FUNDY
MODEL FOREST NETWORK
RÉSEAU DE FORÊTS MODÈLES

Fundy Model Forest

~Partners in Sustainability~

Report Title: Forest Management Guidelines to Protect Native Biodiversity in the Fundy Model Forest

Author: Dr. Steven Woodley, Dr. Graham Forbes

Year of project: 1997

Principal contact information:

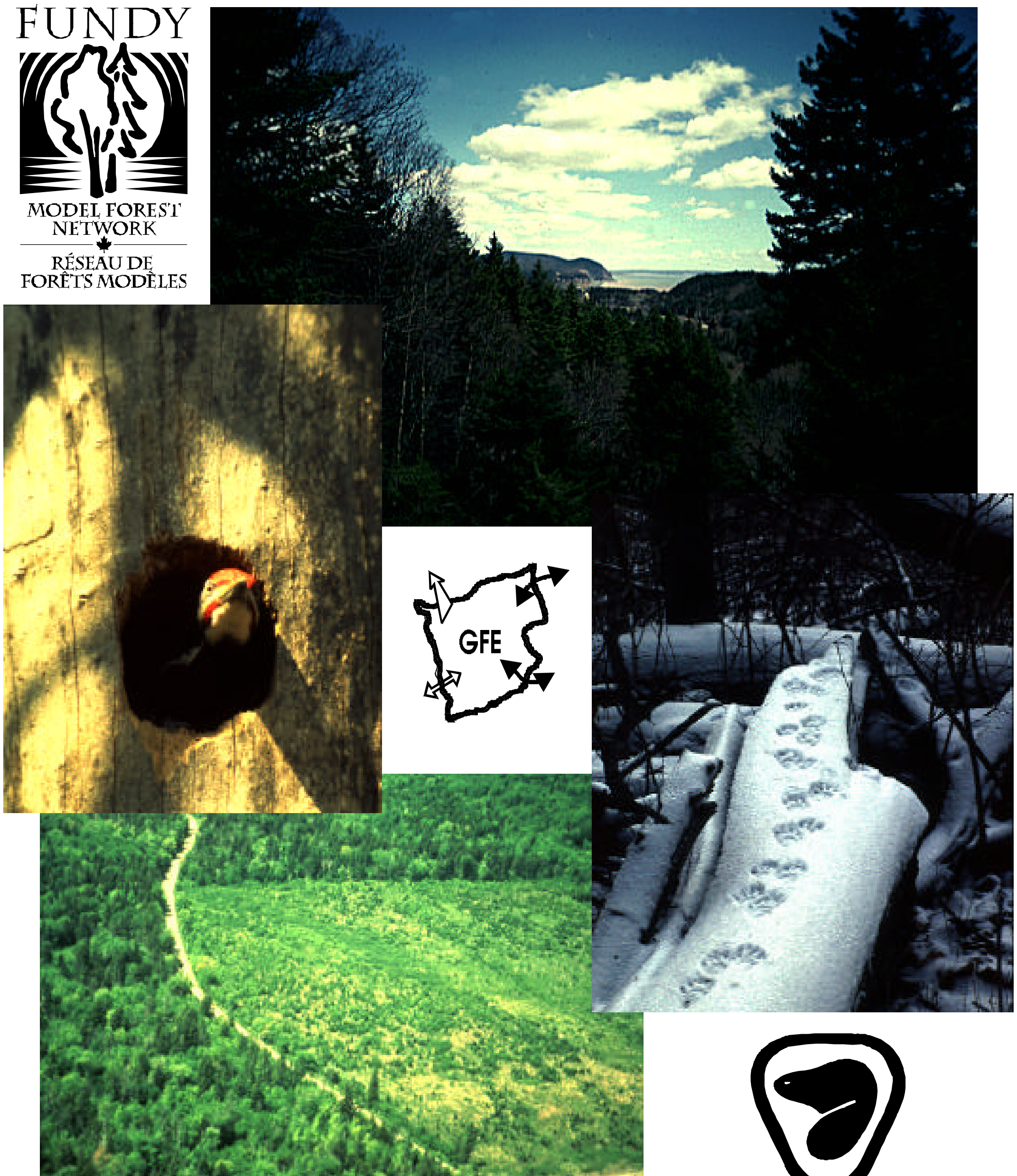
File Name: Biodiversity_1997_Woodley_Forest Management Guidelines to Protect Native Biodiversity in the Fundy Model Forest

The Fundy Model Forest…
…Partners in Sustainability

"The Fundy Model Forest (FMF) is a partnership of 38 organizations that are promoting sustainable forest management practices in the Acadian Forest region."

Atlantic Society of Fish and Wildlife Biologists
Canadian Institute of Forestry
Canadian Forest Service
City of Moncton
Conservation Council of New Brunswick
Fisheries and Oceans Canada
Indian and Northern Affairs Canada
Eel Ground First Nation
Elgin Eco Association
Elmhurst Outdoors
Environment Canada
Fawcett Lumber Company
Fundy Environmental Action Group
Fundy National Park
Greater Fundy Ecosystem Research Group
INFOR, Inc.
J.D. Irving, Limited
KC Irving Chair for Sustainable Development
Maritime College of Forest Technology
NB Department of the Environment and Local Government
NB Department of Natural Resources
NB Federation of Naturalists
New Brunswick Federation of Woodlot Owners
NB Premier's Round Table on the Environment & Economy
New Brunswick School District 2
New Brunswick School District 6
Nova Forest Alliance
Petitcodiac Sportsman's Club
Red Bank First Nation
Remsoft Inc.
Southern New Brunswick Wood Cooperative Limited
Sussex and District Chamber of Commerce
Sussex Fish and Game Association
Town of Sussex
Université de Moncton
University of NB, Fredericton - Faculty of Forestry
University of NB - Saint John Campus
Village of Petitcodiac
Washademoak Environmentalists

Forest Management Guidelines To Protect Native Biodiversity In The Fundy Model Forest



Greater Fundy Ecosystem Research Group

January 1997

FOREST MANAGEMENT GUIDELINES TO PROTECT NATIVE BIODIVERSITY IN THE FUNDY MODEL FOREST

(G. Forbes)

Greater Fundy Ecosystem Research Group

Editors:

Dr. Stephen Woodley
Chair, GFE Research Project
Natural Resources Branch,
Parks Canada

Dr. Graham Forbes
Co-ordinator, GFE Research Project
Faculty of Forestry and Environmental Management, University of New Brunswick

Design: Andrew Skibicki, University of New Brunswick

A list of contributors can be found in Appendix 4.

Published by the New Brunswick Co-operative Fish and Wildlife Research Unit, University of New Brunswick

January 1997

PREAMBLE

The Greater Fundy Ecosystem (GFE) Research Project was established in 1991 to provide the type of ecosystem-based research and science support necessary to manage a sustainable landscape. Its overall objective is to protect ecological structures, functions and processes while providing sustainable flow of goods and services for people.

The GFE Research Group is multidisciplinary, with members from industry, government and universities. Since the Group's establishment its aim has been to be inclusive and not to be seen as solely aligned with the aspirations of a particular group or agency.

The GFE research group pre-dates the Fundy Model Forest (FMF) and was instrumental in its development. Since the establishment of the Fundy Model Forest in 1992, the GFE Research Group has worked within the FMF partnership to provide the ecological research necessary to conduct forestry in an ecologically sustainable manner.

These guidelines were submitted to the Fundy Model Forest Partnership for use in planning for the wise harvest of forested lands to conserve biodiversity. They were developed after considerable on-site research and the review of other similar efforts. Because they focus on the conservation of biodiversity, these guidelines are only part of a larger, more comprehensive set of guidelines that are required for sound forest management. Absent from this set of guidelines are such things as best practices for stream crossings and skidding trails. These are important but have already been well developed by others.

This set of guidelines takes as its primary focus a series of broad, landscape-level considerations which have been absent from most sets of forest guidelines. The emphasis of these guidelines is on activities occurring on crown and freehold licences.

Aerial view of inoperable steep slopes and forest harvest on the plateaus. (G. Forbes)

Private woodlot management often exists at smaller scales such that larger-scale issues of connectivity, minimum patch size, and mature provisions are more difficult to achieve. Many of the principles still apply to private woodlots, particularly those stand level considerations that can be implemented on a smaller scale.

We consider these guidelines to be a work in progress and they are open to comments, revisions and future modifications. Their formulation has been a collaborative effort between scientists and managers from various levels of government, several universities and private industry. A list of contact addresses and contributors is provided in Appendix 4 of this document.

We have developed these guidelines in good faith, with a recognition of the importance of the forest industry to New Brunswick and a belief that forest harvest and biodiversity conservation can co-exist in the same landscape.

- The Editors

EXECUTIVE SUMMARY

Biodiversity is simply the variety of life and the processes that support it. Scientists usually characterise biodiversity at different scales: the gene, the species, the community and the landscape. All these scales interact to produce what we know as the "diversity of life" or biodiversity.

The area of the Fundy Model Forest has a characteristic native biodiversity. At the genetic level, for example, stands of Red Spruce trees have different characteristics from neighbouring stands only a few kilometres away. The species level - which is best known - is characterised by 42 species of mammals, about 250 species of birds, about 1000 species of vascular plants and an unknown number of insects and other life forms. These species naturally form communities which we refer to by such terms as "Upland Sugar Maple forest" or "Lowland Spruce Forest". In turn, communities are organised into broad landscape patterns that are controlled by bedrock, topography, slope, climate and disturbance history. We sometimes refer to these landscape patterns as "ecoregions" or "ecodistricts".

It is impossible to plan for the conservation of biodiversity on a species-by-species basis. There are simply too many species and we don't know nearly enough about each one. Thus, to conserve native biodiversity, we have taken a combined top-down (coarse-filter) and bottom-up (fine-filter) approach. The coarse-filter approach allows for planning of larger scale arrangements of communities, including their composition, size, adjacency and age class distribution. The needs of the vast majority of native species may be accommodated by a coarse-filter approach. However, to ensure that no species fall through or are missed by the coarse-filter approach, we have also examined the very specific requirements of species or species groups that are likely to become vulnerable given the significant stand- and landscape-level changes to the forest that are a consequence of modern forest management and a growing human population.

Our recommendations for forest management, using a combined coarse-filter and fine-filter approach, are summarized below. These recommendations are tempered by our recognition of the economic importance of the forest industry to New Brunswick but are driven by the biological "bottom line", which is the continued viability of native populations, species and ecosystems in the Greater Fundy Ecosystem.

The Coarse-Filter Approach:

Ecological Land Classification
+
Natural Disturbance Regime
+
12% in Mature-Overmature Patches
+
Connectivity
+
Silviculture by Disturbance
+
Protected Areas
=
Coarse-filter Scale Biodiversity

Coarse-Filter and Management Planning Level Guidelines

Patch sizes and disturbance regimes - Forests should be managed as either gap or stand-replacing disturbance regimes. This duplicates the historical disturbance pattern. The division into disturbance regimes should be done first at the ecodistrict level, which accounts for climate differences and enduring landscape features. Secondly, the forest should be subdivided into ecological units with an aim to maintain forest types that exist because of gap-type disturbance. In all gap-type stands, the aim should be to maintain a predominantly closed-canopy cover, a mixed-age distribution of overstory trees and sufficient regeneration to restock the forest. This can be accomplished by selection cuts. For forests managed under a stand-replacing disturbance regime, the operating patch size should be between 375 to 500 ha. However, this should not mean that yearly cuts of that size be conducted. To approximate natural patchiness, the 375-500 ha blocks should be cut over a period of 10-15 years, which would allow working cuts in the range 25-50 ha.

Guidelines for the amount of tree removal on a watershed are being developed. It has been shown that the hydrology and nutrient quantity of a watershed changes with disturbance and we hope to present this relationship in the future.

Connectivity - A network of forested connections needs to be maintained across the Model Forest landscape, with a minimum corridor width of 300 meters and maximum corridor length of 3 km. The forested connections should have a closed canopy forest (minimum 35% crown closure) of any species, with a minimum canopy height of 12 meters. From preliminary research, it appears that selection harvesting will meet the requirements of connectivity.

Stream side buffers - The GFE research group supports the direction and content of the Watercourse Buffer Zone Guidelines for Crown Land (see text). However, the steep river valley slopes of the FMF present an additional concern for water quality in the area. We recommend that these steep valley slope areas represent unique and sensitive conditions that should be specifically identified in buffer zone guidelines. A general rule should maintain the current buffer setback of 60 m but beginning at the top of the valley (instead of the shoreline), at a point where the slope is <20%. Forest harvest activity would follow the guidelines established within the 60 m buffer, except that no cutting or very controlled cutting should occur within 5m of shorelines.

Mature-Overmature forest classes - A minimum of 12% of each community type (except regenerating and non-forest communities) should be maintained in a mature-overmature age class; 4% should be in the overmature age class. On an ecodistrict level the mature component should exceed the minimum patch size of 375-500 ha. For selection cut forests, mature forests should have a minimum canopy crown closure of 60 %.

The contribution of plantations to mature habitat objectives is possible if they :

1. are comprised of native species that are characteristic of the ecozone,
2. meet the maturity window for the species,
3. meet stand level guidelines for snags and coarse woody debris, and
4. have at least 5% other species in the forest canopy.
5. in total, plantations of non-native or non-site species should not comprise more than 5% of the total area of the ecodistrict.

Network of protected areas - We recommend that a network of protected areas be established in the model forest to protect rare, unique and representative species and features. These protected areas should be off limits to any development except:

1. Sustainable, non-motorised recreational hunting and fishing, which may be allowed in areas where they are currently being practised (e.g. Fundy coastal ravines [allow sporadic fishing, except for Atlantic Salmon] and Fundy upland bogs [allow Moose hunting])
2. In some of the forested sites, some form of limited extraction may be acceptable as long as it:
   a) excludes the harvest of Hemlock
   b) reflects existing natural disturbance regimes (e.g. selection harvesting in tolerant hardwood stands)
   c) maintains late seral forest in areas where it presently exists
   d) respects stream buffer zones, and avoids areas hosting rare or uncommon plants. Management plans for timber extraction and road design within the watersheds encompassing the protected areas will be necessary to integrate the protected area into the working landscape, and to improve the role of the protected area as an "eco-bank".

The Fine-Filter Approach:

Special Status Species
(Rare, Keystone, Economic)
+
Snag and Cavity Tree Retention
+
Coarse Woody Debris
=
Fine-filter Scale Biodiversity

Fine-Filter and Operational Level Guidelines

Coarse woody debris - Intensive forest management practices tend to eliminate large pieces of decaying wood from the forest. Tree limbs and tops should be left on site after harvest. On all managed sites or stands, there should be a minimum of 200 pieces/ha of coarse woody debris (average piece diameter $\geq$ 10 cm) and a minimum total of $10 m^3$/ha throughout the rotation of the stand.

Retention of snags - In intensively managed forests, a lack of suitable numbers and types of large decaying or preferred nesting trees often limits species that need cavities. Forests can be best managed for cavity nesting species of birds by selection harvesting techniques. After commercial timber is removed during the first intervention, the best management option for cavity nesters is to leave a minimum of 10-12 snags (defined as standing dead trees, preferably greater than 20 cm dbh (diameter breast height)) per hectare for feeding, plus 12-15 live, or partially dead, mature Aspen or Beech (in the absence of Aspen or Beech, Maple and Yellow Birch may be substituted) with minimum dbh of 25 cm to be used for nesting. Subsequent interventions should maintain those numbers and ratio and consideration must be given to regenerating young trees as well. Single snags or live trees in clearcuts less than 4 ha. in size may be useful as feeding and nesting trees for certain species of cavity nesters. Live Aspen, Beech, Maple or Birch are preferred over conifer species. Trees should be mature, with a minimum dbh of 25 cm. Clumps of trees are preferable over single trees. The minimum number remaining should be no less than 12-15 single trees per hectare and, in any situation, more is always better than less.

In larger clearcuts (> 4 hectares), managers should pay special attention to leaving scattered clumps of live trees - both mixed deciduous and mixed coniferous. Large clumps are always better than small clumps but a minimum clump size should be 25 m^2. In forest clear-cut operations, managers should have knowledge of what there is in terms of potential nest trees (i.e. live Aspen and Beech with 25 cm dbh) and snags (i.e. dead trees with 20 cm dbh) as well as the amount of commercial timber.

In cuts < 4 hectares, 10-12 potential nest trees and 12-15 snags should be left per hectare. Managers should pay special attention to leaving clumps of trees rather than single trees. Where dead, leaning and down trees do not present a hazard or otherwise interfere with selective timber removal, they should be left undisturbed as an important component of the forest ecosystem.

Improvements to plantations:-

Options for existing plantations:

1. Overall, plantations of non-native species, such as Norway Spruce, or species not normally forming pure stands in the ecodistrict (e.g. Jack Pine along the Fundy Coast), should not cover more than 5% of the total area of each ecodistrict. Plantations of non-native species or species not normally forming pure stands in the ecodistrict should not be included in inventories of old age class forest types. For example, Norway Spruce can never be considered a substitute for Red Spruce.

2. Plantations can meet mature habitat requirements by letting the plantation age to the maturity window for that particular forest type. The plantation can then meet the criteria for mature habitat, with the following restrictions:
   a) the plantation should have at least 5% of canopy tree species that are other than the dominant planted species;
   b) the plantation should meet the guidelines for coarse woody debris and snags contained in this document (i.e. minimum of 200 pieces of coarse woody debris per hectare and 10 m^3/ha., average diameter of pieces $\geq$ 10 cm). This requirement may be met by early thinning or girdling of trees;
   c) the plantation should have a minimum canopy closure of 60%.

3. Retain as many tree species as feasible during thinning operations.

4. Replant Aspen and Poplar in clumps within maturing plantations for their use by cavity nesting species

For new or planned plantations:

1. Follow snag and clump guidelines, retaining Aspen, Poplar and Birch trees where possible.

2. Retain coarse woody debris

3. Limit crush-and-burn site preparation in order to retain coarse woody debris

4. Retain strips or clumps of competing species during herbicide or thinning operations

5. Use native species only

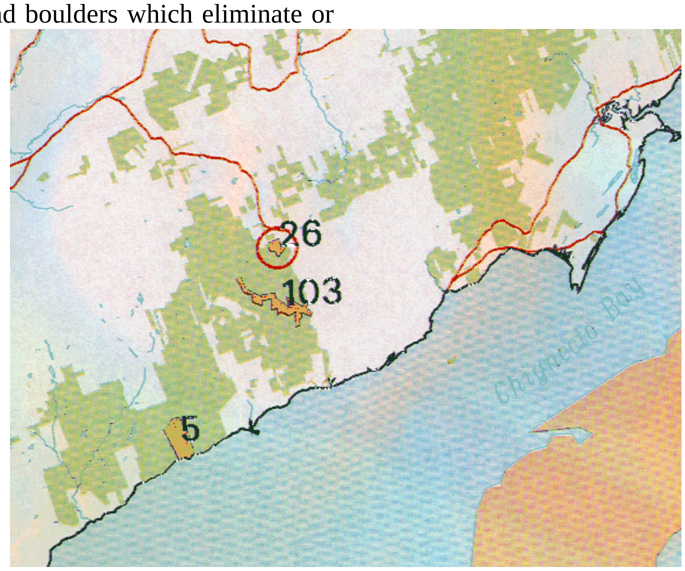
6. Reflect the site's ecological classification by not converting mixed stands into softwood or hardwood (i.e. plantations on converted sites are not eligible).

Habitat needs for threatened species - Population and habitat objectives will be developed for these species in the near future.

Special status tree species -Tree species that are uncommon or rare due to human activity should be retained in forests by limiting their harvest and creating the conditions needed for regeneration. The identified species are Eastern White-cedar, Eastern Hemlock, Bur Oak, Red Oak, Basswood, Butternut, Ironwood, Black Cherry, and Black Ash. Red Spruce and American Beech are common but require selection harvest to promote regeneration. The identification and regeneration of disease-resistant trees for American Beech is also critical.

Roads - An unplanned consequence of forestry is a dramatic change in access through road networks. Roads allow increased legal and illegal hunting, fishing and other harvest. They also fragment habitat and allow the spread of disease and exotic species. Road networks should be at a low density, avoid crossing water and be positioned so as to limit access to unique sites. We recommend a target road density of less than 0.58 km of road per km^2 of land. As many roads as possible that are not required for ongoing silviculture should be temporarily closed using embankments and boulders which eliminate or decrease vehicle access. Road networks should avoid loop roads and promote cul-de-sac roads.

Snags provide nesting and feeding habitat for many wildlife species such as beetles, woodpeckers and mushrooms. (G. Forbes)



Conservation Areas around Fundy National Park: (5) Little Salmon River Gorge, (26) McManus Hill, (103) Point Wolfe River Gorge (DNRE map (1996)). Dark areas indicate Crown Land and light areas indicate industry-owned land or private woodlots.

TABLE OF CONTENTS

PREAMBLE ii

EXECUTIVE SUMMARY iii

TABLE OF CONTENTS vii

INTRODUCTION 1

ISSUES OF SCIENTIFIC ACCURACY 2

APPROACHES TO THE DEVELOPMENT OF FOREST MANAGEMENT GUIDELINES 3

PRINCIPLES OF FOREST MANAGEMENT TO CONSERVE BIODIVERSITY 4

FOREST MANAGEMENT GUIDELINES FOR PROTECTING BIODIVERSITY 5

LANDSCAPE LEVEL CONSIDERATIONS 5
- *Patch Size (forest stand size)* 6
- *Connectivity* 7
- *Stand Age* **-** *Provisions for Mature Forest Stands* 8
- *Incorporating Maturity into Forest Harvest Schedules* 9
- *Plantations* 10
- *Stand Conversion* 11
- *Roads* 12
- *Protected Areas* 12
- *Water Course Buffers* 17

SITE LEVEL CONSIDERATIONS 19
- *Habitat Considerations for Specific Species* 19
- *Special Status Tree Species* 19
- *Coarse Woody Debris* 20
- *Snag and Cavity Tree Retention* 20

APPLICATION TO THE FUNDY MODEL FOREST CASE STUDY AREA 23
- *EASTERN LOWLANDS (PETITCODIAC RIVER -ECODISTRICT 30)* 24
- *CONTINENTAL LOWLANDS (ANAGANCE RIDGE - ECODISTRICT 29)* 25
- *SOUTHERN UPLANDS (FUNDY HIGHLANDS/PLATEAU - ECODISTRICT 12)* 26
- *FUNDY COASTAL (FUNDY COASTAL - ECODISTRICT 32)* 27

REFERENCES 31

APPENDIX 1: APPLICATION OF GUIDELINES TO PRIVATE WOODLOTS 32

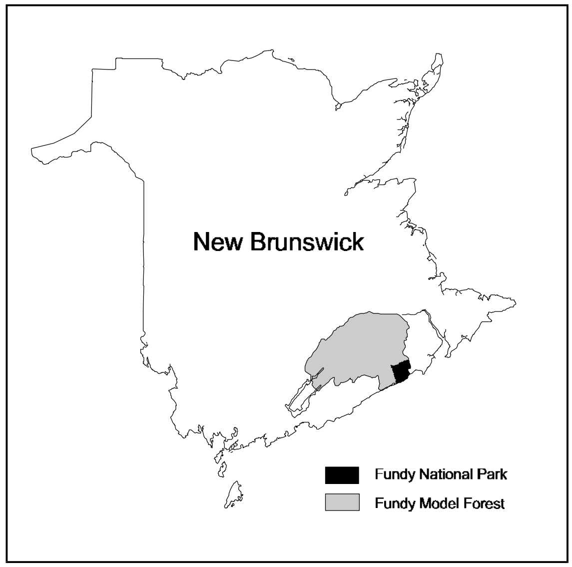
APPENDIX 2: COMMON AND LATIN NAMES FOR SPECIES 33

APPENDIX 3: PROPOSED HARVEST STRATEGY FOR STANDS IN THE CASE STUDY AREA 34

APPENDIX 4: LIST OF CONTACTS AND PARTICIPANTS 35

INTRODUCTION

For the past four years, the Greater Fundy Ecosystem Research Group has been conducting research in the Fundy Model Forest. This research has been sanctioned and funded, in part, by the Fundy Model Forest. The goals of the research have always been:



1. To identify strategies to maintain viable populations of native species within the Greater Fundy Ecosystem by focusing on species whose population levels are perceived to be at risk. We share with the Fundy Model Forest a first goal of protecting native biodiversity.

2. To quantify species-habitat relationships for selected species in the Greater Fundy Ecosystem so that the information can be used in land management decisions.

3. To examine ecological stressors in the Greater Fundy area, and to determine how they affect valued resources.

4. To identify operational management options that will ensure the sustainability of the Greater Fundy Ecosystem.

To meet the above goals, a range of research projects have been conducted over the last four years, most of which are ongoing. The majority of research was based on one model: comparing the impacts of forestry between reference stands and stands that were harvested and managed. Most of the research looked at the impacts of clear-cutting and plantations, as this type of forest management dominates the area surrounding Fundy National Park. Studies have also been done that examined other harvest techniques, such as selection cuts. Overall, a range of variables, both biotic and abiotic, have been or are being measured in the studies. In many cases the research projects are not completed and the results presented here are based on the best available data.

An ongoing management planning exercise being conducted by the Fundy Model Forest dictated the need for a set of forest management guidelines. This set of Forest Management Guidelines was developed to meet the timing requirements of that exercise.

The researchers and resource managers involved in developing this set of guidelines view them as a work in progress. As is characteristic of most aspects of forest management, these guidelines are neither complete nor comprehensive. As further research results become available, we will continue to develop these guidelines with the goal of providing a more complete set based on the best available information and understanding.

ISSUES OF SCIENTIFIC ACCURACY

The Greater Fundy Ecosystem Group is a coalition of more than 30 researchers and resource managers that have been drawn together to do collaborative research and management on a landscape basis. The group includes researchers from several universities, mainly the University of New Brunswick and Dalhousie University. There are also researchers and resource managers from a range of government agencies, including the federal government (Parks Canada, Canadian Forest Service, Environment Canada), and the provincial government (New Brunswick Department of Natural Resources and Energy). There is also representation from industry, notably J.D. Irving Woodlands. Collectively, this group has hundreds of years of experience in research and resource management.

Despite this wealth of experience and training, however, is it a difficult exercise for scientists to prescribe detailed sets of forest management guidelines. There are several reasons for this difficulty and it is important to discuss them prior to setting out a series of guidelines.

First and foremost, ecosystems are far more complex than any other system that humans have tried to understand or manage. Ecosystem science has many informing concepts that are useful in a general sense but fail to qualify as analytical concepts. Ecosystem science is especially limited by the simple fact that studies have traditionally taken place on short temporal and small spatial scales. Brown and Roughgarden (1990) noted that 60% of all ecological studies had been conducted on a spatial scale less than one square meter and 70% on a time scale less than one year. Thus, it is not surprising that ecosystem scientists understand a lot about individuals, less about populations, and little about communities and ecosystems. The problem is that there are few long-term, large-scale studies that are directly relevant to forest level management.

Because ecosystems are so complex, scientists and resource managers are forced to measure only parts of the system. A common method is to use the notion of indicator species in making generalisations about the larger systems. For example, the Province of New Brunswick is using American Marten as an indicator species for mature-overmature conifer forest. This approach has limitations but is necessary because not all species can be monitored and studied. In our research in the Greater Fundy area, we have focused on species that are likely to be vulnerable to the predicted forest changes that are a consequence of the forest management path we are on. These indicator species include Pileated Woodpeckers, Flying Squirrels, and Black Bears. However, we have also taken a broader approach which expands the focus away from just indicator species. For example, we have looked at guilds of cavity-nesting birds, groups of moths, birds, and vascular plants. In other studies we have measured a range of ecosystem parameters such as water quality and quantity, temperature, genetic diversity of selected species, and amounts of coarse woody debris.

Ecosystems are far more complex than financial systems, yet society spends billions monitoring, assessing and tracking financial systems, often with poor results in terms of predicting future changes. It is not surprising then that there is extreme difficulty in trying to predict responses to forest management activities within highly variable and complex ecosystems. Scientists are trained always to be aware of levels of accuracy and precision. Thus scientists are often reluctant to specify exact prescriptions when uncertainty exists. What is presented in the present guidelines is based on the best available science and represents the professional judgement of the scientists and resource managers in the Greater Fundy Ecosystem Research Group.

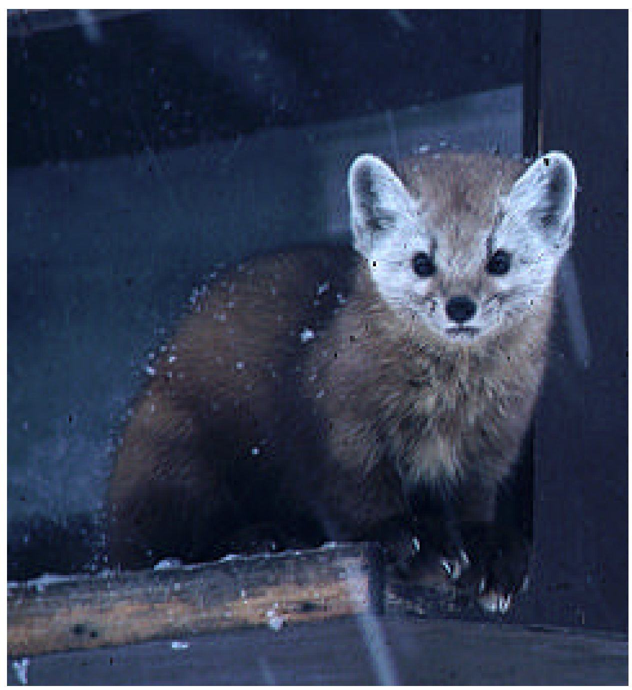
For the reasons discussed above, predicting the behaviour of an ecosystem almost always involves some level of uncertainty. Conversely, a forest harvesting system operates to minimise uncertainly and maximise predictability of the resource. There is almost always a gap in the precision between the two approaches. A forest manager can easily predict the impacts of a 75 m versus 100 m stream-side buffer on the allowable cut. However, researchers cannot easily predict the varying effects on biodiversity, wildlife movement, or water quality between the same two buffers. Research can say with some certainly that buffers are important but has a more difficult time specifying the influence of 30 or 60 m widths. This “precision gap” is often a source of misunderstanding between researchers, and managers of resources. The only solution to the precision gap, short of more research, is to rely on best professional judgement and the precautionary principle. The precautionary principle simply implies that in an absence of sound information, it is the best policy to err on the side of caution and conservation.

APPROACHES TO THE DEVELOPMENT OF FOREST MANAGEMENT GUIDELINES

The development of these guidelines has gone through several stages. A research agenda was developed by the Greater Fundy Ecosystem Research Group during a series of meetings in 1991-92, and then accepted by the Model Forest Partnership. It is important to stress that this agenda was not any single researcher's personal research agenda, but rather a collective effort. Once the research began, we met yearly to present our results and to exchange information and ideas. In all cases, the researchers were asked to ensure that their work was designed to provide useful forest management prescriptions. The development of the guidelines also involved subdividing the larger research group into sub-groups, with each sub-group tasked with providing a set of recommendations on their subject area. The sub-groups then presented their findings back to the larger research group.

The guidelines presented in this document represent a consensus on the subject. In many cases, research is still on-going and most of the recommendations may be modified, or added to, in the future. We have attempted to develop a set of recommendations that is objective-oriented rather that simply restrictive. This approach was taken to allow resource managers maximum flexibility. We tried to objectively specify attributes of the forest that are needed for conservation of native biodiversity and other ecological attributes. This approach is consistent with that of the Department of Natural Resources and Energy in the Province of New Brunswick. Such a consistency was sought wherever possible, in order to simplify the approach for managers and to recognise the importance of related work already done within the province.

One new aspect to these guidelines is that they are sometimes divided by Ecological Land Classification (ELC). An ELC is the grouping of forest assemblages based on enduring features such as climate, geology, soils, and others elements of the landscape. Use of an ELC as the operating unit for forest management is an example of the coarse-filter strategy of biodiversity management (Hunter et al., 1988). The GFE research group promotes the idea of managing on the basis of these ecological units. There are essential differences between the various ecological units and these should be reflected in the objectives for a particular landscape as well as the amount and type of harvesting that occurs. In many cases, objectives need to be harmonised, as similar types of objectives can arise from different perspectives. For example, consider the objective of a minimum patch size. From the perspective of managing a given species of wildlife, such as American Marten, there might be a requirement for a minimum patch size of forest to maintain the required habitat conditions of this species. A minimum patch size of forest might also be required from the perspective of maintaining natural disturbance regimes. Wherever possible, the two perspectives have been harmonised to allow for management simplicity.



American Marten are being used in New Brunswick as an indicator of mature-overmature coniferous forest habitat. (G. Forbes)

PRINCIPLES OF FOREST MANAGEMENT TO CONSERVE BIODIVERSITY

Before presenting any forest management rules, the GFE Research Group developed a set of principles that were seen as fundamental to understanding and managing the forest as an ecosystem. These are as follows:

1. There are groups of native species that are obligate to, or strongly associated with, particular seral stages of native forest types in the GFE. Short-term rotation, fibre-based forest management has the potential to eliminate some native biodiversity that is dependent upon stand structures associated with older seral stages. Conservation strategies should focus on these species rather than on ubiquitous, or less vulnerable species associated with young seral stages.

2. Native species have adapted to a range of disturbance regimes, which have created forest patches of various sizes and configurations. Forest management should reflect natural disturbance regimes that allow for the survival of local populations in minimum size patches of habitat, as well as metapopulations in functionally-connected patches on the landscape.

3. The composition and structure of natural forest stands in the GFE tend to be more complex when contrasted with stands managed intensively for wood fibre production. Fibre-based forest management - which can involve stander tending, herbicide use, and plantations - generally eliminates or reduces the lifetimes of complex early and late seral forest stages. This may be especially true for late successional forest stages. It is likely that the percentage of many mature and overmature forest communities on the landscape is now much smaller than in pre-European times.

4. Forest disturbances affect nutrient budgets, microclimates and hydrology on both a site, watershed, and regional basis. Forestry operations have the potential to affect nutrient budgets, microclimates, and hydrology beyond the normal ranges of variation found in natural forest succession.

5. Management to protect native biodiversity must be applied at a variety of scales. At a landscape scale, management must be applied to ecologically-based units, such as watersheds and ecological land classification divisions, and not administrative units (e.g. sub-licence boundaries). Not all elements of biodiversity need to be maintained on every hectare. Rather, the focus should be to protect healthy, viable populations of native species on the larger landscape.

6. At a regional scale, conservation of biodiversity requires permanent networks of protected areas that are connected by corridors acting as functional linkages between populations. This need is based on the precautionary principle of conservation management wherein our management actions are tempered by caution and the ability to respond to change. Protected area networks should be a combination of large representative areas and also smaller areas established to conserve sensitive and unique sites.

7. In addition to the direct effects of wood harvesting, intensive forest management has significant indirect impacts. Prominent among these is the creation of road access networks. Road networks tend to fragment habitat, change animal movement patterns, alter microclimates, provide a mechanism for the invasion of exotic species, and modify surface drainage patterns. The nature and duration of these secondary impacts vary, but they can have significant effects on native species. Also, the road network allows for increase in the exploitation of wildlife through hunting, trapping, fishing, and other activities.

8. Standing dead and fallen woody material provides habitat for many species and is necessary to sustain elements of biological diversity. Some plantation forestry practices (i.e. whole tree removal, crushed site preparation) can greatly reduce the amounts of cavity trees, snags and woody debris on the forest floor. It may be possible to ameliorate this impact by altered harvest practices.

9. Much of the Fundy Model Forest area has undergone significant ecological stress. The most productive lands have been converted to agriculture and housing. Native species, such as Woodland Caribou and Grey Wolf, have been lost and some have been reduced in ecological importance (e.g., American Beech trees). Whole communities have also been affected because of human caused impacts. In many cases ecological restoration is required to restore these components of natural heritage.

FOREST MANAGEMENT GUIDELINES FOR PROTECTING BIODIVERSITY

Landscape Level Considerations

At the landscape or forest level, management must consider the type, size and configuration of forest stands on the landscape (see review by Hansen et al., 1991). Biodiversity, no matter how it is measured, is never restricted to one stand. A given organism survives because it is able to exploit a combination of resources for food, shelter, reproduction, and competition. Thus, the type, shape and configuration of forest stands (or "patches" in ecological terminology) are critical to the survival of most wildlife. Unfortunately, this is one of the least understood aspects of forest ecology - making the development of prescriptive goals for forest harvest and management difficult.

Forests are dynamic, and they rarely, if ever, reach a steady-state or equilibrium state. The forces that drive ecosystems are many, including succession, senescence, and disturbance by insects, herbivores, fire, and weather (see review by Attiwill, 1994). Generally, ecologists group these forest disturbances into two main types. The first categories include high-intensity events that replace the stand. Fire is an example. The second category includes those disturbances that occur at a smaller scale, killing individual trees or small groups of trees. This is termed "gap" type disturbance and it typically occurs over a longer time scale of many years. Even-aged stands originate from stand replacing disturbances, while uneven-aged stands originate from gap-type disturbances.

The various ecological zones and forest types in New Brunswick can be classified as predominantly stand replacing or gap disturbance regimes. If a goal of forest harvesting is to protect biodiversity, the preferred approach to forest harvesting is to use a technique that approximates the disturbance regime characteristic of the area or forest type. The reason for this is that the native biodiversity of the area is adapted to the characteristic disturbance regime and will likely persist if such a regime is approximated by harvest. Below is a map of ecodistricts in the Fundy Model Forest and a table showing the disturbance considered characteristic of the ecodistricts (Figure 1)(Table 1). In some cases the ecodistricts are subdivided by major forest types, because both types of disturbance listed are characteristic of the area. The forest communities identified as gap or stand replacing stands are listed in Appendix 3).

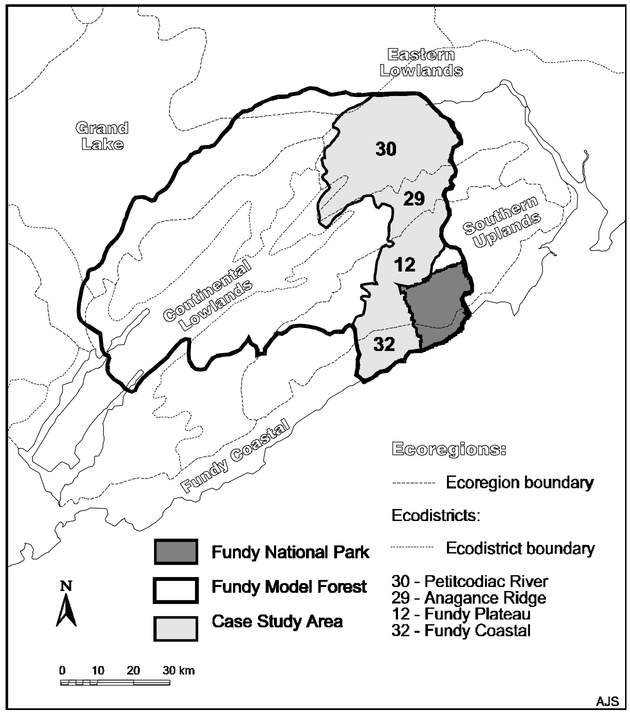
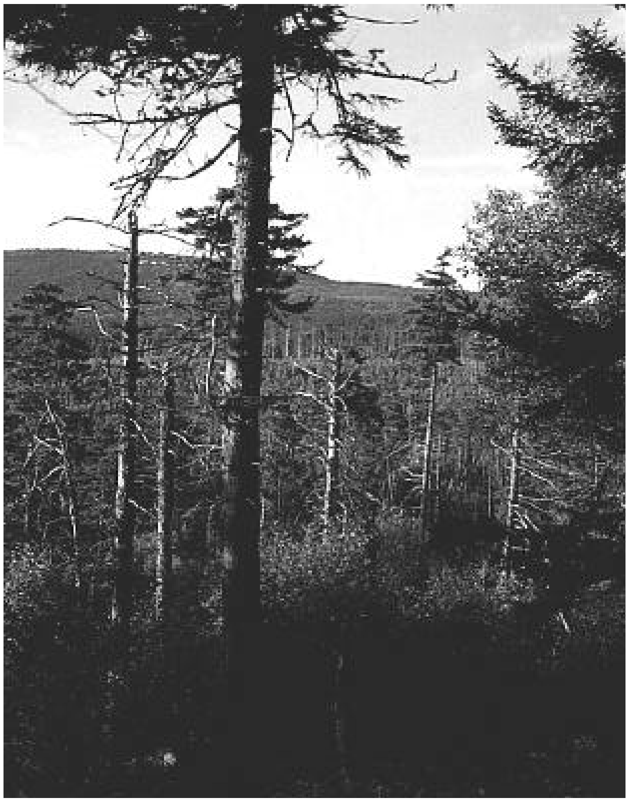


Figure 1. The Fundy Model Forest.

Table 1. Disturbance Categories by Ecodistrict

Ecodistrict:	Primary Disturbance Regime:	Notes:
(32) Fundy Coastal	- gap	- few Balsam Fir stands - low budworm due to cool climate
(12) Fundy Plateau	- gap - some stand replacing	- hardwood ridges - Red Spruce on lower slopes
(29) Anagance Ridge	- mainly stand replacing - some gap forests	- fire history present - Cedar common in past
(30) Petitcodiac River	- mix of gap and stand replacing	- Red Spruce dominant - intolerant hardwoods - some fire



Fundy National Park after 1970's Spruce Budworm outbreak; an example of the gap-replacing response to disturbance. (G. Forbes)

Patch Size (forest stand size)

A landscape is comprised of patches of habitat that influence the distribution, abundance, and movement of wildlife (see review by Franklin and Forman, 1987). Patch size refers to the size of the stand or patch of forest following a disturbance. Gap-type disturbances create a forest of small patches, while stand-replacing disturbances, such as fires, make larger ones. Table 2 presents the characteristics of patch sizes created by the most important natural disturbances in the model forest - wildfire and Spruce Budworm. Values are taken from the literature for New Brunswick (Wein and Moore, 1977) and the southern boreal forest (Dansereau and Bergeron, 1991). Values for Spruce Budworm are from Blais (1983). In the Fundy Model Forest, along the Fundy coast, we consider Spruce Budworm to be a gap-type disturbance. The dominant tree is Red Spruce, which requires several years of defoliation to cause mortality. At a stand level, it takes many years for the stand to open and die from Spruce Budworm attack and there are always survivors. The percentage of mortality is highly variable. Although it is not classic gap-type pattern, it fits this pattern better than the stand replacing model (Gordon, 1996).

Red Spruce selection cut in the Fundy Model Forest; the appropriate harvest technique for regenerating Red Spruce forests. (G.Forbes)

Table 2. The characteristics of patches created by wildfire and Spruce Budworm and recommended best management practices.

	Patch Size:	**Return Interval:**	**Comment**
Wildfire:	30%<50 ha 30% >1000 ha	50-300 yrs	- highly variable in effect - Ave. = 7294 ha. - modal = 400 ha.
Spruce Budworm:	- varying intensity	42-75 yrs.	- overstory mortality variable - generally a gap process in area
Best Management Practice:			
Gap replacing:	375-500 ha.	NA	- selection cuts to minimal crown closure
Stand replacing:	NA	NA	- may require multi-stage cuts to allow seeding

Based on this type of information, we conclude that forests should be managed for either gap or stand-replacing disturbance regimes. The division should be done first along the basis of ecodistricts. Second, the forest should be subdivided into vegetation types (forest types) with an aim to maintain forest types that exist because of gap-type disturbance. In all gap-type stands, the aim should be to maintain a closed-canopy cover, a mixed-age distribution of overstory trees and sufficient regeneration to restock the forest. The aim should also be to maintain a mix of species characteristic of the stand. For example, a coastal forest that is characteristically 60% Red Spruce and 40% Yellow Birch should be selection harvested to maintain that relative abundance. In addition, there should be no conversion of mixed wood forests to conifer-dominated forests.

For forests managed under a stand-replacing disturbance regime, the operating patch size should be between 375 to 500 ha. This does not mean, however, that yearly cuts of that size be undertaken. Natural stand replacing disturbances such as fires are highly patchy. Fires sometimes leave unburned islands and display areas that are not intensively burned. To approximate this patchiness, the 375-500 ha blocks should be harvested over a period of 10-15 years, which would allow working cuts in the range 25-50 ha.

Connectivity

Connectivity refers to the arrangement of patches on the landscape and the ability of organisms to use those patches (see review by Lindenmayer, 1994). If a given species of wildlife cannot travel between forest patches, then those patches are considered disconnected. Since many organisms use a variety of patches on the landscape, maintaining connectivity between them is essential.

The exact specifications for connectivity are not well known. Most connectivity-related research has been done in predominately agricultural rather than forested landscapes. Furthermore, it is difficult to extrapolate from individual species connectivity requirements to general rules. However, it is known with certainty that connectivity is important for the survival of populations.

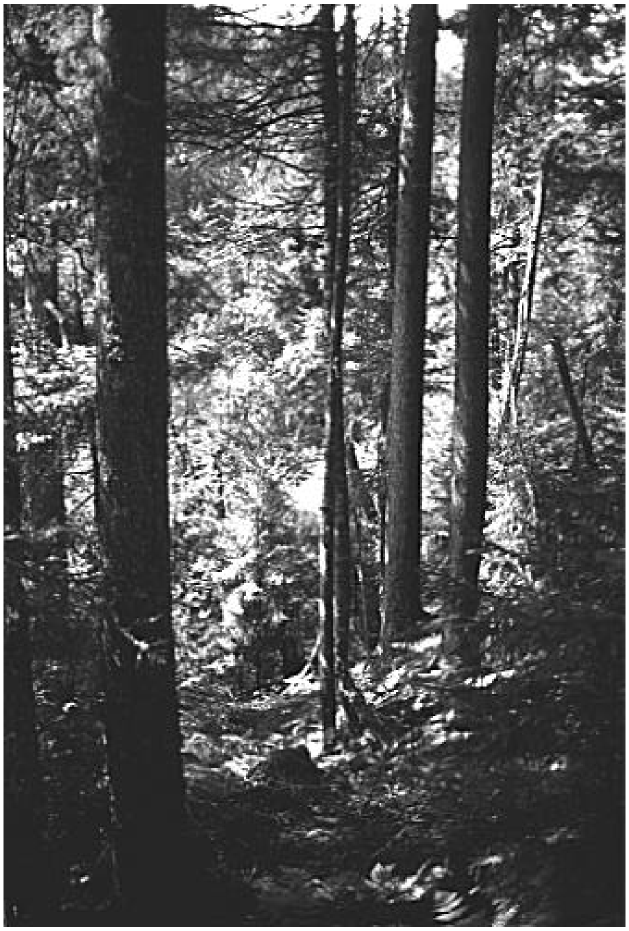
There are three important elements to connectivity. Any connection between patches of forest must be defined in terms of vegetative cover, corridor width, and corridor length. The goal is to maintain functional connections on the landscape rather than have ribbons of uncut forest running between patches of forest. To devise some general rules, relevant data were examined from a number of sources. There is specific research underway on Flying Squirrels and their connectivity requirements in the Fundy Model Forest. There is also relevant research on Grey Wolf and American Marten from Banff National Park and Bachman's Sparrow from forested areas in Florida. We also searched for rules from other jurisdictions, and found some from British Columbia. That information is presented in Table 3.

Table 3. Specifications for functional forest connections

	Species				British Columbia
	Wolf	Marten	Flying Squirrel	Bachman's Sparrow	
Width:	1 km	300 m	?	?	600 m
Length:	?	?	?	<3 km	5 km
Cover Type:	forest	forest	>12m	forest	forest

<u>Best Management Practice</u> - Based on the available relevant research, we recommend that the Fundy Model Forest works towards the implementation and maintenance of forested connections of a minimum width of 300 m and a maximum length of 3 km. The 300 m width reflects the minimum value from the above studies and should still permit much of the habitat conditions for the slower movement of plant species. The forested connections should have a closed canopy forest (minimum 35% crown closure) of any species, with a minimum canopy height of 12 m. From preliminary research, it appears that selection cuts will meet the requirements of connectivity. It is possible that block harvest scheduling and buffer strips will accommodate the connections. Corridors do not need to be permanent features if adjacent areas grow to equal standards and maintain the connection.

There is an important project ongoing in the Fundy Model Forest on the effects of fragmentation on Flying Squirrels. Although the data are not yet fully analysed, the best management practice selected are consistent with the preliminary findings of that study. There is much to be done in this area and the above guidelines are still developing standards. Connections also will have to be considered between broad regional areas.



Mature-overmature Red Spruce forest along Rose Brook. (G. Forbes)

Stand Age - Provisions for Mature Forest Stands

Forests intensively managed for timber production generally rely on short-rotation harvest to allow the maximum timber yield. This system does not permit the persistence of mature and overmature stands - a habitat type that supports many species not found in young and middle-age stands. The maintenance of biodiversity is a major objective of the GFE and the FMF. As such, it is important to maintain a part of the landscape in mature and overmature conditions. This provision should be made for all forest community types.

Defining which parameters constitute the components of the habitat needed by mature-dependent species is difficult because of the number of species involved and our limited understanding of even the most abundant ones. Therefore, we use a broad index of maturity to provide a surrogate for the habitat requirements of many species. Maturity is defined as the onset of significant mortality of the overstory cohort of trees. Permanent sample plot (PSP) data from the entire province were used to calculate the age at which tree mortality typically occurs. Not enough PSP sites exist within the FMF to use only local site data. Small sample sizes for some tree species in the PSP data set limit some conclusions but Table 4 indicates the typical age for mortality (for stems that were >10 cm dbh and >20 cm dbh):

Table 4. Typical age (years) of mortality for selected tree species.

“Species”	> 10 cm dbh Sample	> 20 cm dbh Sample
Black Spruce	80	80
Spruce sp.	90 (?)	90 (?)
Balsam Fir	60	60
Tolerant Hardwood	?	120 (?)
Intolerant Hardwood	80 (?)	80

Note: a “?” indicates caution due to high variance, and unknown for Tolerant Hardwood.

An analysis of the PSP data set was conducted on the 11 community types in the GFE. Analyses were done on the survival of softwood stems within a softwood-dominated community type and for hardwood stems in hardwood-dominated communities (Table 5).

Based on these analyses the onset of maturity can be defined for species and communities composed of these species as:

BFSP	60 yrs.
BSBF	80 yrs.
THMIX	120 yrs.
IHMIX	80 yrs.
SPBF	90 yrs. (best estimate)

Table 5.

Community	> 10 cm dbh	> 20 cm dbh
SPBF (Red Spruce)	? 80	? 80
BFSP	60	60
BSBF	80	80
BSJP	? 80	? 80
BSWP	? 90	? 90
JPMIX	90	? 90
CESW	? 70	? 70
SPTHMIX	80	? 80
Community	**> 10 cm dbh**	**> 20 cm dbh**
THMIX	100 (?)	100 (?)
IHMIX	80 (?)	80
SPTHMIX	?	?

Key:

SP - Spruce
RS - Red Spruce
BS - Black Spruce
WS - White Spruce
BF - Balsam Fir
JP - Jack Pine
WP - White Pine
RP - Red Pine
EC or CE - Cedar
RM - Red Maple
SM - Sugar Maple
BE - Beech
PO - Poplar
YB - Yellow Birch
WB - White Birch
MIX - mixed forest
SW - softwood
TH - tolerant hardwood
IH - intolerant hardwood

Incorporating Maturity into Forest Harvest Schedules

The above estimates represent the beginning of what we would consider maturity. How do we define the closure of a maturity window? New Brunswick's Ecological Land Classification of the enduring features (climate, geology, soils) of the province allows forest managers to identify the optimal tree species for particular growing conditions. The enduring features also provide an index to the proportion of forest communities found in each Ecodistrict. Some species and communities have been altered by human activity, notably agricultural areas. But, at a broad scale, and with extrapolation from other sites, we can use the existing abundance of forest communities to determine the composition and amount that should be retained in a working landscape. Estimates tend to be general, particularly in historical-to-present estimates of the agriculturally dominated non-forested community. Large areas of the region were cleared for agriculture and, to varying degrees, have reverted back to natural communities, mostly early-successional assemblages.

The forest strata are still being developed and therefore may vary from those on this list. Work is still underway to estimate the historical abundance of these strata because large areas of the case study ecodistricts presently support proportions of forest types that are atypical for the ecodistrict. For example, the amount of Jack Pine and intolerant hardwood-White Spruce in some areas reflect human-caused disturbances instead of natural processes. These areas (and also regenerating stands) need to be re-allocated into typical forest types to estimate the amount of mature forest types. The historical abundance (i.e. near time of European arrival) is to be based on the enduring features (climate, geology, soils) for that ecodistrict. Where elevation influences community type, the managed strata can be re-allocated to natural strata based on the corresponding elevation range of the stand. The mature provisions will be estimated once these re-allocations are complete.

At present, the table consists of the dominant natural community types for the ecodistrict in the case study area, and the unallocated plantation and thinned stands in young-overmature age class ("PLAN"), regenerating ("REGEN"), and various community types that are in small quantity ("Other"). We have combined some strata to limit the total number because of the difficulties of spatially defining a large number of community types. The communities to be maintained in some proportion of a mature state are:

CONIFER (= RS, BS, RSBF, BSRS, BSJP, and other combinations)
CEDAR (= EC)
PINE (= JP, WPRP, and other Pine-dominated combinations)
MIXED (= RMMIX, POSP, RSSM, and other mix combinations)
TOLERANT HARDWOOD (= SMYB, SMBE)
INTOLERANT HARDWOOD (= RM, and other combinations of PO, WB)

Letters in brackets refer to strata that have been developed for the wood supply and management models in the FMF.

Twelve percent of each forest community type (except regenerating and non-forest communities) should be maintained in mature-overmature age class. The 12% value is a minimum value. The value is derived from the fact that under a sustainable stand-replacing disturbance regime of 100 years, roughly 37% of the forest would be composed of stands greater than 100 yrs. old.

While it would be ideal to replicate this 37% for forest management purposes, it was recognized by us that this figure was unattainable given wood supply considerations and the importance of the forestry industry to New Brunswick's economy. Furthermore, the entire forest is not necessary for biodiversity conservation needs. Therefore, we recommend 12% (a third of the 37% value) as a safe level to conserve biodiversity. Again, this figure is based on a consensus judgement of professionals.

Overmature Forest - Overmature age classes also are important habitats, particularly for species requiring large amounts of old and rotting forest. Fungi, lichens, beetles and woodpeckers require this "extra-old" forest. A curve showing the distribution of age classes in a fire-dominated region would indicate that about 10-12% of an area would be in an overmature age class.

Similar to the reasoning for the mature age class, we recommend that 4% or one-third of the forest community be in an overmature state.

Size of mature-overmature patches - On an ecodistrict level, the mature-overmature component should always exceed the minimum patch size of 375-500 ha. Thus, the mature values were calculated on the basis of minimum patch size - or 12% of the historical forest type area.

A range of sizes were chosen to reflect the variability of patch size in fire-affected Pine communities. Simulations of fire patch size in the area by Methven and Kendrick (1995) suggested fire-origin patches were 778 ha on average and, at times, as large as 111,000 ha. Fires vary in size and typically create many small patches and several large ones. Around 30% of patches are less than 50 ha and about 30% are greater than 1000 ha. It is not practical today to promote huge mature patches of Pine forest even if they are a natural phenomena. We suggest that mature, Pine-dominated stands exist in a range where 50% are 400 ha (modal value in typical fire distributions) and the remainder at a minimum of 20 ha.

Incorporating provisions for mature-overmature habitat into forest harvest schedules is easier for short-lived species like Balsam Fir, which die-off in even-aged stands. Incorporating long-lived communities such as Red Spruce forests is more difficult. Tree core samples taken of Red Spruce in FNP have indicated the presence of 300 year-old trees in the coastal ravines. Red Spruce can be considered 'mature' at an age when large-diameter rotting trees provide cavity conditions. Additional field surveys are needed to identify the age at which large and rotting Red Spruce generally occur within the GFE. At present, we recommend that the mature class window for Red Spruce communities be from 80-300 years. Twelve percent should be maintained within this age group, of which 20% of the trees are over 150 years old. In mixed hardwood-softwood stands, the mature age class would begin with the species first reaching its typical maturity age. For example, a mixed stand containing Balsam Fir would be classified as mature after trees reach 60 years of age.

For forests harvested by selection cuts, the old age category must be defined by age as well as crown closure. We recommend that old age forest types in the 12% category have a minimum crown closure of 60% and that 20% of old age forests have a minimum crown closure of 80%. This higher number is especially important in tolerant hardwood forests.

Young Spruce plantation near Fundy National Park. (G. Forbes)

Plantations

From a timber perspective, plantations represent intensive forestry for the production of fibre or wood. Landowners may wish to pursue biodiversity objectives on their entire forest or only on specific proportions. In some jurisdictions it is felt that the existence of intensive sites offsets the demand for intense forest management on the rest of the landscape. Plantations have a number of deleterious impacts to the environment, particularly if a large amount of land is converted from natural forest to plantation (see review by Freedman et al., 1994). A strategy which advocates replacing diverse mixed species stands with pure softwood plantations is not acceptable for biodiversity values.

If the objective of the landowner is to promote biodiversity on all managed stands then a number of options are available:

Options for existing plantations:

1. Overall, plantations of non-native species, such as Norway Spruce, or species not normally forming pure stands in the ecodistrict (e.g. Jack Pine along the Fundy Coast), should not cover more than 5% of the total area of each ecodistrict. Plantations of non-native species or species not normally forming pure stands in the ecodistrict should not be included in inventories of old age class forest types. For example, Norway Spruce can never be considered a substitute for Red Spruce.

2. Plantations can meet mature habitat requirements by letting the plantation age to the maturity window for that particular forest type. The plantation can then meet the criteria for mature habitat, with the following restrictions:
   a. the plantation should have at least 5% of canopy tree species that are other than the dominant planted species
   b. the plantation should meet the guidelines for coarse woody debris and snags (i.e. minimum of 200 pieces of cwd/ha and 10 m^3/ha., average diameter of pieces ³ 10 cm) contained in this document. This requirement may be met by early thinning or girdling of trees
   c. the plantation should have a minimum canopy closure of 60%

3. Retain as many tree species as feasible during thinning operations.

4. Replant Aspen and Poplar in clumps within maturing plantations for their use by cavity nesting species

For new or planned plantations:

1. Follow snag and clump guidelines, retaining Aspen, Poplar and Birch trees where possible.

2. Retain coarse woody debris

3. Limit crush-and-burn site preparation in order to retain coarse woody debris

4. Retain strips or clumps of competing species during herbicide or thinning operations

5. Use native species only

6. Reflect the site's ecological classification by not converting mixed stands into softwood or hardwood (i.e. plantations on converted sites are not eligible).

Stand Conversion

Biodiversity management that is based on an Ecological Land Classification (ELC) relies on forest planning that recognises and maintains forest stands that would occur naturally under local conditions. Although it is recognised that stands can be dominated by softwood or hardwood species through the course of their succession, it is important to recognise the eventual sub-climax and climax make-up for that stand and the ELC. Conversion and maintenance of these sites to a softwood condition changes the landscape heterogeneity of stands and the diversity of habitat types and tree species.

Many tree species in the FMF presently are lumped as intolerant or tolerant hardwood categories and thus are not given adequate consideration in forest planning exercises. By not recognizing the abundance and distribution of these species, they are relegated to minor roles and potentially lumbered out of the landscape. The maintenance of many intolerant hardwoods requires more consideration in the FMF. Some large mixed stands dominated by species such as Red Oak or Black Cherry should be managed as either wildlife areas (acorns for deer and bear) or high-value timber areas. Conversion of these areas to softwood plantations should be avoided.

In many areas of the Fundy Model Forest, mixed stands of coniferous and deciduous species are typical. There has been a tendency to convert these stands to pure conifer because of market forces. Such conversions are also undesirable. We have tried to account for the distributions and historical abundance of these stands in the historical distributions by ecodistrict.

Road networks allow silviculture and fire control but also permit uncontrolled access for recreational uses and influence wildlife movement. (G. Forbes)

Roads

Roads affect biodiversity by changing habitat, fragmenting contiguous forest, and increasing access to a site or area (e.g. McGurk and Fong, 1995). From a timber perspective, they are required for forest harvesting and silvicultural activities such as thinning and planting. The maintenance of roads is also valuable for accessing and controlling forest fires.

The provincial guidelines suggest that a maximum of 10% of an area be in road condition. We believe that the indirect impacts of forest roads, which allow increased access to wildlife and result in fragmentation of the forest, warrant the development of guidelines that promote biodiversity without constraining timber values.

Our guidelines recommend:

1. maximum of 0.58 km roads/km^2;
2. a policy to limit road construction to the lowest density possible. This guideline also reflects timber interests to limit the cost of road construction;
3. closure of most roads not required for ongoing silvicultural activities;
4. avoidance of stream crossings;
5. avoidance of loop networks of roads that promote easy access to areas with little relative effort.

Protected Areas

A system of protected areas in managed landscapes offers safeguards against the known and unknown impacts of various extractive resource uses. They can also act, to varying degrees, as benchmarks for comparative research (Agee and Johnson, 1988). The GFE and FMF contain an assortment of protected areas, ranging from a national park (20,618 ha.) to several conservation areas (1,259 ha.). The amount of lands currently designated as park, ecological reserve or conservation areas equals 5.2 % of the Fundy Model Forest area. However, a number of habitats and special features are not protected within the boundaries of the protected areas.

A primary role of protected areas within the FMF is to provide a source or bank of ecological material in case of local failure of the sustainable management plan for the forest as a whole. To fulfil this role it is necessary to recognise that the total area of most protected sites is inadequate to maintain viable populations of most ‘visible’ wildlife species. Protected areas can only be viewed as the core of the eco-bank of the FMF. To maintain these cores as viable, we need to provide maximum sensitivity to harvesting operations immediately adjacent to any area deemed significant enough to protect.

The lands adjacent to a protected area and the watersheds flowing immediately into it must be considered for individual management plans. These sub-plans should provide sensitive harvest techniques, maintenance of connectivity with the larger landscape, and regular ecological monitoring to ensure the protected area is fulfilling its role in the overall management plan. The sub-plans should encompass the watershed(s) containing the protected area. The concept of a protected area surrounded by buffers of variable size with differing management actions has been used in many sustainable land management programs world-wide. These objectives follow those of the Man And Biosphere (MAB) program that has been promoted world wide by UNESCO.

The 206 km^2 Fundy National Park can act as an eco-bank within the larger landscape. (G. Forbes)

Work is underway to identify potential protected sites at two scales. One project is province-wide and focuses on maintaining large-scale processes and representative landscape features. The other project, focusing at a finer scale of analysis, is identifying features of ecological significance within the Fundy Model Forest. We presently have not attempted to overlap the two scales of these exercises. Both exercises are iterative and need to be integrated at a later date.

Representative Areas Exercise - The Department of Natural Resources and Energy has undertaken a pilot project to assess the contribution of parks and ecological reserves (IUCN Classes I-II) toward representation of the natural regions of New Brunswick. This research was intended to provide an ecological foundation for the establishment of a viable network of protected areas to ensure the in-situ conservation of biological diversity and the maintenance of ecological processes in a dynamic and evolutionary state. These wildlands would conserve our natural heritage, while creating development opportunities for environmental education, eco-tourism, outdoor recreation and integrated landscape management. They would also serve as benchmarks for long-term environmental monitoring and provide a scientific basis for adjusting land-use planning and adaptive management strategies to better reflect the natural patterns and processes that support the diversity of species, ecosystems and landscapes found in New Brunswick.

The concept of representation interprets bio-physical factors associated with the enduring features of the landscape, which affect the geographic distribution of plants and animals, as a surrogate measure for biological diversity at the genetic, species and community level. According to this ecosystem perspective, species have evolved over geological and historical time by adapting to environmental conditions which can be classified into series of relatively uniform categories and mapped as discrete ecological units. An ecological classification system, such as the framework currently being developed for New Brunswick, has been used to stratify the landscape into hierarchical units based on climate, geomorphology, soils and vegetation. A representative area is then delineated to encompass the environmental variability in each unit, such as the surficial, topographic and vegetation classes within a climate zone.

To recognize the more subtle ecological processes influencing the maintenance of species and ecosystems, another set of criteria based on ecological integrity has been adopted to determine the minimum size, configuration and management regime for sites within the proposed conservation network.

The technical procedures for identifying representative areas were relatively straightforward: an iterative mapping exercise was initiated, using 1:500,000 and 1:250,000 scale mylar overlays of the ecoregions, ecodistricts and ecosections on maps of topography, geomorphology and soil lithology. This was supplemented by personal knowledge and land-use information available in the NBGIC Provincial Map Book. Recognising that landscape features do not converge in one location, it was necessary to choose sites that offered the greatest opportunity for capturing the widest range of topographic and geological diversity within a limited geographic area.

Although there were few opportunities to select a "pristine" natural area, it was preferable that a substantial proportion the site was relatively undisturbed by roads, settlements or other types of development, so that it would remain in a semi-natural condition or naturalise over time, particularly for core areas that were intended to serve as ecological benchmarks. A GIS-based analysis is now underway to assess the contribution of these proposed study areas toward the representation goals and identify elements that are missing from the system.

Ecological integrity criteria are being used to delineate core areas and refine the boundaries to accommodate natural disturbances, the home range requirements of area-sensitive species and secondary considerations related to critical habitats, biological hotspots and special features of cultural or scientific value.

It has been difficult to find sites meeting the selection criteria for ecoregion level representation and ecological integrity within the more developed regions of the Saint John River Valley, the Northumberland Coast and Southern New Brunswick. Only three study areas have been identified within the geographic boundaries of the Fundy Model Forest: the Glades (5,400 hectares), a site extending from Fundy Park along the Fundy Coast (13,600 hectares) and a more disturbed site around Goshen (3,800 hectares).

Gap Analysis Exercise - The goal of a Gap Analysis is to identify the deficiencies or gaps in the existing framework to protect ecological variability across a region. The first step in the Fundy Model Forest Gap

Analysis was to identify elements of ecological variability through classification and delineation of biophysical units.

For large and relatively homogeneous features, classification is fairly straight-forward using a variety of remote sensing techniques and coarse-scale maps of topographic and geologic variation. However, for ecological units occurring at lower levels of resolution, for example, areas less than 100 ha., alternate procedures are required. The FMF Gap Analysis project used a combination of anecdotal and occurrence record-based information with a habitat-based approach to identify features of ecological significance at fine geographic scales.

The criteria for ecologically significant areas are:

1. Presence of uncommon or rare species.
2. Presence of "rare - spatially restricted" assemblage of species.
3. Little-disturbed remnants of once-more-common community types.
4. Representative examples of community or ecological assemblages.

It was assumed that most of the species likely to occur in the FMF could be identified using herbaria and museum records, distribution maps from taxonomic keys and field guides, and by consultation with local experts. A list of species believed to occur in the FMF was compiled. By order of the quantity of available information, the groups put on this list were: plants, birds, mammals, fish, and freshwater aquatic bivalves. The only officially recognised endangered species in the FMF is a Freshwater Wedge-mussel.

Species occurrence records provided some information on their location but often the records represent a non-random, incomplete subset of present-day distribution. A systematic, habitat-based assessment of fine-scale ecological variation in the FMF was used to identify additional potential sites for target species. First, habitat requirements were identified for each species known to be associated with habitats of small size or restricted distribution. These habitats include:

- coastal headlands
- dry exposed ledges and crevices
- rich tolerant hardwood forest
- sphagnum bogs and margins
- high energy shorelines
- inland salt springs
- moist rock crevices
- wet calcareous ledges
- wet Cedar forest
- freshwater marshes
- salt marshes
- shallow aquatic
- ponds & pond margins
- hemlock slope forest

After compiling a list of fine-scale habitat types, the next step was to locate them within the FMF. It was assumed that the habitats could be characterised by one or a combination of abiotic features, often influenced by "structural species" which create environmental conditions upon which other species are dependent. Canopy-forming tree species are examples of structural species. For each identified habitat type, a profile of abiotic and biotic parameters using available land resource data bases was created. Available spatially-referenced data include:

- soil type, fertility, and drainage
- forest cover type, including dominant species groups and non-forested areas
- age-class information
- a Maritime Wetland inventory of all wetlands greater than 0.4 ha in size
- geologic parent material
- watershed divisions

Ground assessment was conducted on all sites identified by the above process. For a variety of reasons including habitat destruction or colonisation/persistence failure, approximately 50% of the identified sites did not meet any of our criteria.

Description of Identified Ecologically Significant Areas Occurring on Crown Land or Lease #7

Although ecologically significant sites and areas totalling 7,661 ha have been identified in the FMF, their locations have not presently been mapped due to confidentiality concerns and on-going negotiations with land owners.

1. Fundy Coastal Ravines

All eleven of the Fundy coastal ravines that occur within the FMF boundaries were selected. This included the non-park side of Goose River, the upper reaches of the Point Wolfe River found outside the FNP, and the eastern half of the Little Salmon River gorge. The decision to include all 11 ravines was based on the following:

a) It was determined that including only one or several of the ravines could not adequately represent the total diversity of species associated with these features. Variations in geologic substrate result in differences in species diversity and composition among the ravines, especially for the rare arctic-alpine species found at these locations.

b) All of the larger ravines are important in the effort to re-establish viable breeding populations of Atlantic Salmon in the Bay of Fundy.

c) Each ravine has steep slopes, many of which are cloaked in Red Spruce of considerable age and stature. Harvesting these trees could cause severe erosion and would destroy a forest stage no longer found elsewhere in the FMF.

d) Though not related to biodiversity, the Fundy Hiking Trail fords each of the ravines except the upper reaches of the Point Wolfe. The aesthetic integrity, and recreation value of the trail depends on maintaining the existing forest cover.

The steep forested ravines of the Point Wolfe River, Fundy National Park. (G. Forbes)

2. Fundy Plateau Bogs and Associated Lakes and Ponds

Three such areas have been identified along the coastal edge of the Fundy Plateau: the "airplane bog", the “curly grass fen” and Dowdall Lake. Each of these features contains bog habitat-types and associated species, some of which are rare in New Brunswick and are not contained in Fundy National Park (S. Clayden, pers comm.). The two rarest plants are Curly-grass Fern and Screw-stem. The lake and pond features found in these and other smaller but similar sites along the Fundy Coast of the FMF may also contain the rare Four-toed Salamander, which has only been recorded only once in New Brunswick in Fundy National Park.

3. Fundy Coastal Headlands

The Fundy coastal headlands are rocky, windswept formations found along most of the Fundy coast within the FMF. The most spectacular example is Martin Head. Numerous rare plant species are found scattered in the crevices and cracks at these sites, including Glaucous Poa, Rand's Eyebright, Livelong Saxifrage, and Bird's-eye Primrose.

4. Fundy Coastal Marshes and Tidal Flats

The presence of steep coastal headlands limits the formation of salt marshes and tidal flats along the Fundy coast of the FMF. The two largest such formations are at the mouth of the Alma and Quiddy Rivers. These features support a large complement of species strictly associated with this habitat-type, as well as serving as feeding grounds for migrant shorebirds.

5. McManus Hill Hardwood Stand

A large percentage of McManus Hill occurs on crown land at the border of FNP near Wolfe Lake. This stand has an extensive canopy of Sugar Maple and Beech, with ground flora that is diverse, though typical of these forest types. One provincially uncommon species has been recorded here - a grass species *Milium affusum*. It has been recognised in previous inventories of critical natural areas in New Brunswick. From an aesthetic perspective, the hill is an important part of the viewscape surrounding Wolfe Lake inside Fundy National Park.

6. Babcock Brook Sedge Meadows and Wet Jack Pine Forest

Located on crown land near The Glades, are a series of sedge meadows bordered by extensive stands of wet Jack Pine forest. The meadows host extensive populations of several orchid species, including a rare hybrid of the Ragged Orchis and Large Purple-fringed Orchis. The Jack Pine stands occur on wet organic soils, with an understory dominated by Sphagnum Moss and heath species. The uncommon plant, Pinesap, occurs in this area.

Waterside Marsh - an example of freshwater habitat. (G. Forbes)

Description of Identified Ecologically Significant Habitat Types Occurring on Private Land in the FMF

1. Wet Cedar Forest

Wet Cedar forest may possess highly species-rich floristic assemblages, including species of rare orchids. As a result of habitat destruction, however, these forests are now very uncommon within the FMF and in New Brunswick in general. They also face increasing harvesting pressure due to the current high commercial demand for Eastern White-cedar. It appears that much of the floristic understory of this forest does not recover following disturbance, unless seed sources are available nearby. As a result, there is an urgent need to protect the few remaining, undisturbed stands of this community type. One such site within the FMF has been located along the North River near Lewis Mountain. This Cedar-Black Spruce stand covers over 50 ha and hosts a large assemblage of provincially uncommon, rare, and very rare plant species, including Showy Lady's-slipper, Hookers Orchis, Yellow Lady's-slipper, and Small Yellow Water-buttercup.

2. Freshwater Marsh

Extensive freshwater marsh systems are not common in the FMF. Most are small and spatially discrete, averaging less than 6 ha in total area. Freshwater marshes provide breeding habitat for a large number of bird species, including waterfowl, rails, and bitterns. Ducks Unlimited (DU) currently manages all or parts of 12 freshwater marshes within the FMF. However, most FMF wetlands remain under no form of special management. As well, the focus of DU is waterfowl. By maintaining high water levels throughout the year, some wetland species, especially vegetation, are adversely affected.

3. Hemlock

Hemlock stands are uncommon in the FMF, due to past exploitation, conversion of forest-cover to other more commercially valuable species, and limited suitable habitat. At present 9 Hemlock stands, all small in total area, have been identified within the FMF.

4. Mixed Species Forest

Land management practices in the FMF have altered the species composition of the forest. Mixed assemblages containing a variety of conifer and deciduous species in a late successional stage are uncommon. Two extensive stands of mature mixed forest have been identified within the FMF, at Gibson Creek near the Pollett River Gorge, and in the Parlee Brook Valley. Both contain a mix of Hemlock, White Pine, Red Spruce, Balsam Fir, White Ash, Yellow Birch, Sugar Maple and Beech. Butternut occurs at the Parlee Brook site. Several provincially uncommon or rare ground flora occur at both sites, including *Pyrola minor* and Frog-Orchis at Gibson Creek, and the Large Round-leaved Orchis, Laurentian Bladderfern, and Livelong Saxifrage at Parlee Brook.

5. Cliff Faces and Forested Talus Slope

Rocky substrate, in the form of cliffs, escarpment, and talus, provide specialised habitat that often supports uncommon or rare species of vascular plants, mosses, lichens, and liverworts. Cliff faces supporting uncommon or rare plants are scattered throughout the FMF, including along the coastal river ravines, in the Sussex uplands, and at Mount Zachy-Jonah. Escarpments are restricted to the Sussex Uplands at Rockville and in the Parlee Brook area. Talus forest escapes human disturbance due to substrate instability, and often supports mature tolerant hardwood forest, including - in some areas - pure stands of Ironwood. Talus forests can be found in the Sussex Uplands, Mount Zachy-Jonah, Urney, and in the Hampton area.

Management Options for Described Habitat Types of These Sites

We recommend complete protection of all habitat types discussed above. However, the following activities may be allowed:

1. Recreational hunting and fishing may be allowed in areas where they are currently being practised (for example Fundy coastal ravines [sporadic fishing, except Salmon] and Fundy upland bogs [Moose])

2. In some of the forested sites, some form of limited extraction may be acceptable as long as it:
   a) excludes the harvest of Hemlock
   b) reflects existing natural disturbance regimes (e.g. selective harvesting in tolerant hardwood stands)
   c) maintains late seral forest in areas where it presently exists
   d) respects stream buffer zones, and avoids areas containing rare or uncommon plants.

Water Course Buffers

It has long been recognised that forest harvest activities have the potential to significantly affect the quality and quantity of freshwater systems. The proximity and extent of harvests near waterways can alter the amount of coarse woody debris, water temperature, siltation levels, nutrient availability, and stream hydrology. In turn, these abiotic factors have been shown to effect the abundance and functions of fish, amphibians, invertebrates, and vegetation (see overview by O'Laughlin and Belt, 1995). In response, managers have implemented a series of buffer zone guidelines that limit the amount and type of harvest within a prescribed distance from the waterway. The following are some considerations from the existing New Brunswick buffer zone guidelines and some additional recommendations for use in the Greater Fundy Ecosystem.

Existing Buffer Zone Guidelines:

Buffer zone guidelines have generally been proposed based on their value as;

1. filters - the ability of a band of shoreline vegetation to absorb nutrients before they enter a waterway;
2. shelters - the amount of canopy needed to keep water temperature from surpassing the tolerances of fish species requiring cool water;
3. stabilisers - preventing erosion on steep slopes and the siltation of waterways, and;
4. detritus suppliers - provide input of coarse woody debris.

At a landscape level, the creation of a relatively uncut, older-aged buffer system network also has value in that it creates corridors that are important for wildlife movement. In New Brunswick, these buffer guidelines are set under the Watercourse Buffer Zone Guidelines for Crown Land Forestry Activities (NBDNRE, 1996) and the Clean Water Act. The Clean Water Act requires a minimum 30 m buffer zone on all watercourses. On small watersheds (< 600 ha) located on crown land, exceptions may be authorised by DNRE.

The GFE Research Group endorses the application of the buffer guidelines used on crown land. These guidelines include objective-based rules on identification of waterways, mapping and reporting procedures, forestry activities within buffers, and various special situations needing buffers such as recreation routes, moose calving areas, snags, wildlife corridors, and waterfowl production areas. The following text and Table 6 outline the guidelines we see as most relevant to ecosystem management:

Water quality and habitat conservation should be practised through riparian zone guidelines. (G. Forbes)

Identification

A waterway or watercourse is any natural drainage feature with a discernible channel. In terms of vegetation make-up, the edge of the watercourse begins with Alder or Willow zones rather than grasses and ericaceous shrubs.

Table 6. Buffer Width Size
(all values refer to one side of a waterway)

For all watercourses >0.5 m in width:

	Parameter	Req. buffer slope width:
	1 - 5%	15-30 m (30 m for watersheds >600 ha)
	6 - 10%	30 m
	> 10%	60 m
Erosion: Rating*	Low	15-30 m (30 m for watersheds >600 ha)
	Moderate High	30 m 60 m
Windthrow Rating*	Low	15-30 m
	Mod - High	30 m

*Rating system defined in DNRE Forest Manual

For all watercourses <0.5 m in width:

	Required buffer width Slope:
Fish Habitat (defined as continuous flow, fish present)	15 m
Other Sites	3 m (only shrubs required)

Special Sites:

	Required buffer width slope:
Identified Critical Fish Habitat:	30 - 60 m (standing timber)
Moose Calving Areas:	
Known site:	60 m (tree species and stand age specified)
Bogs:	30 - 60 m (tree species and stand age specified)
Waterfowl Production Areas:	
Golet Score* 70-84:	60 m (standing timber)
Golet Score > 85:	100 m (standing timber)
Wildlife Corridors:	
On rivers, lakes:	100 m
On streams:	50 m

Note: *Golet score is a standard rating of waterfowl production potential

Activities Within Buffer

Selection harvest within the buffer is allowed in watersheds <600 ha based on an approved harvest prescription, with permits needed for areas >600 ha. A maximum cut of 30% of merchantable basal area is allowed every 10 yrs. As well, the site must retain a Basal Area >18m^2/ha, Canopy Cover >50%, and Canopy Height >10 m. Maximum removal of 30% dead and dying trees every 10 yrs., within 15 m on any watercourse >15 m wide, is advised. Harvest operations will not create openings >10 m wide. Tree tops or slash are to be kept out of the water.

Best Management Guidelines:

The GFE research group supports the direction and content of these revised guidelines. The guidelines reflect the importance of naturally functioning aquatic environments, and are based upon a combination of empirical research and established guidelines developed by forest managers throughout North America.

We recommend the following additions to the provincial guidelines:

1. Special effort is required to identify a range of diameter class trees to ensure large trees are retained in the buffer strips.

2. Woody debris is an essential component to the diversity of habitat along watercourses. Removal of this debris has negative effects on fish abundance. Fish abundance can be increased by input of woody debris back into the system. In order to achieve a sustained

input of woody debris, riparian zones should include sufficient numbers of large mature trees immediately adjacent to the stream or river bank. To achieve this goal it is recommended than a 5 m no cut zone be put in place along all watercourses.

3. The steep river valley slopes of the FMF present an additional concern for water quality in the area. The high slopes of the Point Wolfe, Goose, and Big Salmon Rivers, for example, often extend several hundred meters away from the shoreline, well beyond the prescribed 60 m maximum buffer width on steep slopes. In some areas, small plateaus exist part way up slopes. These steep slopes are considered inoperable due to present harvesting technology and costs. We believe that these steep valley slope areas represent unique and sensitive conditions that should be specifically identified in buffer zone guidelines. A general rule should be to maintain the current buffer setback of 60 m but begin it at the top of the valley (instead of at the shoreline) at a point where the slope is <20%. Forest harvest activity would follow the guidelines established within the 60 m buffer, except no cutting would occur within 5 m of the shoreline.

Site Level Considerations

Habitat Considerations for Specific Species

Some species within the FMF require habitats that may not be implicitly provided by stands that otherwise meet maturity criteria. These species may require the implementation of additional management guidelines to ensure their viability. The stands may need to be of a certain minimum size with connections to critical habitat during parts of the year. The habitat requirements of several species are currently being studied. These include the Pileated Woodpecker, Northern Flying Squirrel, species of cavity nesting birds, and Black Bear. These species have additional strategic value for conservation because they exist as keystone species within the ecosystem. A keystone species creates habitat that is required by other species (review by Mills et al., 1993). Population and habitat objectives will be developed for these species in the near future.

Special Status Tree Species

A number of tree species in the GFE and FMF area have been significantly reduced in abundance and distribution. Their loss represents a decrease in the integrity of the ecosystem and causes a trickle-down effect on species that utilise these tree species. Research on the abundance of tree species during colonial times (150-200 years ago) has identified that the following tree species were much more common than today:

Eastern White Cedar
Black Ash
Eastern Hemlock
Red Oak
Ironwood
Black Cherry
Butternut
Bur Oak
Basswood
American Elm

Selective logging pressure or habitat change due to human activity has reduced all of these species except for American Elm which has been reduced by disease. We recommend attempts be made to identify and retain these species through selective treatment for regeneration in the cases of Hemlock and Cedar, and/or limited or no cutting of the other rare species. Species such as Bur Oak, Red Oak, Ironwood, Butternut, Black Cherry, Basswood and Black Ash are intolerant or tolerant hardwood associated species that are not given enough recognition as components of the forest, or as potentially valuable wood products. Considering their low present abundance and their limited recognition in forest planning, there is concern that their retention within the FMF is threatened by pulp-based forestry and the increased harvest of hardwood stands.

Concerns about Red Spruce retention are discussed under the harvest prescriptions for each ecodistrict. Red Spruce areas should not be clearcut in the Fundy Coastal Ecodistrict but should be selection harvested. Only 2- or 3-pass shelterwood methods should be applied in the other ecodistricts. Red Spruce dominated stands should not be cut until advanced regeneration has occurred in the understory. Blowdown of remnant trees should not be a major issue because these species exist in forests where selection harvesting techniques should apply.

American Beech in the FMF has been affected by a canker disease that limits its growth and fruit production. A tendency to remove this species from the forest may develop as tolerant hardwood markets are opened. The Beech is an important natural component in terms of biomass and wildlife and should not be lost from the FMF. The retention of American Beech in hardwood stands will require the identification and retention of non-diseased individuals. These individuals exist in most stands, recognisable by their larger size and smooth bark. Surrounding diseased trees should be removed to allow for the growth of disease-resistant trees and eventual restocking of healthy Beech trees in the FMF

Coarse woody debris is important for nutrient cycling and wildlife use. (G. Forbes)

Coarse Woody Debris

There is considerable research to show the importance of both standing and down coarse woody debris (CWD) for maintenance of biodiversity (see review by Freedman et al. (in press)). Such material is important for denning sites, decomposition, feeding areas, and thermal and drought refuges, among other values. It is important that forest management leave any surplus coarse woody debris on site and not remove it during harvest. As a first consideration, practices such as whole tree harvesting should be avoided. Tree limbs and tops should be left on site after harvest.

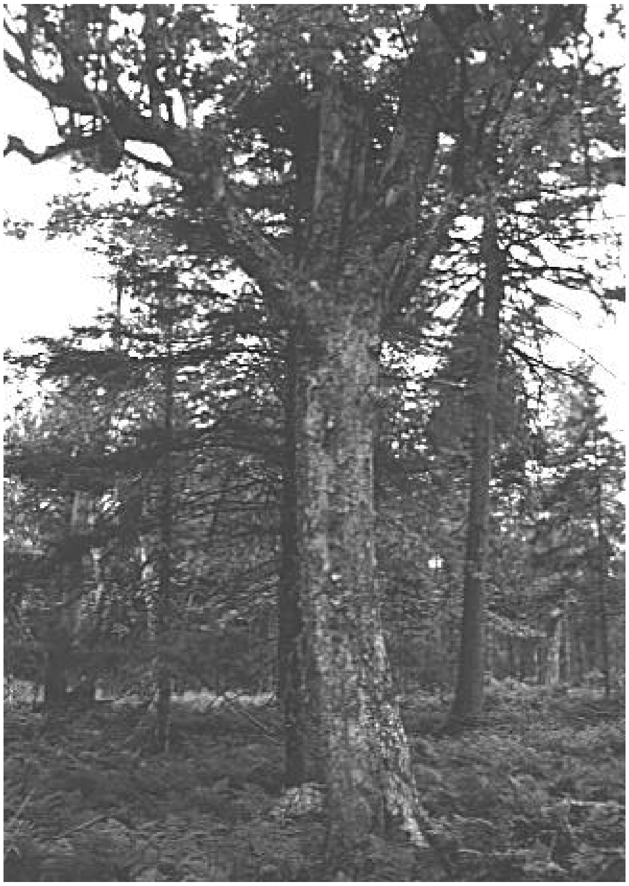
A more difficult problem is to specify the amounts of the larger classes of coarse woody debris, including whole trees and large tree boles. It is known that this type of debris is important. Areas managed as plantations will have a significant reduction in coarse woody debris input with second and subsequent rotations. Research in the GFE has shown that natural stands have 300 - 1000 pieces/ha of coarse woody debris comprising 13 - 57 m^3/ha total per stand. The larger totals occur in conifer-dominated stands which have large amounts of coarse woody debris because of tree damage caused by the Spruce Budworm. We recommend that there should be a minimum of 200 pieces/ha of coarse woody debris (average piece diameter ³ 10 cm), and a minimum total of 10 m^3/ha throughout the rotation of the stand.

Snag and Cavity Tree Retention

Clearcutting and short rotational forest management are not compatible with the immediate needs of most species of wildlife which require tree cavities at some point during the year. Multiple-entry harvesting of plantations and thinned stands may extend the window of maturity for these sites. Selective removal of a portion of timber from a stand - or group of stands - is the type of timber harvest most compatible with implementing management prescriptions which protect, enhance or mitigate damage to the habitat required by most species of cavity-dependent wildlife. For most species of cavity-dependent wildlife, other components of "forest maturity" are required for successful occupancy, especially those which address food and cover.

Most species of wildlife dependent on tree cavities have different food, cover, and spatial requirements. A lone dead Maple tree in a clear-cut might be used for nesting by a Northern Flicker, Tree Swallow or American Kestrel, and is quickly labelled as a "wildlife tree." However, this does not tell the entire story. Such species select for open or partially open sites and, with intensive timber harvest, such species are seldom lacking for nesting or feeding habitat. They are not the species of most concern. Forest management guidelines requiring a token number of "snags" left per hectare of clear-cut are of little or no practical use to most species of cavity-dependent wildlife until the regenerating forest is at least greater than 20 years old. Guidelines for the benefit of most "cavity-dependent wildlife" will manage towards maintaining components of forest stand maturity, on a sustainable basis.

Forest stand maturity must be defined by ecological and not economic parameters. For example, a stand sufficiently "mature" to cut (e.g. a 60 year-old planted Black Spruce stand on a clear cut and scarified site) cannot be equated with an ecologically mature 150 year-old Red Spruce dominated stand which developed following fire and natural regeneration. The abundance of snags should reflect the post-disturbance environment for that forest type.


This large Yellow Birch has been left for wildlife values within a selection harvest site (G. Forbes)

Information Sources

There are studies, mostly from outside New Brunswick, which have measured tree cavity selection and use by birds and mammals. Those studies of most relevance to the northeast have been summarised by Hunter (1990). There are also two Fundy Model Forest projects on cavity nesting species currently underway. Some preliminary results are also included. Cavity tree selection data from 1983 and 1984 are also available for northern New Brunswick (Parker, unpublished data).

General Principles:

1. At the Provincial level, the needs of tree cavity dependent wildlife (TCDW) can only be adequately accommodated through modifications to regional forest harvest and silviculture strategies.

2. TCDW require both nesting and feeding habitat. Large-scale clear-cutting, site preparations and conifer plantations are not conducive to providing such needed nesting and feeding habitats.

3. The selective removal of timber in a manner which maintains elements of stand ecological maturity within diversified horizontal and vertical profiles is the preferred manner of forest management for TCDW. In stand-replacing sites, clumps of standing trees need to be retained.
4. Research must be directed towards measuring specific life requirements of TCDW so that forest management strategies can be adaptive and incorporate new information and knowledge.

Specific Concepts

1. Most cavity dependent mammals use existing tree cavities (they are termed secondary cavity users).

2. Cavity dependent birds may be primary (excavate a new cavity each year) or secondary (use existing cavities) cavity nesters.

3. In New Brunswick, most species of primary cavity nesting birds select live or partially dead deciduous trees for excavating nesting cavities, especially Trembling Aspen (in the south) and Beech (in the north).

4. Bole diameter and tree height are important characteristics of cavity tree selection, and appear to vary with each bird species.

5. In a mature mixed-forest, dead standing trees, or snags, commonly represent 5 - 10% of the trees.

6. Most snags show some form of use by insectivorous birds. Most of this use is from searching for and feeding on insects.

7. The influence of adjacent trees and shrubs (i.e. microhabitat) on the level of use of snags or cavity trees for feeding and nesting, is relatively unknown.

8. All snags are not of equal value. A snag that is used heavily for feeding (or nesting) by woodpeckers in a closed mature forest will probably receive little or no use when left standing and exposed after a forest harvest.

9. The science of snag ecology is still young. Much additional information on snags and their use is needed before useful predictive models can be developed.

It is clear that integrated forest-wildlife management strategies must consider what types of trees cavity-nesting species of birds need and select. It is also clear from the available data that most primary cavity nesting birds utilise mature Aspen in southern New Brunswick and Beech in the north. Since most snags are alive or only partially dead, leaving dead snags as potential nesting sites for most species of primary cavity nesters is pointless. Such trees may, however, be used by primary cavity nesters for feeding. Mean bole dbh for such trees should be 30 to 50 cm. The optimum distribution of potential nest trees is unknown, but 10 - 12 /ha, would be a reasonable number. Potential nest trees are of little use if left solitary in clearcuts. In fact, with very few exceptions, lone trees left scattered in clearcuts are of little benefit to cavity nesting species of birds. Exceptions might be Northern Flicker, Eastern Bluebird, Tree Swallow and American Kestrel. Most are secondary cavity nesters.

Management of nest trees for primary cavity nesters must be done in concert with selection harvesting techniques. Selection harvesting leaves elements of a mature forest intact, along with potential nest trees, thus providing required cover and feeding sites for most primary cavity nesters.

There are great differences between trees used for nesting and trees used for feeding. Most nest trees used by primary cavity users are living or partially dead hardwoods, usually Aspen species and Beech. Most feeding occurs on partially dead or fully dead hardwood and softwood trees. Although the snag component of the forest is important to cavity nesters, the presence of snags alone with the living component of the forest having been removed, would be misdirected. It is estimated that a Hairy Woodpecker, for example, requires 160 snags per 40 ha of habitat, a Pileated Woodpecker 14 snags per 40 ha (most are for feeding, a few may be used for roosting). However, the territory of a Pileated Woodpecker may be 12 times that of a Hairy Woodpecker. Thus, the Pileated has access to a greater area and thus a greater variety of snags.

Best Practices Recommendations for Snags and Cavity Trees

1. Forests can be best managed for cavity nesting species of birds by selection harvesting techniques. If, for example, 40% of commercial timber is removed during the first cut, the best management for cavity nesters is to leave a minimum of 12-15 snags (defined as standing dead trees, preferably 20 cm or greater dbh) per hectare for feeding plus 10-12 live, or partially dead, mature Aspen or Beech. In the absence of Aspen or Birch, Maple and Yellow Birch with a minimum dbh of 25 cm may be substituted for nesting (White Birch is of limited value as a nesting tree in this region). Subsequent interventions should strive to maintain those numbers and ratio. Single snags or live trees in clearcuts less than 4 hectares in size may be useful as feeding and nest trees for certain species of cavity nesters. As live Aspen, Beech, Maple or Birch (Yellow preferred over White; Grey of little value) soon die, become partially dead, or otherwise become suitable as feeding and nest trees, those species are preferred over conifer species. Trees should be mature, with a minimum dbh of 25 cm. Clumps of trees are preferable over single trees. The minimum number to be left should be no less than 12-15 single trees per hectare; more is always better than less. Solitary trees left in clearcuts greater than 4 hectares are of limited value, but, when possible, the recommendations for smaller clearcuts should apply. In larger clearcuts, managers should pay special attention to leaving scattered clumps of live trees, both deciduous and coniferous mixed; large clumps are always better than small clumps. Although larger dbh's are best, a diversity of diameters is possible in clumps. Harvest and silviculture operations should be site specific.

2. In an area of forest clear-cut operations, managers should have an inventory of potential nest trees (live Aspen and Beech 25 cm dbh) and snags (dead trees 20 cm dbh) as well as the amount of commercial timber. In cuts <4 hectares, a minimum 10-12 potential nest trees and 12-15 snags should be left per hectare. Clumps of trees are better than single trees. In clear-cut operations >4 hectares, the same numbers apply, except managers should pay special attention to leaving clumps of trees rather than single trees. Potential nest trees in company of other trees (snags or merely non-commercial) is preferred. Dead and down trees are very useful to certain species of insectivorous birds, as well as a wide range of other living organisms. In selective timber harvest operations, managers should strive to maintain that element of remaining forest structure. Where dead and down trees do not present a hazard or otherwise interfere with selective timber removal, they should be left as an important component of the forest ecosystem. No numerical recommendations are practical, other than leave whenever possible.

APPLICATION TO THE FUNDY MODEL FOREST CASE STUDY AREA

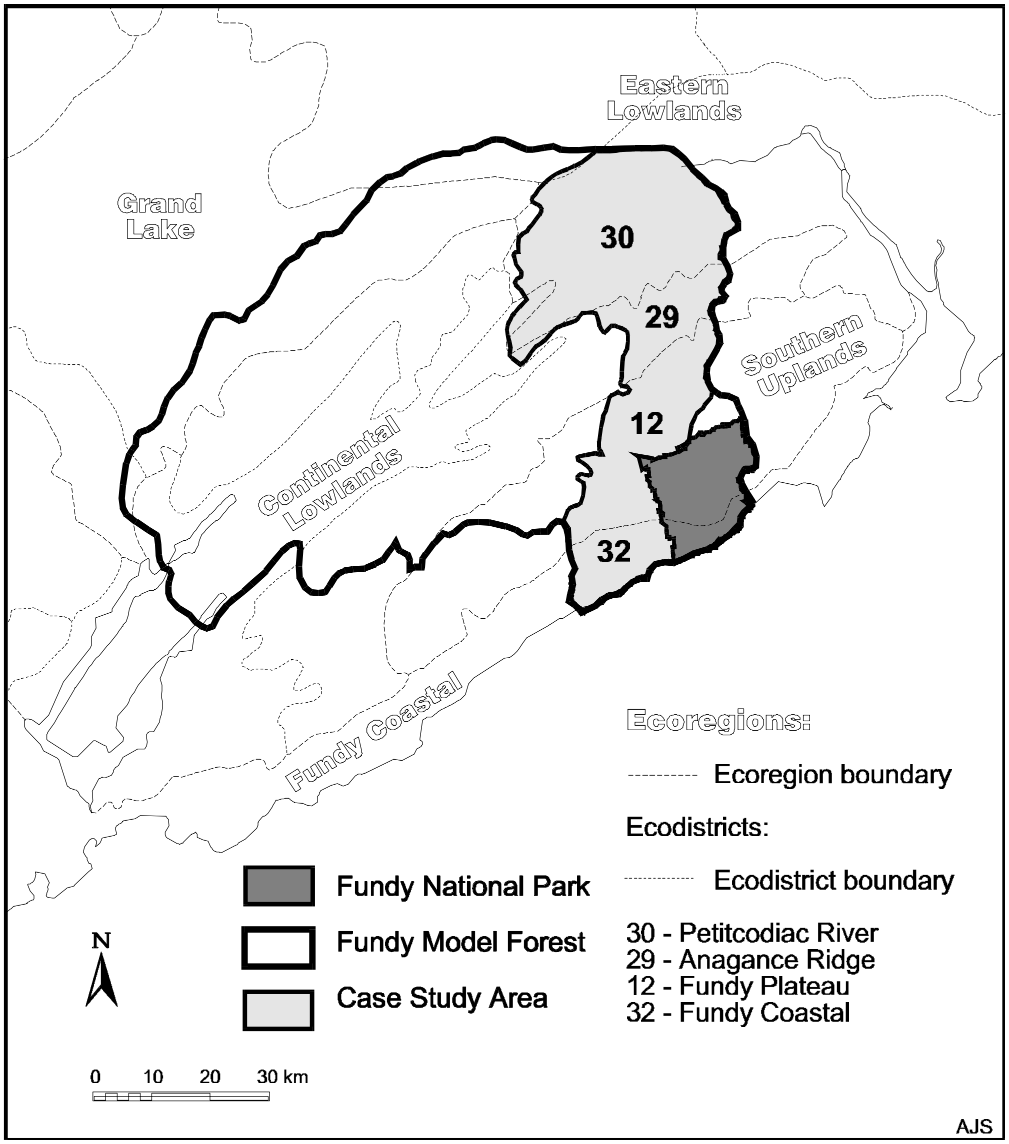


Figure 2. Location of Fundy Model Forest and Case Study Area.

One of the goals of the Fundy Model Forest is to develop an integrated management plan. A case study area, approximately one-third of the FMF area, was chosen by the FMF partners as a trial application of the guidelines and recommendations of the Partnership.

The case study area (Figure 2) is 114,782 ha (1149 km^2) of which 83% (95,507 ha, 955 km^2) is productive forest. The area is composed of 4 Ecodistricts: the Petitcodiac Ecodistrict (Eastern Lowlands Ecoregion) (29,844 ha); the Anagance Ridge Ecodistrict (Continental Lowlands Ecoregion)(15,568 ha); the Fundy Plateau Ecodistrict (Southern Uplands Ecoregion) (32,271 ha); and the Fundy Coastal Ecodistrict (Fundy Coastal Ecoregion)(16,061 ha)

Land ownership in the case study area is SNB (46%), Crown (24%), J.D. Irving (20%), Fundy National Park (9%) and Other (1%). It is not known how much of the forest is managed for timber but no cutting occurs in FNP. Most of the area (62% or 71,401 ha) is in "natural" forest condition, 11% (12,626 ha) in regenerating condition, and 8% (9,478 ha) is in plantation.

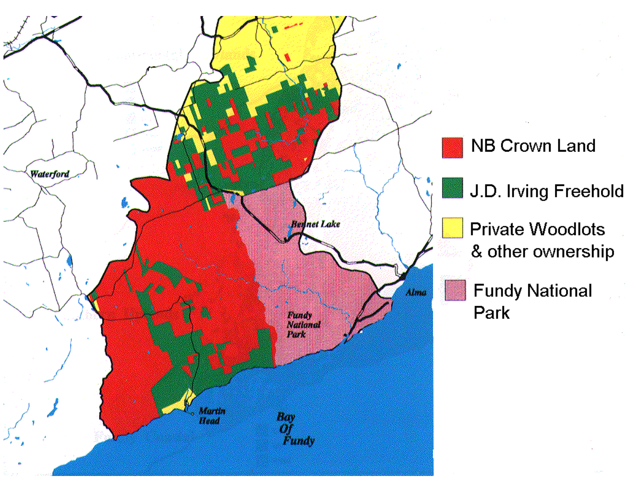
Ownership And Scale

The original mandate of the GFE research project focused on the crown and freehold properties adjacent to Fundy National Park. Much of this area is dominated by large-scale forest operations.

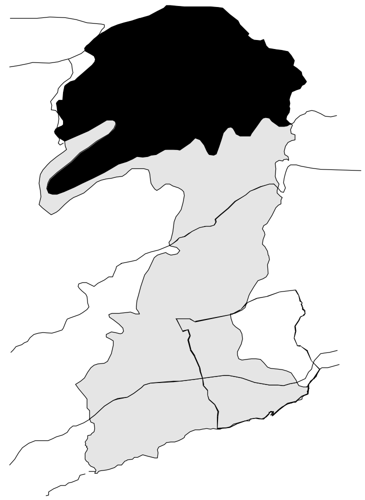
We believe that biodiversity conservation management is best accomplished through a combination of coarse-filter and fine-filter strategies. The GFE guidelines, at present, emphasise the coarse-filter approaches. Best management practices will be developed further to promote operational activities that can retain biodiversity.

The application of coarse-filter guidelines to the small-sized properties of the private woodlot owner is more difficult. For example, the minimum size of mature patches is harder to implement on 500 ha owned by 10 people than 500 ha owned by one person, particularly if the multiple-owned 500 ha is the only revenue-generating forest the owner has. Appendix 1 provides some suggestions on applying the GFE guidelines to smaller-sized woodlots.

The following information outlines the application of the GFE Guidelines for biodiversity to the case study area.



Land ownership around Fundy National Park (FMF)



EASTERN LOWLANDS (PETITCODIAC RIVER -ECODISTRICT 30)

Harvest Pattern:

The disturbance regime in this ecodistrict is related to Spruce Budworm and fire (stand-replacing) and wind/disease (gap-replacing). We recommend clearcut harvest (on Black Spruce-Balsam Fir stands) and modified "3-pass" shelterwood harvest (Red Spruce stands) on even-aged conifer sites and selection harvest on hardwoods. Adjacency rules established by DNRE should be followed.

Cut Block Size:

On stand-replacing sites, cut size should be 25-50 ha over 10-15 years within a 375-500 ha operating block. On gap-replacing sites, selection cuts are not limited by size as long as they maintain closed canopy cover (>60%), and a mixed-age distribution of overstory trees.

Connectivity:

300 m wide and <3 km long corridors. Harvest within the corridors follows DNRE Water Course Buffer Guidelines but with a minimum 35% crown closure and minimum canopy height of 12 m.

Water Course Buffers:

Follow existing DNRE Water Course Buffer Guidelines for delineation and operation activity and add the following: 1) begin 60 m buffer at the site where slope <20; 2) the harvest schedule must retain a range of size classes within the buffer.

Mature Provisions:

Note: Since restoration of existing agricultural areas to forest is unlikely, agricultural lands are not considered in calculations for historical abundance.

Strata	Present Abund-ance: (%)	(ha.)	Historical Abund-ance: (%)	(ha.)	Mature Pro-vision: (ha.)
BSRS	17	5126	20	5975	717
BSJP	7	2078	15	4481	538
BS	6	1834	10	2987	358
EC *	4	1282	15	4481	538
RMMX	43	13023	30	8962	1075
REGEN	16	4616	10(other)		
PLAN	6	1885			

* Should be managed as selection cuts only

Key:

BS - Black Spruce
RS - Red Spruce
JP - Jack Pine
EC - Cedar
RM - Red Maple
MX - mixed
REGEN - regenerating
PLAN - plantation

Forest communities requiring mature provisions in this ecodistrict are:

1) CONIFER (=BSRS, BSJP, BS) = 1613 ha
2) CEDAR (=EC) = 538 ha
3) MIXED (=RMMX) = 1075 ha

Size of Mature Patches:

The goal is a minimum patch size of 375 ha for all community types. For CEDAR, large Cedar patches presently are rare but need protection and restoration. Some of these areas may exist as recognised deer wintering areas. For MIXED, large patches of Red Maple mixed-forest are rare and mature provisions can only be met with harvesting that leads to restoration of this community.

Protected Areas:

Follow those protected areas delineated by the Province and the gap analysis project.

Snag Retention:

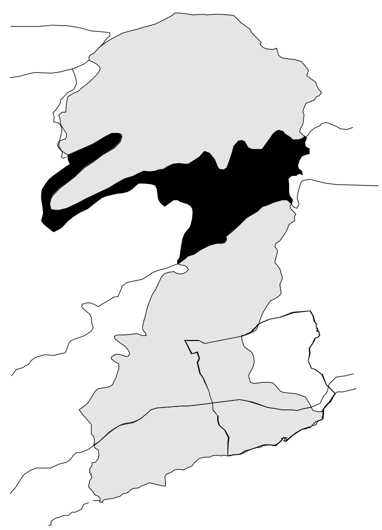
On selection cut sites, leave a minimum 12-15 standing dead trees >20 cm dbh/ha and 12-15 live or partially dead Aspen or Beech >25 cm dbh/ha.

On small clearcuts (<5 ha) leave a minimum of 12-15, >25 cm dbh trees/ha, preferably in clumps.

On large clearcuts (>5 ha) leave scattered clumps of live coniferous and deciduous trees. Trees >25 cm dbh are preferred.

Species of Concern:

Hemlock and Cedar were once much more common in this ecodistrict. Harvest of Hemlock should be eliminated and harvest of Cedar should be restricted to shelterwood cuts. A number of species such as Ironwood were also more common. These trees should be left during selection harvests.



CONTINENTAL LOWLANDS (ANAGANCE RIDGE - ECODISTRICT 29)

Harvest Pattern:

The disturbance regime here is mainly stand replacing from Spruce Budworm and fire history and some gap-replacing tolerant hardwood forests. Follow guidelines under Eastern Lowlands section. Adjacency rules from DNRE should be followed.

Cut Block Size / Connectivity /
Water Course Buffers / Protected Areas /

Snag Retention:

Same as guideline under Eastern Lowlands

Mature Provisions:

Strata	Present Abund-ance: (%)	(ha.)	Historical Abund-ance: (%)	(ha.)	Mature Pro-vision: (ha.)
POSP	40	6227	30	4670	560
WP	15	2335	30	4670	560
JPRP	9	1401	10	1557	187
RSBF	8	1259	10	1557	187
SMBE *	7	1090	10	1557	187
Other	<1	70			
REGEN	14	2180			
PLAN	2	311			

* Should be managed as selection cuts only

Key:
PO - Poplar
SP - Spruce
WP - White Pine
JP - Jack Pine
RP - Red Pine
RS - Red Spruce
BF - Balsam Fir
SM - Sugar Maple
BE - Beech
REGEN - regenerating
PLAN - plantation

Forest communities requiring mature provision in this ecodistrict are:

1) MIXED (=POSP) = 560 ha
2) WHITE PINE (=WP) = 560 ha
3) JACK PINE/RED PINE (=JPRP) =187 ha
4) CONIFER (=RSBF) = 187 ha
5) TOLERANT HARDWOOD (=SMBE) = 187 ha

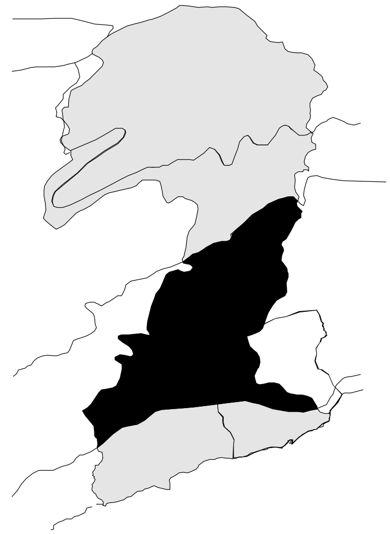
Note: Maturity window for Red Spruce stands is 80-300 years

Size of Mature Patches:

For PINE, 50% should be of 400 ha, and 50% should be >20 ha to reflect the range of patches created by fire (i.e.. 30% <50 ha, 30% >1000 ha, and modal of 400 ha). MIXED should be a 375 ha and 200 ha patch. Others should be 19 ha patches

Species of Concern:

Hemlock and Cedar were once much more common in this ecodistrict. Harvest of Hemlock should be eliminated and harvest of Cedar should be restricted to shelterwood cuts.



SOUTHERN UPLANDS (FUNDY HIGHLANDS/PLATEAU - ECODISTRICT 12)

Harvest Pattern:

This forest is dominated by gap-replacing disturbances on hardwood ridges (patchy mortality from budworm and fire) and Red Spruce on lower slopes. Emphasis should be on selection cuts. Adjacency rules by DNRE should be followed.

Cut Block Size / Connectivity / Water Course Buffers / Snag Retention /

Same as guideline under Eastern Lowlands

Mature Forest Provisions:

Strata	Present Abund-ance: (%)	(ha.)	Historical Abund-ance: (%)	(ha.)	Mature Pro-vision: (ha.)
RSSM	35	11183	30	9721	1167
RSBF	14	4489	30	9721	1167
SMYB *	15	4982	30	9721	1167
Other	3	1038	10	324	-
REGEN	14	4642			
PLAN	19	6069			

* Should be managed as selection cuts only

Key:
RS - Red Spruce
SM - Sugar Maple
BF - Balsam Fir
YB - Yellow Birch
REGEN - regenerating
PLAN - plantation

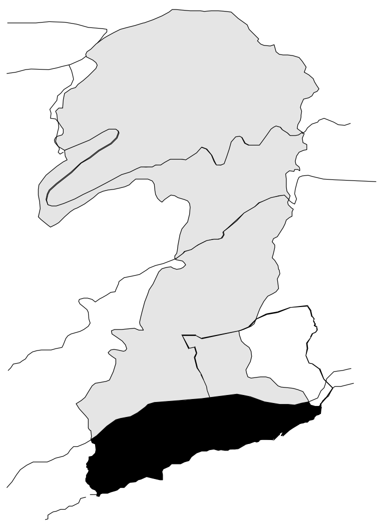
Communities requiring mature provisions in this ecodistrict are:

1) MIXED (=RSSM) = 1167 ha
2) CONIFER (=RSBF) = 1167 ha
3) HARDWOOD (=SMYB) = 1167 ha

Note: Maturity window for Red Spruce stands is 80-300 years

Size of Mature Patches:

Goal is for all to be a minimum of 375 ha



FUNDY COASTAL (FUNDY COASTAL - ECODISTRICT 32)

Harvest Pattern:

The disturbance regime here is related to Spruce Budworm patches. These are best reflected by selection cuts or modified "3-pass" shelterwood for Red Spruce stands. Fire is rare along the coast. Adjacency rules established by DNRE should be followed.

Cut Block Size / Connectivity /
Water Course Buffers /
Snag Retention

Same as guideline under Eastern Lowlands

Mature Provisions:

Strata	Present Abund-ance: (%)	(ha.)	Historical Abund-ance: (%)	(ha.)	Mature Pro-vision: (ha.)
RSBI *	50	7850	50	7853	942
RS *	22	3443	30	4712	565
BS	7	1013	20	3141	377
Other	1	143			
REGEN	6	919			
PLAN	15	2337			

* Should be managed as selection cuts only

Key:
RS - Red Spruce
BI - Birch
BS - Black Spruce
REGEN - regenerating
PLAN - plantation

Communities requiring mature provisions in this ecodistrict are:

1) MIXED (=RSBI) = 942 ha
2) CONIFER (=RS, BS) = 942 ha

Note: Maturity window for Red Spruce stands is 80-300 years

Size of Mature Patches:

Goal is for minimum sized patch(s) of 375 ha

Protected Areas:

The 1 km wide no-harvest buffer established by DNRE along the coast should be maintained. The provincial park likely lies within this area but should be recognised.

Species of Concern:

Relative to the other ecodistricts, this ecodistrict contains a high proportion of large diameter Red Spruce trees, some of which are over 250 years old. A proportion of large (>40 cm dbh) Red Spruce need to be retained in cut areas.

The mature class window for Red Spruce should be 80-300 years old; 12% of these stands should be maintained of which 20% of the trees are >150 yrs old.

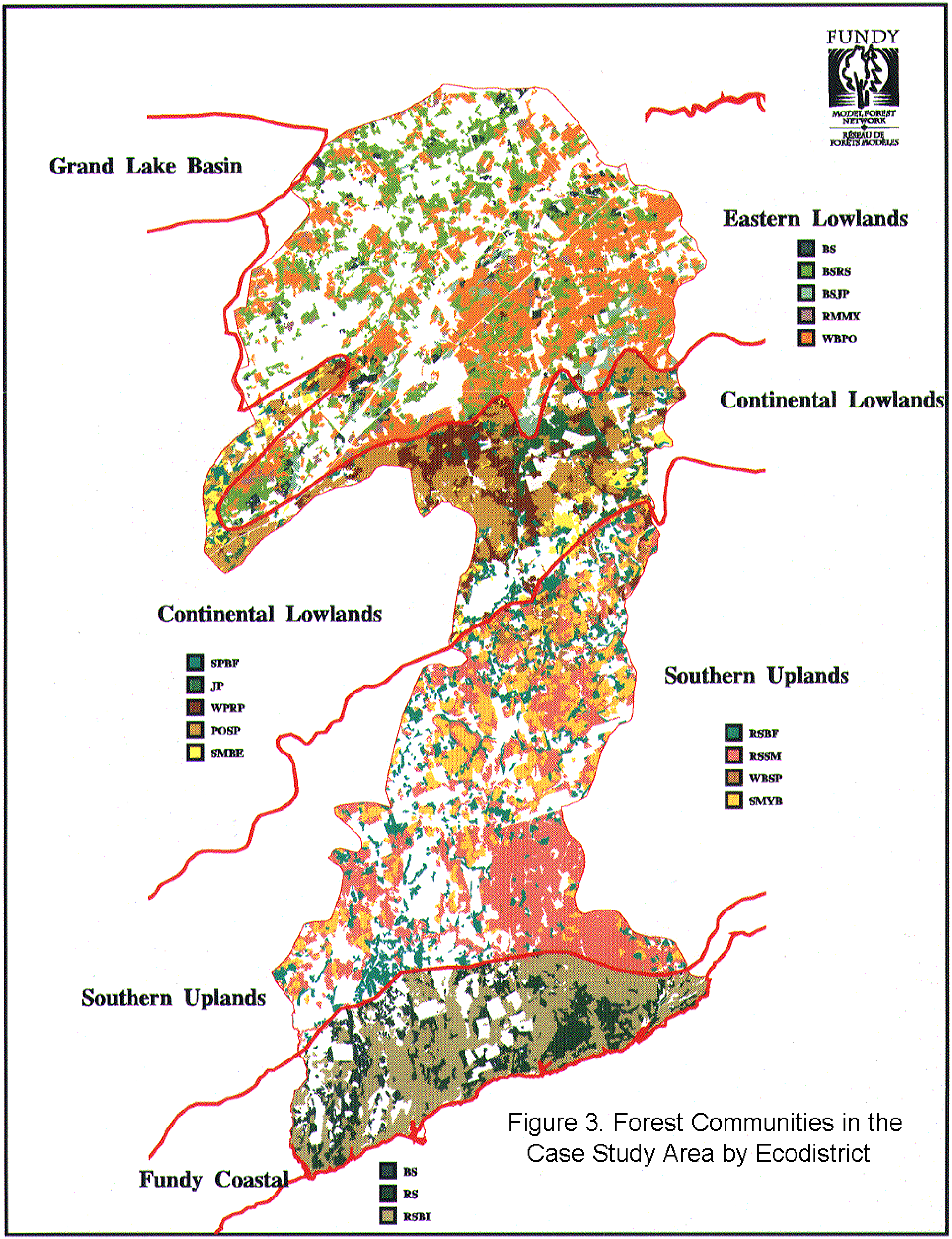


Figure 3. Forest Communities in the Case Study Area by Ecodistrict

FUNDY
MODEL FOREST NETWORK
RÉSEAU DE FORÊTS MODÈLES

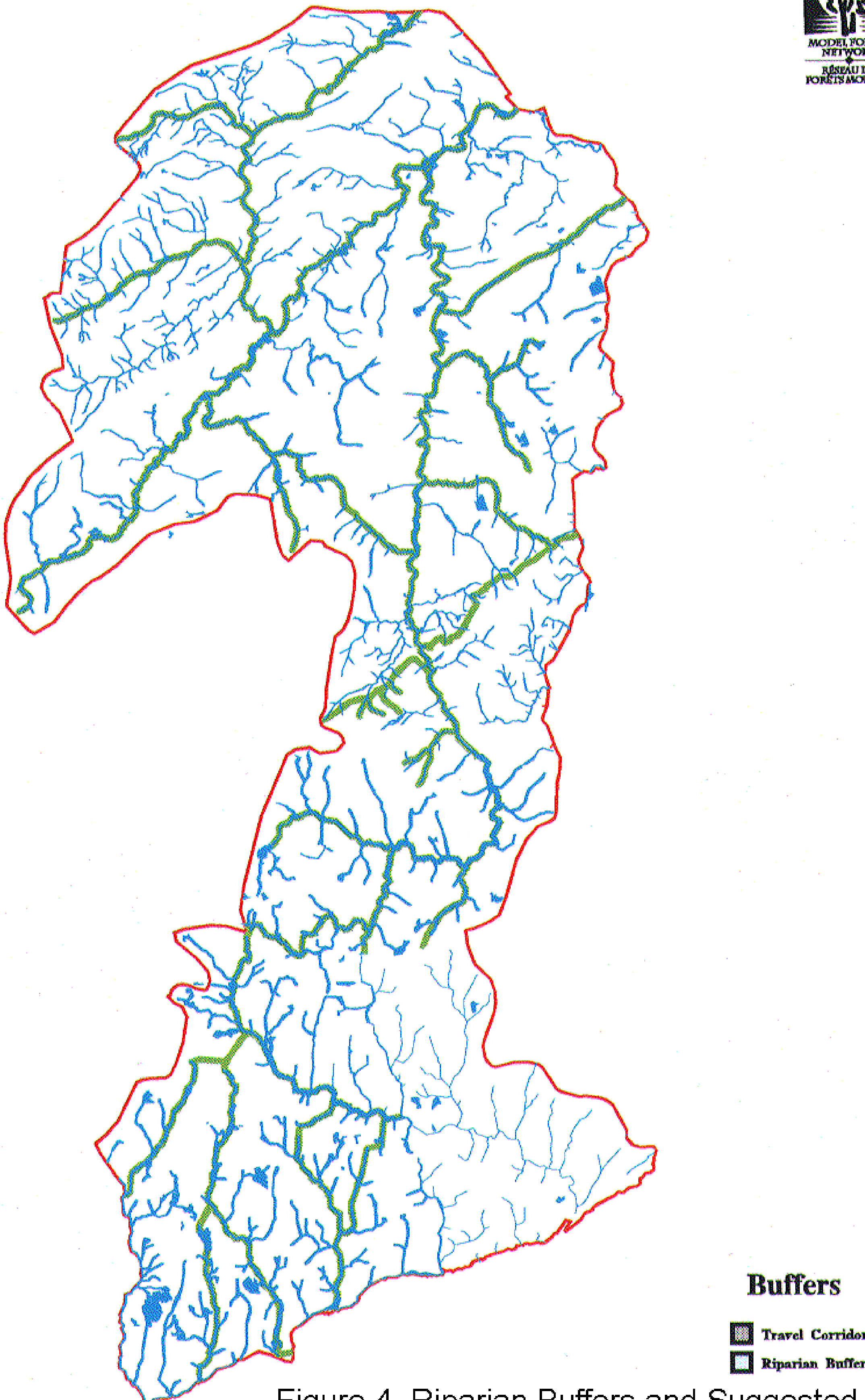


Figure 4. Riparian Buffers and Suggested Travel Corridors

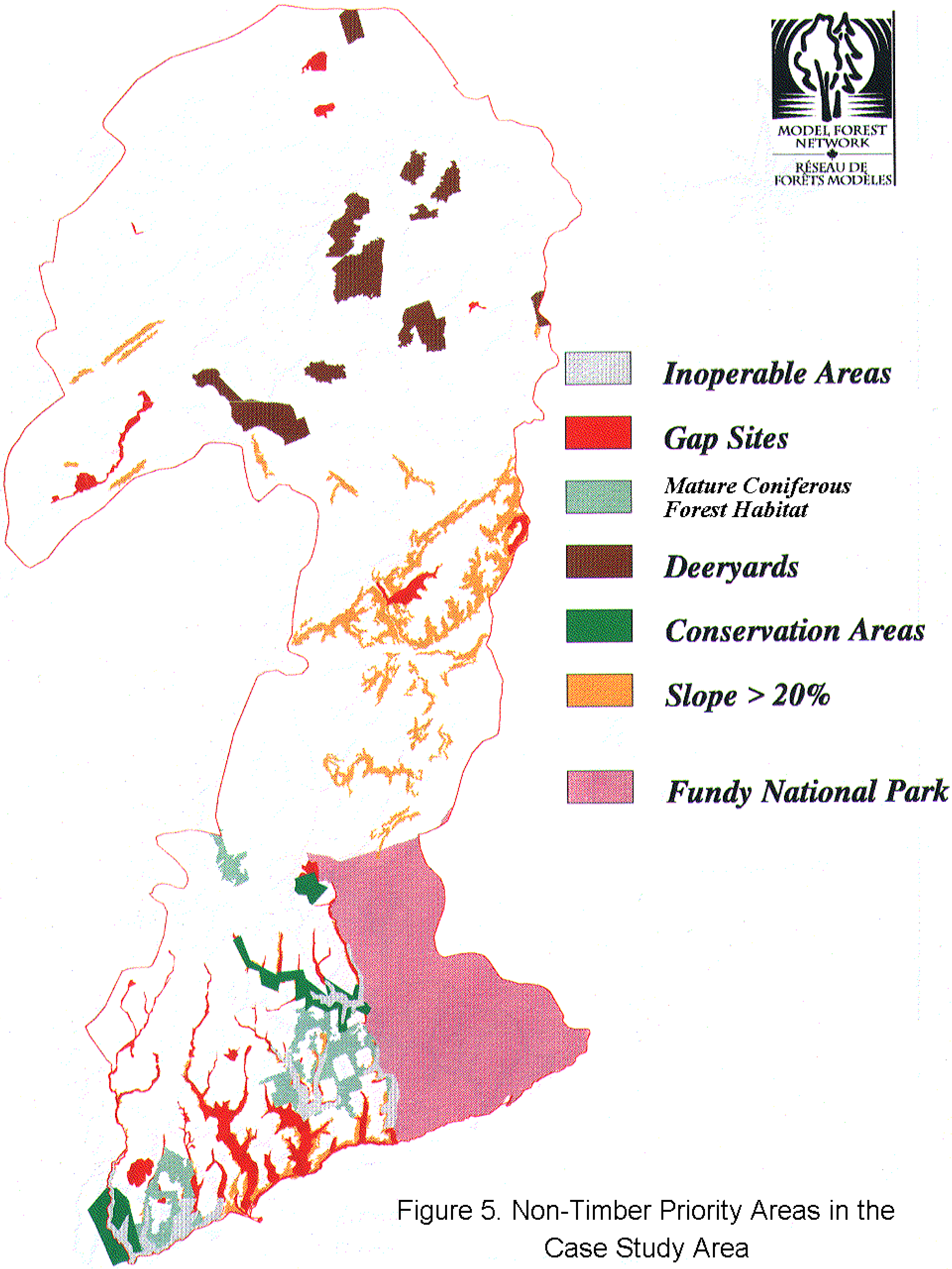


Figure 5. Non-Timber Priority Areas in the Case Study Area

REFERENCES

Agee, J. K., and D. R. Johnson. 1988. Ecosystem Management for Parks and Wilderness. University of Washington Press. Seattle, WA. 237 pp.

Anonymous, 1994. Forest Management Manual for Crown Lands. New Brunswick Dept. of Natural Resources and Energy. Fredericton, N.B.

Attiwill, P. 1994. The disturbance of forest ecosystems: the ecological basis for conservative management. Forest Ecology and Management 63:247-300.

Blais, J.R. 1983. Trends in the frequency, extent and severity of spruce budworm outbreaks in eastern Canada. Can. J. For. Res. 13: 539-545.

Brown, J.H. and J. Roughgarden 1990. Ecology for a changing earth. Bulletin of the Ecological Society of America 71: 173-188.

Dansereau, P.-R. and Y. Bergeron. 1991. Fire history in the southern boreal forest of north-western Quebec. Can. J. For. Res. 23:25-32.

DNRE 1996. Watercourse Buffer Zone Guidelines for Crown Land Forestry Activities. New Brunswick Natural Resources and Energy. Fredericton, N.B. 20 pp.

Franklin, J. F. and R. T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles. Landscape Ecology 1:5-18.

Freedman, B., S. Woodley and J. Loo. 1994. Forestry practices and biodiversity with particular reference to the Maritime provinces. Environmental Reviews. 2:33-77.

Freedman, B., V. Zelazny, D. Beaudette, T. Fleming, S. Flemming, G. Forbes, J. Gerrow, G. Johnson, and S. Woodley. (in press). Biodiversity implications of changes in the quantity of dead organic matter in forests, with particular reference to Atlantic Canada. Environmental Review.

Gordon, A.R. 1996. The sweep of the boreal in time and space, from forest formations to genes, and implications for management. Forestry Chronicle 72:19-30.

Hansen, A. J., T. Spies, F. Swanson, and J. Ohmann. 1991. Conserving biodiversity in managed forests. Bioscience 41:382-392.

Hunter, M. L., G. L. Jacobson Jr., and T Webb. 1988. Paleoecology and the coarse-filter approach to maintaining biological diversity. Conservation Biology 2:375-385.

Lindenmayer, D. B. 1994. Wildlife corridors and the mitigation of logging impacts on fauna in wood production forests in south-eastern Australia: a review. Wildlife Research 21:323-340.

McGurk, B. J. and D. Fong. 1995. Equivalent roaded area as a measure of cumulative effect of logging. Environmental Management 19:609-621.

Methven, I. and M. Kendrick. 1995. A Disturbance History Analysis of the Fundy Model Forest Area. Final Report to Fundy Model Forest. Unpublished report to the Fundy Model Forest. 16 pp.

O'Laughlin, J., and G. Belt. 1995. Functional approaches to riparian buffer strip design. Journal of Forestry. 29-32.

Wein, R and J. Moore. 1977. Fire history and rotations in New Brunswick Acadian Forest. Can. J. For. Res. 7:285-294.

APPENDIX 1:
APPLICATION OF GUIDELINES TO PRIVATE WOODLOTS

The issue of scale will dictate much of what any individual or group of woodlot owner wishes to implement on his or her property. The fine-filter strategies should be emphasised due to their relative ease of implementation. They include all of the operational best management practices mentioned earlier under the following headlines:

- Landscape Level Considerations
- Site Level Considerations
- Water Course Buffers
- Special Status Tree Species
- Coarse Woody Debris
- Snag and Cavity Tree Retention

One aspect that may be particularly advantageous to promoting biodiversity and wood values on private woodlots is the development of high-quality tree species like Black Cherry, Oaks, and Butternut. The smaller scale of many woodlots permits easier identification and consideration of rarer species. Some of these species are valuable as timber and speciality products. At present the general ignorance of these species and their ecological and financial value, and the preponderance of fibre-based strategies, limits the role these species can play in the ecological health of the FMF.

Coarse-filter strategies of mature forest blocks of different community types may be possible; 1) on larger-sized properties; 2) from agreements between adjacent owners, or; 3) in cases of uncut stands due to ownership preference, by identifying and formally recognising such sites. Similar approaches could be used to delineate buffers and travel corridors. We note that the importance of a travel corridor increases with the extent of habitat change through an ecodistricts. It may be worthwhile to promote a co-operative plan of forestry and even restoration among numerous landowners along a corridor.

Priorities for coarse-filter practices include:

- Mature Forest Retention
- Patch Size Considered
- Corridor Retention or Restoration

APPENDIX 2: COMMON AND LATIN NAMES FOR SPECIES MENTIONED IN THE GUIDELINES

Plants

Curly Grass Fern (*Schizea pusilla*)
Rand's Eyebright (*Euphrasia randi*)
Small Yellow Water-buttercup (*Ranunculus flabellaris)*
Livelong Saxifrage (*Saxifraga paniculata*)
Birds-eye Primrose (*Primula mistassinica)*
Yellow Lady-slipper (*Cypripedium calceolus)*
Ragged-fringed Orchis (*Plantathera lacera*)
Large Purple-fringed Orchis (*P. grandiflora*)
Hookers Orchis (*P. hookeri*)
Large Round-leaved Orchis (*P. macrophylla*)
Showy Lady-slipper *(Cypripedium reginae)*
Laurentian Bladderfern (*Cystopteris laurentiana)*
White Pine (*Pinus strobus*)
Red Pine (*P. resinosa*)
Jack Pine (*P. banksiana*)
Red Spruce (*Picea rubens*)
Black Spruce (*P. mariana*)
Eastern White-cedar (*Thuja occidentalis*)
Eastern Hemlock (*Tsuga canadensis*)
Balsam Fir (*Abies balsamea*)
Sugar Maple (*Acer saccharum*)
Red Maple (*A. rubrum*)
Yellow Birch (*Betula alleghaniensis*)
White Birch (*B. papyrifera*)
Trembling Aspen (*Populus tremuloides*)
American Beech (*Fagus grandifolia*)
Bur Oak (*Quercus macrocarpa*)
Red Oak (*Quercus rubra*)
Black Cherry (*Prunus serotina*)
Black Ash (*Fraxinus nigra*)
Basswood (*Tilia americana*)
Butternut (*Juglans cinerea*)
Ironwood (*Ostrya virginiana*)

Animals

Freshwater Wedge Mussel (*Alasmidonta sp*.)
Spruce Budworm (*Choristoneura fumiferana*)
Four-toed Salamander (*Hemidactylium scutatum*)
Woodland Caribou (*Rangifer caribou*)
Moose (*Alces alces*)
White-tailed Deer (*Odocoileus virginanus*)
American Marten (*Martes americana*)
Northern Flying Squirrel (*Glaucomys sabrinus*)
Grey Wolf (*Canis lupus*)
Black Bear (*Ursus americana*)
Pileated Woodpecker (*Dryocopus pileatus*)
Hairy Woodpecker (*Picoides villosus*)
Northern Flicker (*Colaptes auratus*)
Tree Swallow (*Tachycineta bicolor*)
American Kestrel (*Falco sparverius*)
Eastern Bluebird (*Sialia sialis*)
Bachman's Sparrow (*Aimophila aestivalis*)

APPENDIX 3:
PROPOSED HARVEST STRATEGY FOR STANDS IN THE CASE STUDY AREA

Eco-District:	Curve Name:	Comm. Type:	Character:	Desc.:	Cover Type	Area (Ha.)	Succession Type: Gap:	Succession Type: Stand:	Harvest: Clear-Cut:	Harvest: Shelterwood: 2 stage pass	Harvest: Shelterwood: 3 stage pass	Harvest: Selection Cut:
Anagance Ridge: (Continental Lowlands)	C01	POSP	Mixed	IHFSRM	HS	57		●	●			
	C02	POSP	Mixed	IHSFRM	HS	1999		●	●			
	C03	POSP	Mixed	IHSWRM	HS	428		●	●			
	C04	POSP	Mixed	IHRMSF	H	3188		●	●			
	C05	POSP	Mixed	IHTHSW	H	823		●	●			
	C07	JPRP	JPRP	JPWPMX	SH	1463		●	●		●	
	C08	JPRP	JPRP	RPWPMX	S	121		●			●	
	C09	RSBF	Conifer	SPBFHW	S	570	●	●		●		
	C11	RSBF	Conifer	SPIHBF	SH	161	●	●		●		
	C12	RSBF	Conifer	SPIHMX	SH	307	●	●			●	
	C13	RSBF	Conifer	BFIHMX	SH	88		●		●		
	C15	RSBF	Conifer	SPTHIH	SH	132	●	●		●		
	C16	SMBE	Tol. Hwd	TH	TH	164	●					●
	C18	SMBE	Tol. Hwd	THSFIH	TH	200	●					●
	C20	SMBE	Tol. Hwd	THSFIH	TH	104	●					●
	C21	SMBE	Tol. Hwd	THIHSF	TH	621	●		●			●
	C23	WP	WP	IHWPSF	HS	1470	●	●		●		
	C24	WP	WP	IHWPSF	SH	1030	●	●		●		
	C25	WP	WP	WPSPIH	SH	657	●	●			●	
Petitcodiac River: (Eastern Lowlands)	C26	BS	Conifer	BSHWJP	SH	1086		●	●			
	C27	BSJP	Conifer	JPBSMX	S	599		●	●			
	C28	BSJP	Conifer	BSJPRM	S	661		●	●			
	C29	CED	Cedar	ECHWFS	SH	1282	●					●
	C30	RMMX	Mixed	PORMFS	H	1968	●	●	●	●		
	C31	RMMX	Mixed	POFSRM	HS	9920	●	●	●			
	C32	SPMX	Conifer	SWPOR	SH	1929		●	●		●	
	C33	SPMX	Conifer	SFPORM	HS	1833		●		●		
	C34	SPMX	Conifer	SWPOR	SH	1493		●		●		
	C35	SPMX	Conifer	SPBFHW	SH	1745		●	●		●	
	C36	RMMX	Mixed	RMPOFS	H	755	●	●	●			
Fundy Coastal: (Fundy Coastal)	C37	BS	Conifer	BSRS	S	1013		●	●			
	C38	RS	Conifer	RS	S	3444	●				●	
	C39	RSBI	Mixed	RSBFWB	SH	313	●		●			
	C40	RSBI	Mixed	THRS	TH	1020	●					●
	C41	RSBI	Mixed	RSTH	SH	1683	●				●	
	C42	RSBI	Mixed	RS	S	4834	●			●		
	C43	RSBI	Mixed	RSBI	S	499	●				●	
Fundy Plateau: (Southern Uplands)	C44	RSBF	Conifer	BFSP	S	928		●		●		
	C45	WBRS	Other	IHSPTH	HS	1088		●	●			
	C46	RSBF	Conifer	SP	S	1172	●	●			●	
	C47	RSBF	Conifer	SPSMRM	SH	1897	●	●	●			
	C48	RSBF	Conifer	SFWBTH	SH	492	●	●		●		
	C49	RSSM	Mixed	SPTH	SH	1555	●			●		
	C50	RSSM	Mixed	SPTH	SH	1017	●			●	●	
	C51	RSSM	Mixed	RS	S	2940	●	●		●	●	
	C52	SMYB	Tol. Hwd	TH	TH	654	●					●
	C53	SMYB	Tol. Hwd	TH	TH	1240	●					●
	C54	SMYB	Tol. Hwd	TH	TH	872	●					●
	C55	SMYB	Tol. Hwd	TH	TH	1296	●					●
	C56	SMYB	Tol. Hwd	THSFIH	HS	921	●		●			

	C57	RSSM	Mixed	THSF	HS	936	●		●			
	C58	RSSM	Mixed	THRS	HS	1317	●		●			
	C59	RSSM	Mixed	TH	TH	713	●					●
	C60	RSSM	Mixed	TH	TH	2706	●					●

Key:

SP or S - Spruce	WP - White Pine	RM - Red Maple	YB - Yellow Birch	HS - Hardwood dominated mixed
RS - Red Spruce	RP - Red Pine	SM - Sugar Maple	WB - White Birch	SH - Softwood dominated mixed
BS - Black Spruce	CED or EC - Cedar	BE - Beech	IH - Intolerant Hardwood	S - Softwood dominated forest
WS - White Spruce	MIX - Mixed	BI - Birch	TH - Tolerant Hardwood	H - Hardwood dominated forest
BF or F - Balsam Fir	HW - Hardwood	PO - Poplar	SW - Softwood	
JP - Jack Pine				

APPENDIX 4:
LIST OF CONTACTS AND PARTICIPANTS

This set of guidelines was developed by the Greater Fundy Ecosystem Research Group. To provide comments on this set of guidelines, please contact the editors:

Dr. Stephen Woodley
Chair, GFE Research Project
Natural Resources Branch,
Parks Canada,
Hull, Quebec
KIA OM5

Tel. 819-994-2446
Stephen_Woodley@pch.gc.ca

Dr. Graham Forbes
Co-ordinator, GFE Research Project
Faculty of Forestry and Environmental Management
University of New Brunswick
Fredericton, New Brunswick
E3B 6C2

Tel. 506-453-4929
forbes@unb.ca

Principal Participants in the Greater Fundy Ecosystem Research Project and the Guidelines:

Harry Beach, Parks Canada

Dan Beaudette, NB Dept. Natural Resources

Dr. Alyre Chiasson, Universite’ de Moncton

Dr. Doug Clay, Parks Canada

Edouard Daigle, Parks Canada

Dr. Stephen Flemming, Parks Canada

Dr. Graham Forbes, University of New Brunswick

Dr. Bill Freedman, Dalhousie University

John Gilbert, J. D. Irving

Martha Gorman, NB Dept. Natural Resources

Dr. Helmut Krause, University of New Brunswick

Dr. Judy Loo, Canadian Forest Service

Andrew MacDougall, Canadian Forest Service

Dr. Dave Maclean, Canadian Forest Service

Dr. Ian Methven, University of New Brunswick

Gerry Parker, Canadian Wildlife Service

Dr. Tom Pollock, Environment Canada

Joe Pomeroy, Environment Canada

Dr. Mark Roberts, University of New Brunswick

Mike Sullivan, NB Dept. Natural Resources

Hilary Veen, NB Dept. Natural Resources

Dr. Stephen Woodley, Parks Canada

Vince Zelazny, NB Dept. Natural Resources

Graduate Students:

Maryse Bourgeois, Acadia University

Tracy Fleming, Dalhousie University

Shawn Gerrow, Acadia University

Greg Johnson, Dalhousie University

Serge Lutz, University of New Brunswick

Minga O’Brian, Dalhousie University

Dwayne Sabine, University of New Brunswick

Cam Veinotte, Dalhousie University

Ruth Waldick, Dalhousie University