell, PEI; Jean-Guy Comeau, Nelson-Miramichi, NB; Jim and Margaret Drescher, New Germany, NS; Tom and Lori Miller, New Glasgow, NS; and Wade and Julie Prest, Mooseland, NS.

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A thorough compilation of literature on the subjects of woodlot stewardship and the Acadian Forest was completed by Flora Cordis Johnson as a prequel to this project. It can be accessed on the Nova Forest Alliance's webpage at www.novaforestalliance.com.

Jamie Simpson

Jamie Simpson has a Bachelor of Science degree in biology from Acadia University and a Master of Science in Forestry degree from the University of New Brunswick. He owns and enjoys working with a woodlot in south-western New Brunswick. When not cutting, splitting or stacking firewood, Jamie enjoys rock climbing, cycling and canoeing.

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- Managing the Riparian Habitat (Chapter 2, page 23): Bob Bancroft
- Planting Trees and Shrubs (Chapter 3, pages 68 - 72): Gary Schneider and Jamie Simpson
- Creating Urban Habitat: A visit with Bill Freedman (Chapter 3, pages 74-76): Flora Cordis Johnson
- Providing Habitat (Chapter 3, page 73-79): Jamie Simpson, Lillian Harris and Karen DeWolfe
- Owls and Old Forests (Chapter 3, page 78): Nature Trust of Nova Scotia
- Other Revenue Sources (Chapter 4, pages 82 - 83): Jamie Simpson and Lance Bishop
- Profiles of Jean Guy Comeau and Whaelghinbran Farm (Chapter 5, pages 93 - 96): Jamie Simpson and George Fullerton, with additional material from the Conservation Council of New Brunswick (page 96)

Editor: Alison Hughes

INTRODUCTION

While studying at Acadia University, I first became aware that there are two contrasting approaches to forest management. I was on a committee to create a standard for sustainable forest management in the Maritime Provinces. It would be used for forest certification evaluations under the Forest Stewardship Council, an international organization that promotes certification of well-managed forests. Before joining the committee I asked the Chair how long the process would take; six months to a year was his answer. I sat on the committee for nearly seven years, and we never reached complete consensus. We met for days at a time; we shared laughs, frustrations,


Jamie Simpson

Jamie Simpson viewing a white pine on Cape Breton Island

This book is for those who identify with the second group that Leopold described, those who see value in working with the natural diversity of the Acadian Forest. Many of the ideas in this book have been presented elsewhere by various people in a variety of formats. It is original only in that it brings these ideas together under one cover, in a presentation that I hope will be accessible and enjoyable.

More specifically, this book is about owning and working with woodlots in the Acadian Forest of eastern Canada and the north-eastern United States. It describes what the Acadian Forest is and how it works, and provides information on planning, harvesting, thinning and planting, all in the context of working with the natural forest to restore ecological and economic value.

meals, the odd beer, and even an aerial tour of land owned by a large, industrial forestry company. Yet, from my perspective, we continually stumbled over two fundamentally different approaches to forest management. On one hand was the vision to promote a forest that conforms to the objectives of the forest industry through intensive silviculture; on the other hand, was the vision to work with the natural forest and its biodiversity.

The difficulties our committee faced were not new. In 1949, forester and ecologist Aldo Leopold clearly described the same two approaches to forestry in *A Sand County Almanac:*

> *"[In forest management] one group (A) regards the land as soil, and its function as commodity-production; another group (B) regards the land as a biota, and its function as something broader…. … group A is quite content to grow trees like cabbages, with cellulose as the basic forest commodity…. Group B, on the other hand, sees forestry as fundamentally different from agronomy because it employs natural species, and manages a natural environment rather than creating an artificial one."*

Working with a woodlot is an individual endeavour. No two woodlots are exactly alike, and there are no set-in-stone rules for good woodlot management. There are as many approaches to managing woodlots as there are woodlot owners. Some may wish to promote as many high-value trees as possible, some may wish to focus on wildlife habitat, and some may wish to simply leave the forest alone to enjoy. All of these are valid approaches. The key to good woodlot management, and the theme of this book, is simply to work with the forest rather than against it.

NOTE TO READERS:

Readers are encouraged to provide comments, point out errors and suggest additional material for this publication. Visit the Res Telluris website at www.restelluris.ca for information on how to contact the author.

> *"We grieve only for what we know."*
> *Aldo Leopold,* A Sand County Almanac, *1949*

Dedication:

This book is dedicated to the memory of Pam Langille, who spent most of her time during the past two decades advocating for the Acadian Forest and responsible forestry practices. Pam took many of the photos that appear in this book.

I also wish to recognize those who have encouraged my passion for the Acadian Forest and my understanding of forestry, including David Thompson, Soren Bondrup-Nielsen, David Palmer, Judy Loo and Thom Erdle.

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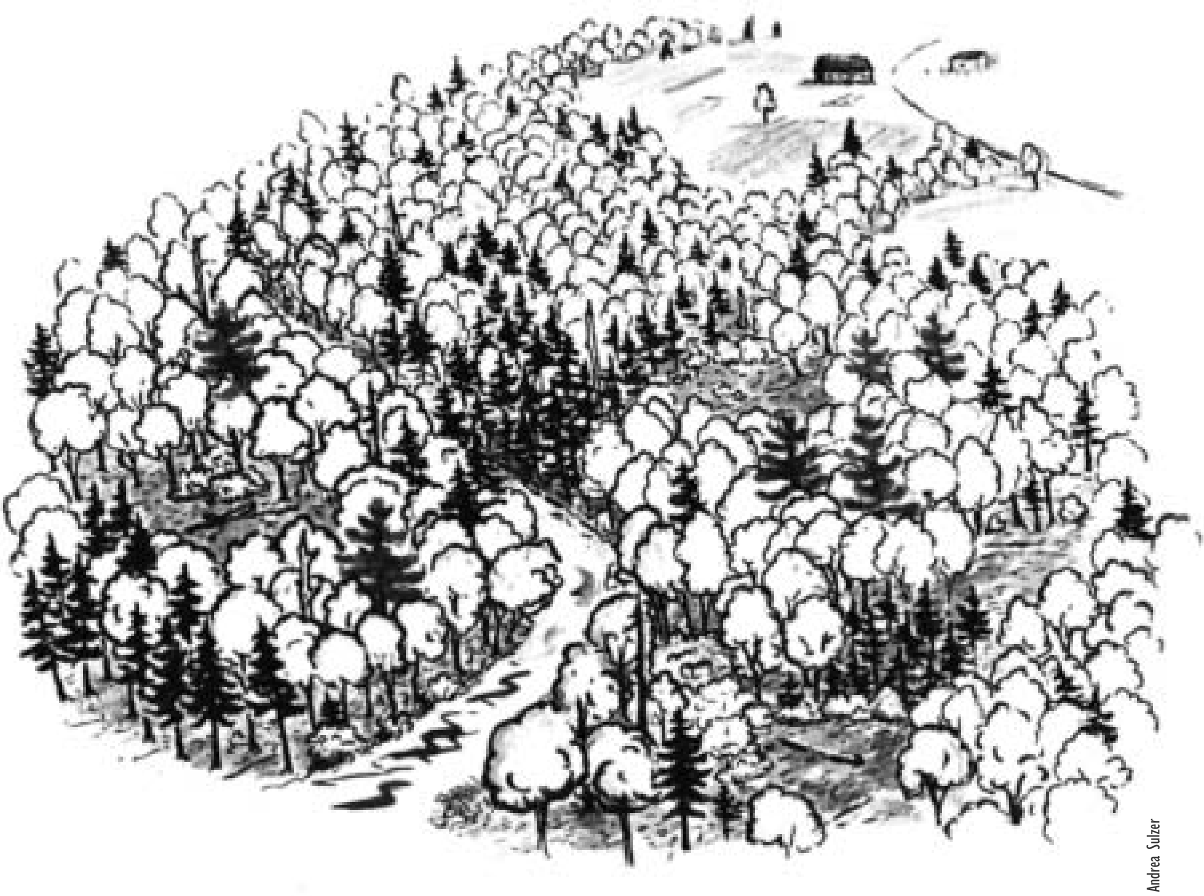
Understanding the Acadian Forest



Andrea Sulzer

"The woods hereabouts [in mid-central Maine] abounded in beech and yellow birch, of which last there were some very large specimens; also spruce, cedar, fir, and hemlock; but we saw only the stumps of the white-pine here, some of them of great size, these having been already culled out, being the only tree much sought after…."

Henry David Thoreau, The Maine Woods, *1864*

CHAPTER 1:

UNDERSTANDING THE ACADIAN FOREST

The Acadian Forest covers much of the Maritime Provinces, and extends into Maine, parts of northern New England and Quebec's Gaspé Peninsula. It is an area of transition between two larger forest ecosystems, the Northern Hardwood Forest to the south and the Boreal Forest to the north. As such, the Acadian Forest combines elements from each of these forests, creating a blend of softwood and hardwood trees (32 species in all) found nowhere else. In its natural state, the Acadian Forest is one of the most richly diverse temperate forests in the world.

Red spruce is a defining species of the Acadian Forest, often referred to as the forest's signature tree. Other common trees include sugar maple, red maple, yellow birch, American beech, white ash, eastern hemlock and white pine (which have a southern affinity), and white birch, trembling and large-tooth aspen, tamarack, balsam fir and black spruce (which have a northern, or Boreal Forest affinity).

The Nature Conservancy / Nature Conservancy of Canada

The forest has grown and adapted to this corner of the earth since the retreat of the glaciers some ten thousand years ago. In the absence of human disturbances, most of the forest would be mature. Large-scale natural disturbances, such as forest fires, windstorms and insect outbreaks, occur hundreds or even thousands of years apart in this region, allowing plenty of time for the trees to grow. However, mature Acadian Forest is not stagnant, but rather is constantly renewed by small disturbances. When trees die, small gaps open in the forest canopy that provide enough light for seedlings to grow. In this way, the Acadian Forest is constantly adapting to the environment, while maintaining a more or less intact forest canopy of the species that are best suited to local growing conditions.

Mapping the Acadian Forest

The map above combines Canada's Acadian Forest and the United States' Northern Appalachian region into one forest. This map represents the broad extent of the Acadian Forest's international range.

Courtesy Jon Sawyer and Kathy Ball

White pine cut in southwestern NB, circa 1950

A Changed Forest

The Acadian Forest has been hugely altered by a long history of land clearing, intensive timber harvesting and, more recently, silviculture practices such as tree plantations. Trees in the present Acadian Forest are much younger and smaller on average than they would have originally been. As well, species such as balsam fir, white spruce, white birch and tamarack are more abundant today. These short-lived trees thrive in the harsh conditions associated with abandoned farmland and intensive harvesting. In many areas, they now dominate at the expense of long-lived, late successional trees such as red spruce, sugar maple, hemlock and white pine.

Introduced tree diseases also have had a major impact on the Acadian Forest. Beech bark disease, introduced to Nova Scotia in 1890 in a shipment of European beech seedlings, has decimated beech trees across the Maritimes. The white elm that was once common on the rich soil of river floodplains has been all but destroyed by the Dutch elm disease. Similarly, white pine has been attacked

The newspaper article accompanying the photo above stated:

"A huge pine tree cut recently... turns back the pages of memory to those early days when the forests... were humming with the music of axe and cross-cut and big logs floated endlessly down the streams and rivers. This particular log is by no means a record, but it is unusually large for this modern day. The noble tree stood 120 feet. The stump measured five feet in diameter and 38 feet of the log scaled 2,099 feet of fine, clear lumber."

• • •

"There were in 1837, as I read, two hundred and fifty saw-mills on the Penobscot and its tributaries above Bangor …. No wonder that we hear so often of vessels which are becalmed off our coast, being surrounded a week at a time by floating lumber from the Maine woods. The mission of men there seems to be, like so many busy demons, to drive the forest all out of the county, from every solitary beaver-swamp and mountain-side, as soon as possible.

Henry David Thoreau,
The Maine Woods, *1864*

by the blister rust fungus. Settlement also changed wildlife diversity in the Acadian Forest. The wolf and wolverine have disappeared, as well as the woodland caribou. The eastern panther and Canada lynx are considered endangered, while the number of marten and fisher has decreased severely. Conversely, new arrivals, such as white-tailed deer and coyotes, now form a significant part of the Acadian Forest ecosystem.

These changes have important consequences. Today's Acadian Forest provides fewer habitats for wildlife and is more vulnerable to fire, windstorms and insect infestations. It is also less economically valuable. Stands of small trees are worth less money than stands with fewer but larger trees. Species such as balsam fir, white birch and tamarack also have a lower monetary value than species such as red spruce, white pine, yellow birch and sugar maple. As well, wood grows less efficiently in forests with even-aged trees than in forests with multiple ages of trees. Overall, a forest managed with intensive silviculture and clear-cut harvests is less economically and ecologically valuable than a mature, naturally diverse Acadian Forest woodlot.

FROM PAST TO PRESENT

Early European settlers found a tall forest of mostly mature trees, forming a canopy that stretched largely unbroken across the land. Trees were often hundreds of years old and of a size rarely seen today. Although Aboriginal peoples elsewhere in North America may have used forest fires to clear land for food plants, there is no evidence that the Mi'kmaq, Maliseet or Passamaquoddy peoples living within the Acadian Forest area altered the forest in this way.[1] Instead, European arrivals found a forest that had grown free of significant human disturbance for thousands of years.

Provincial Archives of NB

A river log drive in New Brunswick circa 1900

The mature, valuable trees in the Acadian Forest made possible much of the early colonization and economic development of eastern North America. White pine and, later, red spruce and other species were harvested for European shipbuilding and lumber markets and for local construction and fuel. Hemlock bark provided tannins for the fur trade and leather industry, while the wood became timbers for railway ties. Lumber from the Acadian Forest also went to the West Indies in return for molasses and other trade products. In 1784, the prominent St. Andrews businessman William Pagan commented on the thriving trade: [2]

> *"There is a large growth of White Pine fit for Masts & Spars of any dimensions. In fact from my own observation and from the information I have had from undoubted authority I am fully convinced that the Grand Bay of Passamaquoddy [south-west New Brunswick] alone can supply the whole British West India Islands with Boards, Planks, Scantling, Ranging Timber, Shingles, Clapboards and every species of Lumber that can be shipped from New Brunwick…."*

The Acadian Forest was also cut for fields and pastures. Early settlers realized that the most productive soils were found under the best stands of trees. Seventy per cent of Prince Edward Island, for example, was cleared of forest for agricultural land by the late 1800s. Forests growing on the fertile soil of the St. John River valley in New Brunswick were also almost entirely cut down.

Historical accounts provide glimpses of the Acadian Forest during the early colonial period. These early reports describe a landscape largely covered with trees that would be considered gigantic by current standards. Titus Smith, a land surveyor hired by the Nova Scotia government in 1801, reported white pine over 150 feet high (45m), along with beech and other hardwoods dominating large areas of Nova Scotia's landscape. Similarly, in 1806, Prince Edward

Restoring Woodlot Value

Fortunately, the Acadian Forest is resilient in spite of the severe changes it has undergone. Forest soils are still productive and mature-forest species are often found scattered among the young forest growth. This gives woodlot owners an opportunity to help their woodlots to grow into mature, self-sustaining forests and to promote and eventually harvest valuable trees. The woodlot owners profiled in Chapter 5, and many others like them, are doing just this. It takes time, but they are growing large trees of many species, increasing the value of their land and their marketing options.

Importantly, the benefit of restoring woodlots reaches far beyond the property lines. Growing and selling high-value trees benefits the local economy by providing raw material for value-added industries. In turn, this provides higher levels of employment per unit of wood compared with industries based on lower value trees. Restoring a woodlot also improves the ecological services that woodlots provide, such as clean air, water and wildlife habitat, as well as reducing flooding – services which all of society relies upon. Healthy Acadian Forest also has a better chance of adapting to climate change. A naturally diverse forest is less prone to fire, windstorm damage, diseases and insect infestations, all of which are expected to increase as the climate warms. A mature forest is actually part of the solution to climate change because long-lived trees take carbon dioxide out of the atmosphere and store it for centuries, both when alive and as they eventually decompose into soil.

At present, however, there is little reward for woodlot owners who work to restore woodlots. Some believe that government polices are more a hindrance than a help, and current markets for wood products make it hard to make money from a typical woodlot. Low value pulpwood and fuelwood are often not worth enough to cover the costs of good management. To say the least, anyone trying to make a living cutting trees today while improving the forest for the future faces a difficult situation.

In spite of the current lack of incentives to restore value to woodlots, many woodlot owners strive to do the right thing in their woods. Most recognize that owning a woodlot offers more than utilitarian benefits. Woodlots are places to enjoy walks in the woods, to relax and enjoy nature's beauty. Some are places to hunt game and catch fish. They are places for children to play and explore, and they are an outdoor classroom for anyone who wishes to learn more about the natural world. There is also the satisfaction and pride that comes with careful, thoughtful woodlot ownership. By promoting a healthy and valuable woodlot, woodlot owners know they are leaving their woodlots improved for the nature that lives there, and for the sons, daughters and grandchildren who may one day become stewards of the land.


Provincial Archives of NB

Early logging operation

Island resident John Stewart described beech forests covering almost half of the Island, and white pine growing three to five feet in diameter (1 to 1.5m).[3]

In 1847, government administrator Moses Perley wrote an article entitled "The Forest Trees of New Brunswick," which provides a first-hand account of the abundance and composition of tree species in southern and eastern New Brunswick. Perley reported that hemlock was common in softwood-dominated areas and often grew among beech and sugar maple trees on rich soils. He estimated that red spruce comprised a third of New Brunswick's forest, and reported that balsam fir, unlike today, "does not constitute masses of wood, but is disseminated in greater or less abundance among the hemlock and … spruces."[4]

In recent years, forest scientists have carried out studies that support the accuracy of the early reports, creating a quantitative description of the forest before European settlement. By studying tree pollen that was preserved in bogs and lake sediments, scientists have learned that old growth Acadian Forest covered most of the Maritime and New England landscape for thousands of years prior to European settlement.[5] Records of red spruce logs cut in Maine during the 1890s show that 72% were from trees between 150 and 250 years old.[6]

Studies of land surveys from the 1800s also provide clues to the original forest composition. Forest ecologist Craig Lorimer used 'witness tree' information (trees marked and recorded at every lot corner) to determine that the dominant forest type in northeastern Maine was shade-tolerant mixed forest with very few pure hardwood or pure softwood stands.[7] Nearly 66% of the forest in his study area was over 150 years old, and over 80% was older than 75 years. Shorter lived, less shade-tolerant species, such as white birch, aspen, pin cherry, tamarack and pine, were of minor importance. A similar study conducted for Kings County, New Brunswick, reported that cedar and balsam fir were equally common circa 1800.[8] Today, however, balsam fir is four times more abundant than cedar in this area. Balsam fir and species of spruce grouped together now make up 50% of the forest in Kings County, twice as much as circa 1800.

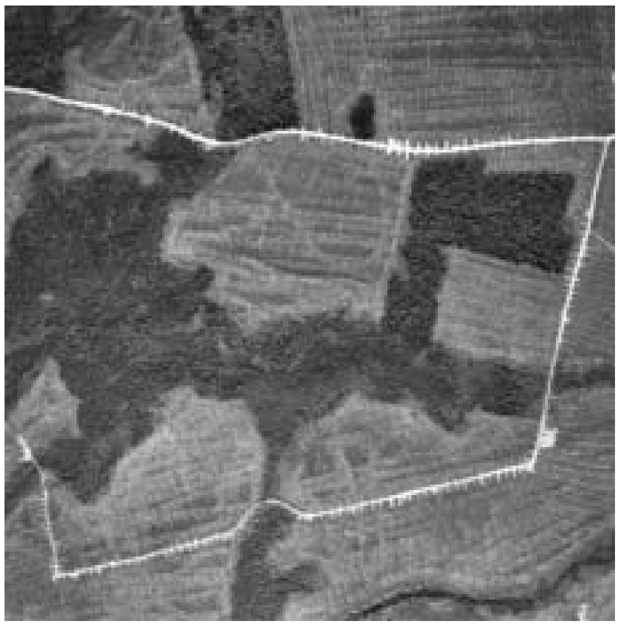
Records of timber sales from the 1800s reinforce these findings, showing the changes in the economically important trees as each species became scarcer. In the 10 years between 1825 and 1835, shipments of white pine from New Brunswick fell by 50% and spruce logs became the targeted product. As average tree size continued to decrease due to heavy cutting, spruce pulpwood became the dominant forest product in New Brunswick by the 1920s.[9]

By studying first-hand reports of the Acadian Forest made during the 1800s, Robert Seymour, a forest scientist with the University of Maine, concluded that red spruce forests were largely uneven-aged: "… *the evidence appears to support a regime of disturbances that were perhaps quite frequent relative to the life span of red spruce, but which rarely resulted in complete overstory mortality.*"[10]

THE ACADIAN FOREST TODAY

Although forests cover most of the Maritime landscape today, it is a forest much changed from its natural condition. These changes are so profound that the World Wildlife Fund (an international conservation organization) lists the New England/ Acadian Forest as endangered. Changes to the Acadian Forest can be assessed in several ways. The forest of today is much younger. Where old growth forest covered an estimated 50% of the land prior to European settlement, old growth now represents little more than 1% of the forest.[11] (See Chapter 2 for information on old growth forest.) The current forest is also more fragmented. It once stretched across a landscape unbroken by roads, farms and cities. The abundances of tree species have also changed. Trees that thrive on abandoned farmland or clearcuts have replaced species that thrived in an old forest. White and grey birch, trembling and large-tooth aspen, red maple, tamarack, balsam fir, and white spruce, for example, have increased in abundance and distribution while red spruce, hemlock, cedar and sugar maple have decreased.

Changes in the Acadian Forest are more rapid and severe today because an increasing amount of land is dedicated to intensive forestry practices. A recent study found that approximately 0.27% of the



Provided by the Ecology Action Centre

Aerial view of clearcuts in the Acadian Forest

Acadian Forest is converted to softwood plantations every year. At this rate, softwood plantations could cover 10% of the Maritimes by 2010.[12] As well, thinning young stands of trees to favour softwood species has created near-plantation conditions on much of the rest of the land used for intensive forestry.

Other research has found that mature forest in New Brunswick was lost at a net rate of 1.5% per year between 1974 and 2001.[16] In comparison, the study's authors note that the global mangrove forests are also declining at a rate of 1.5% per year, and are considered one of the world's most threatened ecosystems. Although mature Acadian Forest is more easily restored than mangrove forest, this rate of loss is nonetheless alarming.

> *Currently, density management [thinning] of young stands is implemented on virtually every harvested hectare of Crown land in New Brunswick. Clearcuts are forecast to be either planted (about 30% of total harvested area), likely with black spruce or jack pine, or they will be precommercially thinned at roughly 10 years post-harvest.... In the absence of clear guidelines promoting species diversity at the stand level, patterns of decline of some species and increases of others will be reinforced by silviculture and harvesting."*
>
> *V. Zelazny and H. Veen, 1997* [13]

'Borealization'

Borealization is a term given by some to describe the increasing abundance in the Acadian Forest of tree species common in the Boreal Forest.[17] These species are exposure-resistant trees such as poplar species, white birch, black spruce, jack pine and balsam fir, all of which are well adapted to frequent, large-scale disturbances that are common in the Boreal Forest. Borealization of the Acadian Forest reduces the ecological resilience of the forest by making it more susceptible to large-scale disturbances such as diseases, windstorms and insect infestations, a risky trend in the face of climate change.

A Resilient Forest

Given this long history of cutting and land clearing, the Acadian Forest is remarkably resilient. Many tree species have been reduced in abundance, but

A Forest Time Line[14]

12,000 years before present:	glaciers retreat from Martimes; forest begins to colonize
11,000-3,000 years before present:	Aboriginal peoples enter and inhabit region
1612:	first sawmill in North America built in the Annapolis area of NS
1700s:	NB supplies the bulk of pine used by the British Navy
1769:	commercial shipbuilding begins in NB
1770s:	wolverine disappears from the region
1801:	Titus Smith is commissioned to survey parts of Nova Scotia; he reports pine trees 125-175 feet tall, and a landscape largly dominated by beech, with smaller amounts of birch and maple
1811:	lower St. John River is said to be "denuded of great pine"; British Navy contractors look for other sources of white pine[15]
1830s:	steam-powered sawmills introduced
1835:	white pine cut in NB falls to 1/2 of 1825 levels; spruce becomes the targeted tree
1847:	Moses Perley reports white pine 160 feet high and 5 feet in diameter
1860:	timber wolf disappears from NB
1870s:	extensive cutting of high-quality spruce
1875:	first white-tailed deer seen in the area of present-day Fundy National Park
Late 1800s:	white-tailed deer present in NS and NB
1918:	woodland caribou disappear from southern NB
1920:	pulpwood harvesting begins in southern NB; diameter-limited cutting (no cutting of trees less than 25 cm / 10 in diameter) largely abandoned
1926:	woodland caribou disappear from NS
1930s:	woodland caribou disappear from NB
1950s:	coyotes present in NB
1970s:	coyotes present in PEI and NS
1999:	average log diameter at one NB mill reported to be 15 cm (6 in)


Oliver Maass

Old hardwood forest

none has been completely eliminated. A forest, albeit degraded, still dominates the landscape, in contrast to parts of the world contending with desertification or slash and burn clearing for agriculture. Compared with the forests of some South American and Scandinavian countries, for example, the Acadian Forest has relatively few known threatened and endangered species.

Climate Change

Climate change will undoubtedly affect the Acadian Forest. Forest scientists forecast that climate change over the coming decades will bring an increased risk of insect infestations, winter thaws, and wind and ice storms. Each of these can stress and damage trees, with potential economic and ecological losses. Further into the future, scientists predict that some species with northern affinities, such as balsam fir and black spruce, may be largely reduced in abundance in the Acadian Forest region by 2100.[18]

Forests with an uneven-aged mix of species, well suited to local growing conditions, are likely to have the best chances of resisting and recovering from the effects of climate change. Even-aged forests dominated by one or two species are most likely to suffer increased damage from climate change because they are usually more susceptible to insect, storm and fire damage.

The Rise of Balsam Fir

"Thick as the hair on a dog's back" is one way to describe balsam fir growing in some Maritime woodlots. Indeed, balsam fir thickets are a common sight throughout much of the Acadian Forest. However, balsam fir has a much greater presence in the forest now than it had a few generations ago.

Forest cutting practices often create conditions favourable to balsam fir. High-grade cutting removes species that grow with balsam fir, such as white pine, red spruce, hemlock, cedar and hardwoods. Balsam fir has been largely ignored as a commercial species until recently, giving it an artificial dominance in many harvested woodlots.

> The Acadian Forest does not consist of one, homogeneous forest type. Rather, at least ten distinct forest types are found within the Acadian Forest region. Each contributes to the overall character of the Acadian Forest, yet has recognizably different characteristics from neighbouring forest types. One of these types is the Appalachian Hardwood Forest. It grows in well-drained, calcium-rich and fertile soils in New Brunswick's St. John River Valley and its characteristic trees are basswood, ironwood, butternut and sugar maple. Except for its occurrence in New Brunswick, the Appalachian Hardwood Forest is found much further south, in the hills of central New England.
>
> Several centuries of land clearing and logging have reduced the Appalachian Hardwood Forest in New Brunswick to a fraction of its former distribution. Research by the Nature Trust of New Brunswick documents 65 patches (some smaller than one hectare) of Appalachian Hardwood Forest that retain a diversity of characteristic trees and plants. These patches represent approximately 1% of the former range of this forest type in New Brunswick, and they are scattered within a landscape of settlements and active or abandoned agricultural land.
>
> Despite the severe fragmentation of the Appalachian Hardwood Forest in New Brunswick, remnant patches still harbour 35 species of plants that are uncommon or rare, along with exemplary stands of rich hardwood forest. One plant believed to be lost from New Brunswick (*Desmodium glutinousum* – a species of tick-trefoil) was rediscovered during Nature Trust research of these remnant patches. Other uncommon plants growing in these patches include bloodroot, dutchman's breeches, rattlesnake fern, round-leaved hepatica, yellow lady's slipper, showy orchis, Canada violet and maidenhair fern, just to name a few.

Clearcutting, too, promotes balsam fir by creating growing conditions in which the aggressive fir seedlings gain advantage over seedlings of other species. Balsam fir has rather large seed and fir seedlings have strong root systems that access water more easily than spruce seedlings do, giving balsam fir an advantage in the relatively dry conditions of a clearcut. Finally, because forests are often cut before they are ecologically mature, tree species that would normally gain dominance over balsam fir trees by simply out-living them are cut before they have a chance to grow old, further perpetuating balsam fir growth on harvested lands.

Patterns and Processes in the Forest

WHY TREES GROW WHERE THEY DO

The Acadian Forest is far from homogenous. A drive across the Maritimes or Maine reveals a diversity of trees and tree communities. Some places support shade-tolerant hardwoods like sugar maple and beech; other areas are rich with cedar, or perhaps support a mix of red spruce, balsam fir and yellow birch. From the coastal Bay of Fundy forest to upland ridges, or even from one end of a woodlot to the other, the Acadian Forest is full of variety.

The natural mix of tree species in a given area is shaped by many factors, and the interaction of these factors is not easily analyzed. Random events certainly play a large part: what seeds or seedlings, for example, might be ready to grow after a disturbance? Physical and climatic factors such as soil, rainfall and temperature control where different species of trees can grow. The warm summers, moderate rainfall and rich soils of New Brunswick's upper St. John River valley, for example, favour a hardwood-dominant mix, including butternut, beech, sugar maple and ironwood. These species would be out of place along the Bay of Fundy, where acidic soils, cooler temperatures and humid air favour red spruce, balsam fir and yellow birch.

The mix of trees is also shaped on a smaller scale. Differences in soil richness, moisture and depth, and even direction of slope can give a woodlot a distinct distribution of trees. Red spruce might be found mixed with birch on a slope, and black spruce or tamarack might occupy low-lying wet areas. Hemlock can often be found on north-facing slopes while white pine grows more commonly on slopes that face south or west. Factors such as competition among trees or animal browsing also play a role in determining the species mix for an area.

The soil, climate, elevation and other bio-physical factors can be used to identify where different trees tend to grow in the Acadian Forest in a process known as an ecological land classification. It is a rough blueprint because it is hard to account for all the potential factors that influence where trees grow. There is always randomness as birds drop seeds here and there and pockets of good soil are found in random locations. Nonetheless, this map of tree communities can be a useful tool when choosing

Matthew Betts

The Mountain Pine Beetle

The mountain pine beetle has wreaked phenomenal devastation in the forests of British Columbia; the BC Government estimated 9.2 million hectares killed by the beetle in 2006.The principle reasons for its increased presence in these forests is (1) warmer winters, which allow the beetle to successfully over-winter in areas it could not before and (2) an over-abundance of mature lodge-pole pine, a favourite food source. Warmer winters are attributable to climate change, and the over-abundance of mature lodge-pole pine results from forest management practices such as suppressing natural forest fires and replacing diverse forest stands with plantations of lodge-pole pine.

which trees are appropriate to encourage in a given area of the Maritimes. See Chapter 3 for more detail on this topic.

Over the next century, the changing climate will change the ranges where different trees grow. Therefore, it may make sense to explore the potential to promote species with southern affinities, such as the maples, red oak and white pine, in northern areas of the Acadian Forest where they currently are not common.

FOREST DISTURBANCES

Walking in a woodlot after a wind storm often reveals the odd blown-down tree, or more than a few after a rare event like Hurricane Juan. These blow downs, along with trees killed by insects and disease, create numerous gaps in the forest canopy that allow the growth of young trees. This process results in a natural patchwork of different-aged trees, a forest condition called uneven-aged.

In the Acadian Forest, this pattern of small-scale disturbances is common, and most of the forest is naturally uneven-aged in the absence of clearcutting or land clearing. Over time, gaps open and close in the forest canopy, creating a constantly shifting mosaic of tree ages throughout the forest. At the scale of a few trees at a time, the Acadian Forest is constantly changed and renewed.

Large-scale disturbances, such as major fires, insect outbreaks and windstorms that kill trees over hundreds or even thousands of hectares, are generally rare in the Acadian Forest. On average, natural large scale disturbances are believed to have occurred at approximately 800 year intervals in the pre-settlement forest.[22] When they do occur, the result is a mostly even-aged forest, in which tree seedlings start growing at roughly the same time amongst the scattered survivors from the former forest. These tracts of even-aged forest eventually revert to uneven-aged forest by the action of numerous, small disturbances that breakup the forest canopy and allow young trees to grow.

The long interval between large-scale disturbances is an important characteristic of the Acadian Forest because it allows a mature structure to develop. It is estimated that 50% of the Acadian Forest would be dominated by mature, shade-tolerant trees if it were not for the long history of lumbering and land clearing. [23]

Two Scientists' Thoughts on a Changed Forest

"In general, successional status and age distribution of the [Acadian] forest has shifted, with increased frequency of relatively young, often even-aged, early successional types with high frequencies of balsam fir, red maple, white spruce, white birch, and trembling aspen. Balsam fir has increased in many areas as a result of harvesting practices that are favourable for its establishment, combined with a lack of commercial interest in the species until recently. The frequency of white spruce has increased primarily as a result of abandonment of farmland that had originally been covered by tolerant hardwood or mixedwood. High-grading for valuable softwood species resulted in increased proportions of hardwood in some areas and intolerant hardwood often regenerates in clearcut and burned areas. The abundance and age of late-successional species such as sugar maple, red spruce, eastern hemlock, yellow birch, beech and cedar have declined. In many parts of the region, the forest has been simplified, both in species and ecosystem diversity. Among these species, beech has declined most because of the effects of introduced beech bark disease and land clearance.

"The increase in severity and frequency of [spruce budworm] outbreaks can probably be attributed to a number of human activities that have favoured the growth of balsam fir. These include the long-term selective harvesting of spruce, conversion of mixed-wood forests to conifer forests dominated by balsam fir, changes in harvesting standards brought about by the development of the pulp and paper industry, pesticide spraying to protect balsam fir and fire suppression. These activities have brought about a situation where there are even-aged stands of mature balsam fir that are largely susceptible to mortality during an outbreak. The balsam fir forests of Cape Breton have probably always been "renewed" by outbreaks of spruce budworm; this situation has now spread to other areas, where historically this insect has had a relatively minor impact."

Judy Loo and Nadine Ives, 2003[19]

Jamie Simpson

A tree's death opens a gap in the canopy

Disturbance and Woodlot Management

Understanding the role of forest disturbance in the Acadian Forest is as central to woodlot management as understanding natural tree distribution. While climate and geography shape overall tree distribution, disturbance shapes the mosaic of tree ages and canopy structure in a forest. Disturbances open gaps that provide increased light for forest floor plants to grow. They create the standing dead trees that become homes for wildlife, and the tipped-over tree roots that make pits and mounds on the forest floor. By shaping forest structure, disturbances shape the web of forest life.

The low-risk approach to woodlot management is to imitate natural disturbances when harvesting. Because the Acadian Forest is well-adapted to natural

Do We Influence Natural Disturbance?

As forest ecologist David Perry has noted, "The structure of the forest has a great deal to do with the ability of disturbances to move through it."[20] Changes in the composition of tree species of a forest can lead to changes in disturbance patterns. For example, when a tree species with a common insect problem becomes abundant, forest disturbances increase because there is more food for the insect. An example is the increased balsam fir in the Acadian Forest causing an increase in the severity and frequency of spruce budworm outbreaks in the 20th century.[21] Given this, it makes sense to promote a diversity of species and ages of trees for a healthy forest ecosystem that is less susceptabe to large-scale disturbance.

disturbance patterns, harvesting that resembles this pattern is least harmful to the ecosystem. Although patterns of natural disturbance vary throughout the Acadian Forest, a safe harvesting approach is to cut small patches of trees similar to those left by natural disturbances. Chapter 3 explains in more detail how knowledge of forest disturbance can be used when planning woodlot management.

FOREST SUCCESSION

A large disturbance in a forest, such as a forest fire or clearcut, changes the temperature, moisture and sunlight conditions, leading to changes in the plant community. Some plants that live in mature forest may not survive post-disturbance conditions, and plants that thrive in recently disturbed areas may not survive as a forest re-establishes. This change in plant community is known as succession: the changes a forest undergoes from the time of a major disturbance until it reaches an old growth condition. Depending on the type of forest and the severity of disturbance, it can take centuries for a forest to once again reach ecological maturity.

Early successional species – such as certain fern and grass species, pin cherry, raspberry, white and grey birch, poplar, white spruce and tamarack – have a distinct survival strategy. They produce an abundance of seed that is easily transported over large areas by wind or animals. Some also produce rapidly growing root sprouts that reduce the risk of soil erosion and nutrient loss when a forest system loses most of its tree canopy. These species are adapted to survive the increased light, higher temperatures and lower air moisture when forest canopy is lost. They also tend to be short-lived and produce seeds at a young age, giving them an advantage during large-scale disturbances. These species, however, need high light levels and do not reproduce under a forest canopy. They need large-scale disturbances, such as fire, insect infestations or clearcutting, to provide the conditions necessary for regeneration.

In contrast, late successional species, such as sugar maple, American beech, hemlock, red spruce and yellow birch, follow a different survival strategy. They tend to produce fewer seeds than early-successional species, and have longer life-spans. Importantly, they can survive in the low light conditions of an established forest, so they flourish where large-scale disturbances are rare, as in the Acadian Forest. These late successional forests are constantly renewed by disturbances too small to create good conditions for the early successional species.

In the absence of forest cutting and agriculture, the Acadian Forest would be dominated by late successional species. Early successional species would play a minor role within large areas of mature forest – a stark contrast to today's Acadian Forest. Although early successional forest provides habitat for certain wildlife species, its increased abundance reflects the loss of mature forest and its associated wildlife. Clearcutting affects forest succession since creating large canopy openings encourages early successional species. On the other hand, harvesting that resembles small-scale natural disturbance, such as selection harvesting, can be used to favour the later successional species that grow in a mature forest.

Scattered throughout the Acadian Forest are sites where succession is curtailed because of environmental factors such as high elevation, exceptionally thin or nutrient-poor soil, or excessively wet or dry soil. Examples include red and silver maple forests that are periodically flooded, black spruce and tamarack wetlands, and high-elevation spruce and balsam fir forests. A

Fire in the Acadian Forest

Naturally occurring forest fires are rare in the Acadian Forest. Scientists estimate the average length of time between natural forest fires ranges from 300 to 1200 years depending on the area and point in time considered. In recent history, natural fires (that is, caused by lightning) account for a small proportion of total fires. A study in Maine found that less than 5% of fires between the years 1926 and 1940 were of natural origin (caused by lightning). In Nova Scotia, researchers found that less than 1% of fires from 1931 to 1945 were of natural origin. [24]

Tamarack and white birch are common early successional species

combination of environmental factors also maintains a Boreal-like, early successional forest of balsam fir, white spruce and other species in the high-elevation areas of northern New Brunswick and the Cape Breton highlands.

By one estimate, 200,000 hectares (500,000 acres) of land in Nova Scotia in 1957 was occupied by white spruce trees while in the pre-settlement forest, white spruce was not abundant except along the Atlantic seashore in areas influenced by salt spray.[25]

Forest Microtopography: Pits and mounds

Trees are occasionally uprooted from the soil by wind. The result of numerous uprootings over time is a 'pit and mound' structure on the forest floor. The holes resulting from blown-down trees are the pits, and the mass of up-turned roots and soil become mounds. This process results in mixing of the soil and can lead to more diverse plant and animal communities. Compared to pits, mounds are relatively warm and well-drained and are excellent growing sites for hemlock, red spruce and yellow birch seedlings.

Old Growth in the Acadian Forest

Old growth forest once dominated the Maritime landscape, with many trees over 150 years old, and some reaching ages of 300 years or more. Lumbering and land clearing, however, have reduced old growth forest to scattered remnants, now less than 1% of the Acadian Forest.

WHAT IS OLD GROWTH?

Old growth forest contains trees of all ages and sizes, and deadwood abounds, both standing and fallen. Older deadwood is covered with mosses, lichens, liverworts, herbaceous plants and young trees. Trees uprooted by wind create a characteristic pit-and-mound surface and a diversity of habitats. Old growth generally has a tall and largely unbroken forest canopy, save for occasional gaps caused by deaths of scattered trees, and can last for thousands of years in a more-or-less steady condition. However, it is far from stagnant. It is in a state of constant renewal as old trees die and create gaps for young trees to grow. Most old growth tree species can survive decades in shaded under-story conditions until a gap gives them sunlight and space to grow into the canopy. Forest ecologists describe this phenomenon as a 'shifting mosaic', in which small changes occur constantly throughout the forest, while the forest as a whole retains a common character.

While dominant tree species in old growth forest vary according to local climate and soil, they tend

Does Old Growth = Virgin Forest?

Virgin forest is forest that has never been altered by people. In general, mature virgin forest is old growth forest. But from an ecosystem point of view, old growth forest is not necessarily virgin forest. There is no reason why a forest that has been harvested at some point in time, but otherwise looks and functions like virgin forest, should not be considered old growth. If old growth Acadian Forest is to be restored on the Maritime landscape, it cannot be defined by a complete absence of human influence.

Rochelle Owen

Old growth forest in Nova Scotia

to be long-lived, late successional, shade-tolerant species. Typical old growth forest includes mixes of sugar maple, hemlock, beech, red spruce, cedar and white pine, sometimes in association with yellow birch, ironwood, white ash and balsam fir. Specific plants and animals are associated with old growth forest. Calypso orchids, for example, grow only in old growth cedar stands and the northern goshawk nests only in old hardwood or mixed-wood forests.

OLD GROWTH FOR THE FUTURE

Restoring old growth takes time – no one alive today will live to see vast tracts of old growth Acadian Forest. Nonetheless, woodlot owners can restore old forest for the future by encouraging typical tree species, restoring deadwood and creating new age classes by cutting patches in stands of even-aged trees. Most critically, trees can be allowed to grow big and old. These trees play a unique role in the forest ecosystem, both during their centuries-long lifespan and throughout their slow decay and return to forest soil.

What does Old Growth Look Like?[26]

- Abundance of old trees, large for local growing conditions
- Large diameter fallen logs in all stages of decomposition
- Plentiful snags of a range of diameters
- Large and small canopy gaps
- Uneven forest floor, resulting from uprooted trees
- Often multiple growth layers
- Abundance and diversity of herbaceous layer plants, lichens and fungi
- Late successional tree species

The Genetic Worth of Old Forests

Researchers at the Canadian Forest Service in Fredericton, New Brunswick have found that old red spruce trees tend to have superior reproduction qualities. They produced better quality seedlings and also a higher proportion of viable seeds than younger trees. This research suggests that reproductive and genetic fitness may be directly related to the age of the parent tree. [27]

Jamie Simpson

THOUGHTS ON THE ACADIAN FOREST ECOSYSTEM …

"… when I use the word stability, I don't mean no change. The idea that forests are stable in the sense that they don't ever change is just not true. All forests change to one degree or another, and all forests are disturbed to one level or another. Stability boils down to retaining the capacity for self-renewal…."

David Perry, 2002[28]

"These species [white birch, trembling aspen, jack pine, black spruce and balsam fir] rarely form extensive monoculture stands in the Acadian forest region, except after rare, stand-replacing disturbances to which they are well-adapted. Biotic disturbance agents – insects and pathogens – all have narrow host ranges and often species-specific, often attacking only old individuals in a population. Given the [Acadian Forest's] high diversity of both species and ages, it is easy to see that such disturbances would produce only small gaps in the forest."

R.S. Seymour, A.S. White, P.G. deMaynadier, 2002[29]

"…unlike the boreal spruce-fir forest, large scale stand-creating disturbances were much less common in the red spruce region prior to extensive logging of spruce. Rather the evidence appears to support a regime of disturbances that were perhaps quite frequent relative to the life span of red spruce, but which rarely resulted in complete overstory removal. The typical origin of virgin spruce appears to be a gradual response to a series of releasing disturbances, until reaching the overstory at relatively advanced ages."

R.S. Seymour, 1992[30]

"According to the Canadian Hurricane Centre, Hurricane Juan was one of the most powerful and damaging hurricanes ever to affect Canada. Yet when you quantify the blowdown, only 5% of the forested portion of the storm swath underwent 30 to 100% blowdown, or 23,000 ha (which is roughly 0.55% of Nova Scotia's forests). If Juan-scale events occurred every 50 years, which is unlikely, on average 0.55%/ 50 or 0.01% (1/10,000) of the province would be affected by moderate-severe (30 to 100%) blowdown every year."

Minga O'Brien, 2007[31]

"What is most striking in the Maine wilderness is the continuousness of the forest, with fewer open intervals or glades than you had imagined. Except the few burnt lands, the narrow intervals on the rivers, the bare tops of the high mountains, and the lakes and streams, the forest is uninterrupted. It is even more grim and wild than you had anticipated, a damp and intricate wilderness, in the spring everywhere wet and miry. … Here prevail no forest laws but those of nature."

Henry David Thoreau, The Maine Woods, *1847*

"Old growth is not simply a marker of past glory, an elegy for all that once was. It is a promise of the future, a glimpse of the systemic soundness we will not see completed in our lifetimes but that can fire our hopes for the timelessness to come."

Bill McKibben[32]

"Natural ecological processes and time are all that are really required to bring old growth into being. But the point is not just restoring old growth. The point is restoring it soon enough to restore and protect biological integrity in forest ecosystems and avoid the biological impoverishment that will come from its absence."

Stephen C. Trombulak[33]

"Larger and older forests appear to have an important evolutionary role as reservoirs of both genetic diversity and reproductive fitness. Given the rapid environmental changes anticipated (as a result of climate change, increasing population isolation through fragmentation, or following the introduction of exotic pests and diseases) these older populations of trees may have a valuable function in maintaining the adaptive potential of tree species."

A. Mosseler, J. Major, O. Rajora, 2003[34]

Living in the Acadian Forest

"Like the human body, we have a lot to learn about the forests, and all of the species which inhabit the forest. It's unlikely we will even know all there is to know – that's the beauty and the mystery of nature. It is far more complex than either we or our computers can comprehend. The interaction of the various species – trees, shrubs, wildflowers, mosses, lichens, ferns, worms, micro-organisms, insects, birds and mammals – with one another and with humans forms what we call "ecosystems." The permutations and combinations are not yet fully understood and in all likelihood never will be."

Glen Blouin, Weeds of the Woods, *1992*

CHAPTER 2:

LIVING IN THE ACADIAN FOREST

Water and Woods: The Riparian Ecosystem

"Riparian ecosystems are the most diverse, dynamic and complex biophysical habitats on land."[1]

Steven Pelletier

Water is essential to a healthy forest ecosystem. A close look at a forest stream or pond reveals abundant life, from plants and mosses to salamanders, frogs, turtles, fish and countless insects. Animals such as moose, bobcats and bats use the riparian zone for sheltering, feeding and travelling. As well, the moist, fertile soils found near woodland waterways are often home to rare or uncommon plants.

The forest is equally important to ensuring healthy waterways. Forests provide:

Cooling Shade
Trees shade streams, ponds, lake edges and rivers. This helps keep the water cool in summer when aquatic wildlife needs the extra oxygen that cool water holds. Trout and salmon, for example, suffer when water temperatures rise.

Erosion Control
The roots of trees and other plants stabilize the edges of rivers and streams and slow soil erosion, especially during spring flooding. In the absence of plant roots, sediment caused by erosion can clog stream bottoms, making it difficult for fish eggs to survive.

Water Filtration
The forest floor filters water as it flows toward watercourses, removing sediments before they reach rivers and streams. The forest also removes excess nutrients from surface water (from farm runoff, for example) before they have a chance to pollute watercourses.

Flood Reduction
The forest reduces flooding and road washouts by slowing the rate that water from storms or snowmelt enters watercourses.

Food
The forest provides food for the aquatic life that is at the very centre of the food web. Numerous small, water-dwelling creatures eat fallen leaves, branches, decaying trees and other dead organic matter, known as detritus, that the forest provides. These creatures, in turn, are food for fish, birds and a variety of other larger creatures.

Habitat
Fallen trees in streams and rivers create habitat for fish and other species by creating pools and shaded hiding spots. Fallen trees also aerate water as it flows around and through them.

A 'watercourse buffer zone' is a common concept in forest management to restrict forest activities around a waterway. Such buffer zones are necessary to prevent intensive forestry operations from clearcutting trees to the edge of a brook, stream or lake, damaging the waterway and adjacent riparian habitat. In contrast, restoration or low-impact forestry practices often treats an entire woodlot in the same manner as a buffer zone.

Nonetheless woodlot owners should be aware of provincial buffer zone requirements. They vary by province and by size of watercourse, but a safe buffer zone is commonly defined as 30m (100ft) extending outward from the edge of the water. If the ground is steeper than a 20% grade, then the zone starts at the point where the grade becomes less than 20%,

Tips for Working near Water

•Keep machinery well back from watercourses (at least 30m / 100ft) unless the ground is snow-covered and frozen to help prevent ruts and damage to ground vegetation.

•Avoid cutting trees within 5m (16ft) of a watercourse to reduce disturbance to the most sensitive area, near the water. The odd tree can be cut without damage, but must be done with care.

•Preserve snags, cavity trees and deadwood within 30m (100ft) of a watercourse and leave an abundance of large diameter trees to supply future snags and deadwood to provide wildlife habitat.

•Maintain at least 70% canopy cover within the buffer zone to help to reduce the risk of erosion and the loss of shade over the watercourse.

•Do not locate roads within the buffer zone because of the risk of erosion they present. When a road must cross a waterway, bridges are better than culverts. If culverts are used, they should handle peak flows and be set at least 15cm (6in) into the streambed, so fish can swim through; even small streams often support fish.

•Stabilize stream and river banks with rock around bridges or culverts to help reduce erosion of sediment into the watercourse.

•When cutting trees, do not leave slash or tops in a stream because they can obstruct fish passage and will deplete oxygen levels as they decompose.

•Divert ditches into the forest to stop runoff from flowing directly into a watercourse.

Riparian Zones

A riparian zone is the land area adjacent to water bodies such as streams, rivers, ponds, lakes and marshes. This zone can extend up to 300m (1,000ft) from the water's edge, influencing and influenced by the aquatic ecosystem. Riparian zones are utilized by some 90% of forest wildlife. [2]

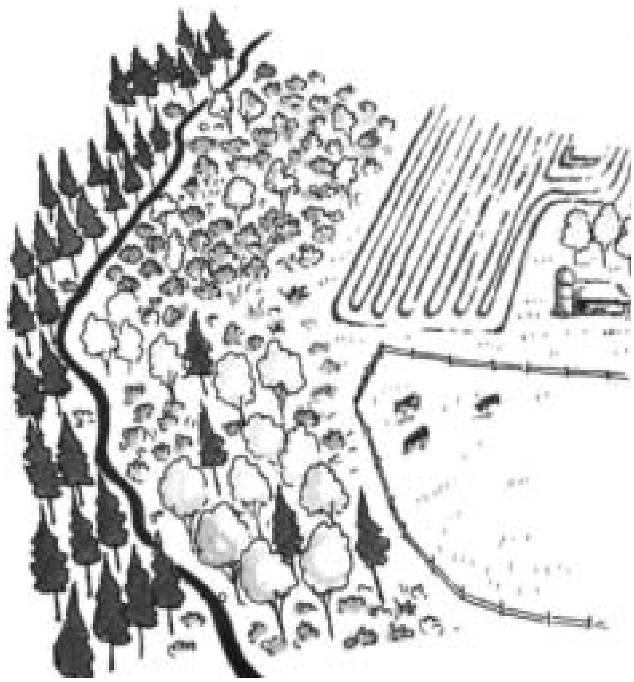
rather than at the bank. Provincial governments can provide more detailed information on watercourse regulations for specific areas.

WATERCOURSE RESTORATION

Restoring a forest along the banks of a stream, river or lake is a simple but effective action with major ecological benefits. Following are several ways to do this.

1. Let nature take its course
Where fields or pastures extend close to the water's edge, allowing shrubs and trees to grow along the bank, rather than mowing or bush-hogging to the water's edge, will help to re-create riparian habitat. Shrubs such as alder, sumac and red-osier dogwood make excellent initial cover along waterways because their strong root systems can help to prevent erosion.

2. Keep farm animals away
Fencing riparian areas prevents farm animals from eating or trampling vegetation, and keeps them from polluting the waterways. Funding is sometimes available to pay for fencing; provincial agriculture or natural resources departments, or local environmental or watershed groups, can provide information on funding possibilities.


Andrea Sulzer

Restoring riparian forest

Watersheds

A watershed is the area of land from which a stream, river or other watercourse receives its water. The size of a watershed is measured as the total area of land that drains into a particular watercourse. The St. John River, for example, flows from Maine through New Brunswick and into the Bay of Fundy and has a correspondingly large watershed, some 55,000 square kilometres (21,300 square miles). Within this watershed are numerous smaller watersheds – one for each river and stream that feeds into the St. John River. In contrast, a small woodlot stream might have a watershed of only a few hundred hectares (600-1,000 acres).

With its interconnected waterways, a watershed is a natural land management unit. Actions in one area affect water quality in other areas downstream. The quality of fish habitat in a woodlot stream, for instance, is affected by forestry practices on all of the woodlots within that stream's watershed.

3. Start planting
Several species that generally work well in the wet soil found near watercourses are tamarack, black ash, white ash, red maple, alder and red-osier dogwood. Natural forest along a watercourse can provide clues as to which trees and shrubs grow well in a particular area.

VERNAL POOLS

Vernal pools are shallow-water forest pools that have no year-round inlets or outlets, appear in the spring, and often dry up during the summer. They are typically less than half a hectare (an acre) in size and can be as small as a large puddle. Despite their small size and seasonal nature, vernal pools are an important part of the forest ecosystem.

Vernal pools benefit wildlife in important ways. First, because vernal pools do not support predatory fish, they provide a safe environment. Species of frogs and salamanders depend on vernal pools when they are young. Second, vernal pools have high biological activity and generate food for life in the surrounding forest. Third, they allow wetland-dependent species to move across the landscape from pool to pool.

The health of vernal pools is directly connected to the surrounding forest. Fallen leaves and other organic materials provide food, the forest canopy provides cooling shade, and the forest floor filters and moderates water flowing into the pools. Many creatures spend only part of their lives in the pools, also living in nearby forested areas where they require tree cover and deadwood to survive.

In some regions of the Acadian Forest, vernal pools support rare species of wildlife such as Blanding's turtle, the spotted turtle, the wood turtle, the ribbon snake, the four-toed salamander and the ringed-boghaunter dragonfly.

Vernal pools: rich forest habitat

Conserving Vernal Pool Habitat

Spring is the best time to find vernal pools, by listening for the spring-peepers or other frogs that live in them. To support frog and salamander eggs, pools must contain water for at least two and a half months and be at least 30cm (1ft) deep at the spring high-water levels. Checking a pool for egg masses in spring can reveal whether frogs or salamanders are using the pool. Although the pools tend to dry up in the summer, they leave water stains on trees and rocks, or a film of sediment in a forest depression.

It is wise to restrict forestry activities near vernal pools year-round, even when wildlife is not actively using them. The first 30m (100ft) from the edges is the most important, so it is best to leave this area undisturbed. Low-impact cutting is acceptable within 30 to 100m (100 to 300ft) of the pool, but the forest canopy should be maintained. It is important not to cut trees within one tree-length of a pool and never to drive machinery through one.

WOODLAND WETLANDS

> *"Wetlands are not wastelands."*
> *North American Wetlands Conservation Council*

Taking a walk near a wetland on a warm summer's day reveals a wealth of life. Wetlands are home to mammals, birds, reptiles, amphibians, fish, insects and plants because they provide a unique blend of forest and aquatic habitats.

Wetlands efficiently remove carbon from the air and turn it into plant matter that, in turn, fuels the wetland's complex ecosystem. Wetlands also filter pathogens, pesticides and other toxic chemicals out of water, and reduce the severity of floods, soaking up water during heavy rains and releasing it slowly during drier times.

Wetlands also improve the water quality of streams by slowing rainwater run-off and filtering out sediments.

In the Acadian Forest however, wetlands have been drained for forestry and agriculture uses, or polluted with excessive fertilizer or animal waste.

Wetland Diversity

Wetlands are divided into five distinct types, each with its own specific characteristics.

•Bogs have a dense layer of peat and water near the surface, along with low nutrient levels. Bogs are usually covered in moss, shrubs, sedges and occasional trees.

•Fens are also covered in peat and have water close to the surface, but they have higher nutrient levels than bogs. Sedges, grasses and occasional trees and shrubs grow in fens.

•Swamps have standing or gently moving water and high nutrient levels, usually with trees or clumps of shrubs.

Trout and the Forest

The health of trout depends on the quality of the forest that borders its watery world. Trout depend on clean streams for spawning and feeding. When a stream suffers from poor land-use practices, so does the trout population in the stream, and in connected ponds and lakes. Streams as small as half a metre wide (1.5ft) can support trout, even if they dry up from time to time.

During spawning time, trout need clean, loose gravel through which water can flow. They need cold water with lots of dissolved oxygen, and deep pools, overhanging vegetation and fallen deadwood for shelter. A natural forest provides these conditions.

If a forest is cut close to a stream, the fish may suffer because:
•Oxygen is depleted by increased water temperatures, as well as by decomposing logging debris.
•Spawning and rearing areas are damaged by silt from roads, exposed soil and bank erosion.
•Annual migration upstream to spawn can be blocked by logging slash.

•Marshes are flooded either occasionally or permanently, have high nutrient levels and contain no trees.

•Shallow open-water wetlands are the sloughs, ponds and wet areas along lakes and rivers with submerged plants and floating-leaved plants, such as pond lilies.

Wetland restoration ideas:

Wetlands are best managed by leaving them alone and letting nature take its course. Just as with streams and other watercourses, it is important to leave a zone of minimal activity around them. Damaged wetlands can be restored with the following techniques:

Plug the drains
If a wetland is drained, block the ditches that were used to drain it and allow water to accumulate naturally.

Stop mowing
Save the effort of cutting brush and allow trees and shrubs to grow.

Plant the edges
If a forest was cut to the edges of a wetland, plant native trees and/or shrubs to create a forested buffer zone at least 30m (100ft) wide.

Breathing Easy

Anyone who has touched a salamander or frog knows that they have cool, moist skin. These creatures breathe through their skin in a process that requires moisture to function well. This makes them sensitive to dryness and increased temperatures – conditions that result from heavy forest cutting. In order to survive outside their vernal pools, frogs and salamanders require abundant leaf litter, coarse woody debris and canopy shade to keep their skins moist and the oxygen flowing.

Amphibians: Small but Heavy

Dr. Bryan Windmiller, a forest ecologist working in Massachusetts, found that the total weight of amphibians breeding in vernal pools within a 20ha (50ac) study area was greater than the combined weight of all the breeding birds and small mammals found in the same area.

Donald McAlpine

Jamie Simpson

Forest and wetland

Managing the Riparian Habitat
by Bob Bancroft

Long ago, a green blanket of rich forests grew along the riverbanks, or the 'riparian zones' as they are sometimes called, in the Acadian Forest. The entire region (or watershed) that drains into a waterway exerts an influence on its rivers, streams and lakes. But the riparian zone is most critical. Although it accounts for only two per cent of the land base, this is the part that is closest to the water and most connected to a river's health.

Pristine Atlantic salmon and trout rivers obtain nearly 99% of the nutrients for their food chain from the forest ecosystem within their watershed and, in particular, from the riparian zone. Therefore, the health of Atlantic salmon and speckled trout is inextricably linked to healthy forested riverbanks and cool shaded water. Adults spawn in late fall, eggs over-winter in river bottoms, and fry emerge each spring; sediment caused by soil erosion is particularly harmful for the eggs and upsets this cycle. Unfortunately for the salmon and trout, most riparian zones have been stripped of old growth trees, and no longer function to shade the water, maintain the banks and protect the coldwater fish habitats.

Historically, when flooding occurred in valleys, a river topped its banks and spread onto the floodplain. Forest vegetation slowed the water spread, causing sediments to be deposited on the ground and creating rich soil well-suited for farming. In earlier times, the floodplain also acted like a giant sponge during high-water events, soaking up water into its underlying gravel seams and organic layers. When droughts occurred, this reservoir of cool, pure water would seep back into the river, augmenting the water flow and maintaining salmon habitats. When the older, massive trees along riverbanks died and toppled into the river, they produced shady cover and created pools that also served the salmon well.

Pre-settlement rivers and streams tended to be more deep and narrow than they are today. Land clearers who ripped up riparian zones either ignored or failed to recognize that the root systems of large trees served to armour and bind river and stream banks, acting much like steel reinforcing rods in concrete. They also neglected to note the importance of the river's winding, meandering path, which served to slow the water's downstream flow. Land clearing, log driving, drainage projects and other human endeavours have also served to straighten rivers, increasing their slope or gradient, and speed. With trees eliminated, ice and high water create more bank erosion. Doubling the speed of a river's flow allows it to erode four times as much bank material and to carry 64 times the amount of material downstream.

Rivers without riparian zone protection can suffer another consequence. Weak-banked and widened, some become ice factories. When winter descends during low water conditions, wide, shallow rivers sometimes freeze all the way down to the bottom, likely killing the insect life and young salmonids hiding in spaces between rocks. Whenever thawing occurs, water begins to flow over this existing ice. Then, as temperatures drop below freezing again, new ice layers form on top of the original ice. Successive layers accumulate with fluctuating weather until thicknesses of more than two metres (six feet) can develop. When the thick ice is finally wrenched off the bottom after a major spell of warm weather, an enhanced form of riverbank bashing begins with mega-blocks of ice. They often fetch up on bridge abutments, creating ice dams and flooding neighbourhoods. Newspapers proclaim that nature and the river have run amuck. However, it is humans, albeit unintentionally, who have derailed nature's forces and, in doing so, have exacerbated the flood problems.

For these reasons, forest management in riparian zones should be selective, gradually replacing short-lived, shallow-rooted softwoods, such as fir and white spruce, with longer-lived, deeper-rooted softwoods and hardwoods, such as red spruce, hemlock, ash and sugar maple. Generally, cutting should not occur immediately along the riverbank. If some cutting must be done, it should be carried out in a manner that avoids erosion. Farm fields, golf courses, residential areas and other open sites along riverbanks should be reforested with a variety of native tree species that are suited to the site.

The minimum required width of a healthy, forested riparian zone varies, depending upon topography, geology and the aquatic species the river accommodates. However, the forested zone should contribute shade, nutrients and, in time, produce large trees that will eventually topple, creating pools and in-stream habitats. One Canadian study showed that, for some sites, a 10m (32.8ft) width of growth on each bank is adequate from a water quality and temperature perspective.

If riparian areas are managed for songbirds, as well as salmon and trout, scientific studies in Maine show that 100m (328ft) on each side of the watercourse will accommodate the territorial areas of most species. Within this zone, but away from the critical area near the banks and water, specific forest harvesting techniques and levels of removal have been suggested. These include single tree and small group selection, shelter wood patches and seed-tree cuts, to encourage vegetation diversity vertically as well as horizontally. This approach protects stream banks, while sustaining birds and larger mammals such as the white-tailed deer.

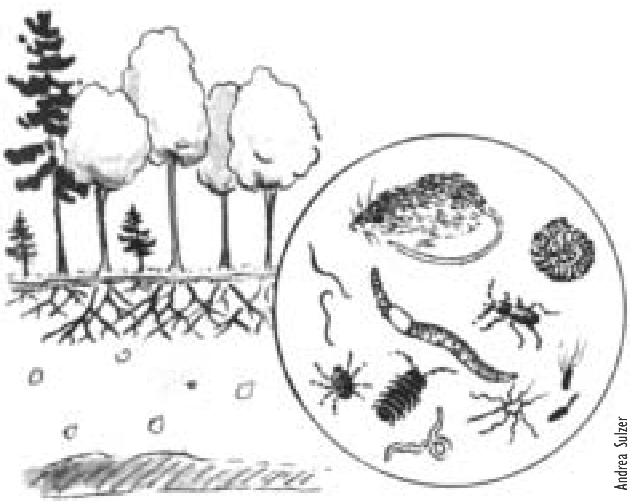
Forest Soils: The World Beneath Our Feet

"Heaven is under our feet as well as over our heads."
Henry David Thoreau, Walden*, 1854*

Soil is to the forest what a foundation is to a house: mostly unseen but all-important. Soil anchors trees, supplies plants with water and stores nutrients essential for plant growth. It also houses a complex ecosystem that, in turn, builds and maintains soil fertility. Soil is the link between Acadian Forest restoration and woodlot productivity because restoring and maintaining natural forest cover can improve soil quality, thereby promoting a healthy ecosystem and optimum tree growth. Taking a closer look at a woodlot's soil, and understanding how soil and trees interact, can provide a better understanding of how forestry activities affect the forest.

What is Soil Fertility?

Soil fertility is a measure of how well soil meets the demands of a given plant, thus how well that plant can grow, other factors being equal. It includes the availability of macro- and micro-nutrients, the moisture and oxygen levels, the presence of helpful fungi and bacteria, and adequate soil structure to allow easy root growth.



Forest and soil connection

"Some years ago, scientists blocked off a small section of forest soil in New York State and removed the top layer of earth to a depth of one inch. In all, there was an average of 1,356 [visible] living creatures present in each square foot…. Had an estimate been made of the microscopic population, it might have ranged up to 2 billion bacteria and many millions of fungi, protozoa and algae – in a mere teaspoonful of soil."
Peter Farb, The Forest*, 1978*

THE LIVING SOIL

Soil is alive: it is an intricate mix of minerals, organic matter, nutrients, water, plant roots, and a variety of organisms, including fungi, bacteria, protozoa, mites, insects, nematodes, worms, amphibians and small mammals. An entire ecosystem lives underfoot in the forest.

The soil ecosystem is an essential part of the forest because it maintains forest fertility. It does this in two key ways. First, it functions as a massive composter, which decomposes most of the organic material that reaches the forest floor. Second, it includes organisms – primarily fungi – that live interdependently with the roots of most plants and aid in their growth and survival. These fungi, called mycorrhyzae, help plants absorb water and nutrients from the soil.

The Decomposers

The forest floor could well be called the stomach of the forest. This is where bacteria, fungi, insects and other creatures transform dead organic material – leaves, branches, fallen trees, dead roots, feces and dead animals – into the soluble nutrients that nourish forest plants, and the 'non-digested' organic matter that builds soil structure. Consequently, the bulk of plant roots grow within the forest floor layer (the upper few centimetres of the soil), taking advantage of the abundant nutrients and adequate moisture and oxygen found in it – thanks to the action of the decomposers.

The Symbiotics

In addition to the decomposers, the 'symbiotics' are another group of forest organisms that are critical to forest productivity. The bulk of these are the mycorrhizal fungi that help plants to grow and, in return, derive benefits from a symbiotic relationship with the plants. Most of the trees and plants in the Acadian Forest share in this important relationship, and individual trees can have dozens of different fungi living symbiotically with their roots throughout their entire lives.

Mycorrhizal fungi form large networks of root-like structures, or mycelia, throughout the upper layers of forest soil. The mycelia grow into the roots of suitable plants, and thereby become an extension of a plant's own root system. In fact, these fungi are more efficient than the plants at extracting and transporting water and certain nutrients (such as phosphorous). Plants that are colonized by these fungi have better growth rates and are more resistant to environmental stresses, such as drought, cold and root diseases, than plants that do not share a relationship with mycorrhizal fungi. The fungi, for their part, benefit from products of plant photosynthesis, such as carbohydrates.

Scientists have found that mycorrhizal fungi actually connect trees to each other beneath the forest floor by passing carbohydrates and nutrients between tree roots. Carbohydrates have been shown to move from a tree growing in the sun to a tree growing in the shade, thereby reducing the competition for sunlight. Not surprisingly, associations with mycorrhizal fungi are common among an estimated 85% of terrestrial plants. There is even evidence that these relationships with mycorrhizal fungi enabled plants to make the transition from water to land some 400 million years ago.

Chanterelle mushrooms are a common (and tasty!) mycorrhizal fungus species found throughout the Acadian Forest. Another common edible fungus is the honey mushroom; unlike the chanterelle, however, honey mushrooms are associated with a root rot fungus know as Armillaria, which feeds on dead and nearly dead trees.

Large-scale Composting:

Annual litter production (leaf fall and deadwood) in the Acadian Forest ranges from 2.5 to 3.75 tonnes per hectare (1.1 to 1.6 tons per acre). A host of earthworms, millipedes, sowbugs, fly larvae, springtails, mites, and numerous species of fungi and bacteria compost this matter each year, releasing nutrients and organic matter that is essential for plant growth.

Balancing growth and decomposition

In the intervals between large-scale natural disturbances, most forest communities in the Acadian Forest region achieve a rough balance between the accumulation and the decomposition of dead organic matter. Hardwood-dominated communities tend to have faster decomposition rates than softwood-dominated communities, with the result that the forest floor layer in hardwood stands is often much thinner than those in softwood stands.

NUTRIENTS

In the forest ecosystem, nutrients are always on the move, continuously entering, leaving and cycling through the forest ecosystem. Understanding nutrient cycles and the reasons for nutrient loss and gain can help woodlot owners to optimize forest productivity. In the Acadian Forest, the availability of such major nutrients as nitrogen, phosphorus and calcium is often the limiting factor in tree growth.

In forest ecosystems, nutrients become available for use by plants in three ways: (1) many nutrients, particularly nitrogen, enter the forest system from the atmosphere; (2) others are added by the gradual weathering, or break-down, of soil and bedrock material, and (3) most importantly, nutrients are added through the break-down of organic material during the nutrient cycling process. Nutrients can leave the system in several ways, including forest harvesting, forest fires, topsoil erosion, water runoff and a process known as leaching, wherein nutrients are washed into lower levels of the soil by the downward movement of water.

Soil Diversity = Tree Diversity

Soil can vary a great deal from place to place and even within a single woodlot. Features such as depth, drainage, clay content, organic matter content and slope position all impact soil fertility and the types of trees that can grow or survive on a given piece of land. Differences in soil characteristics explain much about the distribution of tree species in the Acadian Forest. Deep, rich, floodplain soils support hardwood forests, while nutrient-poor soils support low volume 'scrubby' forests. Wet lowland soils might support black spruce and tamarack trees, rich upland soils might support a mix of shade-tolerant species, while thin, but well-drained, soils might support a red spruce and balsam fir mixture. A soil that is rich in calcium, known as a calcareous soil, may support calcium-loving plants such as eastern cedar.

The Nutrient Cycle

Productive woodlot soil is maintained by keeping as much as possible of the nutrient supply in a constant cycle of use. It is a classic case of 'use it or lose it'. Unused nutrients are at risk of being washed out of the root zone of plants, or out of the soil altogether (and into nearby watercourses). The nutrient cycle starts when plants, animals and all other forest organisms take in nutrients to grow and to stay alive. The cycle continues as dying and dead material collects on the forest floor and in underlying soil, and is decomposed into nutrients and other materials that are once again available to sustain forest life.

The nutrient cycle works most efficiently to maintain optimum forest productivity when two key conditions are met. The first is biodiversity: a diversity of plants and other organisms are needed to fully utilize all the available nutrients. Different plants have different rooting depths and nutrient requirements, so some organisms can make use of nutrients that others cannot. Therefore, a naturally diverse, mature Acadian Forest can be seen as an interconnected system that efficiently captures and recycles nutrients, keeping the environment rich and productive. However, decreasing the diversity of species in the forest results in less efficient nutrient cycles, ultimately reducing forest growth as the pool of nutrients decreases and those remaining become harder for plants to access.

Of particular importance to woodlot management is that deep-rooted hardwoods act as 'nutrient pumps' as they bring nutrients back to the surface (as leaf fall) that have been transported downward by the flow of water through the soil. Softwood trees, on the other hand, tend to have shallower root systems and more acidic foliage than hardwood trees, which can eventually lead to reduced soil productivity and more acidic soil. Hardwoods therefore are an important component of the nutrient cycle, especially in stands that are predominately softwood.

The second key condition for optimal forest productivity is the efficient breakdown of dead material, which provides nutrients that feed plants and organic matter that builds good soil structure. Abundant and diverse populations of decomposing organisms, particularly bacteria, fungi and insects, are needed to transform the dead material into the nutrients and organic matter that benefit plant growth. Certain changes in the forest affect how fast these organisms break down dead organic material. Loss of deadwood or compaction of soil, for instance, reduces the habitat needed by decomposing organisms. A large increase or decrease in the amount of water in the soil also slows the rate of decomposition. Elevated temperatures, on the other hand, tend to increase the rate of decomposition.

"When you restrict the forest to, for example, birches and balsam fir, the litter that enters the soil system is much more acid in nature than the litter that would come from a complicated mixture of trees…. Acadian Forest systems, with their complicated forest structure ... their root systems, their associated vegetation, their regeneration… make it difficult for nutrients to escape. They don't leach down through the soil profile easily – there's something there to use them."

Stephen Manley, 1989[3]

Acid Rain and Soil Fertility

Acid precipitation from air pollutants is a potential source of soil acidification which (if not buffered) can intensify nutrient loss. Acid precipitation may even lead to a net loss of nutrients from sites with low fertility in the absence of any other disturbance. This risk is very site specific, depending on the amount of acid precipitation and the capacity of the soil to buffer the acidity. The granite-based soils of western Nova Scotia, for example, are potentially susceptible to nutrient loss due to acid precipitation. Fortunately, the effects of acid precipitation on soil are relatively minor in most areas of the Acadian Forest.[4]

SOILS AND WOODLOTS

The effects of forestry practices on soil fertility are complex and highly site specific: actions that may damage soil fertility on one woodlot may be acceptable on another. The following suggestions for optimizing soil productivity, therefore, do not necessarily apply equally to all woodlots, but rather represent a low-risk, precautionary approach to woodlot management.

1. Encourage natural diversity
Plants interact with the soil in different ways, feeding at different soil depths, taking in different proportions of nutrients, and cycling different nutrients back into the soil. Promoting natural forest diversity, therefore, helps to ensure that available nutrients are used as efficiently and completely as possible. As well, a naturally diverse plant community produces a diversity of forest floor litter, which in turn encourages organisms that compost the dead materials, reduce acidity and improve soil productivity.

2. Restore and encourage hardwoods
Softwood trees are more abundant in some areas of the Acadian Forest than they would be naturally because they often colonize abandoned farmland and because they are often promoted during forestry practices such as herbicide application, planting and thinning.

Restoring hardwood trees to such areas can help to improve soil conditions. Hardwood foliage is generally less acidic and tends to decompose more readily than litter from softwood trees. As a result, litter from hardwood trees supports a greater abundance and diversity of decomposing organisms, and in turn a faster cycling of nutrients. Hardwood trees also tend to have wider and deeper root systems that utilize more of the available soil nutrients than softwood trees do, thus help conserve nutrients and keep them cycling within the forest system. As a result, soil productivity increases.

3. Maintain and encourage deadwood
Although the nutrient concentration in deadwood is low compared with that in leaves and small branches, deadwood provides significant nutrients because of the large amount of biomass involved. Because deadwood breaks down slowly, it provides a steady source of nutrients to the forest system. Deadwood also adds large amounts of organic matter to the soil as humus, thereby improving soil structure for plant growth.

Deadwood also provides vitally important habitat for a diversity of decomposing organisms. Especially important are the deadwood-dwelling bacteria that convert atmospheric nitrogen into a form that plants can use.

4. Leave branches and tops in the woods when harvesting
Whole-tree harvesting, or taking everything from the stump up, removes 100 to 215% more nutrients from the forest than removing only the stem of the tree and leaving the tops and branches.[5] The branches also provide shelter for wildlife and protect the forest floor from compaction, erosion and excessive heat.

Although the air we breathe is comprised of up to 80% nitrogen, none of this nitrogen can be used by living organisms until it is transformed into a useable state. In the forest, this is done by certain species of bacteria, some of which live in deadwood and some of which live symbiotically with certain species of plants.

5. Keep forest canopy when harvesting
Reducing canopy cover, especially with large-scale clearcutting, can cause soil to heat up and dramatically increase decomposition. Increased decomposition can result in a flush of nutrients – more than can be utilized by the plants and soil organisms remaining after the harvest. Because a loss of trees also results in increased water flow over and through the soil, unused nutrients may be leached away from the rooting zone or washed into nearby watercourses during rains.

Leaving behind an abundance of living vegetation after a harvest both helps to keep soil from getting too hot or too cold, and helps to retain nutrients produced during a nutrient flush, keeping them cycling in the forest system; killing vegetation by broad-scale herbicide use should not be used for these reasons. A canopy of vegetation, especially one that has multiple levels, also slows rainfall and extends snowmelt time, which reduces the risk of water-stress and nutrient movement by leaching and water run-off.

6. Protect the forest floor
The upper layer of the soil, the forest floor, is the forest's engine of decomposition, so it is critical to soil fertility. It also cushions the underlying soil during harvesting, protecting its ability to hold and transmit air and water – both important factors for plant growth. Harvesting only when the soil is relatively dry or frozen and using equipment with low ground-pressure tires or tracks will help to protect the forest floor and the underlying soil. Importantly, it is the pressure per unit of area that forest machinery exerts on the ground rather than the actual weight of the machinery that determines the risk of damage. A small tractor with narrow tires, for example, could do more damage to the soil than a larger machine with low ground-pressure tires because the pressure per unit area can be much greater.

Soil Erosion and Compaction

Soil erosion becomes a risk when the supply of water exceeds the rate at which it is absorbed into the soil. This situation is most commonly associated with poor road and trail building techniques that allow water to flow downhill at great speed. The local soil erosion seen in gullies and washouts is unsightly and reduces fertility, but the more significant damage occurs when soil is washed into streams and rivers where it can be extremely harmful to aquatic habitats (see the section "Water and Woods: the Riparian Ecosystem"). Generally, shallow soils and soils with high levels of silt and fine sands are most prone to erosion. The risk of erosion also increases as the steepness of the land increases.

> *"One of the classic studies in ecology was done on the Hubbard Brook Experimental Forest [New Hampshire] back in the late 1960s. They logged some areas, herbicided all of the early-successional vegetation, and then looked to see what happened in the streams. What happened was predictable, but it had never been demonstrated quite so elegantly before. When you knock out that early-successional recovery mechanism, nutrients start bombing out of the system, soil integrity is disrupted. A lot of nutrients are lost, and it may take a long, long time to build those back up again."*
>
> *David Perry, 2002*[6]

The most effective means to reduce the risk of soil erosion is to keep an intact cover of vegetation, organic matter and, where applicable, logging debris (branches and tops). This protects the upper mineral soil from the beating action of rain, which can clog the pore spaces in soil with fine particles that result from the break-down of soil clumps. Following best management practices (BMPs) for road design and layout will also help prevent water runoff and the risk of erosion; BMPs can be obtained from government departments of natural resources.

Soil compaction occurs when heavy objects, such as forestry machinery, compress soil and decrease the pore space in it. Decreased pore space reduces the soil's ability to transmit water and air, which negatively affects plant growth by discouraging root growth. Studies in the State of Maine have shown a 6 to 16% decrease in forest productivity due to compaction from skid trails during logging.

The most important factors affecting soil compaction are (1) the amount of pressure exerted on the ground by vehicles or other forestry equipment, and (2) the moisture level of soil at the time of compaction. Wet soils compact much more easily than dry soils, which is another of many reasons to keep machinery out of the woods during wet times of the year. Soil texture also plays a role because soils high in silt and clay compact more easily than sandy or gravelly soils. Organic matter in the soil, added by the decomposition of leaf litter, deadwood and other organic material, helps reduce the risk of soil compaction.

Soils can recover from compaction, but this recovery can take years or decades. It is better to avoid compaction by using machinery in the woods only when the soil is relatively dry or frozen. Using machines with low ground pressure tires and laying branches and tops in the path of machinery can also help avoid compaction.

Organic Soils: Is that Certified Organic?

Organic soil is a soil type that has a deep layer of decomposing plant material that measures 40cm (16in) or more from the soil surface to the underlying mineral soil. Organic soil tends to be found in low-lying areas with high water tables. Because of the waterlogged conditions, organic matter decomposes very slowly and the organic layer accumulates over time. Black spruce, tamarack and sometimes cedar tend to grow on organic soils, along with ericaceous shrubs such as Labrador tea, leather leaf and rhodora.

Organic soils are very sensitive to disturbance during forestry activities such as harvesting or road building. Partial harvesting can sometimes be acceptable if carried out when the soil surface is frozen hard. Removing trees from these soils, however, can cause the water table to rise even further because the harvested trees no longer draw down the water.

Alders, Bacteria and Nitrogen

Despite popular opinion, the majority of bacteria are beneficial to humans and the forest. Good examples are species of soil-dwelling bacteria that form colonies on the roots of certain plants. Similar to mycorrhizal fungi, these bacteria benefit from the carbohydrates produced by the plant and, in return, provide the plant with a valuable resource, in this case, nitrogen. The bacteria take nitrogen from the air and change it into a form usable by plants in a process known as nitrogen fixation. Because usable nitrogen is often in short supply for plants, nitrogen-fixing bacteria are a valuable asset to the forest.

Alder is one plant that partners with nitrogen-fixing bacteria and, in the process, helps to build soil fertility. One source reports that thanks to the bacteria and the annual litter of nitrogen-rich leaves, alders can add up to 160 kg of nitrogen to the soil per hectare per year (140 pounds / acre / year). [7]


Jamie Simpson

Alders: soil builders

Soil Identification
Soil has three main inorganic components: sand, silt and clay. Sand feels gritty and is not sticky when wet. Silt can feel smooth, slippery or powdery and is also not sticky when wet. Clay feels smooth and is sticky and mouldable when wet; it forms hard clods when dry. Soil is classified by the relative amounts of sand, silt and clay it contains: for example, loamy sand, sandy loam, silt loam and clay loam.

Soil Grab Test:
Grab some moist soil in your hand, squeeze it tightly, and toss it from hand to hand to determine the type of soil:
• Falls apart under light touch - sandy soil
• Stays together with careful handling - sandy loam
• Handles easily without breaking - loam
• Mouldable and withstands handling - clay loam
• Mouldable and sticky - clay soil

Biomass Harvesting

Given today's pressure to develop non-fossil fuel energy sources, burning of 'waste' forest biomass, such as branches, tops and otherwise non-saleable trees, to produce energy is gaining in popularity. Removing more than stem wood (that is, tree trunks) from the forest, however, has potentially negative consequences for long-term soil productivity.

The following is excerpted from an article by Taumey Mahendrappa and Peter Salonius, forest science researchers with the Canadian Forest Service, Atlantic Region.[8]

"There is abundant historical evidence that the gathering of nutrient-rich foliage from European forest floors, used as livestock bedding and then spread on agricultural fields… caused serious changes in tree species composition, decreased biodiversity and forest growth, and increased soil acidification and nutrient depletion.


Tamara Heikalo

"Coordinated, large-scale studies in New Zealand and the United States 25 years ago… substantiated these earlier observations concerning forest soil impoverishment in Europe. Recent research results from Finland, showing 8 to 12% declines in growth rates of rotations of pine and spruce that follow full tree harvest, indicate that removing nutrient-rich slash from many forest sites would not be sustainable.

"…full tree harvest methods have been flagged as problematic on many site types because of the significant removals of calcium, nitrogen and potassium in the small branches with high bark to wood ratios and the attached foliage."

"In forests with limited nutrient capital, such as much of the forest landscape in New England, the efficient cycling of nutrients between soil, plant and forest floor is critical to maintaining healthy and productive forests…. New England forests in particular have been subject to heavy acid deposition loads and repeated timber harvest. Continuing losses of base cations [nutrients] due to these disturbances will lead to nutrient deficiencies and imbalances and subsequent declines in forest health and productivity."

USDA Forest Service, Northeastern Research Station, 2003[9]