Canada's Report

on the

Montréal Process

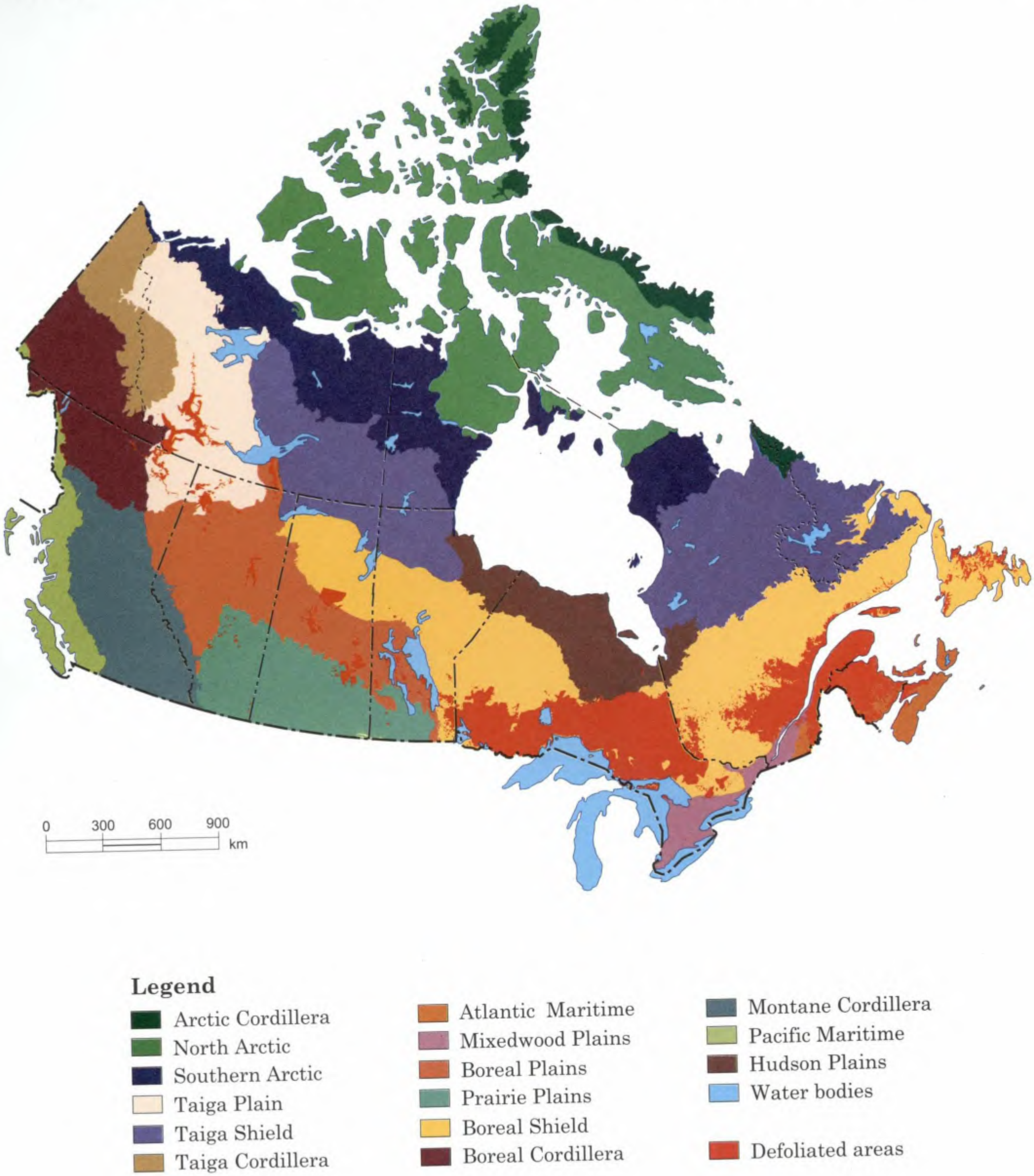
Criteria and Indicators

for the

Conservation and Sustainable Management of Temperate and Boreal Forests

August 1997

Figure 3.a.1
Areas of Defoliation by Eastern Spruce Budworm, 1980-1995



Data compiled by Forest Health Network, Atlantic Forestry Centre, Canadian Forest Service, Natural Resources Canada.
Map co-produced by ***GeoAccess*** Division, Canada Centre for Remote Sensing, Geomatics Canada, Natural Resources Canada.

CANADA'S REPORT ON THE MONTRÉAL PROCESS CRITERIA AND INDICATORS FOR THE CONSERVATION AND SUSTAINABLE MANAGEMENT OF TEMPERATE AND BOREAL FORESTS

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FOREWORD

Criteria and indicators for sustainable forest management are one of the priority issues under discussion internationally and within Canada. Criteria and indicators for sustainable forest management have been developed to assess trends in the state of forests and forest management. They are considered as a policy instrument to evaluate progress towards sustainable forest management. They have the potential to help the orientation of forest and environmental policies and research, and guide forest practices towards sustainable forest management which corresponds to the expectations of society.

Canada has been a major player in the global discussions on criteria and indicators for sustainable forest management. Because Canada accounts for 10% of the world's forested land and almost 20% of global trade in forest products, Canadian decisions and actions with regard to sustainability can have a major impact on global economic, social and environmental systems.

Canada's commitment to sustainability was enshrined in the National Forest Strategy entitled Sustainable Forests: A Canadian Commitment, which was endorsed in March 1992 by federal, provincial and territorial governments and other interested forest community groups (e.g., industry, academia, Aboriginal peoples, environmental groups, etc). The Strategy sets out nine strategic directions and 96 commitments, including a commitment to formulate indicators to measure and report on sustainable forest management. In June of that year, at the United Nations Conference on Environment and Development (UNCED), Canada successfully argued for recognition of the importance of sustainable forest management through the adoption of a statement of forest principles.

Following UNCED, in September 1993 the Conference on Security and Cooperation in Europe sponsored an international seminar in Montréal, Canada on Sustainable Development of Temperate and Boreal Forests. This conference led to subsequent regional and international initiatives to develop criteria and indicators for sustainable forest management.

In June 1994 the "Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests" was formed to advance the development of internationally agreed upon criteria and indicators through a series of meetings hosted by participating countries. This Working Group is known as the Montréal Process.

In February 1995 in Santiago, Chile, the original ten Montréal Process countries endorsed a statement of political commitment known as the "Santiago Declaration", together with a comprehensive set of seven criteria and 67 indicators for the conservation and sustainable management of temperate and boreal forests for use by respective policy-makers at the national level.

The Montréal Process Working Group now includes Argentina, Australia, Canada, Chile, China, Japan, Republic of Korea, Mexico, New Zealand, Russian Federation, United States of America and Uruguay. These countries cover five continents and together represent 90% of the world's temperate and boreal forests (as well as areas of tropical forests) and 60% of all forests. They also account for 45% of world trade in wood and wood products and 35% of the world's population.

Canada has been a member of the Working Group since its formation in June 1994, and has hosted the Montréal Process Liaison Office since that time. Canada will continue to participate in the Montréal Process and will encourage the group to maintain its momentum to work towards implementing the criteria and indicators on a national level. The Canadian commitment to this process is further demonstrated by the development of a domestic set of criteria and indicators, which was developed through the sponsorship of the Canadian Council of Forest Ministers. Canada will issue a report on *Defining Sustainable Forest Management: A Canadian Approach to Criteria and Indicators* late in 1997.

The seven criteria included in the Montréal Process framework are each further defined by indicators which are intended to provide a measure of a specific aspect of forest sustainability. Six of the criteria and indicators relate to forest conditions, attributes, functions or benefits. Criterion 7 relates to the overall policy framework that can facilitate sustainable forest management and support efforts to conserve, maintain or enhance the conditions, attributes and benefits captured in Criteria 1 to 6.

This report includes an introduction describing forest ecosystems and forest management in Canada, explaining the area of forest covered by the report, and identifying Canada-specific forest-management characteristics to help place the criteria and indicators framework in context. Reports on the criteria each begin with an introduction, followed by the indicator reports. A brief summary provides highlights of the indicator findings. The final chapter contains a summary of all the criteria, as well as an overview of Canada's ability to report on them and plans to enhance reporting capability for the future.

Taken together, the Montréal Process criteria and indicators provide a common understanding and implicit definition of what is meant by sustainable forest management. They are tools for assessing national trends in forest conditions and management and provide a common framework for describing, monitoring and evaluating progress towards sustainability at the country level. They are not performance standards and are not intended to assess sustainability directly at the forest management unit level.

Application of the criteria and indicators will help provide an international reference for policy-makers when formulating national policies founded on science, focus research efforts in the areas in which more knowledge is needed, improve the quality of information available to decision-makers and the public, and better inform the forest policy debate at the national and international level. They will also allow countries to gain a better understanding of the challenges facing other countries and identify common solutions.

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I. Introduction

i) Description of the forest ecosystems in Canada

Probably more than anything else, Canada is known for its vast forested landscapes. With 10% of the world's forests, Canada is one of the few developed nations still richly endowed with large areas of natural forests. The total area of Canada is 997 million hectares, of which 927 million hectares are land. About half of the land mass (417.6 million hectares) is covered by forests.

Forests are a dominant feature of the Canadian environment, economy, culture, traditions and history, and are part of this country's national heritage and identity. Even the national flag depicts the leaf of one of Canada's best known trees–the maple. From the earliest times, the inhabitants of this land have relied heavily on the forest to meet their basic needs. With the arrival of Europeans only a few hundred years ago, the Canadian economy quickly came to be based on furs and lumber. In 1906, Prime Minister Wilfred Laurier presided over the country's first national forest congress, called to discuss the future of forests. The fact that Canada was not quite forty years old at the time gives an indication of the prominent role forests played, and play, for this nation.

Approximately 57% of the forests in Canada are considered commercial, although not all of them are currently accessible and managed for timber production. Annually, Canada harvests less than 1% of its commercial forest area. Most of Canada's forests (94%) are publicly owned; provincial governments are responsible for managing 71% and the federal and territorial governments manage 23%. The remaining 6% are the private property of more than 425 000 landowners. The fifteen terrestrial ecozones of Canada (based largely on climate and landform variations) have been broken down into 194 different ecoregions, which in turn have been subdivided into 1 020 ecodistricts. Eleven of the ecozones have 15% or more forest cover, with distinct mixes and numbers of species.

Forests are home to roughly two thirds of the 140 000 non-viral species estimated to occur in Canada, only half of which have been described by taxonomists. There are approximately 180 indigenous tree species in Canada, of which 100 can be found in the Mixedwood Plains ecozone. Sixty-three percent of Canada's commercial forest is composed of softwoods, 15% is hardwoods, and 22% is mixedwoods. The average age of Canada's forests increases from east to west, reflecting differences in disturbance frequencies (fire, insect outbreaks, timber harvesting) and natural variations in species longevity. There is a general shift from hardwood to softwood dominance with increasing age of forest stands.

Currently, some 337 communities in Canada depend largely on forestry, and 880 000 Canadians (1995) work in the forest sector or for organizations or companies associated with it. The forest sector pays out more than $10.4 billion[1] per year in wages. In 1994, shipments of forest products were valued at $58.7 billion, making Canada one of the world's largest producers of wood products. In 1995, exports contributed $34.7 billion to the country's net balance of trade–more than energy, fishing, mining and agriculture combined.

ii) Explanation of coverage of the report

All of Canada's forests are temperate or boreal. For the Montréal Process, Canada will report primarily on the forest area covered by *Canada's Forest Inventory 1991*. The inventory is a spatially referenced database containing the best information available in 1991. It is the authoritative national statement on the distribution and structure of Canada's commercial forests. Forest management agencies have recently begun to broaden the scope of forest inventories to encompass non-timber values. Information on forest values is more readily available for publicly owned lands than for privately owned forest land.

Generally, data on disturbances and activities affecting Canada's forests are collected on a national scale by administrative rather than ecological boundaries. Some species in some ecozones have declined in numbers over the past 100 years, largely due to clearing for agriculture and development, as well as hunting and trapping and loss of mature forest habitat. Natural disturbances such as insect defoliation and fires also influence Canada's forests. More recent factors such as airborne pollutants can be considered sources of stress in parts of Canada.

iii) Identification of nation-specific forest-based characteristics and/or information to place the criteria and indicators framework in context

The challenges of sustainable forest management are very evident in Canada. Canadians rely on the contribution of forests to trade, recreational opportunities, quality of the environment, spiritual values, tourism and many other aspects of their lives. In survey after survey, Canadians have consistently stated their belief that the sustainable management of Canada's forests is fundamental to national economic, environmental, as well as quality of life issues.

Under the Canadian Constitution, forest management is a matter of provincial jurisdiction, and each province has its own legislation, policies and regulations governing forest activities within its borders. Province-like responsibilities have been devolved to the Government of the Northwest Territories, with the federal government retaining ownership of the landbase. Preparations are underway for a similar transfer to the Yukon Territory. Currently in that territory, the federal government oversees the management of forest lands through the Department of Indian Affairs and Northern Development. The federal government also manages forests on federal lands, including national parks, transportation corridors and military reserves. Its additional roles in forestry stem from its responsibilities in the areas of trade and investment, national statistics, forest science and technology, Aboriginal affairs, environmental affairs and international relations.

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1 All dollars in this report are Canadian. One billion equals 1 000 000 000

Over 80% of Aboriginal communities in Canada are situated in rural and remote forested areas. The clarification and recognition of Aboriginal rights and the meaningful participation of Aboriginal people in forest management require an understanding of their value systems. The Aboriginal land ethic is deeply rooted in traditional cultural beliefs, which hold that land and forests should be viewed as a whole. This ethic embodies the concept that land and its resources must be protected out of respect for past, present and future generations. This is one of the main tenets of sustainable forest management. Recent land claim settlements and self-government agreements have begun to recognize and define Aboriginal and treaty rights, including the right to access natural resources within the claim area. Voluntary measures, such as co-management agreements, also serve to bridge cultures and establish common interests.

Gathering and reporting on national forest statistics for a report such as this is challenging due to the fact that 13 different jurisdictions are involved in the process, and that data collection methodologies differ. This is evident in such areas as reporting on the age of Canada's forests, where provincial databases have differing definitions and age limits for mature and overmature stands. Provincial and territorial reporting requirements, which address operational demands, are targeted at a single region and are more specific than the country-wide data required for developing national policies and establishing national research priorities. The Canadian Council of Forest Ministers (CCFM), which is made up of the federal, provincial and territorial ministers responsible for forests, is currently working to address reporting and database standards for timber and non-timber values.

The CCFM is also making progress in forging a consensus on sustainable forest management on the domestic front, and in measuring Canadian achievements. In March of 1992, following nationwide public consultations, the CCFM released Canada's "National Forest Strategy", entitled *Sustainable Forests: A Canadian Commitment.* The stated goal is "... to maintain and enhance the long-term health of our forest ecosystems for the benefit of all living things, both nationally and globally, while providing environmental, economic, social and cultural opportunities for the benefit of present and future generations". The Strategy sets out nine strategic directions and 96 commitments, including a commitment to formulate indicators to measure and report on sustainable forest management. The Canadian framework of criteria and indicators, *Defining Sustainable Development: A Canadian Approach to Criteria and Indicators* was released in October 1995. The first report on this framework will be released in late 1997.

The Canadian criteria and indicators, which reflect the unique characteristics of Canada's forests, parallel in many respects those of the Montréal Process. Viewed as a whole, the domestic framework is intended to provide a common understanding of what is meant by sustainable forest management in the Canadian context. It allows Canada to describe the state of domestic forests and forest management and to identify those elements of the forest ecosystem, as well as the social and economic systems, that must be sustained or enhanced.

Canada has recognized the importance of conserving biological diversity in order to ensure the viability, resiliency and future sustainability of ecosystems. Canada ratified the *Convention on Biological Diversity,* which was first signed at the June 1992 UNCED

Earth Summit. Subsequently, all Canadian governments have been involved in the development of the *Canadian Biodiversity Strategy* and will use it to guide their policies. In addition, the "National Forest Strategy"positioned the Canadian forest sector to address a variety of biodiversity issues.

Canada's Model Forest Program was established in 1992. Already there are ten sites, with another currently being developed. Based on working partnerships and shared decision making, the objective of the model forests is to define, test and apply new approaches to sustainable forest management. Key to the program is that each site be managed for a wide range of forest values, such as wildlife and biodiversity, watersheds, recreation and traditional activities; and that the partners have a long-term commitment to sustainable management.

As leaders in the development and application of new approaches to sustainable forest management, the model forests of the Canadian network will each be developing local level indicators to monitor change and progress over time. These will be based on the Canadian criteria and indicators of sustainable forest management.

Canada strongly believes in the mutual benefits to be gained from the sharing of technology and expertise among the world's forest nations. Canadian scientists and researchers collaborate with those in other countries on a great many issues ranging from the global carbon cycle to systems to forecast and monitor wildfires. In addition, numerous government agencies spend millions of dollars on forest programs in developing countries.

Canada views the Montréal Process criteria and indicators as an important policy and science tool to help guide and assess progress toward sustainable forest management. In addition, Canada recognizes that the development and implementation of the criteria and indicators will require continuous refinement as science evolves, public values change and new knowledge of forest ecosystems is acquired.

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2. Natural Resources Canada—Canadian Forest Service, *The State of Canada's Forests, 1995-1996* (Ottawa, Ontario: 1996).
3. Canadian Council of Forest Ministers, *Defining Sustainable Management: A Canadian Approach to Criteria and Indicators* (CCFM, Ottawa, Ontario: 1995).

II CRITERION ONE

Conservation of biological diversity

II. Criterion 1: Conservation of biological diversity

i) Introduction

Biological diversity (biodiversity) refers to the variability among living organisms and the ecological complexes (ecosystems) of which they are a part. It is measured or observed at three different levels: ecosystems, species and genes. Conserving forest biodiversity ensures that they remain productive and resilient to disturbance. This allows the forests to fulfill their important multi-faceted role within ecosystems: recycling nutrients, and providing clean water and oxygen, in addition to producing commercial goods for society.

Canada has highly diverse forest ecosystems spanning wide ranges in temperature and precipitation–from the Carolinian forest in southwestern Ontario to the narrow strings of trees growing along Arctic rivers, and from the West Coast rainforests to the dry ponderosa pine forests in the southern part of interior British Columbia. Boreal ecosystems are also diverse, with complex mixtures of bogs, lakes and sparsely vegetated rocks and with forest stands at varying stages of development following fires and insect infestations. The northern portion of Canada's boreal forest includes vast expanses of open lichen woodland.

ii) Indicator Reports

1.1 Ecosystem diversity

1.1.a. Extent of area by forest type relative to total forest area

a. <u>What are we measuring?</u>

There are a number of issues which must be addressed before an accurate report can be made on this indicator. These are set out below:

* *In order to precisely define Canada's "total forest area", there must first be agreement on the minimum tree cover and minimum tree height needed to qualify an area as "forest".* At the northern fringe of the boreal forest, open subarctic lichen woodland grades into areas of tundra with scattered, stunted trees. The southern limit of the boreal forest is also poorly defined where aspen parkland and prairie meet. Efforts are underway by federal government agencies to develop a standard land cover classification for Canada using remote sensing data from satellites. Individual provinces and territories are also making efforts to address the issue. There is a need for national coordination.

* *It must be clear whether water bodies form part of Canada's "total forest area".* National forest statistics currently exclude any detectable water bodies and treeless wetlands. Boreal landscapes in particular tend to have high surface water and wetland areas, and the total forest area would increase significantly if these were included.

* *No common definition of forest type is used by Canada's federal, provincial, and territorial governments.* Reporting at the national level has historically involved

classifying forests into "softwoods", "mixedwoods" and "hardwoods". This classification provides only limited information on status of and trends in forest ecosystem diversity.

The federal government (NRCan — CFS[1]) maintains *Canada's Forest Inventory.* This is largely assembled from data in provincial and territorial timber inventories, which are produced by interpreting aerial photographs and are updated at the national level periodically; the last compilation dates to 1991. The main function of these provincial and territorial inventories is to assess timber volumes in areas allocated for timber sales or licenses. There is only limited information on the vast area of "non-commercial" forest in the boreal-tundra transition. Younger forests are under-represented owing to the focus on stands scheduled for harvest. Not all tree species can be distinguished in aerial photographs, and species are sometimes grouped under general headings, such as "spruces" or "unspecified broadleaves". In some cases, species data are omitted altogether. Nevertheless, *Canada's Forest Inventory 1991* provides the best available overview of the composition of Canada's forests.

All jurisdictions have some ground-based sample plots that provide accurate data on tree species composition, but frequency and method of sampling vary. Sample plot data are not integrated into inventories in a consistent fashion, and are not available at the national level.

b. Factual description

A 1996 National Ecological Framework (Figure 1.1.a.1) divides Canada into 15 terrestrial ecozones, 194 ecoregions and 1 020 ecodistricts. The following discussion draws upon a re-analysis of Canada's Forest Inventory 1991 using this framework. Although it is not a forest classification, this framework is useful for reporting existing data on forests.

The total area of Canada is 997.06 million ha, of which 42% is forested. Figure 1.1.a.2 provides an overview of forest cover in the 15 terrestrial ecozones based on data from Canada's Forest Inventory 1991. Eleven of the ecozones have 15% or more forest cover, and eight have at least 15% productive forest (defined in general terms as "capable of producing a harvestable volume of timber within a reasonable length of time"). Figure 1.1.a.3 shows the most common forest types in these eight ecozones.

Pacific Maritime forests are dominated by western and mountain hemlock, western red cedar, various true fir species, and Douglas-fir. Montane Cordillera forests have lodgepole pine, Engelmann and white spruce, subalpine fir, and Douglas-fir. Forests of the Boreal Cordillera are dominated by white and black spruce, lodgepole pine, and subalpine fir, occasionally mixed with poplars. White and black spruce and poplars dominate the Boreal Plains and Taiga Plains, in either pure or mixed stands; lodgepole and jack pine are also common.

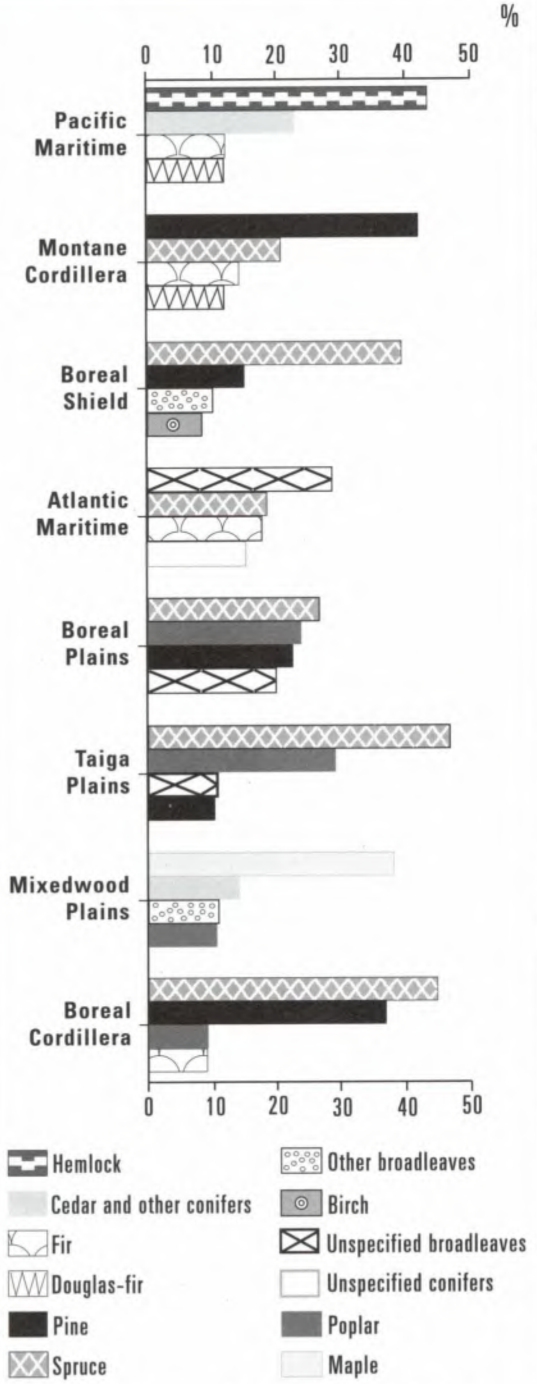
The Boreal Shield is Canada's largest ecozone (195 million hectares), and over three quarters of this area are forested. Data in *Canada's Forest Inventory 1991* suggest

1 Hereinafter referred to as NRCan-CFS

that approximately 40% of the forest area in this ecozone is dominated by black and white spruce, while jack pine occupies roughly 15%, and poplar, birch and balsam fir make up most of the remainder.

With more than 100 tree species, the Mixedwood Plains ecozone is the most diverse in Canada. Sugar maple is its most common species, while white cedar, trembling aspen and white birch are major secondary species. Roughly 10 million hectares of forest have been cleared in this ecozone, largely for agriculture and urban development. Of particular concern is the disappearance of the Carolinian forest, which occupies the southwestern portion of the ecozone. Less than 10% forest cover remains, and roughly 60% of Canada's endangered forest-dependent species are found there.

1.1.a.3 Dominant forest types by ecozone



Source: Natural Resources Canada–Canadian Forest Service

Dominant Atlantic Maritime species include black, white and red spruce, balsam fir, sugar and red maple, white birch, and trembling aspen. The abundance of some species, such as white cedar, white pine, red spruce, and eastern hemlock may have declined considerably during the past 200 years of harvesting, but better data on historical forest composition are needed to assess these changes.

c. Sources for information

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2. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch (Ottawa, Ontario).
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1.1.b. Extent of area by forest type and by age class or successional stage

a. What are we measuring?

Again, certain issues must be resolved before Canada can accurately report on its forest areas by forest type or age class.

Most of Canada's forests are composed of even-aged stands established following major disturbances such as fires, insect outbreaks and harvesting. These stands are dominated by species that grow best in full sunlight: jack pine, lodgepole pine, black spruce, trembling aspen and white birch. The age of stands is generally estimated from aerial photographs.

Age class data in the national inventory are not complete. In many cases, "maturity class" is used instead of "age class". This term reflects timber harvest potential. "Mature" and "over-mature" stands are ready for harvesting, while "regenerating" and "immature" stands are not. There is no simple correspondence between maturity class and age class, because the age of a "mature" stand depends on factors such as species composition, site condition and climate, as well as economic and market conditions.

A more accurate method of measuring stand age would be to record the year of a stand-initiating disturbance. Some timber inventories are updated regularly in this way. In other cases, areas surveyed to obtain timber volume data prior to harvesting may not be resurveyed for decades. Inventories also may not be updated to reflect stand-destroying forest fires. Data in *Canada's Forest Inventory* therefore may underestimate the proportion of younger-aged stands in Canada.

Age data for older stands are also recorded in different ways by individual jurisdictions. Most "over-mature" stands probably have significant proportions of trees that are approaching their maximum age, and large numbers of snags and fallen logs. There are no general guidelines for use of the term "old-growth" in Canada, and it is likely that definitions would differ between, for example, Boreal and Pacific Maritime forests.

A small but economically significant proportion of Canada's forests is composed of species that commonly reproduce in the shade and grow in uneven-aged stands. This includes the mixed conifer forests in the Pacific Maritime ecozone and the northern hardwood forests in the Atlantic Maritime and Mixedwood Plains ecozones. Descriptions of age distributions for these forests vary by jurisdiction. In some cases, the age of the dominant tree species is used to characterize the entire stand. *Canada's Forest Inventory 1991* may underestimate the proportion of uneven-aged stands in Canada's forests.

"Successional stages" could be used instead of "age classes" to describe the temporal dimension of ecosystem diversity. "Succession" refers to a process of change in the composition of an ecosystem as organisms respond to and modify the environment. Successional stages can vary greatly depending on the types of disturbance that occur in a given forest area. Tree species such as lodgepole and jack pine, that depend on heat to open cones and shed seed, tend to be more abundant after fire than after logging. The absence of a consistent system for recording major disturbances makes it impossible at this time to use "successional stages" to describe Canada's forests.

b. Factual description

Some differences in age class structure among ecozones are evident (Figure 1.1.b.1). Forests whose age exceeds 120 years are common mostly in the Pacific Maritime ecozone, where major fires and insect outbreaks are rare and many tree species have natural life spans of several hundred years. Some of these very old stands likely include canopy trees that span a wide range of ages, and could be described as "uneven-aged".

Data in *Canada's Forest Inventory 1991* indicate that substantial proportions of the forests of the Boreal Cordillera (39%) and Montane Cordillera (47%) ecozones are more than 120 years old. The proportion of forests in that age class is much smaller in the Boreal Shield (10%) and Boreal Plains (10%), and is even lower in the Atlantic Maritime (3%) and Mixedwood Plains (2%) ecozones.

Forests in eastern Canada tend to be younger because many of the tree species are short-lived (e.g., trembling aspen and balsam fir) and there is a high probability of major natural disturbances (e.g., fires and severe insect outbreaks).

Figure 1.1.b.1 also shows a decline in the proportion of hardwoods in older age classes in the Boreal Plains and Taiga Plains ecozones. Disturbances–clearcut harvesting in particular–tend to increase the abundance of poplar and birch in the boreal forest, and to decrease the abundance of spruce.

The composition and the age class structure of Canada's forests are continually changing, owing to the varying frequency of fires, insect outbreaks and harvesting. There is evidence that the average area affected annually by harvesting and fire has increased since 1970. This would be expected to lead to increased proportions of younger age classes and hardwoods in Canada's forests.

c. Sources for information

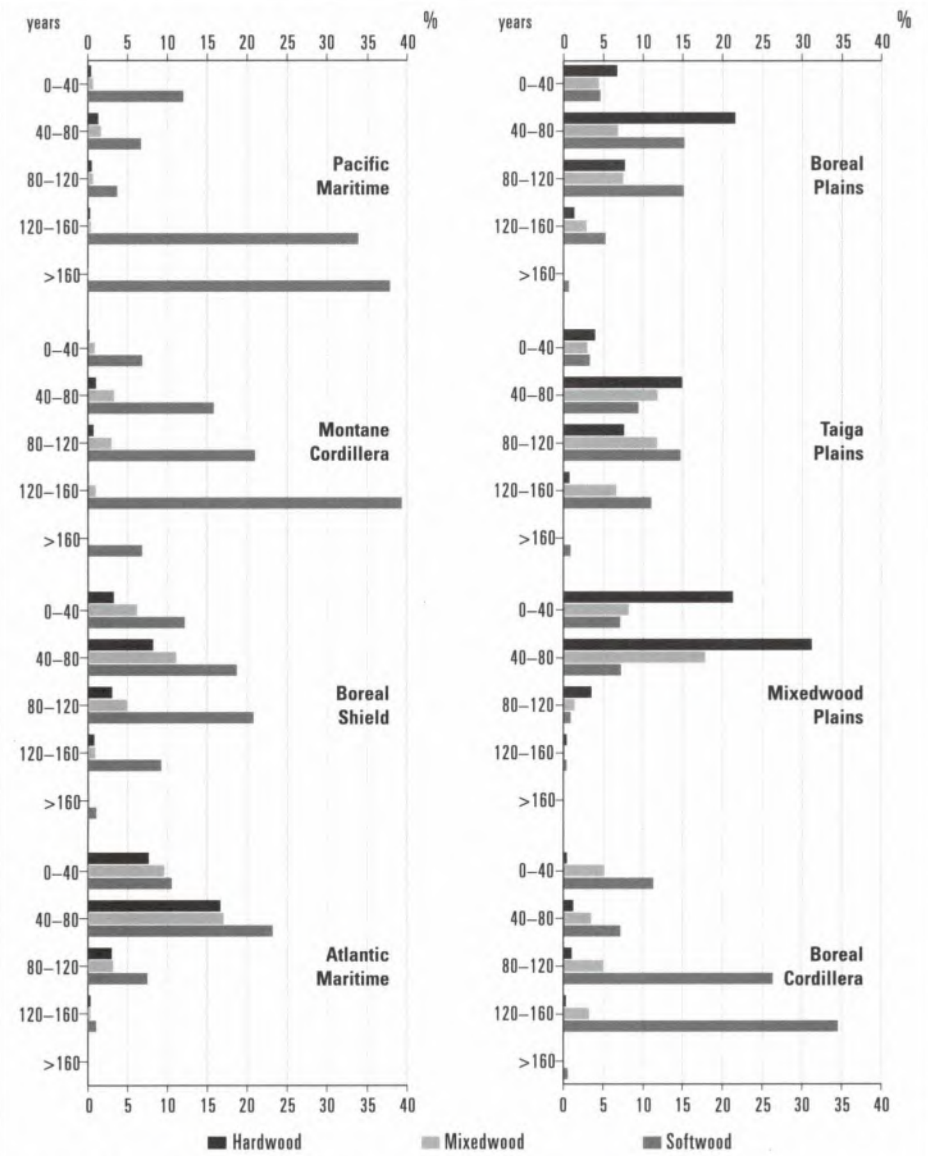
1. J.J. Lowe, K. Power, S.L. Gray.
2. J.J. Lowe, K. Power, M. Marsan.

1.1.c. Extent of area by forest type in protected area categories as defined by IUCN or other classification systems

a. What are we measuring?

Representative protected forest areas serve as ecological benchmarks for assessing the impact of forest management on biodiversity. Additionally, they provide wilderness experiences and other recreational benefits. They also maintain habitat for rare and endangered species and, ideally, allow natural processes to continue unimpeded. In November 1992, representatives of the Councils of Environment, Parks and Wildlife Ministers signed a statement of commitment to complete Canada's networks of protected areas by the year 2000. These networks are to be representative of Canada's land-based natural regions.

1.1.b.1 Age class distribution by ecozone and forest cover type



Source: Natural Resources Canada–Canadian Forest Service

Different categories of protected areas have been identified by the World Conservation Union (IUCN). Logging may occur in some protected areas provided that it does not conflict with the overall objective of conserving natural systems. The federal department of Environment Canada maintains a *Canadian Conservation Areas Database* containing information on protected areas, including date of establishment, location, responsible government agency, and IUCN category. By combining a preliminary land cover classification with the boundaries of protected areas in this database, the area of forest found in protected areas can be estimated and compared with the total area of forest in Canada.

It is not possible to provide a more detailed description of how well different forest types are represented in Canada's protected areas. Most jurisdictions cease forest inventory activities once a forest area is designated in a protected category that does not allow timber harvesting. As a result, *Canada's Forest Inventory 1991* does not include comprehensive information on the forest composition of protected areas.

b. Factual description

Figure 1.1.c.1 shows percentages of total forest area (estimated from satellite imagery) included in protected areas in 1985 and 1995 for the eight ecozones with more than 15% productive forest. Three bars are given for each year: "strictly" protected areas where timber harvest is prohibited, "other" protected areas where limited resource extraction may occur, and the sum of the two.

In 1995, approximately 7.6% of Canada's forest land was protected by legislation– an increase of 11% since 1985. Roughly half of these protected forests are "strictly protected", excluding them from such industrial activities as logging and mining. Because of the discrepancies regarding data and definitions, however, more analysis is needed to determine the exact number, location and size of protected forest areas in Canada.

Increases in the amount of protected forest have been even greater in some ecozones. In the Pacific Maritime, for example, the protected forest area more than doubled between 1985 and 1995, and accounted for approximately 6.6% of the total forest area in that zone at the end of that period. Virtually all of this area is strictly protected (no logging is permitted). In other ecozones, such as the Boreal Shield or the Atlantic Maritime, less than half the protected area has the same degree of protection.

Policies and programs to conserve biodiversity in forests outside protected areas are also being implemented through codes of forest practice, alternative harvesting methods and other measures. In addition to influencing the management of publicly owned forest lands under timber tenures, these programs can provide important benefits in ecozones, such as the Mixedwood Plains and Atlantic Maritime, where a large percentage of forest land is privately owned.

c. Sources for information

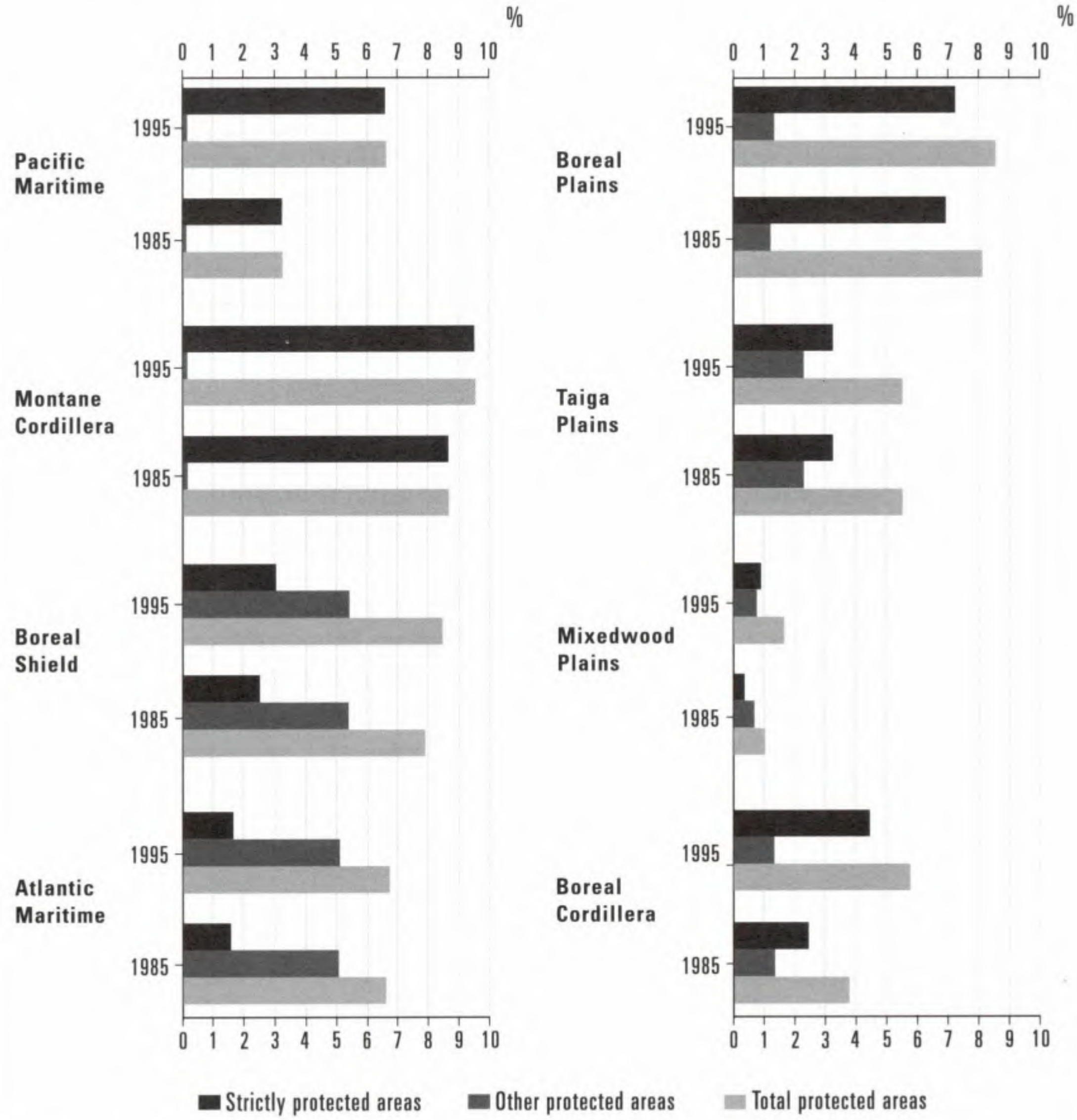
1. Canadian Environmental Advisory Council, *Protected Areas Vision for Canada* (Ottawa, Ontario: Minister of Supply and Services Canada, 1991).
2. IUCN, *Guidelines for Protected Area Management Categories* (Gland, Switzerland and

Cambridge, UK: Commission on National Parks and Protected Areas, with the assistance of the World Conservation Monitoring Centre, 1994).

1.1.d. Extent of areas by forest type in protected areas defined by age class or successional stage

Although some agencies–such as British Columbia's Ministry of Forests and the federal government's Parks Canada–maintain detailed descriptions of the forests in the protected areas they manage, Canada lacks consistent national-level data on forest types and age classes in protected areas.

1.1.c.1 Protected forest areas by ecozone



Source: Environment Canada–Canadian Conservation Areas Database

1.1.e. Fragmentation of forest types

a. What are we measuring?

When ecosystem components become separated in time and space, the integrity of the ecosystem is challenged. This fragmentation can affect critical connections within an ecosystem. For example, the proximity of a mature red pine forest to a recently burned forest of the same type influences natural regeneration, landscape diversity and wildlife habitats. Fragmentation of this forest type will have consequences for ecosystem functioning. From ecological modelling and baseline studies in natural forested landscapes, it may be possible to derive critical thresholds for levels of fragmentation below which there is no known adverse effect on the sustainability of an ecosystem.

By designing harvesting and other silvicultural activities to emulate natural disturbances, forest managers help minimize the impacts on biodiversity. Through ecological modelling and baseline studies in natural forest landscapes, it may be possible to determine the impact of fragmentation and the level at which it does not adversely affect an ecosystem's sustainability.

The first requirement for obtaining data on fragmentation is to map the spatial location of ecosystem components. This has been done for individual study sites in Canada, but not on a wider scale suitable for national reporting. A standard national land cover classification would represent a significant advance in the ability to assess forest fragmentation. The most effective tool for mapping forest fragmentation would be a combination of aerial photography and satellite imagery.

In the absence of national-scale data, a proxy indicator for human intrusion into landscapes can be assessed using road density in two provinces: New Brunswick and British Columbia. Although road density is also a function of terrain, it is an indicator of human intrusion into forest landscapes, with significant consequences for forest fragmentation.

In most parts of Canada, roads are a precursor to human activity. The density of roads clearly illustrates the intensity of human activities, ranging from urban areas with very high densities, to remote areas with sparse or nonexistent road networks. Density is expressed as the length of all existing roads divided by the surface area of the region in question.

Some wildlife species are highly sensitive to roads. Wolves, for example, are almost never found where there are more than 0.45 km of roads per km^2 of land surface.

b. Factual description

While the Atlantic Maritime ecozone has moderate road density throughout (>0.25 km/km^2), the Taiga Plains and Boreal Cordillera ecozones of British Columbia have vast stretches with sparse road densities (<0.25 km/km^2). Comparative figures are available for Alaska (0.08 km/km^2), Maine (0.53 km/km^2), the United Kingdom (2.29 km/km^2), and Connecticut (8.76 km/km^2).

Areas located within a certain distance from any road are more likely to be fragmented by human influences. For example 1 km could be chosen as a distance within which human influences are most pronounced. In British Columbia, only 22% of the landscape is within this range. The remaining 78% is relatively undisturbed.

c. Sources for information

1. Canadian Centre for Geomatics, *Canadian Road Networks Database* (Sherbrooke, Québec).

1.2 Species diversity

1.2.a. The number of forest dependent species

a. What are we measuring?

Some 180 tree species grow in Canada, and it is estimated that the forest is home to approximately 140 000 species of plants, animals and microorganisms (excluding viruses), about half of which have been classified by science. Each of Canada's major forest regions is inhabited by distinct groups of species determined, in part, by the ecosystem's productivity, which in turn is influenced by geography, history, soil nutrients, temperature ranges, growing seasons and moisture levels.

The Montréal Process Technical Advisory Committee has defined a forest-dependent species as one "that needs forest conditions for all or part of its requirements of food, shelter or reproduction". This definition does not provide a precise guide for all species. For example, trees that fall into lakes and rivers provide critical fish spawning habitat during the tens to hundreds of years they take to decay. Fallen tree leaves are essential food sources for a wide variety of aquatic insects, and trees themselves maintain aquatic habitat by providing shade and stabilizing stream banks. It is not clear, however, whether fish and other aquatic organisms are considered "forest-dependent species".

b. Factual description

Canada has roughly 3 300 native vascular plant species, 160 terrestrial mammal species, 610 bird species (435 of which have been recorded as nesting), 85 species of amphibians and reptiles, and 175 freshwater fish species. Although nearly all species in these groups have been described by taxonomists, many species of insects, mites, nematodes, fungi, and other groups of organisms remain to be described. It appears, for example, that the approximately 55 000 species of insects described to date in Canada may be only half the actual total. Studies in the tree-tops of Pacific Maritime forests are revealing many new mite species and a diverse arthropod fauna that differs greatly from that found in the underlying soil. DNA analysis suggests that there are many more fungal species that have not been isolated and grown in pure culture than have been described to date. Microbiologists debate whether the term "species" can be applied to bacteria, while most agree that it is inappropriate for viruses.

In total, Canada's forests are home to approximately 140 000 species of plants, animals and microorganisms, only half of which have been described by science. (If viruses are included, the total number could rise to nearly 300 000). Approximately two thirds of these species are found in forests or are dependent on a forest habitat. Given the difficulty of defining "forest-dependent species", and the gaps in taxonomic understanding for lesser-known groups, the discussion for subsequent indicators will focus on the better known groups of higher plants and vertebrate animals that inhabit Canada's forests.

c. Sources for information

1. Natural Resources Canada-Canadian Forest Service, "Biodiversity–Nature's Safety Net", *The State of Canada's Forests 1993* (1994), p. 18-35.
2. T. Mosquin, P.G. Whiting, and D.E. McAllister, *Canada's Biodiversity: the variety of life, its status, economic benefits, conservation costs and unmet needs* (Ottawa, Ontario: The Canadian Museum of Nature, 1995).

1.2.b. The status (threatened, rare, vulnerable, endangered, or extinct) of forest dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment

a. What are we measuring?

"Extinct" refers to species that no longer exist. Two forest-dependent species in Canada have become extinct due to overhunting: the passenger pigeon (1914) and the Queen Charlotte Islands caribou (1935). Endangered species are those facing imminent extinction or extirpation (extinction in Canada). The wild turkey is an example of a species that was extirpated from its original Canadian range in southern Ontario (it has since been successfully reintroduced using birds from the United States). A threatened species could become endangered if limiting factors are not reversed, and vulnerable species are those that are especially sensitive to human activities or natural disturbances.

The federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is a voluntary scientific organization that includes representatives from all provinces and territories, as well as the federal government and non-governmental agencies. It maintains and updates annually national lists of animals and plants falling into the above categories ("at risk").

Some provinces and territories maintain their own lists of species at risk. Provincial, territorial and national lists do not always correspond because species may be endangered in one jurisdiction but not another, or because national assessments are as yet incomplete for some species.

b. Factual description

Figure 1.2.b.1 lists 78 forest-dependent species at risk at the national level. The national list now includes nine endangered animal species and ten endangered plant species that need forest conditions for all or part of their feeding, breeding or shelter requirements.

The two forest areas that contain the most species at risk are those with the most restricted distribution in Canada: 18 at-risk species are found in the temperate rainforests

1.2.b.1 Forest-dependent species by ecozone that are listed by COSEWIC as vulnerable, threatened or endangered

ECOZONE	ANIMALS			PLANTS		
	Vulnerable	Threatened	Endangered	Vulnerable	Threatened	Endangered
Pacific Maritime	grizzly bear, wolverine, ermine *(Queen Charlotte Island's population)*, Keen's long-eared bat, Pacific giant salamander, Queen Charlotte goshawk	marbled murrelet	Vancouver Island marmot, spotted owl	phantom orchid, cryptic paw lichen, oldgrowth specklebelly lichen, seaside bone lichen	yellow montane violet, white-top aster	seaside centipede lichen, deltoid balsamroot, prairie lupine
Montane Cordillera	grizzly bear, wolverine, Nuttall's cottontail, fringed myotis bat, pallid bat, spotted bat, flammulated owl	yellow-breasted chat, white-headed woodpecker	spotted owl	—	—	—
Great Lakes–St. Lawrence [a]	southern flying squirrel, wood turtle, red-shouldered hawk, cerulean warbler, red-headed woodpecker	eastern Massasauga rattlesnake	Kirtland's warbler	broad beech fern, green dragon	blunt-lobed woodsia, deerberry, ginseng, white wood aster	spotted wintergreen
Carolinian [b]	southern flying squirrel, wood turtle, cerulean warbler, yellow-breasted chat, prairie warbler, Louisiana waterthrush, red-headed woodpecker, grey fox, eastern mole	hooded warbler	blue racer snake, prothonotary warbler, Acadian flycatcher	Shumard oak, common hop tree, dwarf hackberry, American columbo, broad beech fern, false rue-anemone, few-flowered club rush, green dragon, wild hyacinth	American chestnut, blue ash, Kentucky coffee tree, red mulberry, ginseng, bird's-foot violet, deerberry, golden seal, nodding pogonia, purple twayblade, round-leaved greenbriar, white wood aster	cucumber tree, heart-leaved plantain, large whorled pogonia, small whorled pogonia, spotted wintergreen, wood poppy, drooping trillium
Boreal Shield	woodland caribou, wolverine *(western population)*, Gaspé shrew	woodland caribou *(Gaspé population)*	cougar, wolverine *(eastern population)*, Newfoundland pine marten	—	—	—
Boreal Plains	woodland caribou, wolverine	wood bison	—	—	—	—
Atlantic Maritime	southern flying squirrel, Gaspé shrew, wood turtle	Blanding's turtle *(Nova Scotia population)*	cougar	—	—	—

[a] the Great Lakes–St. Lawrence forest, which includes the northern portion of the Mixedwood Plains ecozone and the southern portion of the Boreal Shield ecozone in extreme southeastern Manitoba, Ontario and Quebec, has its own characteristic group of species

[b] the Carolinian forest, which is part of the Mixedwood Plains ecozone in extreme southwestern Ontario, has a unique and characteristic group of species

of British Columbia (Pacific Maritime ecozone) and 41 in the Carolinian forests of Ontario (Mixedwood Plains ecozone). These areas include some of Canada's best soil and climatic conditions for forest growth. Pacific Maritime forests have been heavily used for timber production, and clearing of the Carolinian forest for agriculture and human settlement began more than 300 years ago.

Some endangered species are highly dependent on mature forests. They include the prothonotary warbler and Acadian flycatcher in Ontario, the woodland caribou in the Gaspé Peninsula of Québec, the pine marten in Newfoundland, and the spotted owl in British Columbia.

The two most widespread forest species at risk are the woodland caribou and the wolverine. Woodland caribou require mature coniferous forests, which are disappearing in many areas of their range. Indeed, there is considerable concern over caribou habitat loss in Québec, Ontario, Saskatchewan, Alberta and British Columbia. Wolverines, on the other hand, use a variety of forest habitats. Like grizzly bears, however, they are negatively affected by low levels of disturbance, occur naturally in low abundance, and have been heavily trapped throughout the past century. Wolverines are listed as endangered in Ontario, Québec and Labrador. In Alberta, where approximately 1 000 individuals are estimated to exist, they are listed as vulnerable.

c. Sources for information

1. Committee on the Status of Endangered Wildlife in Canada, *Canadian Species at Risk* (Ottawa, Ontario: 1996).
2. Wildlife Habitat Canada, *Saving Species: Building Habitat into Endangered Species Conservation in Canada* (Ottawa, Ontario: 1995).

1.3 Genetic diversity

1.3.a. Number of forest dependent species that occupy a small portion of their former range

a. What are we measuring?

"Small portion" can be defined as "...a reduction of at least 50% in the proportion of the known historical range within Canada occupied by a given species." Many species currently occupy a small portion of their former range, and most of the reductions result from habitat loss. Other factors, such as hunting and trapping, may also contribute to reduced distributions of species.

Species ranges in Canada have changed over geological time scales, particularly in response to glacial advances and retreats. Changes in Canada's forest landscapes caused by human activity are most pronounced in southern and coastal areas where the climate is moderate and human population densities highest. Another important factor over the past 150 years has been temperature fluctuations. During the warming trend that occurred from 1900 to 1940, an expansion was recorded in the ranges of white-tailed deer, bobcat and grey fox in Ontario; during the subsequent cooling period, their ranges were reduced.

b. Factual description

Figure 1.3.a.1 lists forest-dependent species whose population levels have decreased in comparison with known historical range. Most of these have been affected primarily by habitat loss–through clearing of forest lands for agriculture and settlement–and by reductions in the amount of forest in the older age classes.

Figure 1.3.a.1 includes species that have been listed by individual provinces as being at risk, but that do not appear on the national list prepared by COSEWIC. All the COSEWIC species should also be included under this indicator. In addition to species at risk, some more common species are also included. For example, the amount of black and white spruce in older classes has declined considerably in the eastern boreal forests. During the late 1800s, white pine was heavily harvested in Newfoundland to meet the demands of the British shipbuilding trade. The species, which was never abundant in Newfoundland, has not regenerated to its former levels. In Ontario, white pine forests now support a harvest that is 75% smaller than in 1900. Both the Government of Ontario and that of Newfoundland and Labrador now have programs that are focussed on conserving white pine.

1.3.b. Population levels of representative species from diverse habitats monitored across their range

a. What are we measuring?

Species populations fluctuate in response to many factors, and often to factors acting in combination. Therefore, it is not always possible to attribute simple cause and effect to such factors as habitat and population. At specific study areas throughout the country, individual species or groups of species have been monitored for a number of years, or there are indirect indices of their populations. Examples include breeding songbirds, certain furbearers (e.g., marten in Newfoundland), and moose and deer in most provinces.

An important consideration is that all forests are modified by disturbances, and species have adapted to those disturbances. For example, much of the boreal forest is naturally composed of younger age classes, so many boreal plants and animals inhabit early successional forests. While some species prefer mature stands, a large number of species benefit from forest harvesting, including some of the large ungulates (e.g., moose, white-tailed deer, and elk) and many species of passerine birds (e.g., yellow warbler and most forest sparrows). Therefore, sustainable forest use requires the monitoring of species and communities in all forest age classes.

b. Factual description

The decline of woodland caribou in the interior montane region of British Columbia provides an example of the interactions among species, habitat and functional relationships. In that region, harvesting increased the amount of food available in young regenerating forests and resulted in an expanded moose population. The larger moose population in turn supported an increase in wolves, which meant higher predation rates and lower populations of caribou than would have been expected based solely on the remaining

1.3.a.1 Forest-dependent species by ecozone that occupy only a small portion of their former range (excluding species listed by COSEWIC)

ECOZONE	ANIMALS	PLANTS
Pacific Maritime	black-tailed deer, Roosevelt elk, Townsend's chipmunk, Trowbridge's shrew, Sitka mouse, Pacific jumping mouse, shrew-mole, Townsend's big-eared bat, Yuma myotis bat, silver-haired bat, sharp-tailed snake, clouded salamander, varied thrush, ancient murrelet, Vaux's swift, Peale's peregrine falcon, Lewis' woodpecker	Garry oak, yellow-cedar
Montane Cordillera	Rocky Mountain elk, fisher, silver-haired bat, Yuma myotis bat, Townsend's big-eared bat, gopher snake, tailed frog, Coeur d'Alene salamander, varied thrush, three-toed woodpecker, Williamson's sapsucker, Lewis' woodpecker, Vaux's swift, mountain chickadee	ponderosa pine
Great Lakes–St. Lawrence[a]	Canada lynx, wapiti, river otter, silver-haired bat, small-footed bat, brown snake, spring salamander, pickerel frog, bald eagle, golden eagle, peregrine falcon, Cooper's hawk, great gray owl, barred owl, spruce grouse, black-backed woodpecker	white pine, red pine, eastern hemlock, white spruce, wild leek, autumn coral-root
Carolinian[b]	bobcat, fisher, marten, river otter, woodland vole, wild turkey, screech owl	all forest-dependent species
Boreal Shield	silver-haired bat, barred owl, boreal owl, black-backed woodpecker, three-toed woodpecker, grey-cheeked thrush, red crossbill	white pine, black spruce, white spruce
Boreal Plains	silver-haired bat, barred owl, boreal owl, black-backed woodpecker, three-toed woodpecker, varied thrush	green ash, white spruce
Atlantic Maritime	fisher, lynx, marten, barred owl, black-backed woodpecker, three-toed woodpecker	white pine, red pine, red spruce, eastern hemlock

[a] the Great Lakes–St. Lawrence forest, which includes the northern portion of the Mixedwood Plains ecozone and the southern portion of the Boreal Shield ecozone in extreme southeastern Manitoba, Ontario and Quebec, has its own characteristic group of species

[b] the Carolinian forest, which is part of the Mixedwood Plains ecozone in extreme southwestern Ontario, has a unique and characteristic group of species

suitable habitat. An understanding of this situation was made possible only by the constant monitoring of all of the species in the study area. Data of this type are rarely available.

Ideally, a pool of species for each forest age class would be chosen and monitored to report on the functioning of an ecosystem. Criteria for species selection would include: functional links between species (e.g., predator and prey), body size (to reflect various spatial scales), breeding and feeding requirements, use of specialized habitat features, trophic levels and possible keystone roles (i.e., whether loss of the species would have an impact on several other species). Figure 1.3.b.1 lists species that could be monitored for the various forest ages and ecozones. A more definitive list will be developed following consultations with wildlife biologists across Canada. Data exist for the trees and most of the large-bodied animals, and provincial agencies are beginning to accumulate data for other species. However, not all Canadian species have been identified (especially invertebrates), and historical data for most species are not available.

c. Sources for information

1. Natural Resources Canada–Canadian Forest Service, "Forest wildlife", *The State of Canada's Forests 1994* (Ottawa, Ontario: Natural Resources Canada, 1995), p. 18-41.
2. D. W. McKenney, R.A. Sims, M.E. Soulé, B.G. Mackey, K.L. Campbell, "Towards a Set of Biodiversity Indicators for Canadian Forests", *Proceedings of a Forest Biodiversity Indicators Workshop* (Sault Ste. Marie, Ontario: Natural Resources Canada–Canadian Forest Service, 1994).
3. T. Mosquin, P.G. Whiting.

iii) Summary

The ability of forest species to adapt to changing environmental conditions is determined, in large part, by their genetic diversity–a fundamental element that is the basis for species and ecosystem diversity. Simple, practical measures can conserve genetic diversity where it occurs naturally and in off-site settings, such as seed banks and seed orchards. Governments and industry are applying some of these measures, but coordinated forest genetic conservation strategies are not fully in place, either nationally or provincially.

Conifers are abundant in Canada, notably in the vast spruce and pine forests of the Boreal Shield, and in the hemlock, cedar, fir and Douglas-fir forests of the western mountains. Poplars are commonly found mixed with spruces in the Boreal Plains and Taiga Plains, and mixed with a variety of other conifers and hardwoods (mostly birch and maple) in eastern forests.

The average age of Canada's forests decreases from west to east, reflecting natural variations in species longevity and differences in the frequency of disturbances (e.g., fires, insect outbreaks and timber harvesting). Forests exceeding 120 years in age are common mostly in the Pacific Maritime ecozone.

1.3.b.1 Animal indicator species in forest ecozones by age of stand (continued from page 14)

ECOZONE	FOREST STAGE		
	Young	Mature	Old growth[a]
Montane Cordillera (subalpine)	moose, lynx, mule deer, black bear, golden-crowned sparrow	caribou, grizzly bear, mountain chickadee, red crossbill	caribou, marten, black-backed woodpecker, three-toed woodpecker, spotted owl, Hammond's flycatcher
Boreal Plains (includes Alberta Montane and aspen parkland)	moose, wapiti, lynx, ruffed grouse, hairy woodpecker, snowshoe hare	caribou, elk, grizzly bear, flying squirrel, varied thrush, barred owl, boreal chickadee, red crossbill, Cooper's hawk, wolverine, long-eared bat	marten, wood bison, black-backed woodpecker, boreal owl, three-toed woodpecker, silver-haired bat
Boreal Shield (north)	moose, lynx, snowshoe hare, ruffed grouse, hairy woodpecker	caribou, northern flying squirrel, barred owl, boreal chickadee, red crossbill, wolverine, long-eared bat, rock vole	marten, black-backed woodpecker, three-toed woodpecker, boreal owl, silver-haired bat
Boreal Shield (Newfoundland)	moose, lynx, snowshoe hare, ruffed grouse, hairy woodpecker	caribou, red crossbill, boreal chickadee, ovenbird	marten, black-backed woodpecker, grey-cheeked thrush, meadow vole
Great Lakes–St. Lawrence[b]	moose, white-tailed deer, lynx, snowshoe hare, ruffed grouse, hairy woodpecker	fisher, red-shouldered hawk, red crossbill, Cooper's hawk, barred owl, pileated woodpecker, long-eared bat	marten, pileated woodpecker, silver-haired bat, southern flying squirrel, small-footed bat
Carolinian[c]	white-tailed deer, grey fox, hooded warbler	white-tailed deer, woodland vole, red-bellied woodpecker, cerulean warbler, Acadian flycatcher	southern flying squirrel, prothonotary warbler, screech owl
Atlantic Maritime	white-tailed deer, lynx, snowshoe hare, hairy woodpecker	white-tailed deer, Bicknell's thrush, red crossbill	marten, black-backed woodpecker, barred owl

a "old growth" is defined as stands in which there is a net annual loss of the standing biomass of mature trees; many old-growth species are also found in older mature forests
b the Great Lakes–St. Lawrence forest, which includes the northern portion of the Mixedwood Plains ecozone and the southern portion of the Boreal Shield ecozone in extreme southeastern Manitoba, Ontario and Quebec, has its own characteristic group of species
c the Carolinian forest, which is part of the Mixedwood Plains ecozone in extreme southwestern Ontario, has a unique and characteristic group of species

Approximately 7.6% of Canada's forests are in protected areas, and logging is prohibited in approximately half of these areas (forests classified as strictly protected). Between 1985 and 1995, there was an overall gain of 11% in the amount of protected forest in Canada, including a doubling of the protected forest area in the Pacific Maritime ecozone.

Canada still possesses nearly its entire original complement of forest species and ecosystems. With adequate management and research strategies, Canada should be able to maintain its forest biodiversity for future generations. However, more knowledge is required of all three biodiversity elements–ecosystems, species and genes.

With the exception of the Carolinian forest, the vast majority of species in Canada's forests are not in danger of extinction. Most species use young forests, and with proper planning to maintain sufficient old-growth forests and the habitat features needed by those at risk, Canada should be able to maintain all of its forest species. Several approaches are being taken to protect species that are becoming more rare, including: developing management plans to maintain and develop habitats; incorporating ecosystem and species concerns into forest planning; monitoring populations to ensure that future declines do not occur; and protecting species and their habitats from further destruction due to roads and development.

Existing tools and methodologies could be adapted to assess the status of forest biodiversity in Canada. These include wildlife monitoring programs, remote sensing technologies, and *Canada's Forest Inventory.* However, they are all either currently being applied only on a limited or experimental basis, or have been designed for other purposes. Such tools would have to be redesigned and expanded to provide a system for reporting nationally on the state of forest biodiversity. It is important for Canada to establish adequate databases to provide baseline information on the biodiversity contained in its vast forests. These databases could provide useful information for future forest management decisions.

III CRITERION 2

Maintenance of productive capacity of forest ecosystems

III. Criterion 2: Maintenance of productive capacity of forest ecosystems

I) Introduction

Productive capacity is one way to measure the sustainability of the flow of benefits to society. It applies to both timber and non-timber resources and is a key factor in assessing progress toward sustainable forest and wildlife management.

This criterion focusses on the productive capacity of the forest resource base relative to two of its extractive uses: timber and wildlife. In order to ensure that these renewable resources are conserved for future generations while maintaining a satisfactory flow of benefits in the present, their extraction must not be allowed to exceed the long-term productive capacity of the forest. Rates of extraction which exceed physical productivity will eventually lead to a degraded resource base unable to provide either market or non-market benefits. The potential impacts include a reduction in economic benefits, social disruptions, loss of outdoor recreation opportunities and an elimination of ecosystem services such as biodiversity, soil retention, and clean air and water.

Most of Canada's forest land (94%) is under public ownership. Timber and wildlife on public lands are generally managed on a sustainable-yield basis in Canada in that harvest levels are regulated to ensure they do not result in depletion of resource stocks. In addition to regulating the rate of consumption of products from forest lands, management agencies also make significant investments to enhance resources.

Productive capacity can be measured by evaluating the magnitude and impact of harvesting, land-use changes and natural disturbances on the resource, versus the ability of the resource to sustain itself through a combination of natural processes (e.g., regeneration and growth) and management activities (e.g., silviculture and protection). Some information is available on changes in the commercial forest landbase, population levels of certain species, and forest management activities. All of this information provides some perspective regarding the productive capacity of the forest.

ii) Indicator reports

2.a. Area of forest land and net area of forest land available for timber production

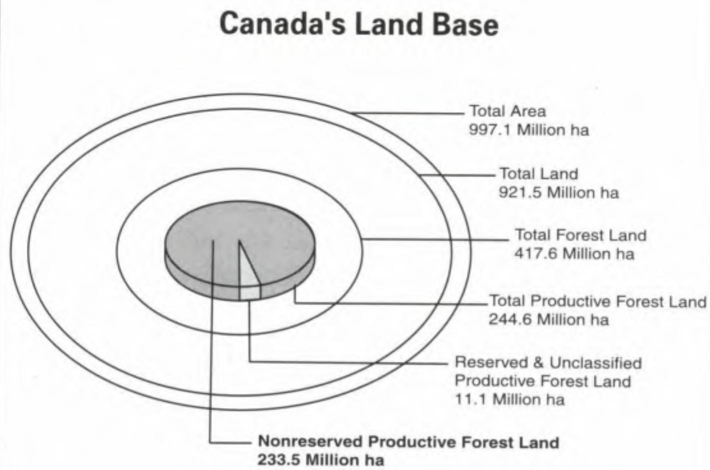
a) <u>What are we measuring?</u>

This indicator measures the extent of the total forest land area in Canada and the proportion thereof that is commercially productive, non-reserved, and economically accessible. Non-reserved forest land is that which has not been placed in parks, wilderness areas, wildlife preserves or ecological reserves. Some discussion is also provided on policies and regulations enacted by resource management agencies to limit the loss of forest land to alternate uses.

b) Factual description

The total area of Canada is 997.1 million hectares. Of this, 93% are land, while the remaining 7% are lakes and rivers. Approximately 41.9% (417.6 million hectares) are classified as forest land (Figure 2.a.1).

Fig. 2.a.1



Compendium of Canadian Forestry Statistics, 1996

Not all land classified as forest is suitable for commercial timber harvesting. Approximately 170 million hectares are classed as timber unproductive forest land where the trees are too small at maturity or too scattered to be suitable for harvesting. Most of this landbase is situated in the transition zone between the northern tundra and the southern coniferous forests. Approximately 3 million hectares of forest land have not been inventoried and their suitability for commercial timber harvesting is undetermined. According to the most recent (1994) *Canada's Forest Inventory,* the timber productive forest landbase is approximately 244.6 million hectares.

The fact that land is considered productive does not mean that it is available to the forest products industry for commercial development. About eleven million hectares have been reserved, mostly in provincial and national parks or are unclassified. This leaves an area of 233.5 million hectares of productive forest land where timber can potentially be harvested. This is referred to as Canada's "commercial" forest landbase. However, about half of this forest land is located in remote areas and is economically inaccessible for harvesting. Thus, the total area of productive forest land that is non-reserved, economically accessible and actively managed for timber production is approximately 117 million hectares. It should be noted that these lands are managed for a range of benefits in addition to timber production. Other values which are considered in land-use planning include game, fur-bearing animals, endangered species protection, culturally important sites, outdoor recreation, water, and landscape aesthetics.

Most of Canada's forest land is under public ownership (provincial, 71%; federal and territorial, 23%). The provincial and territorial governments, which manage most (88%) of the commercial forest land, have enacted a range of policies and regulations to restrict the sale or privatization of forest land and its conversion to other uses. Manitoba, for example, does not permit the sale of its designated public forest land–public lands with forest cover can only be sold if they are designated for agricultural purposes. In British Columbia, the 1994 *Forest Land Reserve Act* ensures that designated land cannot be withdrawn from forest production. Alberta's *Green Area Policy* (established in 1948) states that public forest land will be managed primarily for forest production, watershed protection, recreation and other multiple uses. Disposal of public land in Saskatchewan requires an amendment to the *Forest Act,* while Ontario's *Public Lands Act* enables the

Ministry of Natural Resources to prohibit, regulate and control the sale of public land. The amount of public forest land that is sold to private owners and subsequently converted to alternate uses (e.g., farmland) is minimal. The level of deforestation on public land from flooding, mining or the establishment of pipelines or rights-of-way also appears to be limited.

One factor affecting the availability of forest land for commercial harvesting is the steady increase in the amount of public forest land protected for purposes such as parks, wilderness areas and reserves. Within areas that have not been protected as parks, governments have established policies and guidelines to regulate and control commercial timber harvests and other activities such as mining and agriculture. For example, logging is prohibited or restricted on buffer strips along waterways and on steep slopes. In many regions of Canada, forest cover must also be maintained for scenic values and wildlife habitat. The combined effect of these policies has been, and will continue to be, some local reductions in the amount of public forest land available for timber production.

c) Sources for information

1. Natural Resources Canada–Canadian Forest Service, *Canada's Forest Inventory 1991* (Ottawa, Ontario: 1994).
2. Provincial forestry agencies.

2.b. Total growing stock of both merchantable and non-merchantable tree species on forest land available for timber production

a) What are we measuring?

Canada does not have a Continuous Forest Inventory system. Canada's Forest Inventory takes advantage of existing data available from the provincial and territorial forest services, and uses very economical methods for aggregation to the national level. Although *Canada's Forest Inventory 1991* does include estimates of the volume of growing stock of merchantable species at the national level, these are not provided in this report. The reasons are as follows:

* The national inventory is not able to provide measures of changes in growing stock over time;

* The national inventory does not include estimates of the volume of growing stock of non-commercial species.

2.c. The area and growing stock of plantations of native and exotic species

a) What are we measuring?

This indicator reports on the extent of successful regeneration on publicly owned forest land harvested under even-aged management between 1975 and 1995. Information on the growing stock of plantations of native species is not available at the national level. The volume of growing stock of plantations of exotic species is minimal.

Selection harvesting is commonly used in uneven-aged forest stands. This regeneration technique creates relatively small openings in the forest canopy to maintain an uneven-aged structure with trees of all ages and sizes. Regeneration is continuous in uneven-aged stands–the stands are not removed and replaced as is the case with even-aged stands–and therefore these areas are not included in the landbase described in this indicator. Selection harvesting accounted for slightly more than 11% of the area harvested in Canada in 1995, almost double the percentage in 1975. The regenerating landbase amounted to slightly more than 14 million hectares in 1995.

b) Factual Description

Most Canadian forests are even-aged and comprise species that regenerate following major disturbances such as fire. In Canada, management of even-aged forests attempts to mimic this life cycle.

The silvicultural systems used in managing even-aged forests for timber production are clearcut, seed-tree and shelterwood harvesting. Clearcut harvesting is the most widely used silvicultural system in Canada, although harvesting techniques are changing. In Ontario, for example, increasing use is made of "careful logging around advance growth". In Québec, "cutting with protection of regeneration and soils" was mandated by the new *Forest Act*. This technique accounted for 22% of the area harvested under even-aged management in 1987 when the new act came into force, and 84% in 1995.

Since the 1980s, most jurisdictions in Canada have passed legislation or signed agreements which require logging companies to ensure regeneration on sites they harvest. Alberta has had mandatory reforestation requirements for all tenures since the mid-1960s. Foresters' options include selection cutting in forest types that are suited to uneven-aged management, clearcutting and scarifying[2] to promote natural regeneration, or adopting a modified harvesting method to protect advance regeneration. Clearcut areas may also be regenerated by planting or seeding.

"Understocked" means those harvested areas that will require silvicultural treatment to meet stocking standards, which are an expression of the adequacy of tree cover. It includes unsurveyed harvest areas where regeneration status cannot be predicted. "Successfully regenerated" includes a proportion of recently harvested areas which are expected to become restocked without further treatment.

Provincial planting and seeding programs were substantially increased in the 1980s under the Federal/Provincial Forest Resource Development Agreements (FRDAs) and through new legislation which enforced better regeneration practices. By the early 1990s, planting programs had largely eliminated the backlog of treatable understocked sites, and several provinces began scaling back their planting programs. The exception is British Columbia, which, after cutting back its planting program in 1991, increased it again to account for more than half of the 400 000 hectares planted across Canada in 1994 and 1995.

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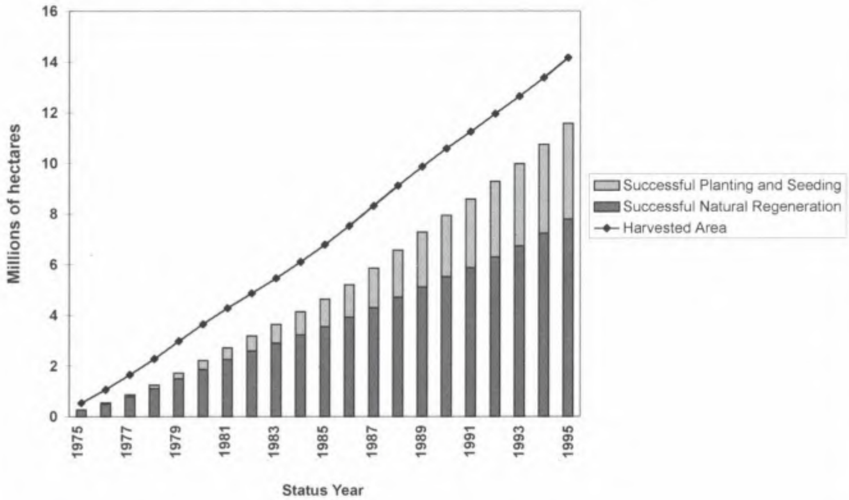
2 "Scarification" is defined in REGEN as mechanical preparation of the forest floor to assist germination of seed from standing trees or slash or to promote the occurrence of coppice or sucker growth.

Today, Canadian forestry relies on advance regeneration and appropriate regeneration techniques to ensure that the majority of harvested areas will regenerate naturally. The remaining sites are regenerated by planting or seeding. Additional seedlings can be planted on sites where existing regeneration is inadequate.

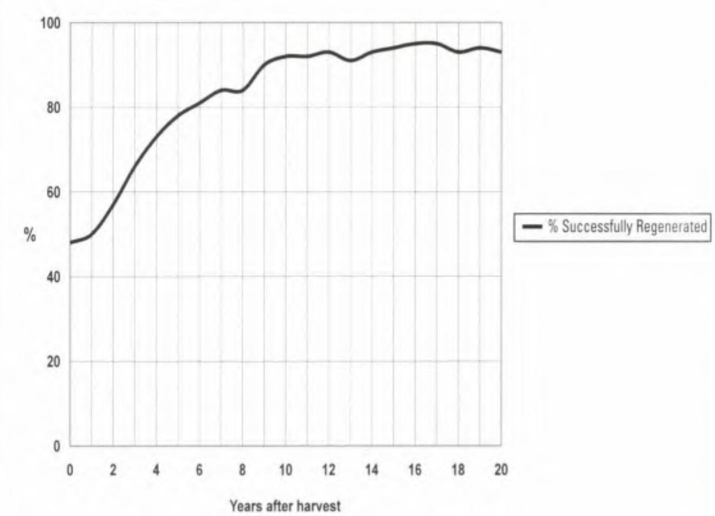
Figure 2.c.1. Successful Regeneration of Crown Lands in Canada



In Figure 2.c.1, the proportion of the area that regenerated naturally and as a result of planting or seeding is illustrated by the bars, while the area harvested is shown as a line. This graph shows cumulative areas starting in 1975. For instance, the column shown for 1975 represents the area harvested that year. The column for 1976 represents the area harvested in 1975 and 1976, and so on. It is evident that natural regeneration plays a much larger role in Canadian forestry than planting or seeding. The space between the line and the top of the bar is the area that remained understocked each year. Although the annual increase in the understocked area is small, the total that has accumulated since 1975 is substantial. By 1992, it amounted to almost 2.7 million hectares. The most recent data available indicate that the understocked area is gradually shrinking. By 1995, it had dropped to just under 2.6 million hectares.

A significant proportion of recently harvested areas will always be reported as understocked because of the time lag between harvesting and observable results of subsequent treatments, such as planting or natural forest stand development. The lag is evident in Figure 2.c.2, which illustrates the regeneration status in 1995 of the area harvested each year since 1975. The area that is reported as understocked for 1995 amounts to slightly more than the amount harvested between 1993 and 1995.

Figure 2.c.2. Regeneration Status in 1995 (Crown Lands)



c) Sources for information

1. Canadian Council of Forest Ministers, *National Forestry Database Program REGEN model.*

2.d. Annual removal of wood products compared to the volume determined to be sustainable

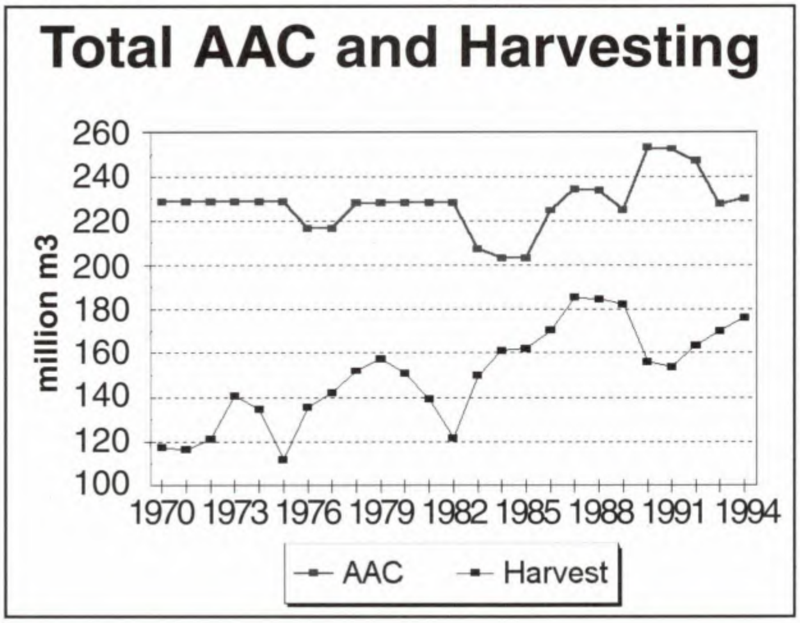
a) What are we measuring?

This indicator compares trends in the softwood and hardwood harvest with the annual harvest determined to be sustainable at the national level. The harvest rate for timber on provincial and territorial lands is determined by annual allowable cuts (AACs), which dictate the maximum volume of timber that can be harvested annually from an area over a period of time. AACs do not include timber in parks or other types of reserves, and are based on biological[3], economic and social considerations. The national AAC is arrived at by adding the total provincial and territorial AACs to the estimated harvest potential of federal and private lands.

b) Factual description

Figure 2.d.1 shows that during the period 1970 to 1994, the national annual harvest of softwoods and hardwoods (176.0 million m^3 in 1994) was consistently below the national AAC (229.8 million m^3 in 1994). The annual harvest of softwoods has increased since 1970, and by 1994, the harvest was close to–but still below–the national AAC. Some local shortages have been reported, however. The hardwood harvest, on the other hand, could be expanded in most areas of Canada.

Fig. 2.d.1



Over the past 20 years, Canada's AAC has remained relatively stable. It may decline, however, in coming years due to such factors as a reduction in the size and number of clearcuts and wider buffer strips. Furthermore, provinces regularly review their AACs, and since 1994, some have reduced them in certain regions to accommodate other land-use requirements such as protected areas, wildlife habitat and Aboriginal land claims. In other regions, improved information has enabled the provinces to increase local AACs.

3 Biological factors include the productive capacity of the forest and losses due to fire and pests.

c) Sources for information

1. Canadian Council of Forest Ministers, *National Forestry Database Program.*
2. Statistics Canada.

2.e. Annual removal of non-timber forest products (e.g., fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable.

a) What are we measuring?

National data are not available on the removal of non-timber forest products relative to the level determined to be sustainable. Although provincial data on annual quotas and harvesting are generally available, to date no effort has been made to aggregate this information at the national level. This indicator provides national data on trends in the harvest of firewood and fuelwood. A case study showing trends in moose density in Ontario between 1975 and 1995 is also provided.

b) Factual description

Canada's forests provide a range of non-timber extractive products, including fuelwood and firewood, wildlife for hunting and subsistence use, and various plant products such as berries, mushrooms, fiddleheads, and wild rice.

The use of wood as a fuel for cooking and heating accounts for approximately 55% of all wood harvested worldwide. In Canada, the use of forests as a source of fuelwood accounts for about 3% of the total harvest. This does not include the use of wood residue as a fuel by the wood industries. According to Statistics Canada, wood was the principal heating fuel in 3.8% of Canada's 11 million households in 1995, down from 4.5% in 1990. Figure 2.e.1 shows the trend in the harvest of fuelwood and firewood since 1970. The significant increase after the mid-1970s coincides with increases in energy prices.

All provincial resource management agencies closely monitor wildlife status and regulate population levels by: providing input to integrated resource management plans; determining quotas for sustainable harvest levels of wildlife; issuing licences for the annual harvest; and providing enforcement to minimize losses due to illegal harvesting activity.

Fig. 2.e.1

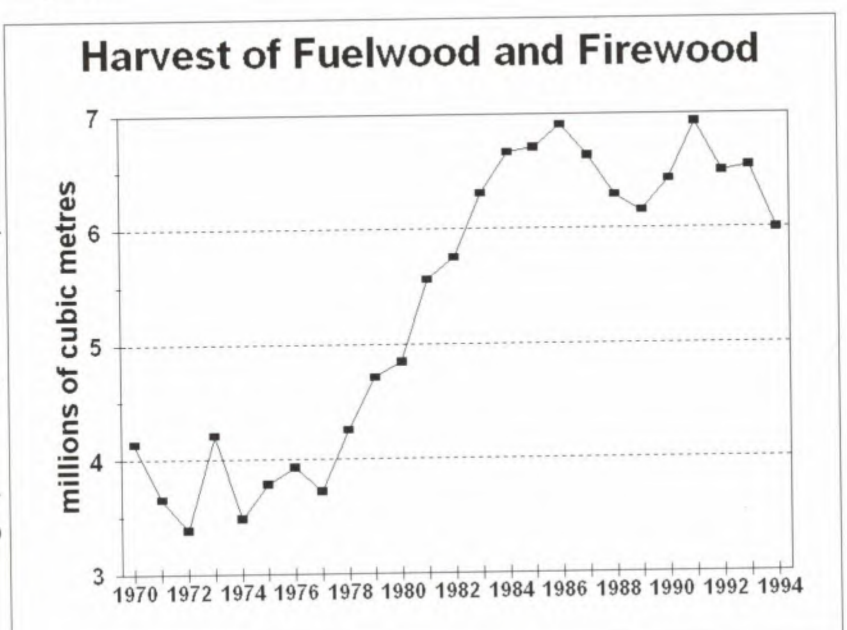
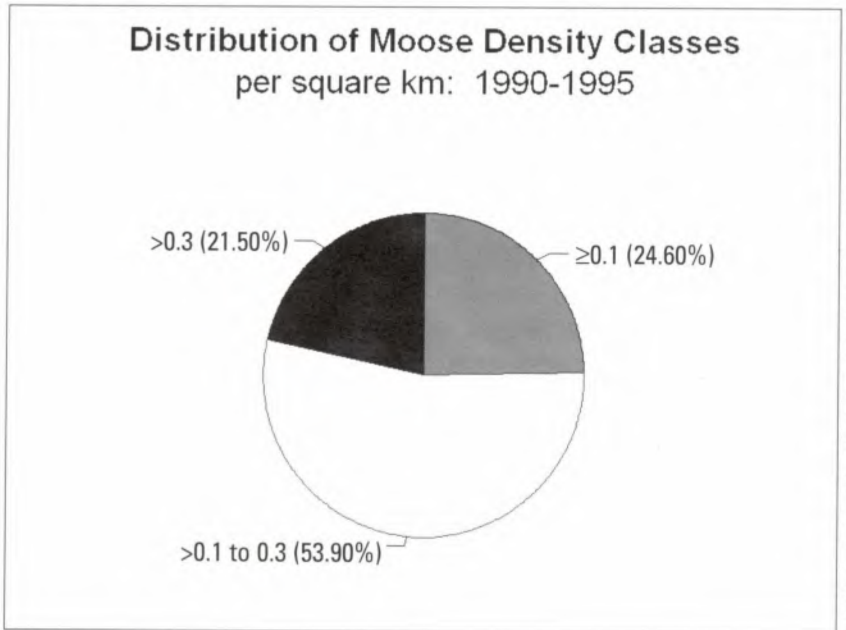


Fig. 2.e.2



Some wildlife species, such as moose, are monitored by the provinces because of their importance for recreational hunting, trapping or subsistence use. In Ontario, the Ministry of Natural Resources (OMNR) has been conducting winter aerial surveys of moose populations since the 1970s. In a collaborative effort between the OMNR and NRCan–CFS, researchers in Sault Ste. Marie are using this information to map historical trends in moose densities. Figure 2.e.2 shows moose density (number of animals per km²) for the period 1990 to 1995. Numbers have increased substantially in parts of the province, particularly in the Algonquin Park area to the south, and in the northwest. Figure 2.e.3 shows the change over time in moose densities in north-central Ontario. Between 1975 and 1995, the portion of the study region that was characterized by high density populations increased from 2.5% to 21.5%.

c) Sources for information

1. Ontario Ministry of Natural Resources.
2. Natural Resources Canada–Canadian Forest Service (Ottawa, Ontario).
3. McKenney, Rempel, and Wong (1997).

Figure 2.e.3 Relative percentage of moose density classes in north-central Ontario

Density per km²	1975 - 1979 %	1980 - 1984 %	1985 - 1989 %	1990 - 1995 %
≤0.1 to 0.3	48.5	40.4	29.4	24.6
0.1 to 0.3	49.0	51.2	56.4	53.9
>0.3	2.5	8.4	14.2	21.5

Sources: OMNR and NRCan-CFS

iii) Summary

Productive capacity is a measure of the ability of the forest landbase to provide a flow of benefits to society. It applies to both timber and non-timber resources and is a key factor in assessing our progress toward sustainable development.

Most of Canada's forest land is under public ownership (provincial, 71%; federal and territorial, 23%). Of the 417.6 million hectares of forests, 57% are considered "commercial"–capable of producing a range of both timber and non-timber benefits. However, only half of those forests are currently accessible and managed for timber production.

The provincial and territorial governments, which manage most (88%) of the commercial forest land, have enacted a range of policies and regulations to restrict the sale of forest land and its conversion to other uses. This enables governments to enact policies to ensure that productive capacity is maintained for socially, economically and ecologically important forest values. For example, public ownership allows Canadian governments to regulate the conversion of forest land to alternate uses, to enact policies that maximize the regeneration success of harvested sites, and to ensure that harvesting methods are environmentally responsible.

Regeneration of forest lands following human activity, such as harvesting, is a good indication of the sustained productivity of forest ecosystems. In Canada, the vast majority of harvested areas regenerate successfully.

At the national level, timber harvesting remains within the limits of sustainability. The annual harvest of softwoods and hardwoods has consistently been below the national AAC.

Similarly, hunting and trapping are closely regulated to ensure that local wildlife populations do not decline to unsustainable levels. However, to improve our ability to monitor the status of wildlife species, more information is required regarding the types of wildlife, their population levels, location and habitat needs.

IV Criterion 3

Maintenance of forest ecosystem health and vitality

IV. Criterion 3: Maintenance of forest ecosystem health and vitality

I) Introduction

Throughout Canada, natural and human-induced disturbances occur as a continuum and may range from small random periodic disturbances (e.g., tree fall) to larger long-term disturbance regimes (e.g., insect infestations, fires). Most disturbance and stress events are fundamental to the recovery and maintenance of forested ecosystems, while others may impede resilience, alter patterns and processes that result in new successional trends, or affect forest health.

Measuring disturbance and stress caused by abiotic and biotic factors provides a basis for managing forests as a renewable resource. Improved decision making and sound policy decisions require greater predictive power and knowledge than currently exist of the effects of disturbance and stress on forest health and vitality. In future, national assessments of forest health will be achieved through negotiated partnerships and alliances with the provinces and other agencies.

A suite of indicators will be measured and integrated to assess and report on the health and vitality of Canada's forests. For example, knowledge on the extent and severity of important insects and diseases, gathered through monitoring systems and a directed research program, will provide information on major forest stressors and serve as an indicator of change occurring or anticipated in the health of forests. Insects and diseases are a natural part of the forest ecosystem, but sometimes occur as spectacular epidemics that alter ecosystem dynamics. Losses must be considered not only in terms of economic value, but also in terms of amenity, recreational, biodiversity and other ecological values inherent in forests.

The introduction of exotic pests into Canadian forests is of concern and interest to forest managers, forest ecologists and the general public. Although some introduced species are innocuous, many inflict damage on the health and sustainability of forests. The presence of exotics serves as an indicator of disturbance and stress, which is one of the parameters for monitoring the health and sustainability of forests. Although the federal department of Agriculture and Agri-Food Canada is responsible for regulations to prevent the entry and further establishment of exotic pests in Canada, most provinces also have regulations with regard to pests entering or spreading within their boundaries.

Wildland fire threatens forest communities, consumes nearly as much wood in the commercial forest as is harvested, and constitutes a dominant ecological disturbance. Fire management accounts for 16% of the cost of forest management in Canada ($386 million of the $2.4 billion spent annually), yet fire exclusion is not always physically possible, economically feasible, nor ecologically desirable. Fire management policies strive to balance suppression in order to take into account both the values at risk and the natural role that fire plays in managing the landscape.

Pollutants impact upon forest ecosystems via dry and wet deposition pathways. Dry deposition includes pollutants in gaseous, particulate and vapour forms. It is highest in the vicinity of point source emitters and in urban airsheds. Wet deposition includes precipitation in the form of rain, snow and fog–it is commonly referred to as "acid rain". Forest ecosystem sensitivity to acid deposition is dependant upon a number of factors, including physical and chemical soil characteristics. Development of critical loads for forest soils is nearing completion.

3.a. Area and percent of forest affected by processes or agents beyond the range of historic variation

a) What are we measuring?

Disturbances and stress that affect the health, vitality and productivity of forests discussed in this criterion include: insects, diseases and fire. They are necessary components of the natural cycle of death and renewal. Floods, storms, land clearance, salinisation and domestic animals may also act alone or in concert to influence the development, structure and function of forests; however, these processes have not historically been well quantified. Reporting on them will entail novel approaches, expanded data collection, and more rigorous analysis.

Since the 1940s, the Forest Insect and Disease Survey of NRCan–CFS has been collecting data and related information on various pests in Canada, including their populations and impact on forest vegetation. Much of this information was collected by provincial administrative district. In future, such information will be reported as part of the national assessment of forest health. There is also a requirement to elucidate host-pathogen interactions and how they influence forest landscape patterns and processes.

The Forest Insect and Disease Survey has also monitored the occurrence and spread of new or unknown pests which have been accidentally introduced into Canada through importation of forest or agricultural products. It is anticipated that accidental introductions will continue each year, and may even increase in the future as a result of increased global trade. Human activities have also influenced the forest, making it vulnerable to naturally-occurring insects.

The National Forest Fire Research Program, in partnership with provincial fire management agencies, has archived annual forest fire statistics for Canada for 75 years. The Canadian Interagency Forest Fire Centre compiles national operational data throughout the fire season. Both data sets are essential inputs to criteria and indicators for wildland fire and are the basis for the current report. Because fire-specific processes strongly affect fire severity, development of satellite monitoring systems for large fires, site-specific national databases, and automated information systems to compile fire C&I have been initiated.

Measuring and reporting on the intensity and extent of disturbances and stress provide information that can promote improved decision-making and the development of sound forest management policies. Experience has shown that evaluation of historic conditions is difficult and that "natural condition" benchmarks can only be approximated. Nevertheless, it is anticipated that forests can be managed for multiple values such that the impacts are contained within the range resulting from natural disturbance.

b) Factual description

Insects

Insects and diseases remain the dominant causes of natural disturbance in most of Canada's forests, and their distribution is largely influenced by the local climate, composition, health and age of these forests. For example, defoliating insects are the major disturbing factors in most forests of eastern Canada, while bark beetles are the major cause of tree mortality in the western part of the country.

The extent of disturbance caused by spruce budworm and forest tent caterpillar is illustrated in Figures 3.a.1 and 3.a.2 (see inside front and back cover of this report). Areas affected are quantified as having moderate to severe defoliation. Spruce budworm occurs predominantly in the boreal forest region, from the Northwest Territories to Newfoundland, but most tree mortality takes place east of the Manitoba-Ontario border. Since 1976, the total area within which moderate to severe defoliation occurred in Canada varied considerably, with over 45 million hectares affected in 1976 and only 5 million hectares in 1994.

The forest tent caterpillar is also widely distributed from coast to coast and is a serious pest of trembling aspen. In 1994, moderate to severe defoliation encompassed 785 000 hectares in Ontario.

One of the most destructive forest insects in western Canada is the mountain pine beetle, which principally attacks lodgepole pine in the montane forests of Alberta and British Columbia. Unlike the spruce budworm, which kills trees only after consecutive years of severe defoliation, the mountain pine beetle can kill trees in just one year. In 1984, moderate to severe defoliation in British Columbia occurred over 483 000 hectares; since 1985, however, defoliation has been limited to less than 50 000 hectares.

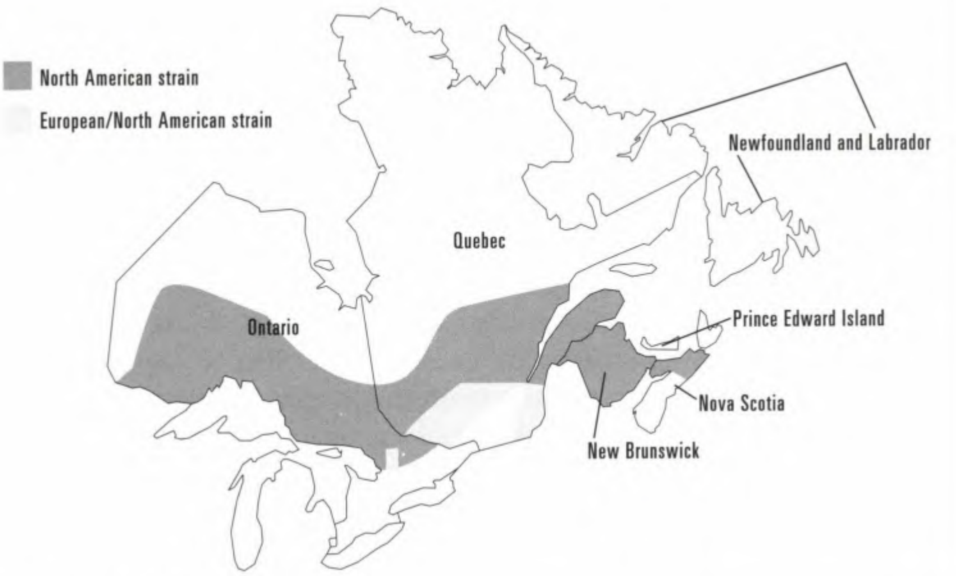
Two other insects–hemlock looper and jack pine budworm–are also highly destructive and capable of causing severe and extensive mortality in less than a year. In 1994, the hemlock looper caused moderate to severe defoliation on approximately 20 000 hectares, and the jack pine budworm, on 420 000 hectares.

Diseases

Native diseases are often chronic and, with the exception of some foliage diseases, slow in expressing their effects on trees and ecosystems. Major disease problems of Canadian forests include wood decays, wilt diseases (e.g., Dutch elm disease), stem cankers (e.g., scleroderris canker), root diseases (e.g., armillaria root rot), leaf and stem rusts (e.g., white pine blister rust), needle casts, anthracnoses, and dwarf mistletoes.

Scleroderris canker remains a concern to forest managers in Canada. The ranges of two scleroderris strains reported in Canada from 1977 to 1993 are illustrated in Figure 3.a.3. The more serious European race is capable of killing large pine trees. Dutch elm disease is a significant disease east of Saskatchewan, where it continues to kill elms of all ages. All species of native North American elm are susceptible.

3.a.3 Distribution of scleroderris canker in eastern Canada, 1977–1993



Source: Natural Resources Canada–Canadian Forest Service

Estimates of losses from diseases across Canada include those attributed to heart and butt rots as well as cankers. Losses are also evenly divided between those caused by diseases and those caused by insects, although the proportion varies widely among provinces. The average annual tree mortality and growth loss from diseases in Canada amounts to 51.2 m^3, which is equivalent to 29% of the total annual harvest.

Exotic species

Approximately 400 exotic species–mostly insects and diseases–are known to attack woody plants in Canada and the continental United States. The vast majority of these exotics arrived accidentally in the past 100 years, primarily through the shipping containers and packaging used for forest and agricultural products (Figure 3.a.4). Largely in response to introductions in the early 1900s, NRCan–CFS developed survey systems for detecting and monitoring exotics in forested ecosystems. In addition, Agriculture and Agri-Food Canada has established strict regulations to control the entry and movement of plant and animal materials into and within Canada.

Figure 3.a.4 Important insects and diseases introduced into Canada.

INSECT/DISEASE	YEAR OF INTRODUCTION INTO CANADA	PRIMARY HOST
Gypsy moth *Lymantria dispar.* (L.)	1924	oak, white birch, grey birch, larch, linden, willow, Manitoba maple, speckled alder.
Balsam woolly adelgid *Adelges piceae* (Ratz.)	1908	balsam fir, grand fir, subalpine fir, Pacific silver fir

European pine sawfly *Neodiprion sertifer* (Geoff.)	1939	scots pine, red pine
Satin moth *Leucoma salicis* (L.)	1920	poplar
Winter moth *Operophtera brumata* (L.)	1920s	oak, maple, willow
Introduced pine sawfly *Diprion similis* (Hartig)	1931	pine
European spruce sawfly *Glipinia hercyniae* (Htg.)	1922	spruce
Spruce bud moth *Zeiraphera canadensis*	1938	spruce
European spruce needleminer *Epinotia nanana* (Treitschke)	1940	Norway spruce, white spruce
Larch casebearer *Coleophora laricella* (Hbn.)	1905	larch
European pine needle midge *Contarinia baeri* (Prell)	1964	scots pine, red pine
European pine shoot moth *Rhyacionia buoliana* (Schiff.)	1925	red pine, scots pine, jack pine
Pine shoot beetle *Tomicus piniperda* (L.)	1993	pine, spruce
Smaller European elm bark beetle *Scolytus multistriatus* (Marsham)	1946	elm
Birch casebearer *Coleophora serratella* (L.)	1933	birch, alder, elm
Late birch leaf edgeminer *Heterarthus nemoratus* (Fallen)	1905	birch
Birch leafminer *Fenusa pusilla* (Lep.)	1929	birch
Browntail moth *Euproctis chrysorrhea* (L.)	1902	deciduous
Early birch leaf edgeminer *Messa nana Klug*	1967	birch
Elm leaf beetle *Pyrrhalta luteola* (Mull.)	1945	elm
Larch sawfly *Pristiphora erichsonii* (Hartig)	1882	larch

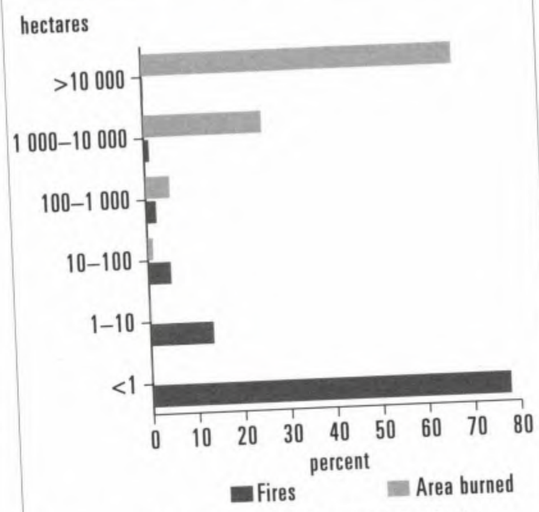
Mountain-ash sawfly *Pristiphora geniculata* (Hartig)	1926	mountain-ash
Poplar sawfly *Trichiocampus viminalis* (Fall.)	1904	lombardy poplar, trembling aspen, balsam poplar, largetooth poplar
Pear thrips *Taeniothrips inconsequens* (Uzel)	1989	sugar maple, red maple
Apple ermine moth *Yponomeuta malinella Zell.*	1957	apple
Ambermarked birch leafminer *Profenusa thomsoni* (Konow)	1948	birch
Willow blight *Venturia saliciperda* (J. Nuesch)	ca 1925	willow
Butternut canker *Sirococcus clavigignenti* juglandacearum (N.B. Nair, Kostichka & Kuntz)	1991	butternut
Dothichiza canker *Cryptodiaporthe populea* (Fckl.) Butin	pre-1900	poplar
Dutch elm disease *Ophistoma ulmi* (Buisman) Nannf	1944	elm
European larch canker *Lachnellula willkommii* (Hartig) Dennis	1980	larch
Chestnut blight *Cryphonectria parasitica* (Murrill) Barr	post-1904	American chestnut
White pine blister rust *Cronartium ribicola* J.C. Fish	1910	white pine
Scleroderris canker *Gremmeniella abietina* (Lagerb.) Morelet European race	1978	pine
Beech bark disease *Nectria coccinea* var. *faginata* Lohm., Wats. & Ayers **and** Beech scale *Cryptococcus fagisuga*	1980	American beech

At present, gypsy moth, balsam woolly adelgid, the European race of scleroderris canker, European larch canker, Dutch elm disease, white pine blister rust, and knapweed are considered among the most important exotics.

Detailed information exists on the distribution and spread of exotics, both in forest and urban conditions, and proper plant health and quarantine measures have been taken to check any further spread. Wherever necessary, proper eradication steps are taken to contain damage. However, chestnut blight virtually eliminated the American chestnut within about 30 years of its introduction, and white pine blister rust has decimated some pine forests. Exotic species like gypsy moth and introduced sawflies are often more outbreak-prone than native insects and diseases, perhaps due to lack of co-evolution between them and their new woody host, and, in the case of insects, lack of specialized natural enemies.

Effective partnerships will be required to provide early detection and response to exotics if Canada is to maintain the long-term sustainability of its forested ecosystems. Despite existing plant health and quarantine regulations, it is important to maintain detection and monitoring capabilities to prevent and respond to future exotic threats.

3.a.5 Fires and area burned by size class and percent

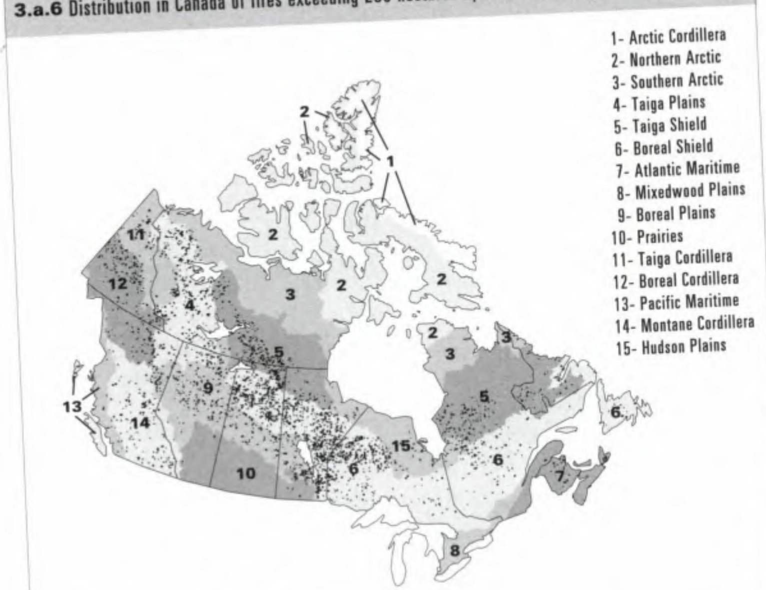


Source: Natural Resources Canada–Canadian Forest Service

Fire

In Canada's commercial forest, wildland fire consumes nearly as much wood as is harvested, and constitutes a dominant ecological and environmental disturbance. Over the past 10 years, an average of 9 600 fires have burned 3.0 million hectares annually–0.7% of the total forested land in Canada (Figure 3.a.5). On average, one third of the total area burned is in commercial forest (0.4% of the commercial forest area). Total area burned ranges from 1 million to 7.5 million hectares per year, with between 25% and 50% of commercial forest affected. An average 50 fires per day are reported during the April to September fire season, but 1 100 fires have been reported by a single province over just four days.

3.a.6 Distribution in Canada of fires exceeding 200 hectares by ecozone, 1980–1989



Source: Natural Resources Canada–Canadian Forest Service

On average, 91.5% of all fires burn less than 10 hectares. Conversely, the 1.5% of all fires that exceed 1 000 hectares burn 93.1% of the total area. People start 58% of all fires in Canada, but these fires burn only 15% of the total area burned, whereas lightning starts 42% of all fires but accounts for 85% of the total area burned. This is largely due to the fact that fires caused by humans are generally accessible, while those caused by lightning are often located in remote areas.

Figure 3.a.6 illustrates the distribution of large fires (>200 ha) across Canada from 1980 to 1989. Large fires occur in all ecozones except agricultural and Arctic regions. Estimated fire return intervals (time between repeated fires at one place) range from 100 to 10 000 years.

Fire is a major component of sustainable forest management in Canada. Fire activity is variable over time and space, greatly complicating both management and measurement. Canadian fire management is effective, but the decision on whether or not to fight a fire has major consequences. The return interval for large fires spans two orders of magnitude, necessitating a broad range of fire policies and appropriate levels of fire management.

Forest harvesting and management have altered forest composition, possibly making forests more vulnerable to fire. On the other hand, improved data collection and fire locating methods, and a better understanding of fire behaviour have led to more efficient suppression techniques.

c) Sources for information

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3.b. Area and percent of forest land subjected to levels of specific air pollutants or ultraviolet B that may cause negative impacts on the forest ecosystem

a) What are we measuring?

A clean atmospheric environment is essential for the long-term maintenance and enhancement of forest ecosystem condition and productivity. Increasingly over the last 50 years, human activities have led to a deterioration in the quality of the atmosphere over areas of Canada's forests.

Pollution, acting alone or in combination with other stressors, affects ecological systems in general, and forests in particular. The need to understand pollution-forest interactions is paramount because of increased evidence linking long-term effects of acid deposition to disruption of biogeochemical processes and decline of annual forest biomass accumulation. Measures of acid deposition and ozone are required to assess the effects of pollutants on the maintenance and productivity of forested ecosystems. Moreover, climate change may exacerbate some air pollution effects on forests.

The Canadian Air and Precipitation Monitoring Network (CAPMON) and the provinces have been providing data on pollutants from 11 sites for more than 13 years. Wet deposition is calculated and mapped where the density of CAPMON and provincial wet deposition monitoring stations is sufficient. Yearly trends have been published for eastern Canada since the early 1980s. Because there are only two CAPMON stations west of Ontario, spatial deposition values cannot be calculated for other forested regions. Values for the southern coastal Atlantic Maritime ecozone do not include data for acid fog, which may in certain years account for an additional 50% of SO_4 and/or SO_3. Values for portions of the Boreal Plain and Mixedwood Plain ecozones do not include droplet deposition through cloud water at higher elevations. Spatial distribution maps may therefore underestimate total deposition in some forests.

Federal and provincial ozone monitoring agencies have been collecting hourly ozone concentration data since 1980. The data are quality-controlled and reported in the National Air Pollution Surveillance Network (NAPS) by the Environmental Protection Service of the federal department of Environment Canada. Data are currently available from 153 sites, 112 of which are considered urban and 41 of which are rural. Ozone is a regional-scale pollutant subject to long-range transport. For this reason, data from 120 rural U.S. sites are also used in the mapping of ozone concentrations in Canada. There are too few monitoring stations in forested ecozones west of Ontario to permit regional scale mapping of ozone concentrations. However, a passive monitoring system implemented in 1996 will allow for an initial assessment of ozone concentrations throughout selected forested areas of Canada.

Recognizing that ecosystems respond to stressors in a cumulative fashion, more work is required to determine the effects on forests of UV-B radiation and pollutants such as heavy metals and volatile organics. Future reports should include discussion of these emerging issues.

b) Factual description

Acid Deposition

The need to understand pollution–forest interactions is paramount in view of the increasing evidence linking the long-term effects of acid rain to disrupted biological processes and declining rates of forest growth (e.g., long-term loss of soil nutrients through leaching).

Acid rain–of which the principal constituents are sulphur dioxide, particulate sulphate, nitric acid, particulate nitrate and ammonia–is generally greatest in southern Ontario and decreases with distance east, west and north. The Canadian Air and Precipitation Monitoring Network (CAPMON) and the provinces have been providing data on these pollutants from 11 sites for more than 13 years. Droplet deposition, including acid fog in certain coastal forests, may add significantly to the pollution load reaching forest ecosystems via wet deposition.

Substantial progress in reducing SO_2 emissions has been made unilaterally in Canada and bilaterally with the United States through the implementation of acid rain control programs. In 1994 Canada's SO_2 reduction program was already ahead of its target, with a 40% reduction from 1980 levels in seven eastern provinces. Despite this progress, acid rain remains a threat to forest ecozone condition and productivity in the Boreal Plains, Mixedwood Plains and Atlantic Maritime terrestrial ecozones. Deposition of SO_4 and NO_3 varies yearly, and is influenced by rates and amounts of pollutant emission, regional climatology and local meteorology.

For the period 1990-93, four-year average excess (sea-salt corrected) wet SO_4 deposition was highest in the Mixedwood Plain, Atlantic Maritimes and southern Boreal Plain ecozones, ranging from 10-30 kg/ha per year. The spatial distribution for 1991 is shown in Figure 3.b.1. For the period 1992-93, excess wet NO3 deposition was also highest in those ecozones, ranging from 5-25 kg/ha per year. Acid rain is not considered to be damaging forest condition in the other terrestrial ecozones, although some damage from dry deposition of sulphur around strong point source emitters has been measured.

3.b.1 Amount of wet sulphate deposition (kg/hectare/year), 1990–1993

Note: The contour lines indicate the average wet sulphate depositions that occur within the areas delineated. A dotted line is used to indicate estimated amounts.

Source: Environment Canada

Ozone

Ground-level ozone is produced when sunlight passes through high concentrations of hydrocarbon gases and other airborne industrial pollutants. When ozone levels are too high they become toxic to vegetation. For example, high levels can change the way trees store carbon, cause premature defoliation, make trees more susceptible to disease and insect attack, and result in slower growth and diminished ecosystem health.

The current National Ambient Air Quality Objective for Ozone and Vegetation is set at 82 ppb ozone per hour. In eastern Canada, the distribution of average hours with ozone concentrations greater than 82 ppb during 1986-1993 is shown in Figure 3.b.2.

3.b.2 Distribution of average hours with ozone exceeding 82 parts per billion, 1986–1993

Note: The contour lines indicate the average hourly concentrations of ozone that occur within the areas delineated.
Source: Environment Canada

Portions of four ecozones (Atlantic Maritime, Mixedwood Plains, Boreal Shield, and Pacific Maritime) are periodically exposed to ozone concentrations exceeding the critical level. Levels were highest in the Mixedwood Plain and decreased north and east. In western Canada, the spatial distribution of average hours with ozone concentrations greater than 82 ppb for the period 1988-1993 can only be mapped for forests in the Lower Fraser Valley region of the Pacific Maritime ecozone. Forests in this region were exposed to ozone concentrations exceeding the critical level 1 to 15 hours per year. Other significant areas of the ecozone are believed to be at risk, but insufficient data are available for mapping purposes. In 1996, passive ozone monitors were introduced to allow for an initial assessment of ozone concentrations throughout selected forested areas. Ozone-like symptoms have been detected on white pine at some health monitoring plots in eastern and western Canada. Critical levels are exceeded in areas where declines of sugar maple and white birch are occurring.

c) Sources for information

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3.c. Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes and/or ecological continuity

a) What are we measuring?

Algae, bacteria, fungi, protozoa, viruses and other invertebrates make up soil biota. A square metre of soil can contain as many as 100 000 invertebrates. Soil biota regulate plant nutrient uptake and release, and organic matter decomposition. They also influence formation of stable soil aggregates, contribute to soil porosity and water infiltration, and act as prime regulators of soil fertility.

Because direct monitoring of biota and ecological processes through time is difficult, indicator species and functional groups could be used to study the biological effects of environmental disturbance. For example, collembola and mites could be used as indicator species when comparing the biodiversity of soil in a natural ecosystem with one that is managed, or to compare the effects of harvesting practices.

In Canada, plot-based ecological monitoring systems (ARNEWS, NAMP) serve to measure how soil processes respond to acid deposition. Related research on changes in insect abundance, fungi and related microflora could be integrated with these systems to better describe how biological components change through time. It is also recognized that it is sometimes more advantageous to study a function within an ecosystem than a particular species or group of organisms.

Given the lack of information on the occurrence of species in Canada and the enormous variability across sites and landscapes, it is not possible to measure changes in most biota on a national scale. Nevertheless, it is clear that natural and human disturbances (conversion of forests for agriculture, community development, mining, oil and gas exploitation and forest management) all affect the health and vitality of forest ecosystems. The forest science community in Canada recognizes that indicators of biotic change may be derived through changes in soil organisms and soil nutrient regimes.

Additional research on seed dispersion and pollination could augment knowledge on how biological resources change through time and space.

b) Factual description

Within any landscape there are both short- and long-term processes that determine the composition and abundance of biota. Diminishing biological components in forest ecosystems are often reflected in changes in the microorganism community, declines in mycorrhizae, and nutrient losses to stream and ground water. It is estimated that Canada's boreal forests alone contain over 100 000 species, 95% of which are arthropods and microorganisms. Only 20% of the taxa in boreal forests have been taxonomically identified.

c) Sources for information

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iii) Summary

Healthy forest ecosystems are essential to the sustainability of forests. In a living system, normal functioning implies appropriate levels of health, vitality and productivity of the various components.

Pollutants, fires, unfavourable climatic conditions, and infestations by insects and diseases often interact to stress forests. Measuring and reporting on the severity and extent of disturbances and stress provide an important ecological measure of the condition, productivity and overall health of forest ecosystems.

Canada's forests are generally healthy, and few large-scale declines have been observed. Tree mortality (caused primarily by competition and natural thinning) ranges from 1-3% annually; although the effects of insects, diseases and windstorms occasionally cause higher rates of mortality. Recent findings in eastern North America, however, suggest that the long-term impact of acid deposition, and possibly ozone concentrations, may lead to the degradation of forest ecosystems.

Data gathered through a national monitoring system and a directed research program will provide information on major forest stressors and on the changes occurring–or anticipated–in the health of our forests. The resulting knowledge will enable Canada to contribute to the stewardship of forest ecosystems, most notably by enhancing forest management regimes, assessing the impacts of pollutants on forests, and integrating non-timber values into forestry decision-making.

A measure of diminishing biota may indicate that ecosystems are no longer able to support and maintain life forms. For future reporting on this criterion, measures of changes in biota could be enhanced.

V CRITERION 4

Conservation and maintenance of soil and water resources

V. Criterion 4: Conservation and maintenance of soil and water resources

i) Introduction

This criterion includes physical environmental indicators related to soil and water characteristics. Physical environmental indicators are essential in tracking sustainable forest management because the maintenance of appropriate levels of soil oxygen, nutrients, moisture and organic matter is key to the long-term productivity and resilience of forest ecosystems.

Specifically forest-related information on soils and water is not available at the national level, although a model to assess the impact of forest activities on soil and water has been developed in British Columbia. Applying national measures for indicators is made more difficult by the variations in climate, soils and forest practices across Canada. Moreover, much of the existing forest-related data reflect earlier, rather than current, practices.

In Canada, the impacts of forestry practices on soil and aquatic systems have been mitigated primarily by the development of codes and guidelines for road construction and harvesting. In most jurisdictions these guidelines limit ground disturbance, provide for the establishment of riparian buffers around water courses and recommend practices and equipment for the reduction of soil erosion and compaction. In addition, federal regulations on the discharge of toxic substances have led to investment in forest industrial plants to meet compliance deadlines.

For the reasons stated above, progress for most indicators is reported using case studies, proxy data and trends observed in research watersheds.

ii) Indicator Reports

4.a. Area and percent of forest land with significant soil erosion

a) What are we measuring?

Improper forest road construction and poor harvesting practices can remove the organic layer of the forest floor, leading to soil displacement by gravity and/or surface water flow. The extent and severity of soil erosion is usually related to the type of soil, slope, season, operator and equipment. This indicator is directly linked to 4.f. and 4.h. because eroded soil frequently enters water courses, thereby changing the physical, chemical and biological characteristics of the habitat.

In Québec and British Columbia, ground disturbance is systematically monitored for compliance with forest codes of practices. Some of the information gathered by these provinces includes the time of harvesting, the percent of area compacted, and the percent of humus removed. In most other provinces and territories, measurements are usually taken in the context of ad hoc surveys related to equipment trials or special research projects. Certain kinds and amounts of soil disturbance are essential for the restoration of forest ecosystems and favour more adequate levels of regeneration on sites that would otherwise revert to non-commercial tree species. For example, in the absence of fire, ground disturbance is essential for the regeneration of some black spruce ecosystems.

Existing data point to the range of disturbances that occur under different conditions; however, in most instances, these data reflect past, rather than current, practices. Thus, while there are a few sites that can serve as case studies, in most jurisdictions, data are not available to help determine whether forest practices are sustainable with respect to the level of soil disturbance.

b) Factual description

The Forest Engineering Research Institute of Canada (FERIC) has studied the impact of various harvesting methods on ground disturbance in eastern Canada. According to FERIC, manual felling with skidding to the roadside causes severe ground disturbance on 7.4% of moderate slopes (an incline of 10-20%) and on 14% of steep slopes (an incline of 20-30%). Mechanical harvesting with transportation (rather than skidding) to the roadside causes severe ground disturbance on 0.1-2.4% of areas with a broad range of terrain conditions.

A study in the interior of British Columbia found that the extent of severe ground disturbance increases with the degree of slope and is partially determined by the season in which harvesting occurs. On slopes with an incline of less than 45%, the level of disturbance is less severe in winter (6.7-10.8%) than in summer (10.6-13.7%).

Ground disturbance is markedly reduced by the implementation of guidelines and codes of practice. For example, with the introduction of provincial guidelines in Alberta, the level of disturbance associated with aspen harvesting decreased from 25% of harvested areas in the mid-1980s, to 10% in 1990, and 3.5% in 1993.

c) Sources for information

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4.b. Area and percent of forest land managed primarily for protective functions, e.g., watersheds, flood protection, avalanche protection, riparian zones

a) What are we measuring?

This indicator monitors the area of forest land managed primarily for the protection of soil and water as opposed to that which is placed in parks and wilderness areas for the protection of biodiversity values (1.1.c. and 1.1.d.).

b) Factual description

National level data for this indicator are not currently available. The areas in question are found in soil and water conservation authorities, municipal watersheds and heritage rivers scattered throughout the country in relatively small areas compared to the total forest landmass (probably less than 5%). Furthermore, the regulations governing protection vary not only from province to province but also from community to community, making the analysis highly complex in relation to the small proportion of land in question. All provinces in Canada currently require buffer zones around water courses. These zones vary from 20 to 50 metres depending on soil conditions and slope. This amounts to 4 to 10 hectares of reserve per kilometre of stream. No accurate national statistics are available on riparian buffers; however, conservative estimates of 10 to 20% of harvest block are reasonable depending on natural variations in the number and distribution of water courses.

c) Sources for information

Nil.

4.c. Percent of stream kilometres in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation

a) What are we measuring?

The natural flow and timing of streams can be dramatically affected by control structures for hydro power generators, flood control measures, agricultural irrigation and human consumption levels. There are currently no national statistics available for this indicator. Methodologies for collecting national data on the trends and timing of events in stream flows from forest catchments are at the early stages of development.

b) Factual description

Stream flows can be impacted dramatically by control structures for hydro power generators, flood control measures, agricultural irrigation and human consumption levels. Natural catastrophes (e.g., an unusually heavy rainfall or spring melt) can also cause extreme fluctuations. Increased stream flows can lead to erosion and stream sedimentation, which can in turn lead to reduced water quality and aquatic habitat for fish and other organisms.

Watershed studies in Canada and elsewhere have demonstrated that the alteration of stream flow rates and timing is usually greatest immediately after forest harvesting and that they return to near background levels within 10 to 20 years. Control structures used to prevent flooding are usually associated with large urban centres and occupy a very small proportion of total stream kilometres in Canada. Environmental guidelines related to hydro projects require the removal of trees prior to flooding shorelines. For both economic and environmental reasons, log driving on rivers is no longer practiced in most areas of Canada.

c) Sources for information

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4.d. Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties

a) What are we measuring?

Soil organic matter is important for the storage of carbon, the retention of moisture and essential plant nutrients and as a source of energy for soil microorganisms. Soil chemicals such as nitrogen, phosphorous, potassium, calcium and magnesium are essential for maintaining the productivity and resilience of forest ecosystems.

Direct monitoring of soil organic matter and soil chemistry is technically difficult and costly. In Canada, research is conducted on the effects of current harvesting systems on nutrient budgets, and computer simulation models are used to predict impacts on carbon and essential plant nutrients.

b) Factual description

Research on nutrient budgets and computer simulation modelling have demonstrated that conventional harvesting techniques with rotation lengths of 60 to 100 years do not significantly impact nutrient or carbon budgets. Losses attributed to harvest removals and leaching are generally replenished by precipitation inputs over the rotation period.

Whole-tree (full-tree) harvesting, because it removes more biomass of high nutrient quality, can potentially create nutrient deficits. This has been demonstrated by computer simulations over several rotations. However, these results need to be verified through more in-depth field research.

c) Sources for information

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4.e. Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities

a) What are we measuring?

Soil compaction is usually measured using bulk density (gm/cc of soil). Compaction of soil reduces plant growth by decreasing gas exchange, aeration, water infiltration and hydrologic conductivity, and by altering the retention and availability of water. These altered hydrologic properties make soils more prone to erosion (Indicator 4.a.).

b) Factual description

Most severe compaction of forest soils occurs where roads are constructed and in landing areas where wood is collected for transportation. Guidelines now generally require these areas to be less than 10% of the harvest block, and in some jurisdictions compaction is mitigated by tilling the soil and planting. Because compaction is not easily observed, it is very difficult to measure. There are no national statistics on compaction. Current information is limited to a number of small sites where its impacts on growth are being studied.

c) Sources for information

Nil.

4.f. Percent of water bodies in forest areas (e.g., stream kilometres, lake hectares) with significant variance of biological diversity from the historic range of variability

a) What are we measuring?

Most aquatic organisms are sensitive to changes in the temperature, chemical composition and particulate matter in water bodies. These factors can be affected by the discharge of municipal wastes, atmospheric pollutants, industrial effluents, and pesticides and fertilizers from agricultural activities.

This indicator assumes knowledge of both historic and existing biological diversity of water bodies in forested areas. In Canada, such databases exist only for specialized research watersheds. Although difficult to measure, this indicator provides a good synoptic measure of the sustainability of management practices within watersheds, with respect to both land and water. This indicator is closely linked to Indicator 4.c.

b) Factual description

A number of studies have been conducted to examine the effects of forest harvesting on aquatic fauna and flora. Relatively few data are available from Canadian sites, however, and most of the existing data are from studies conducted more than a decade ago and do not reflect the more stringent codes of practice currently in place.

Most of the effects on aquatic fauna are closely linked to changes in physical and chemical properties of aquatic ecosystems, particularly in smaller headwater streams. Alteration of riparian vegetation and increased sediment loading in particular cause significant perturbations in aquatic faunal communities. Primary production in streams usually increases following clearcut harvesting. Filamentous green algae tend to flourish in response to increased sunlight penetration and nutrients, and higher water temperatures. This response is often short-term, and reverses as riparian vegetation is re-established and nutrient concentrations and water temperatures return to pre-harvest levels (see Indicator 4.g.). As previously mentioned, it is often difficult to distinguish the effects of forest practices on water bodies from those of other sources such as municipal waste, atmospheric pollution, effluents from industrial plants, and pesticides and fertilizers from agricultural activities.

c) Sources for information

Nil.

4.g. Percent of water bodies in forest areas (e.g., stream kilometres, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change

a) What are we measuring?

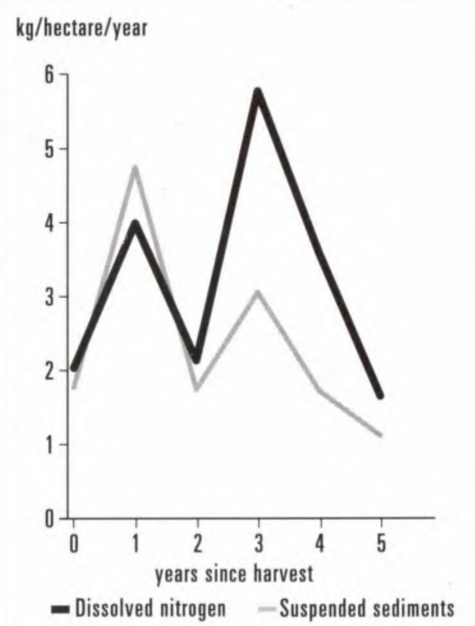
This indicator is intended to monitor changes in the chemical and physical properties of water bodies arising from forest practices. Currently, such data are available only for specialized research watersheds where detailed chemical observations are made within an experimental design that clearly controls the source of disturbances.

b) Factual description

Studies indicate that when roads are constructed through areas with acidic soil, or when those areas are clearcut, the quality of water decreases in terms of both chemistry and turbidity. This decline is reflected in higher concentrations of dissolved nutrients and organic chemicals, and decreased pH levels. These changes are usually small and short-lived, with a return to near pre-logging conditions within three to five years.

Results of catchment studies in Canada, the United States and overseas show that harvesting of forests leads to higher levels of nutrients in the soil and water for a period of three to five years (Figure 4.g.1). The increase in nutrients and organics on the forest floor is due primarily to the removal of the biological demand of trees and other vegetation, and to a lesser extent, to ground disturbance. Ground

4.g.1 Dissolved nitrogen and suspended sediments in the Experimental Lakes Watershed



Source: Natural Resources Canada–Canadian Forest Service

disturbance on the cutover and road construction on adjacent areas can lead to increased turbidity of the water due to soil erosion and siltation. Secondary succession after harvesting restores the biological demand for nutrients, resulting in near background levels of nutrients in the water within three to five years. Increased stream flow after harvesting can be attributed to less biological demand and reduced evapotranspiration, due to a reduction in the foliage surface area. Return of the stream flow to near background levels usually takes at least 20 years, depending on the height and complexity of the forest canopy (see Indicator 4.c.).

c) Sources for information

See Indicator 4.c.

4.h. Area and percent of forest land experiencing an accumulation of persistent toxic substances

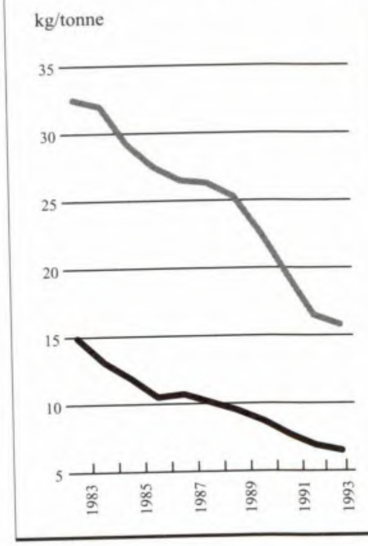
a) What are we measuring?

A wide variety of substances with varying toxicity and persistence are used in forest management in Canada. The use of these substances is closely regulated through a stringent registration process administered by Health Canada.

b) Factual description

Between 1988 and 1994 there was a 98.5% reduction in the release of dioxins and furans by pulp and paper mills in Canada. Environmental enhancements in technology amount to almost a quarter of total capital expenditures in plants. Biological oxygen demand (BOD) and total suspended solids (TSS) discharged from mills have been reduced by 50% in the last decade (Figure 4.h.1).

4.h.1 BOD & TSS production



c) Sources for information

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iii) Summary

Soil and water conservation are critical to sustainable forestry. The physical environmental indicators included in this element are intended to monitor the implementation of guidelines and planning aimed at maintaining the productivity of forest soils and water.

There is no formal process or protocol in place across Canada for monitoring water quality, flow rates and aquatic biota in relation to forest practices. However, Environment Canada and numerous provincial agencies maintain extensive databases on streamflow, water chemistry and fish populations.

Case studies have shown that ground disturbance is affected by the degree of slope, season, and method of movement to roadside. The implementation of guidelines and codes of practice has been shown to reduce considerably ground disturbance from harvesting.

No accurate national information is available on the amount of forest land managed primarily for the protection of soil and water because such areas fall under municipal jurisdiction and are subject to many different regulatory regimes. It is estimated that less than 5% of Canada's total forest landmass would fall into this category. All provinces require buffer zones around water courses, which translates into approximately 10 to 20% of harvest block.

In Canada, harvesting and other human activities are usually subject to guidelines and practices which reduce their impact on stream flow and timing. For example, environmental guidelines for hydro projects require the removal of trees prior to flooding shorelines and log driving on rivers is no longer common.

Research on nutrient budgets and computer simulation modelling have demonstrated that conventional forest practices rarely cause a significant change in organic matter or other chemical properties of soil within the sixty- to one hundred-year rotation period currently used in Canada. There are no national statistics on soil compaction caused by harvesting, but guidelines generally require the areas set aside for road construction and wood collection to be less than 10% of the harvest block. Relatively few data concerning the effects of forest harvesting on aquatic flora and fauna are available from Canadian sites. Most of the existing data are more than a decade old and do not reflect the more stringent codes of practice currently in place. Results of a number of studies show return to pre-harvest conditions takes place within three to five years in the case of water quality, and after at least 20 years in the case of stream flow.

Care must be exercised in separating the impacts of forest practices from those of other industrial, recreational, agricultural and urban activities. This may be achieved by stratifying the data to include only those streams in which changes can be attributed directly to such forestry activities as harvesting or road building. Traditionally, studies of this type have focused on remote headwater streams in areas not affected by other forms of human intervention. Biological and chemical monitoring protocols need to be developed that would rely on key indicator organisms and elements, based on the findings obtained at existing research sites.

VI CRITERION 5

Maintenance of forest contribution to global carbon cycles

VI. Criterion 5: Maintenance of forest contribution to global carbon cycles

i) Introduction

Forests occupy 4 billion hectares, or roughly one third, of the Earth's land surface. Canada's forests cover 417.6 million hectares, which is nearly half its land mass. Because of their size, forests play a major role in the functioning of the Earth's biosphere and contribute to and regulate global biological cycles related to carbon (the carbon cycle) and water (the hydrological cycle). Understanding the role of forests and their soils in the global carbon cycle is vital to developing forest management practices that are sustainable in the long term.

This same understanding also helps to assess sustainability. If forests are losing carbon, particularly standing biomass, it is an indication that current management practices and use may not be sustainable in the long term. If, on the other hand, forests are gaining in terms of standing biomass, current use and management may be sustainable.

The forest carbon budget fluctuates from year to year and decade to decade depending on weather conditions and disturbances that affect forest growth. The aim of sustainable forest management in the context of the global carbon cycle is to maintain, over the long term, a balanced or positive budget in terms of standing biomass. A neutral or positive balance in standing biomass would indicate a sustainable timber supply. At the same time, a positive balance in the overall carbon budget (standing biomass, soils and products), indicates that the forest is part of the solution to climate change, contributing to reduced atmospheric carbon dioxide levels and the mitigation of potential change.

While actual data or observations of the carbon budget of Canadian forests are not available, a carbon budget model is being developed under the leadership of NRCan–CFS. Estimates are available for the amount of carbon stored in standing biomass (trunks, branches, leaves, roots), soil and detritus, and forest products, as well as the fluxes of carbon between these pools and the atmosphere, for the boreal and subarctic forest regions over the period 1920 to 1989. This was achieved using a combination of forest inventory data and mathematical description (models) of the current understanding of forest carbon cycle ecosystem processes.

ii) Indicator reports

5.a. Total forest ecosystem biomass and carbon pool

a) What are we measuring?

Estimates of the total amount of carbon stored in all Canadian forest ecosystems are available for 1986 and more recent results are available for some ecosystems. This report presents modelled estimates of the carbon stored in the standing biomass and soil carbon pools in Canada's boreal and subarctic forests, and outlines changes in these pools over the period 1920 to 1989. These two forest ecosystems represent approximately 75% of Canada's forest area, and therefore provide a good indication of the overall carbon budget for Canadian forests. Estimates for all Canadian forest ecosystems are being prepared.

b) Factual description

Carbon dioxide is one of the principal greenhouse gases in the atmosphere. Global forest ecosystems account for approximately 50% (100 000 million tonnes of carbon [MtC]) of the annual exchange of this gas with the atmosphere. In addition to their significant and dynamic role in the annual carbon cycle, forest ecosystems worldwide store huge amounts of carbon in their soils and detritus (1 500 000 MtC) and standing biomass (650 000 MtC). The amount of carbon stored in Canada's boreal and subarctic forests in 1989 is estimated to have been in the order of 58 980 MtC (Figure 5.a.1). This includes 7 100 MtC in standing vegetation biomass (trunks, branches, roots, etc.), 51 600 MtC in forest soils and detritus, and 280 MtC in forest products.

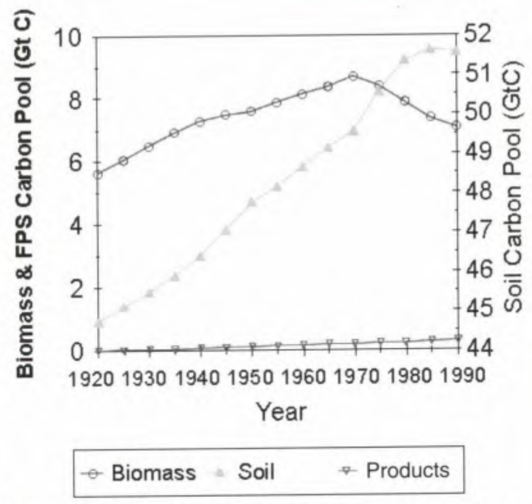


Figure 5.a.1 Change in total C stored in Biomass, Soil and Forest Products Pools over the period 1920-89 for Boreal and Subarctic Forests.

Figures 5.a.1, 5.a.2 and 5.a.3 demonstrate the modelled estimates of the changes in carbon storage in the standing biomass, and soil and detritus carbon pools of the boreal and subarctic forest ecosystems over the period 1920-89. During this period, these pools accumulated an average 118 MtC/yr, increasing from 50 400 to 58 700 MtC. Although these forest ecosystems were accumulating carbon for much of this period, they began abruptly to lose it, first from the standing biomass pool in the early 1970s and then from the soil and detritus pool in the mid-1980s. Storage of carbon in the standing biomass peaked at 8 400 MtC between 1970 and 1974, and then declined by 15.5% to 7 100 MtC in 1989. The soil and detritus pool peaked in 1984 at 51 600 MtC, after which it began losing carbon as well, declining by 60 MtC in the period 1985-89 (a loss of one tenth of one percent). Between 1985 and 1989, both the standing biomass and the soil and detritus carbon pools lost carbon (59 MtC/yr and 12.6 MtC/yr, respectively). The main reason was an apparent twofold increase in losses associated with fire and insect disturbances (Figure 5.a.3). This cannot be stated definitively due to some question as to the accuracy and completeness of fire disturbance data prior to 1960. Harvesting, which increased only slightly during the 1970s and 1980s, appears to have played a minor role in the change (Figure 5.a.3).

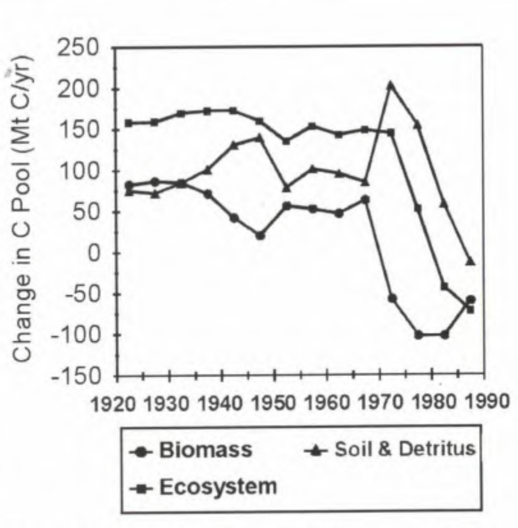


Figure 5.a.2 Change in Biomass, Soil and Total Ecoxyxtem C storage for the Boreal and Subarctic Forests over the period 1920-89.

The age of the forest has a significant influence on the amount of carbon contained in its standing biomass. The older the forest, the more carbon it contains. In response to changes in disturbance regimes, the age class structure of the boreal and subarctic forests has changed markedly since 1920. Between 1920 and 1969, the average age of the boreal and subarctic forests increased from 60.9 to 82.5 years. This suggests that the rate of disturbance was lower during this period than it had been previously. An apparent increase in natural disturbances since 1970 caused a decrease in the average forest age to 76.4 years in 1989. Figure 5.a.1 shows that the forest biomass carbon pool contained an estimated 5 600 MtC in 1920, 8 700 MtC in 1970, and 7 100 MtC in 1989.

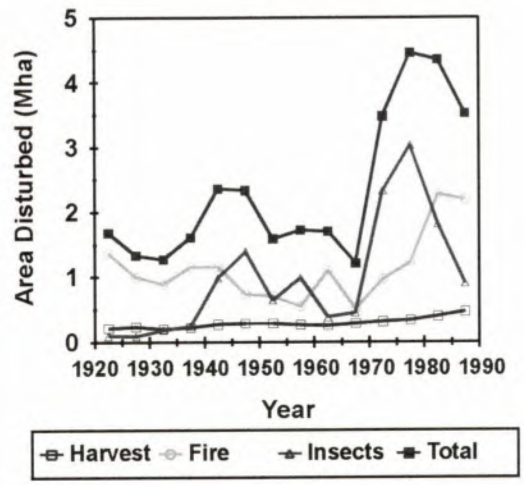


Figure 5.a.3 Average area disturbed by fire, insects and harvesting over the period 1920-89 for Boreal and Subarctic forests

c) Sources for Information

See Indicator 5.c.

5.b. Contribution of forest ecosystems to the total global carbon budget, including absorption and release of carbon (standing biomass, coarse woody debris, peat and soil carbon)

a) What are we measuring?

This report presents estimates of the carbon currently stored in Canadian forests and outlines changes in the carbon budget for the boreal and subarctic zones over the period 1920 to 1989.

b) Factual description

The amount of carbon stored in all Canadian forests in 1986 is estimated to have been approximately 221 000 MtC (Figure 5.b.2). This includes 14 500 MtC in standing vegetation biomass (trunks, branches, roots, etc.), 70 600 MtC in forest soils and detritus, 135 000 MtC in peatland soils and approximately 600 MtC in forest products. The forest products pool is relatively small (0.3% of the total of all forest carbon pools), but is important in terms of the annual flux between pools. The boreal and subarctic forests, although representing about 75% of Canada's forest area, contain only 49% (7 100 MtC) of Canada's total standing biomass carbon, 73% (51 600 MtC) of the carbon stored in the soil and detritus, and 49% (280 MtC) of the forest products carbon pool.

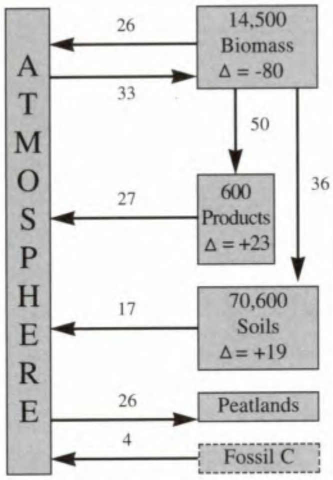


Figure 5.b.2
Overview of the major C pools and fluxes (MtC) for all Canadian forests over the period 1985-90.

As shown in Figure 5.b.1, the forest carbon budget consists of four major carbon pools: forest biomass, forest soils (which include litter and coarse woody debris), peatland soils and forest products derived from forest resources (building materials, wood products, paper, etc.). On a daily, seasonal and annual basis, carbon moves between the four forest carbon pools and the atmosphere, as depicted in Figure 5.b.2.

The modelled carbon budget for the boreal and subarctic forests over the period 1920-89 is illustrated in Figures 5.a.1, 5.a.2, and 5.a.3. A number of changes are evident. While over this period the boreal and subarctic forests were carbon sinks of an average 118 MtC/yr (Figure 5.a.2), they abruptly became sources of atmospheric carbon during the 1980s, averaging 57 MtC/yr. Between 1920 and 1989, these two forest areas accumulated 8 300 MtC; 1 400 MtC in the biomass and 6 800 MtC in the soil and detritus pool (Figure 5.a.1). The amount of carbon stored in biomass (trunks, branches, leaves and roots) increased from 5 600 MtC in 1920 to 8 700 MtC in 1970, and subsequently decreased to 7 100 MtC in 1989. The net transfer of carbon from the biomass carbon pool to that of forest products (Figure 5.a.1) was 280 MtC between 1920 and 1989, increasing annual net carbon storage by 4 MtC/yr over that period.

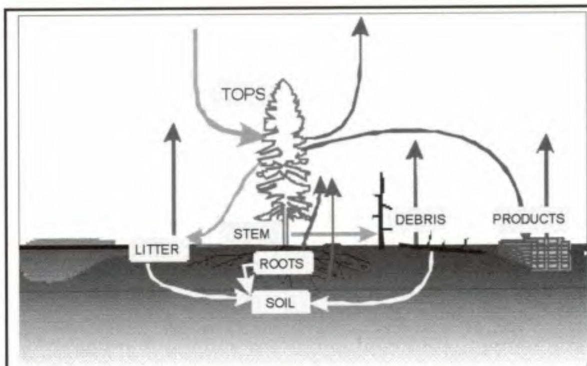


Figure 5.b.1 Carbon pools and transfers in a forest.

c) Sources for information

See Indicator 5.c.

5.c. Contribution of forest products to the global carbon budget

a) What are we measuring?

The carbon budget model for the Canadian forest sector estimates the amount of harvested material that is converted into wood products, as well as the loss of carbon associated with wood and paper products disposed of in landfill. This report presents estimates of the net contribution of forest products from the boreal and subarctic forest zones to the global carbon cycle, and outlines changes in these carbon pools over the period 1920 to 1989. While analysis of the forest products component of the carbon budget is not yet complete, and there are many uncertainties associated with the current estimates, they do represent the best data available at this time.

b) Factual description

The amount of carbon stored in Canada's boreal and subarctic forests, excluding peatland soils, is estimated to be 58 980 MtC. This includes 7 100 MtC in standing vegetation biomass, 51 600 MtC in forest soils, and approximately 280 MtC in forest products. The "forest products" category represents the total accumulated from forest harvesting over the last 40 years after accounting for decomposition and burning of wastes. This carbon pool is only 0.5% of the total forest carbon pool; however, it currently represents a sink for carbon, while the forest soils and standing biomass pools have become sources. Research indicates that more carbon is being accumulated annually in the forest products pool than is being lost through decomposition in landfills. From 1985 to 1989, the forest products carbon pool increased at an average rate of 6.8 MtC/yr. The overall loss of carbon from the boreal and subarctic forest ecosystems is currently estimated at 57 MtC/yr.

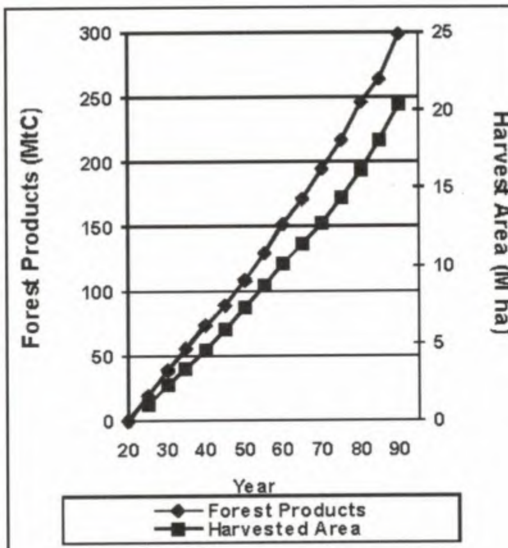


Figure 5.c.1 Total carbon retained in the Forest Products C Pool in relation to Total Area Harvested in the Boreal and Subarctic Forests Over the Period 1920-89.

The area harvested in Canada from 1920 to 1989 was 20.3 Mha, or 6.7% of the total Canadian forest area (Figure 5.c.1). Over that period, the forest products pool in the boreal and subarctic forest ecosystems increased carbon storage by approximately 4.26 MtC/yr. The rate of accumulation in the forest product carbon pool has increased steadily over the last 70 years as forest products use has increased.

c) Sources for information

1. M.J. Apps, W.A. Kurz, "Assessing the Role of Canadian Forests and Forest Sector Activities in the Global Carbon Balance" *World Resource Review,* Vol 3(4) (1991), p. 333-343.
2. W.A. Kurz, M.J. Apps, "Retrospective assessment of carbon flows in Canadian boreal forests" in *Forest Ecosystems, Forest Management and the Global Carbon Cycle,* Edited by M.J. Apps and D.T. Price, NATO ASI Series 1: Global Environmental Change (Springer-Verlag, Heidelberg, Vol. 40), p. 173-182.
3. W.A. Kurz, M.J. Apps, S.J. Beukema, T. Lekstrum, "20th century carbon budget of Canadian forests", *Tellus* 47B (1995), p. 170-177.
4. W.A. Kurz, M.J. Apps, T.M. Webb, P.J. McNamee, *The Carbon Budget of the Canadian Forest Sector: Phase 1.* Information Report NOR-X-326 (Edmonton, Alberta: Forestry Canada Northwest Region, 1992).

iii) Summary

Current estimates suggest that since the second half of the 1980s, Canada's boreal and subarctic forests have been a net source for atmospheric carbon. The precise magnitude of the carbon release is uncertain, but it seems fairly clear that after acting as a sink for atmospheric carbon for mush of this century, these forests have reversed their role in the global carbon cycle.

Recent investigations into the carbon budget suggest a number of important relationships. First, the budget is not constant, but changes over time in response to a number of factors that affect forest productivity, including forest management practices, and fires, insects and diseases. Secondly, the amount of carbon in a forest is strongly influenced by the age distribution of its trees. Hence, the timing and rate of disturbances are important in determining whether our forests are important in determining whether our forests are a sink or source for atmospheric carbon. Lastly, changes in a forest's uptake or release of carbon are primarily the result of fluctuations in natural disturbance regimes. For example, the recent 20-year period of high disturbances in the boreal forest will likely affect the dynamics of the forest carbon budget for decades. Consequently, over the long-term, it is unclear whether Canada's forests can be considered significant sinks for the atmospheric carbon released by society's use of fossil fuel energy sources.

Development of the carbon budget model of Canada's forests is not complete–research to improve various components is continuing. Changes in the carbon estimates can be expected as new data are obtained, improvements to the model are made, and our understanding of the carbon cycle increases.

VII CRITERION 6

Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies

VII. Criterion 6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies

i) Introduction

Canada's forests provide a diverse mix of socioeconomic benefits. These include jobs, wages, profits and tax revenues from producing and consuming forest-related goods and services; user benefits associated with the opportunity to participate in outdoor recreation and tourism; environmental benefits such as clean air and water, erosion control, and the existence of natural wilderness; and benefits that satisfy the cultural, social, and spiritual needs of Canadian society.

Forests are a finite resource. Choices must therefore be made about how they will be managed and utilized, how future consumption demands will be met, and which benefits (and in what proportion) will best satisfy the needs of present and future generations. The mix of benefits provided by forests is determined by markets and governments. Canada has a high percentage of forest land under public ownership, and the flow of benefits from our forests reflects the commitment by governments to provide a broad range of public goods and services to current and future generations of Canadians.

This criterion report provides quantitative and qualitative information on the magnitude of socioeconomic benefits generated by Canada's forests. It does not consider factors which influence the mix of benefits provided by forests as this is determined by the institutional framework in place. The design of social institutions is considered in more detail in Criterion 7.

ii) Indicator reports

6.1 Production and consumption

6.1.a. Value and volume of wood and wood products production, including value added through downstream processing

a) What are we measuring?

National-level data on this indicator are not currently available. Data concerning the contribution of the forest products industry to the Canadian Gross Domestic Product are provided in Indicator 6.1.d.

6.1.b. Value and quantities of production of non-wood forest products

a) What are we measuring?

A wide variety of non-wood forest products are extracted from the forest, including firewood and fuelwood, pelts, game, food (e.g., mushrooms and berries), and a range of botanical medicines and craft materials. At the national level, limited information is available on the harvest of these products.

Information reported includes trends in: the number and value of wild pelts obtained by the commercial trapping industry (note: these values do not include pelts produced on game ranches); the wholesale value of maple products and Christmas trees; and the number of establishments and total revenues of private campgrounds, travel trailer parks, outfitting operations, and other recreation and vacation camps.

b) Factual description

After peak sales of almost $100 million in 1988, the wholesale value of maple products declined overall until 1993, but improved dramatically in 1994 to almost $106 million (Figure 6.1.b.1). The Christmas tree industry averaged $52 million in sales between 1990 and 1995. Maple products and Christmas trees are generally produced on private land.

Figure 6.1.b.1 Trends in the Wholesale Value of Maple Products and Christmas Trees (thousands of dollars)

Year	Maple products	Christmas trees
1980	35 792	
1981	42 589	
1982	28 027	
1983	29 065	
1984	29 643	
1985	45 892	
1986	63 109	
1987	58 076	
1988	96 029	
1989	77 208	
1990	73 279	51 480
1991	59 075	48 901
1992	82 076	47 754
1993	61 332	49 957
1994	105 994	59 448
1995	93 387	55 512

Source: National Forestry Database and Statistics Canada.

Trends in the number and value of animal pelts produced by the commercial trapping industry are presented in Figure 6.1.b.2. On a value basis, beaver and marten are the most important fur-bearing animals trapped in Canada's forests.

Figure 6.1.b.3 shows trends in the number of establishments and total value of receipts for private campgrounds, outfitting operations, and recreation and vacation camps. Total revenues for these sectors in 1993 were $686 240 000. However, it is not possible to determine which of these establishments were situated in forest settings and which were situated along major highways or in non-forested areas. Some decline in outfitting and other recreation and vacation camps has occurred in recent years. This may be attributable to the recession of the early 1990s and a decline in discretionary disposable income.

The total value of products for all non-wood goods and services discussed in this indicator was approximately $820 million in 1993. The total value of shipments of the forest products sector in 1994 was $58.7 billion.

c) Sources for information

1. Natural Resources Canada–Canadian Forest Service, *Compendium of Canadian Forestry Statistics* (Ottawa, Ontario)

Table 6.1.b.2 Number and Value of Wildlife Pelts Produced by Species, 1990/91 - 1994/95

SPECIES	1990–1991		1991–1992		1992–1993		1993–1994		1994–1995	
	Number	$ value	Number	$ value	Number	$ value	Number	$ value	Number	$ value
Badger	574	10 437	933	11 599	686	11 667	758	18 710	863	21 523
Bear	–	–	–	–	2 827	300 646	–	–	–	–
Black/brown bear	1 370	103 342	2 544	712 843	–	–	2 507	180 771	2 991	199 342
Grizzly bear	306	214 200	–	–	–	–	–	–	6	6 008
White bear	267	426 026	–	–	–	–	117	100 016	115	98 035
Beaver	167 519	2 207 143	219 737	3 651 009	85 965	2 776 341	244 561	7 335 439	326 550	8 908 501
Coyote/prairie wolf	24 324	443 445	43 682	1 507 453	48 696	1 890 970	48 752	1 937 164	51 059	1 328 219
Ermine (weasel)	18 675	65 344	30 388	104 862	23 442	106 904	28 460	149 955	51 804	201 981
Fisher	8 791	433 295	15 381	783 000	13 377	412 577	13 105	513 041	14 675	584 406
Blue fox	76	551	–	–	49 427	895 442	–	–	–	–
Cross/red fox	28 502	372 951	–	–	–	–	136	3 395	9 052	233 086
Silver/black fox	491	5 622	–	–	–	–	41 577	956 085	44 255	1 176 058
White fox	1 023	11 455	–	–	–	–	9 884	203 545	2 380	63 947
Lynx	7 579	572 325	11 542	999 170	7 180	511 333	4 713	487 855	4 875	419 235
Marten	157 733	7 979 946	184 222	10 371 796	117 879	4 463 088	109 356	6 067 000	139 552	6 450 572
Mink	41 037	1 052 597	46 512	1 634 104	33 618	802 629	34 450	926 048	39 318	760 548
Muskrat	195 659	321 496	204 112	444 297	218 890	436 133	326 353	875 134	401 372	1 010 933
Otter	8 489	245 647	12 026	601 486	12 575	727 348	15 383	1 500 216	21 132	1 663 749
Raccoon	12 499	75 516	23 493	246 055	26 927	291 093	56 390	957 690	122 660	1 884 386
Skunk	101	306	–	–	–	–	273	1 215	574	1 998
Squirrel	40 530	33 956	95 974	129 709	68 555	113 586	117 107	157 508	103 060	132 655
Wildcat	582	27 894	448	20 873	628	25 756	727	50 402	1 221	74 355
Wolf	2 566	502 267	3 155	559 816	3 770	593 329	3 721	573 024	3 372	387 106
Wolverine	414	78 040	686	147 696	637	106 485	485	85 500	559	105 667
Other	21	26	231	561	1 395	20 446	88	232	–	–
TOTAL	**719 128**	**15 183 827**	**951 876**	**22 919 937**	**816 474**	**14 485 773**	**1 060 662**	**23 115 771**	**1 344 263**	**25 781 387**

Source: Statistics Canada

Figure 6.1.b.3 Trends in the number of establishments and in total revenues for service industries dependent on forests : 1986 - 1993

Year	Sic 913 Campground and travel trailer parks		Sic 914 Outfitters, other recreation and vacation camps	
	Number of establishments	Total revenue $ 000	Number of establishments	Total revenue $ 000
1986	2 003	229 900	1 439	232 000
1987	2 198	256 300	1 337	277 600
1988	2 387	279 100	1 618	299 900
1989	2 405	291 400	1 764	329 800
1990	2 454	310 100	1 826	347 100
1991	2 478	316 300	1 862	339 700
1992	2 514	325 300	1 847	331 300
1993	2 507	340 040	1 826	346 200

Source: Statistics Canada.

6.1.c. Supply and consumption of wood and wood products, including consumption per capita

a) What are we measuring?

This indicator provides information on 1994 consumption per 1 000 Canadians for softwood lumber, wood-based panels, and paper and paperboard products.

b) Factual description

Figure 6.1.c.1 shows consumption per 1 000 people for major forest products commodity groupings. Generally speaking, Canada consumes a significant amount of forest products on a per capita basis. Factors that account for this include:

* Canada possesses huge forest areas, which provide abundant and accessible sources of wood fibre. As a result, wood has a significant price advantage over alternative building materials such as cement and steel;

* Wood fibre has desirable insulation features that make it particularly well suited for use as a building material in northern climates;

* Because forests are a renewable resource and wood is recyclable, wood products have less impact on the environment than alternative materials such as concrete and steel.

Figure 6.1.c.1 Canadian Per capita Consumption of Forest Products (1994)			
Softwood Lumber m^3/ 1 000 people	Wood-based panels m^3/ 1 000 people	Paper & paperboard tonnes/ 1 000 people	Population million
558	134	202	29.5

Source: Statistics Canada

c) Sources for information

1. Statistics Canada.

6.1.d. Value of wood and non-wood products production as percentage of GDP

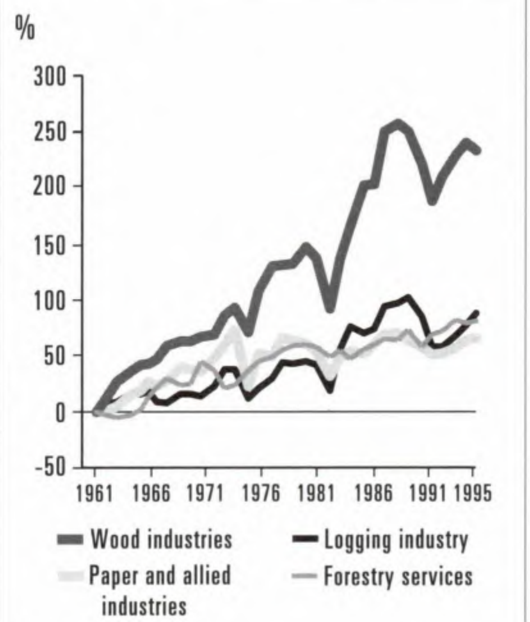
a) What are we measuring?

While Indicator 6.1.b. describes the contribution of some non-timber industries to the economy, its values are not directly comparable with those of 6.1.d. The former provides information on total value of sales, while this indicator describes the contribution of the forest sector to Canada's Gross Domestic Product (GDP) in 1995 and shows the percentage changes in the contributions (constant dollars) between 1961 and 1995.

b) Factual description

Canada's forest sector makes a significant contribution ($20.38 billion in 1995) to the national GDP ($776 billion in 1995). The pulp and allied industries made the largest contribution to the national income in 1995–$9.86 billion. Wood industries contributed $6.37 billion; the logging industry, $3.65 billion; and forestry services, $500 million. Figure 6.1.d.1 shows trends in the forest sector GDP (in real dollars) since 1961. The contribution of the paper and allied industries increased by approximately 66% between 1961 and 1994, while the contribution of the wood industries showed much more significant gains–a 233% increase.

6.1.d.1 Increase in Contribution to GDP by Sector Since 1961



Source: Statistics Canada

c) Sources for information

1. Statistics Canada.

6.1.e. Degree of recycling of forest products

a) What are we measuring?

Recycling efficiency for paper products is measured by comparing the quantity recovered with the quantity used or consumed–the "recovery rate". Another way of measuring this efficiency is the "utilization rate", which is obtained by comparing the quantity of paper recovered with the quantity of pulp and paper produced.

b) Factual description

Canada has made great strides in recycling. Currently, 42% of all paper consumed is recovered, and paper products now contain 22% recycled content, up from 10% in 1990[1]. In 1995, 18.6 million tonnes of paper and paperboard were produced in Canada. The pulp utilized to manufacture these products incorporated 4.1 million tonnes of recycled wood fibre (2.2 million tonnes recovered in Canada and 1.9 million tonnes imported from the United States). The proportion derived from post-consumer waste is not known.

Recycled-material content is not regulated in Canada, but voluntary national goals have been established. From 1990 to 1995, Canada's forest industries invested $1.2 billion to increase their recycling capacity, mostly in recycled newsprint production. Some 60 of the country's 110 paper and paperboard mills now use recovered paper for all or part of their supply. Of these, 23 mills produce newsprint with old newspapers and magazines as an important component of the total fibre supply.

Recent data and trends for recycled products are shown in Figure 6.1.e.1. Total mill receipts of old newspapers and corrugated containers, which each exceeded 1.5 million tonnes, increased in 1995 compared with the previous year. Imports of U.S. newspapers represented more than 55% of consumption, while containers represented 30%. Among other products, receipts of high-grade de-inked papers fell in 1995, with imports accounting for 57%. Total receipts of old magazines also declined overall. Domestic receipts increased, but imports, which represented 75% of the total supply used by mills, decreased.

Wood products, which are relatively inexpensive in Canada, have long been the residential building material of choice. Construction of a typical Canadian dwelling produces 4-7 tonnes of waste materials, of which wood products account for 35-45%. Recently, competition has reduced the cost allowance for off-cuts and waste from 15% to 5% or less. Also, on-site separation of wood wastes has also made it possible to reuse and sell construction debris. In one instance, framers and carpenters were able to reuse approximately 500 kilograms of dimensional lumber that might otherwise have gone to a landfill site–a 20% reduction in wood waste. These savings, added to an already

1 This is an average figure which varies by region and product

reduced allowance for construction wastes, generated an on-site reduction of at least 30% in wood waste.

For every six homes built in Canada, one is demolished. Recycling of demolition waste is a growing market. With tenfold or higher increases in landfill tipping fees, 50 material recycling facilities have opened since 1988 in major urban markets. Approximately one third of these operate retail outlets. These facilities have created a market in Canada for value-added wood products such as large timbers, doors, windows, architectural millwork, cabinet work and hardwood flooring at prices 30-50% below those for new materials. They have also spawned technologies to manufacture new products from demolition wastes (e.g., mulches, animal bedding, fibre-based boards and mats for further manufacture by the automotive industry).

Wooden pallets, which account for 90% of container production, are no longer accepted at many urban landfill sites. They may be reused up to 50 times, however, and each year, the Canadian Pallet Council repairs almost one million pallets for reuse by industry members. (The Council has grown from 200 members in 1983, to more than 800 in 1996.) Pallets that are beyond repair are now recycled as mulch, wood fibre for new-age building products, and chips for composting municipal sewage sludge.

Figure 6.1.e.1 Mills and domestic receipts of recycled products, 1995

PRODUCT	MILL RECEIPTS thousand tonnes	CHANGE 1994-1995 %	DOMESTIC RECEIPTS thousand tonnes	CHANGE 1994-1995 %	IMPORTED FROM USA %
Old newspapers	1 518	+5	675	+2	55
Old corrugated containers	1 512	+5	1 040	+5	30
Hi-grade de-inked papers (e.g., computer print outs and sorted office waste)	527	-1	224	-	57
Old magazines	195	-5	50	+9	75
Source: Canadian Pulp & Paper Association					

c) Sources for information

1. Natural Resources Canada–Canadian Forest Service (personal communication).
2. Canadian Pulp and Paper Association, *Reference Tables, 1995*.

6.1.f. Supply and consumption/use of non-wood products

a) What are we measuring?

Available information on fuelwood use and wildlife harvesting is provided in Indicator 2.e. (Annual removal of non-timber forest products...).

6.2 Recreation and tourism

6.2.a. Area and percent of forest land managed for general recreation and tourism, in relation to the total area of forest land

a) What are we measuring?

Virtually 100% of the public forest landbase in Canada is managed for multiple uses, and thus for general recreation and tourism as well as an array of other uses such as timber extraction.

Although all public forest lands are managed for outdoor recreation and tourism as well as other uses, some areas are protected in parks in order to preserve their unique features and characteristics. The provision of opportunities for outdoor recreation and tourism is an important (although not always dominant) reason for establishing parks. This indicator therefore provides a general overview of Canada's system of provincial and national parks.

b) Factual description

Canada's national park system is comprised of 38 parks covering an area of 224 000 km². The parks range in size from less than 10 km² to over 44 000 km². At 44 802 km², Wood Buffalo National Park in northern Alberta is the second largest national park in the world. Figure 6.2.a.1 shows the location of national parks in Canada.

Figure 6.2.a.1

Although Canada's national parks are widely used for outdoor recreation, the management objectives of Parks Canada are far broader. From 1991 to 1994, Parks Canada's policies were publicly reviewed and revised. The new policy now places greater emphasis on protecting ecological integrity and park ecosystems.

Canada is divided into 39 natural regions, each with distinctive characteristics. The goal is to create a national park for each of these regions by the year 2000. The existing 38 national parks represent about 2% of Canada's land mass.

In addition to the national park system, there are more than 1 200 provincial parks with a combined area of approximately 229 000 km^2.

c) Sources for information

1. Heritage Canada–Parks Canada, *State of the Parks Report, 1996* (Ottawa, Ontario).

6.2.b. Number and type of facilities available for general recreation and tourism, in relation to population and forest area

a) What are we measuring?

National-level consolidation of data on the number and type of recreation and tourism facilities is not available.

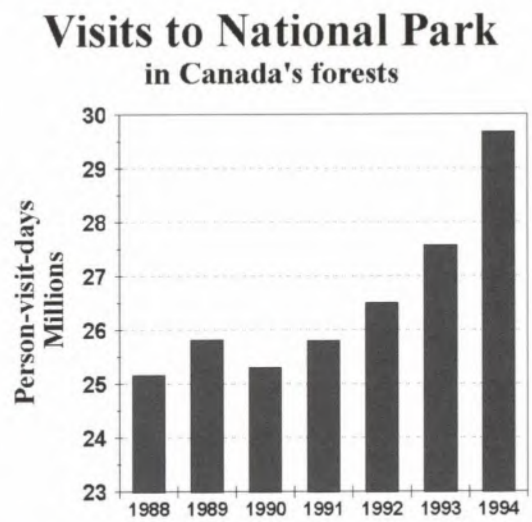
6.2.c. Number of visitor days attributed to recreation and tourism, in relation to population and forest area

a) What are we measuring?

Changes in public preferences and in the availability of forests for outdoor recreation are illustrated by the levels of participation in a small set of forest-based recreation activities. This indicator presents trend data on the number of days in which Canadians were engaged in non-consumptive activities related to wildlife, the number of days in which Canadians were engaged in hunting, and the number of person-visit days to Canada's national parks. The statistics for hunting and non-consumptive wildlife-related activities cover all land categories. It is not possible to differentiate between activities in forested areas and those in non-forested areas. "Visitor days to national parks" is restricted to parks located within Canada's forested areas.

b) Factual description

Trends in the total number of days in which Canadians engaged in hunting are provided in Figure 6.2.c.1. The graph shows a general decline in the level of hunting activity since 1981. Activities related to non-consumptive activities such as wildlife viewing, nature study, and photography increased between 1981 and 1991 (Participation in 1981 was 3.6 million, 1987 was 4.4 million, 1991 was 3.9 million.)

Figure 6.2.c.1	Figure 6.2.c.2
	

The growing interest in the use of Canada's forests for non-consumptive recreation-related activities is illustrated in Figure 6.2.c.2. Visits (by both Canadian residents and foreign tourists) to national parks located within Canada's forest boundaries have increased since 1990.

c) Sources for information

1. Environment Canada, *The importance of wildlife to Canadians: Highlights of the 1991 survey.*
2. Heritage Canada–Parks Canada (unpublished material).

6.3 Investment in the forest sector

6.3.a. Value of investment, including investment in forest growing, forest health and management, planted forests, wood processing, recreation and tourism

a) What are we measuring?

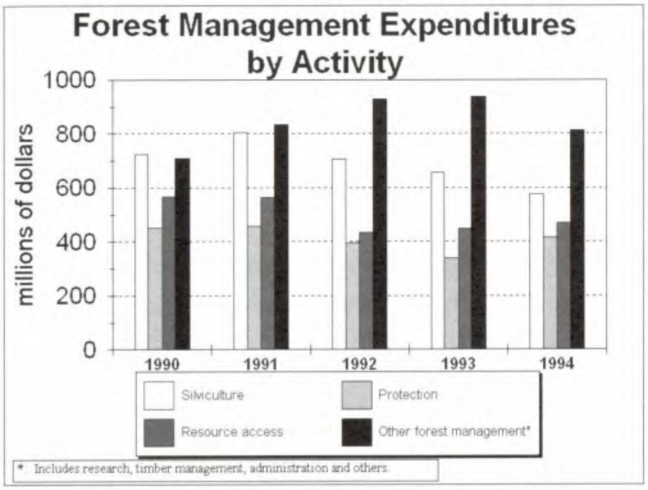
Management and development expenditures have the potential to increase the productive capacity of the landbase. Data for silviculture, resource access (e.g., road construction), protection and general stewardship (e.g., inventory development, research, timber management, integrated resource management and public information) are available at the national level through the National Forestry Database Program (NFDP). Trend data for wildlife management, recreation management, parks programs and costs of protected areas either are not available or are aggregated with general stewardship data. The NFDP could be expanded to include this information.

Trend data on the value of capital and repair expenditures in the forest sector are also provided.

Data on the value of investment in the logging and wood processing industries are not available at the national level.

Expenditures on forestry-related and forest products-related research and development are discussed in Indicator 6.3.b.

Figure 6.3.a.1

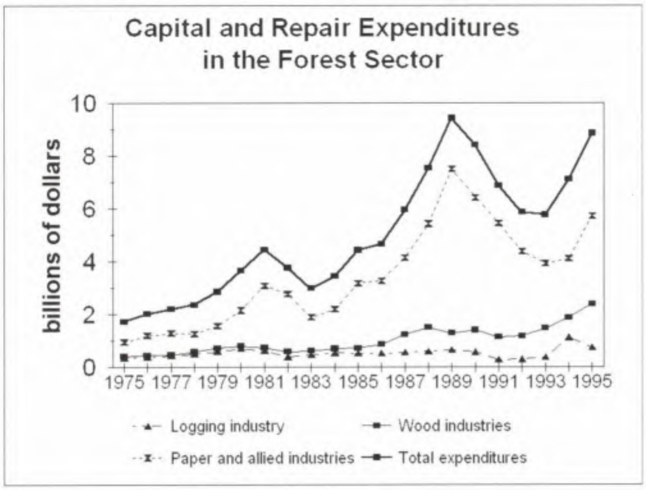


b) Factual description

Figure 6.3.a.1 shows the trends in forest management spending by governments and industry over the period 1990-94. Expenditures on silviculture, protection and resource access decreased, while those for other management activities (e.g., research and timber management) increased slightly. These trends may reflect the shift towards ecosystem-based management regimes, which are information intensive and emphasize natural regeneration of harvested lands, rather than costly planting and seeding.

Figure 6.3.a.2 shows the trend in total capital and repair expenditures in the forest sector over the period 1975-1995. These represent investments made by the logging, wood, and paper and allied industries. Expenditures increased substantially between 1975 and 1989, from $1.7 billion to $9.4 billion. This was driven by an expanding forest sector, the need to replace ageing capital stock with current technologies, and the adoption of more stringent pollution abatement regulations. The level of investment declined in subsequent years, increasing again in 1994 and 1995, when most companies returned to a profit-making position. In 1995, total expenditures amounted to $8.9 billion.

Figure 6.3.a.2



c) Sources for information

1. Canadian Council of Forest Ministers–National Forestry Database Program.
2. Canadian Pulp and Paper Association.
3. Statistics Canada, Cat. No. 25-202, 61-205, and 61-206.

6.3.b. Level of expenditure on research and development, and education

a) What are we measuring?

This indicator reports on trends in expenditures for two categories of research and development (R & D): industry-oriented and forest resource-based. Information is also provided on public forestry education activity in Canada. The data presented in this indicator focus on government spending and direct forest products industry spending on R & D. Expenditures on R & D by equipment suppliers and manufacturers are not included in the totals, nor are expenditures by universities on forest resources research or product and process research.

b) Factual description

The ability of forest products producers to compete in domestic and international markets is determined by their ability to minimize production costs and develop value-added products for specialty markets. Technological progress is important for achieving both of these abjectives.

Trends in R & D expenditures provide a useful preliminary indication of the ability of firms to innovate, and thus maintain their competitiveness. Several studies on the expected net social benefits of R & D in the forest sector indicate that increased investment is desirable and that private returns are high enough for firms to increase their R & D investments, even in the absence of government incentives.

Historically, research efforts in the Canadian forest sector focused on developing the knowledge and technology required to produce a quality product while minimizing production costs. Recently, the emphasis has changed. The sector is continuing its research into efficient processing, but is now focusing its efforts on new and value-added products and on environmental protection activities. It is also responding to changing

Figure 6.3.b.1 Trends in Industrial Intramural R & D Expenditures in Forestry

Performer	1988	1989	1990	1991	1992e	1993	1994p	1995i
				in millions of $				
Logging and forestry	7	8	8	11	8	9	9	9
Wood Industries	20	18	42	19	20	23	24	24
Paper and allied products	145	151	115	98	94	102	102	110
Total	**172**	**177**	**165**	**128**	**122**	**134**	**135**	**143**

Source: STC cat 88-202
e: estimates
p: preliminary
i: intentions

Note: Also includes the following research institutes: FERIC, FORINTEK, PAPRICAN consumer preferences and placing a higher emphasis on research into more environmentally benign products, as well as products made from recycled materials.

Overall, industry-oriented R & D expenditures were $143 million in 1995. This represented about 0.28% of total industry sales for that year. Total expenditures on industry-oriented R & D declined from $172 million in 1988 to $143 million in 1995 (Figure 6.3.b.1). This decline is principally due to a reduction in expenditures by the paper and allied industries. Spending on research in the wood industries, on the other hand, has increased since 1988. These trends indicate either that the return on investment for industry-related research is declining in the paper and allied industries and increasing in wood industries, or that the overall profitability of the paper and allied industries is declining and discretionary funding for R & D is therefore not available.

Figure 6.3.b.2 shows that total expenditures on forest resource-related research increased between 1990 and 1994. This includes the budget of NRCan–CFS and provincial forest agencies, as well as research supported by the federal-provincial agreements in forestry. The totals do not include spending by companies or research conducted at universities.

Figure 6.3.b.2 Government Expenditures of Other Forest-Based Research

1990	1991	1992	1993	1994
in millions of $				
112.8	126.1	137.0	137.0	151.2

Source: National Forestry Database

Most provincial funding goes to applied forest research. Expenditures range from zero in jurisdictions with low forest dependence (e.g., Prince Edward Island and the Yukon Territory), to tens of millions of dollars in jurisdictions heavily dependent on forests (e.g., British Columbia spent $18.7 million in 1995-96, and Québec has averaged $13.5 million per year over the past few years).

NRCan-CFS is the principal forest science research agency in Canada. Its research program was recently reorganized into ten networks, each addressing a strategic policy issue. These networks provide the necessary critical mass for undertaking research in complex areas such as forest biodiversity, forest ecosystem processes, and climate change. A National Advisory Board on forest research will provide strategic recommendations on forest research needs, directions, priorities, and coordination. NRCan-CFS also intends to increase the emphasis on research partnerships with provincial and territorial governments, industry, universities and other stakeholders.

Universities are also significant contributors to forest research and education. Those directly involved in forest research and teaching on an ongoing basis are: the University of British Columbia, the University of Northern British Columbia, the University of Alberta, Lakehead University, the University of Toronto, Laval University, the University of New Brunswick and the University of Moncton. The University of Alberta is leading the Network Centre of Excellence on Sustainable Forest Management. The expenditures for this program totalled $2.4 million in 1995-96 and $4.0 million in 1996-97.

Expenditures on public forestry education are difficult to define and measure. The above-noted universities all have teaching capability, but public awareness and forestry education in the curriculum of public schools are also important aspects of education. The Model Forest Program places a high priority on public awareness and technology transfer, and the 10 model forests spent a total of $1.5 million in these areas in 1994-95. The Canadian Forestry Association has documented more than 200 forestry education programs in local school systems.

c) Sources for information

1. Canadian Council of Forest Ministers, *Compendium of Forest Statistics* (Natural Resources Canada–Canadian Forest Service, 1994).
2. Statistics Canada, *Industrial R & D Statistics,* Cat. 88-202.
3. FERIC, FORINTEK and PAPRICAN, Annual Reports.

6.3.c. Extension and use of new and improved technologies

National-level information is not available at this time.

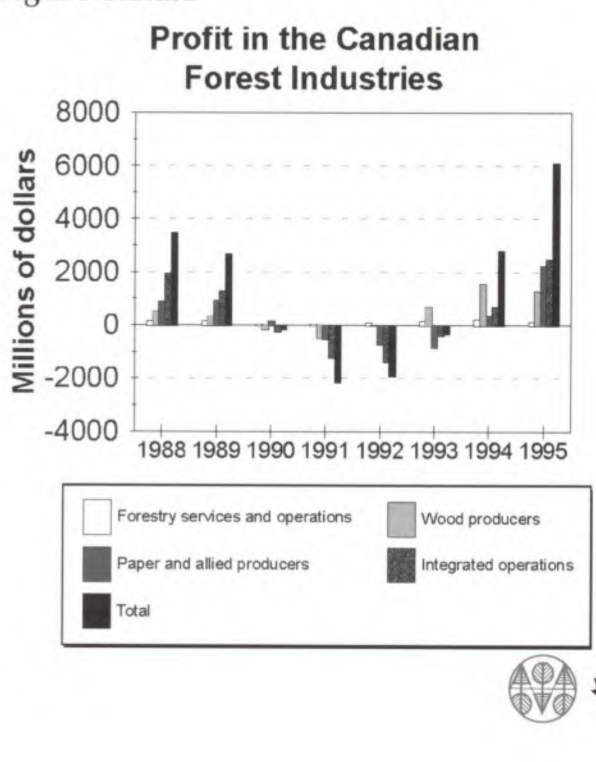
6.3.d. Rates of return on investment

a) What are we measuring?

This indicator does not report on the return on investment, but rather presents trend data on total profits for various forest industries over the period 1988 to 1995.

Monitoring the profitability of the forest sector enables us to assess the structural changes that may be taking place. Canadian firms compete with foreign firms in export markets. In some cases, new low-cost producers may enter traditional markets and reduce prices. However, declining profitability in a particular sub-sector shoud not automatically be equated with unsustainability. The decline may simply be a symptom of structural change occuring in the marketplace.

Figure 6.3.d.1



b) Factual description

Figure 6.3.d.1 shows the profit performance of Canada's forest sector from 1988 to 1995. The graph demonstrates the high levels of profit variability that may be experienced over short periods of time. Canada's forest industries are traditionally cyclical, and reduced profits and financial losses are normal during the down portion of business cycles as experienced in the early 1990s. Profits rose again in 1995.

c) Sources for information

1. Statistics Canada, *Financial and Taxation Statistics for Enterprises 1991-1995* (Oct. 17, 1996).

6.4 Cultural, social and spiritual needs and values

6.4.a. Area and percent of forest land managed in relation to the total area of forest land to protect the range of cultural, social and spiritual needs and values

a) What are we measuring?

This indicator measures the degree to which the social, cultural and spiritual values that Canadians attach to forest landscapes are protected. Sometimes, places of ecological significance also have cultural, social or spiritual significance. In other instances, protection of small areas may be desirable for uniquely cultural or social reasons, in the absence of ecological rationale.

b) Factual description

Approximately 7.6% of Canada's forested land currently has some degree of protection. No area-based calculations have attempted to discern how much of this area is protected on the basis of ecological versus socio-cultural criteria. Roughly half of this area is protected from all commercial natural resource extraction. Between 1986 and 1991, the area of national parks in Canada increased by 28% and the area of provincial parks increased by 14%.

The 1991 *State of Canada's Environment Report* documents 7 876 cultural heritage sites under protection. The methodology used to arrive at this figure is experimental. The list does not include area-based measures of coverage, nor does it specify how many such sites are located in forested landscapes. Many of the sites included are quite small in area, some are located in urban or other non-forested environments, and all vary in their degree of protection.

The reporting strategy employed by the *State of Canada's Environment* authors gives an approximation of protected cultural heritage sites in Canada. However, it does not document protected areas of forest land for places that may have significant and ongoing cultural use values. For example, First Nations Canadians have many sites that are used for ritual purposes, or for subsistence activities such as trapping, gathering, and hunting. These places have cultural, social, and spiritual significance, but there are currently few areas explicitly protected for such activities, and few data regarding the location and size of such sites (see Indicator 6.5.d.).

c) Sources for information

1. Environment Canada, *The State of Canada's Environment* (Ottawa, Ontario: 1991).

6.4.b. Non-consumptive use forest values

a) What are we measuring?

"Non-consumptive forest use values" are defined as "goods and services" that do not lead to the physical taking of products from the forest. These include recreation, photography, birdwatching, education, and contemplation or meditation. In most cases, these values can be estimated using public surveys and questionnaires, or through indirect indicators such as membership in hiking clubs, birdwatching clubs, or forest conservation organizations. This indicator is worded so as to focus on the direct uses of forests for non-consumptive benefits, rather than indirect benefits such as existence values, bequeath values, etc.

Canada's forests provide a number of non-timber values that are difficult to measure because of the absence of information regarding their cost and importance to Canadians. This general lack of information on the social benefits of non-timber values is a challenge for policy-makers, planners and foresters, who must make difficult choices regarding the mix of benefits to provide.

For non-timber values that involve forest use, proxies such as visits to national parks and trends in expenditures provide a partial indication of preferences. One of the most comprehensive databases on Canadians' expenditures and activity patterns for outdoor recreation is the *National Survey on the Importance of Wildlife to Canadians,* conducted by Environment Canada and Statistics Canada.

b) Factual description

In the spring of 1996, the Canadian Institute of Forestry sent a survey to 145 national and provincial organizations representing forest recreation and conservation interests. Information was requested on the number of members and the level of contributions. (The organizations will be surveyed annually to identify trends in Canadians' participation rates.) Seventy-three organizations responded to the survey–a response rate of 55%.

Table 6.4.b.1 Trends in memberships and financial contributions to wildlife organizations between 1981 and 1991

Year	Percent of population who were members %	Number of individuals who were members (millions)	Contributions ($ millions - nominal)
1981	6.0	1.1	119.4
1987	6.9	1.4	73.5
1991	9.0	1.9	151.2

Source: Environment Canada, Survey on the Importance of Wildlife to Canadians.

More than 1.3 million individuals and 1 451 corporations were members of at least one of the outdoor and environmental organizations that responded. Most membership fees were under $100. The annual expenditures of these organizations totalled approximately $45 million. A new survey was also conducted in 1996, however, the results were not available at the time this report was released.

Information on the level of participation in nature-oriented non-governmental organizations can be obtained from the *National Survey on the Importance of Wildlife to Canadians,* which was conducted in 1981, 1987, and 1991. The survey provides information on the percentage of Canadians who are members of wildlife organizations, the number of individuals who are members, and the financial contributions made to these organizations. This information is summarized in Figure 6.4.b.1. Between 1981 and 1991, there was a 73% increase in the number of Canadians who were members of, or contributed to, a wildlife organization. Fees and donations to such groups more than doubled between 1987 and 1991[1]. These trends are a clear indication that the value Canadians hold for wildlife is increasing.

Trends in the total number of days in which Canadians engaged in hunting and the growing interest in the use of Canada's forests for non-consumptive recreation-related activities are discussed in Indicator 6.2.c.

c) Sources for information

1. Statistics Canada / Environment Canada, *National Survey on the Importance of Wildlife to Canadians.* Highlight reports for 1985, 1987 and 1991.
2. Canadian Institute of Forestry, unpublished report (1996).
3. See Indicator 6.2.c.

6.5 Employment and community needs

6.5.a. Direct and indirect employment in the forest sector and forest sector employment as a proportion of total employment

a) What are we measuring?

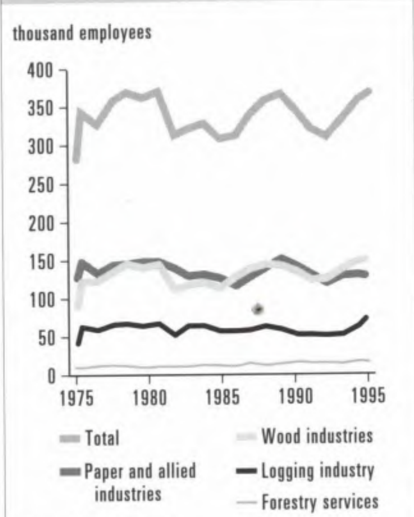
This indicator describes trends in total employment in Canada's forest industries between 1975 and 1995. The information provided is the result of a monthly labour force survey of 58 000 households conducted by Statistics Canada. The survey provides labour force data on all sectors of the economy.

b) Factual description

Figure 6.5.a.1 shows between 1975 and 1995, total direct employment in theforest products industries was fairly constant overall at approximately 340 000. Between 1992 and 1995, however, employment actually increased by more than 59 000. Logging and wood industries (particularly sawmills, oriented strand board [OSB] mills and particle board mills) accounted for most of this increase.

1 Nominal dollars

6.5.a.1 Direct employment in Canada's forest sector



Source: Statistics Canada

The production and sale of goods by the forest sector generate economic activity in other sectors of the economy. The spin-off effects of forestry employment create jobs and incomes in other manufacturing and service sectors. The total impact (direct and indirect) on employment by the forest sector has not been well established; however, NRCan–CFS estimates that for 1995, the total number of forestry-related jobs was 880 000, or 1 in 15 jobs in Canada. Most of these are in rural areas where alternative economic activities are limited.

c) Sources for information

1. Statistics Canada, *Labour Force Survey,* Cat. No 71 001.
2. Natural Resources Canada–Canadian Forest Service

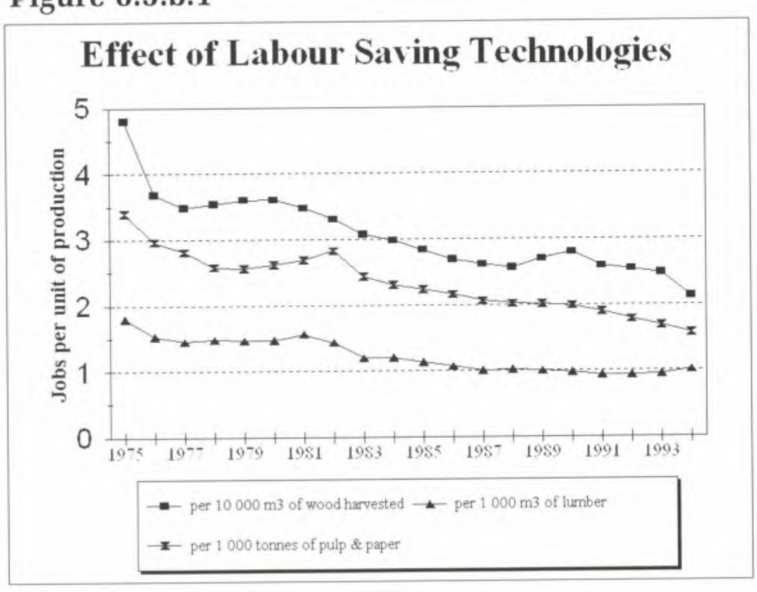
6.5.b. Average wage rates and injury rates in major employment categories within the forest sector

a) What are we measuring?

This indicator reports on 1993 average wage rates in logging, wood industries, paper and allied industries, and the manufacturing sector, as well as the percentage change in average incomes (converted to constant dollars using the GDP deflator) since 1970. Trend data on the number of jobs per unit of production since 1975 are also discussed.

Information on injury rates is not consolidated for reporting at the national level.

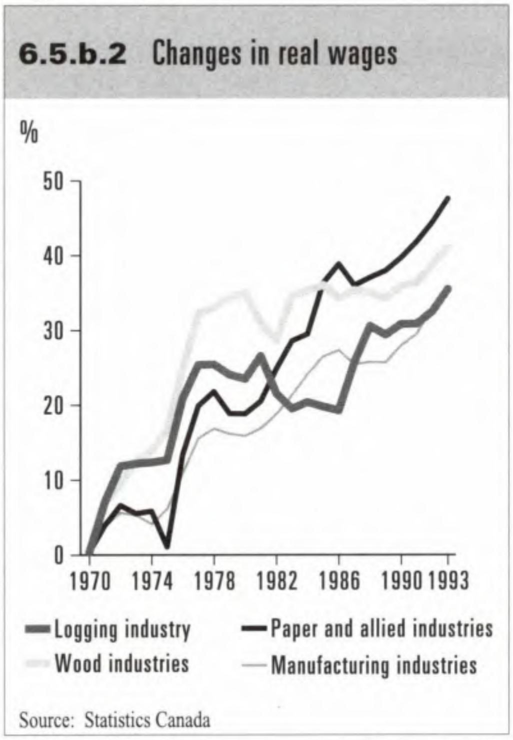
Figure 6.5.b.1



b) Factual description

Forest industry employees in Canada are relatively well paid. In 1993, the average income in the logging, wood industries, and paper and allied industries was \$40 645, \$33 694, and \$45 327 respectively. In comparison, the average income in the entire manufacturing sector in 1993 was \$35 800.

Figure 6.5.b.2



A wide range of labour-saving technologies was adopted by the forest industry between 1975 and 1995. In the logging sector, mechanized harvesting machines have substantially improved labour productivity and reduced the number of individuals required to harvest a stand of trees. In the sawmill sector, highly automated, high-speed processing systems with optimal control scanners have dramatically reduced the number of employees required to produce a truckload of lumber. High-speed newsprint machines in some mills have reduced the amount of labour required to produce a tonne of newsprint. The net result of these new technologies has been a general decline in the number of employees required to produce a unit of output (Figure 6.5.b.1).

The adoption of new technologies in the forest sector has resulted in changes in the production process, and the replacement of low-skilled jobs with higher-skilled jobs. For example, sawmill automation and computerization, and the manufacturing of more engineered and composite-wood products, demand fewer, but more highly skilled personnel. The end result is a higher labour productivity associated with the new technology, which in turn results in higher paying jobs. Figure 6.5.b.2 shows the percentage change (adjusted for inflation) in real wages in the forest industries and the manufacturing sector between 1970 and 1993. Incomes in the paper and allied industries increased by 48% over the 24-year period. Incomes in the manufacturing sector increased by about 36% over the same period.

c) Sources for information

1. Statistics Canada.

6.5.c. Viability and adaptability to changing economic conditions, of forest dependent communities, including indigenous communities

a) What are we measuring?

Most data available for reporting on forest dependence in Canada refer primarily to "timber" dependence and are based on measures of employment income in the industrial forest sector. There are other types of forest dependence, such as dependence on subsistence, non-timber forest products like trapping, wild rice, crafts, and tourism uses of forest ecosystems. Little information is available for many of these aspects because the social dimensions of sustainable forestry have only recently become a priority for government and university researchers. Much of the existing data and information are case-specific, and one of the principal challenges facing forest science researchers is aggregating these data at the national level in a meaningful and scientifically sound manner.

b) Factual description

In Canada, 337 communities are classified as heavily forest dependent–forest industries account for more than 50% of their economic base employment. An additional 1 294 communities are moderately forest-dependent, relying on the forest for 10%-50% of their economic base.

Forest-dependent communities often possess, or are located in proximity to, resources that provide other economic opportunities, such as mining, agriculture or energy. Even communities classified as heavily timber-dependent may have dual- or multiple-sector dependencies.

Data are available on the diversity of the industrial base with respect to natural resources for communities in the Prairie provinces (Alberta, Saskatchewan and Manitoba) with populations exceeding 250. Communities in which one other sector accounts for more than 10% of employment are classified as dual-sector dependent; those with two or more additional sectors are considered diversified.

Ninety-six forest-dependent communities in total were surveyed. Nine of these are heavily forest dependent, while the remainder are moderately forest dependent.

Of the nine heavily forest-dependent communities, four (44%) have one other sector that provides over 10% of base employment. In three cases, the other sector is agriculture, while in the fourth it is hydro-electricity. None of the heavily forest-dependent communities had more than one other sector accounting for more than 10% of basic employment, and therefore, none could be characterized as diversified.

Eighty-seven communities in the Prairies fall into the moderately forest dependent category, and as one would expect, more of these communities have dual-sector dependencies, or are diversified. Forty-seven communities in this category (54%) are dual-sector dependent. An additional seven communities (8%) may be characterized as diversified.

There is no comprehensive database on indigenous subsistence use, or the degree to which subsistence remains important for indigenous communities within the forested regions of Canada. It may be possible to examine this type of forest dependence through case studies. There are no databases that document tourism dependence, or the extent to which communities diversify their local economies through timber and non-timber uses of forests. These are potential areas of future study.

c) Sources for information

1. Williamson, T.B. and Annaramraju, S. "Analysis of the Contribution of the Forest Industry to the Economic Base of Rural Communities in Canada. Working Paper No. 43" (Natural Resources Canada–Canadian Forest Service, 1996).
2. Korber, D. "Measuring forest dependence. Implications for Aboriginal communities" (University of Alberta, unpublished M.Sc. thesis, 1997).

6.5.d. Area and percent of forest land used for subsistence purposes

a) What are we measuring?

The intent of this indicator is to provide data on the extent to which Canada's forests continue to be used for subsistence purposes. Subsistence use of forests may include hunting, trapping, gathering of foods (rice, berries, sap), medicine (sweetgrass, rat root, fungi), fuelwood, and materials for crafts and tools. While subsistence use is most closely associated with First Nations Canadians, and most of the research documenting subsistence deals exclusively with this group, non-Aboriginal Canadians also engage in subsistence activities on both public and private forest land.

b) Factual description

Various studies have documented subsistence use across vast areas of land. Berkes et al. (1994) describe subsistence activities across 250 000 km^2 in the Hudson Bay Lowlands; the Fort McKay First Nations (1994) describe subsistence use of 38 000 km^2 in northeast Alberta; and Beckley and Hirsch (1997) examine subsistence use on 12 100 km^2 in the southwestern region of the Northwest Territories. Opportunities to practice subsistence exist on some 14 000 km^2 of Indian reserve land. Many other studies have documented the subsistence use of forests, and in some forest management areas, companies are documenting subsistence use and important cultural sites.

While it is not possible to provide exact measures of the area in which subsistence forest use is practiced, much of Canada should be included. Experts estimate that active subsistence is practiced in over 60% of the boreal forest. Subsistence is also practiced in coastal and mountain ecosystems in British Columbia, and to a lesser extent in smaller ecosystem types in eastern Canada.

c Sources for information

1. The Arctic Institute of North America, *There is still survival out there: A traditional land use and occupancy study of the Fort Mckay First Nation* (Calgary, Alberta: 1994).
2. T.M. Beckley and B.H. Hirsch, *Subsistence and non-industrial forest use in the lower Liard Valley,* Inf. rep. NOR-X-352 (Natural Resources Canada–Canadian Forest Service, Northern Forestry Centre).
3. F. Berkes, P.J. George, R.J. Preston, A. Hughes, J. Turner and B.D. Cummins, "Wildlife harvesting and sustainable regional native economy in the Hudson and James Bay Lowland, Ontario", *Arctic* 47(4):350-360.

iii) Summary

The contribution of Canada's traditional forest industries (e.g., paper and allied industries and wood industries) to the GDP has increased since 1961 to $20.38 billion per year of Canada's GDP of $776 billion[1]. Canada has a proven track record in producing and delivering high-quality products at a competitive price. However, our overall dominant position in the global marketplace has diminished somewhat in recent years. The profit

1 1995

performance of Canada's forest products sector has been affected by low product prices and increasing production costs. To maintain our export position and compete in the growing Pacific Rim market, Canadian producers may be required to develop miche markets in higher value-added commodity grades.

Between 1986 and 1993, the revenues of campgrounds, outfitting operations, and recreation and vacation camps also increased steadily. In addition, the sale of maple products increased dramatically in 1994 (after declining from 1988 to 1993), while that of Christmas trees has remained stable in recent years.

While hunting remains a significant activity in Canada's forests, the participation rate is declining. Participation in non-consumptive activities such as wildlife viewing and nature studies is on the rise. This can be demonstrated indirectly through such measures as Canadians' increasing contributions to environmental organizations.

Canada's forest industries must continue to innovate to remain competitive. Examination of trends in R & D investment suggests that expenditures are not keeping pace with growth in the sector and that more technological innovation is required. Since 1990, annual expenditures on such activities as silviculture and resource access have decreased, while investment in general stewardship and public information programs have increased. R & D on forest-related issues is carried out or sponsored by the federal government, provinces, industry and universities. Expenditures increased between 1990 and 1994, totalling $151.2 million in 1994. The Canadian forest products sector is traditionally cyclical, and experienced severe and unprecedented losses in the early 1990s. In 1994 and 1995, this began to turn around, with net earnings of Canadian firms increasing.

In addition to economic and subsistence use, Canadians also derive recreational, tourism and spiritual benefits from forests. Virtually all public forest land is managed for multiple uses, and 2% of Canada's total land mass has been set aside in national parks. The goal is to create a national park for each of the 39 natural regions of the country by the year 2000. There are also 22.9 million hectares set aside in provincial parks. In all, 7.6% of Canada's forest land has some degree of protection, including that for sites of cultural, social or spiritual significance.

The study of non-market forest values is not well-developed in Canada. However, the Canadian Forest Service has identified non-market valuation methodologies as a priority research area. The proxy values used to measure Canadian participation rates and expenditures on forest-related activities suggest a general increase in the value of nature to Canadians.

Direct employment in the forest industries has increased since 1992, reaching 369 000 in 1995, with an average of 340 000 since 1975. Historically, the forest sector has provided well-paying jobs. The number and type of positions, however, has been affected by the adoption of new labour-saving technologies, which have enabled the forest sector to increase its production levels. Despite the accessibility of wood products, Canadians are increasingly aware of the need to recycle in order to conserve this precious resource. Currently, 42% of all paper consumed in Canada is recovered, and paper products now contain 22% recycled material, up from 10% in 1990. In 1991, there were

337 heavily forest-dependent communities in Canada. Such communities rely on timber for at least 50% of their base employment, and tend not to be economically diversified.

No national data exist on the utilization of forests for non-market goods and subsistence purposes, although case studies may be used to provide information on a particular community or region.

VIII CRITERION 7

Legal, institutional and economic framework for forest conservation and sustainable management

VIII. Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management

i) Introduction

Canada's legal and regulatory framework supports the sound stewardship of forest resources through mechanisms which ensure clear property rights and forest tenure; comprehensive planning processes; the protection of special places and values; and the effective enforcement of laws, regulations and guidelines.

As Canadians become more aware of the need to sustainably manage forest resources, they are demanding a greater voice in the decision-making process. In addition to requiring public input as a matter of policy, many governments now mandate such participation in their forest or environmental legislation.

The federal, provincial and territorial governments work with industry to ensure that forest workers are well-trained, and meet recognized standards. Both the federal and provincial governments may levy income taxes, while property taxes are the exclusive domain of the provinces. Both levels of government may also provide financial incentives to individuals and corporations, including for such objectives as the use of bioenergy.

Canada is heavily dependent on trade, and has long advocated non-discriminatory and rules-based trade with its partners. This includes rules to define sustainable forest management, particularly in view of the importance of this sector to the Canadian balance of trade.

While the management of most forest resources is the responsibility of provincial and territorial governments, the federal government assumes a major role in areas such as maintaining national statistics, supporting and carrying out research, and coordinating international trade issues and international relations.

7.1 Extent to which the *legal* framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests...

7.2 Extent to which the *institutional framework* supports the conservation and sustainable management of forests...

a) What are we measuring?

This indicator report provides a combined description of the legal and institutional frameworks in Canada, primarily as they apply to public forest land–which constitutes most of Canada's forests. The legal framework applicable to private forests is quite distinct from that applicable to publicly owned forest land, and is not expressly addressed in this report. It is not practical to deal separately with the sub-indicators under these two indicators, as the mechanisms for the conservation and sustainable management of forests are largely governed by the institutional and legal framework.

b) Factual Description

Existence of laws and regulations on forest land management

Legal framework

The provinces own over 71% of Canada's forest land. Twenty-three percent is federally owned, with some managed by or in cooperation with the territorial governments. The balance is in private hands. Although they account for only 6% of Canada's forest land, private forests play a large role in the economies of many regions and rural areas of Canada.

Canada's constitution assigns exclusive responsibility for forest resources to the provincial governments. Section 92A. of the *Constitution Act* states that, in the case of forest resources:

(1) In each province, the legislature may exclusively make laws in relation to : (b) development, conservation and management of non-renewable and forestry resources in the province, including laws in relation to the rate of primary production therefrom;

Responsibility for international relations and trade, and federal and Aboriginal land resides with the federal government. The two levels of government share responsibilities in the areas of science and technology, industrial and regional development, and the environment.

The federal government is responsible for the overall management of the national economy and for international trade and commerce. Achievement of the federal government's environmental, social and economic goals is, to a significant extent, contingent on the health of Canada's forests. The provincial governments' achievement of forest management goals is similarly influenced by federal responsibilities in various areas such as international issues and trade. Therefore, while each level of government has its own responsibilities, their common interests are better met through federal-provincial/territorial cooperation. Both levels of government agree to work together to avoid overlap and duplication.

There has been a long tradition of cooperation between the federal and provincial governments in forestry matters. The creation of the Canadian Council of Forest Ministers in 1985 has provided an important forum for the federal, provincial and territorial governments to work collaboratively to address major areas of common interests.

The *Royal Proclamation* of 1763 required the consent of Aboriginal peoples before their land was occupied, and gave the Crown sole authority to negotiate such land settlements. From the Proclamation flowed treaties that outlined the Crown's responsibility to protect Aboriginal peoples' way of life, including hunting, trapping, fishing and gathering.

The *Constitution Act* of 1867 gave the federal government jurisdiction over all matters concerning "Indians" and "Indian lands". In 1982, the Act was updated to further affirm and protect Aboriginal and treaty rights. Specifically, Section 35 states, in part, that the "existing Aboriginal and treaty rights of the Aboriginal peoples of Canada are hereby recognized and confirmed". In 1992, the "National Forest Strategy" recognized the importance of these rights in forest management and reflected the commitment made by Canada at the 1992 United Nations Conference on the Environment and Development–to recognize the role of Aboriginal peoples in forests, traditional use, knowledge and ways of life.

In addition to statutes and regulations, the legal framework for forest management in Canada is comprised of guidelines, standards, rules and manuals that provide direction to forest managers in their daily operations. Those guidelines and standards that have been incorporated into operating permits and certificates of managed land carry the weight of law. Most of Canada's forest land is provincially owned and most of the legal framework for forest management is aimed at these forests.

Legislation is beginning to reflect the fact that forest policies are increasingly being based on environmental and social considerations, in addition to economics, in order to achieve sustainable development goals. The codification in law and the stricter enforcement of forest policies and guidelines are indicative of the response of Canadian forest agencies to new social, economic and environmental imperatives.

The need to sustainably manage forest resources is acknowledged by all levels of government in Canada and is entrenched in the 1992 "National Forest Strategy". Three provinces have already passed new legislation based on the principles of sustainability: British Columbia, with its 1994 *Forest Practices Code Act;* Ontario in the 1994 *Crown Forest Sustainability Act* and Saskatchewan with the 1996 *Forest Resources Management Act.* The Province of Québec amended its *Forest Act* in 1996 to reflect the same commitment.

Forest lands are also subject to environmental protection legislation which applies regardless of ownership. For instance, water pollution and other activities which may be harmful to fish habitat are prohibited under both federal (*Fisheries Act*) and provincial statutes, and subject to prosecution.

In addition to those already noted, a wide range of federal and provincial regulations and legislation also have an effect on forest management activities in Canada. For example, workplace health and safety standards and environmental regulations are generally administered by other than forestry agencies. Parks may be established by either federal, provincial or local (e.g., regional conservancy authorities or municipalities) governments.

Tenure arrangements

In Canada, all timber harvested on public lands is harvested under some form of tenure, which is defined as a right or interest granted by the government to harvest timber on public lands. Although timber production is the predominant use of forest land under tenure, arrangements have also provided for access by other users to areas designated for integrated or multiple-use management. The government retains ownership of the land, and grants only the right to harvest and grow the timber and occupy the land for such purposes. Long-term tenures account for the bulk of timber cutting rights. Under tenure arrangements, the provincial government and large forest companies negotiate an agreement that allows the province to retain full ownership of the land, while conveying on the company exclusive rights to harvest timber in a sustainable manner. The tenure agreements include financial arrangements for assigning responsibility for management costs between the parties.

A wide variety of tenure arrangements exists across Canada for the harvesting of timber, with the two main categories being long-term, usually area-based, tenures; and shorter-term volume-based tenures (Figure 7.1.a.1). The rights and obligations of tenure holders are defined by statute, regulation and the terms and conditions of the tenure documents. The rights conveyed under tenure vary greatly in their comprehensiveness, duration and exclusiveness, and the obligations assumed by tenure holders increase with the security and length of the allocated tenure.

Figure 7.1.a.1
Proportion of committed timber cutting rights in form of long-term tenure (1990)

Province		Percent of Annual Allowable Cut
British Columbia	Tree Farm Licences Forest Licences	25 56
Alberta	Forest Management Agreements	47
Saskatchewan	Forest Management Licence Agreement	93
Manitoba	Forest Management Licences	60
Ontario	Forest Management Agreements	70
Québec	Contrats d'approvisionnement et d'aménagement forestier	100
New Brunswick	Crown Timber Licences	73
Nova Scotia	Licence and Management Agreements	86
Newfoundland	Leases and licenced land	65
Sources: David Haley and Martin K. Luckart, 1990; Monique M. Ross, 1995		

Access to and use of non-timber forest resources (e.g., wildlife, water, minerals) are often granted by government departments operating under the authority of various statutes. For instance, agricultural activities in forested areas require grazing leases, licences or permits, as well as hay cutting licences or permits. Mineral exploration and development are subject to a variety of permits and licences. Hunting, fishing and guide outfitting are licensed, while trapping is authorized by trapping licences on registered trap lines. Water uses, too, are regulated and subject to a permitting system.

Tenure arrangements for timber harvesting may overlap, with several tenure holders operating on the same area. Coordination and joint planning of harvesting and forest management activities by tenure holders are encouraged and sometimes mandated (e.g., in Québec and New Brunswick). In cases of overlapping use of timber and non-timber resources, integrated planning processes exist to establish priorities and provide a mechanism for departmental consultation.

7.1.c. and 7.2.a Public participation

Public participation in policy development and review, resource planning, resource allocation and management of public forests is increasing all across Canada. Public involvement has been incorporated by government and industry as a matter of policy, and now legal requirements for involving the public in all of these aspects of forest development are expanding as well.

Increasingly, there are legal requirements for public hearings in the case of actual allocation, planning and management of public forests, under both forest-specific and environmental impact assessment legislation.

In some provinces, there are legal requirements for public participation, primarily in the granting of long-term tenure agreements. For example, in British Columbia public hearings are held prior to the allocation of long-term tenures, and major tenures are advertised and applications made available for public review. As well, public participation is used to develop recommendations on new protected forest areas, and to set regional land-use plans. In most cases, public meetings are held locally as a matter of policy.

In most provinces, the public is not formally involved in monitoring the activities of forest managers and ensuring that they meet their obligations. British Columbia is an exception in that specific provisions in its forest legislation enable the public to lodge complaints regarding compliance of tenure holders with their legal requirements, and the appropriateness of government enforcement.

There are no legal provisions with regard to community involvement in managing public forests, although there are some examples of "community forests" in British Columbia, Ontario and Québec. Memoranda of understanding for the management of specific areas such as municipal watersheds have been signed in Nova Scotia, and Québec is amending its forest legislation to provide for tenure arrangements which facilitate the participation of local groups or communities in forest management.

Canadians have ready access to public forest-related information. Most governments require Ministers responsible for forests to publish periodic state-of-the-forest reports. In addition, statistics and forest-related resource information are published annually by governments and can be obtained on request. Access to information acts are a last resort for obtaining government information about public forests.

7.1.e. Conservation of special places and values

The conservation of special environmental, cultural, social and/or scientific values may be achieved through: setting aside certain valuable areas; environmental legislation that imposes restrictions on forest management operations; or regulations which ensure that forest activities respect and preserve non-timber values in areas under management. The degree of protection varies by province and type of area designation. Ecological reserves and provincial and national parks are normally afforded the greatest degree of protection.

Environmental protection legislation also contributes to the conservation of various forest values. For example, water resources and fish habitat are protected under a federal statute–the *Fisheries Act*–and individual provincial water-related statutes.

In areas managed for timber production, governments have initiated standards or guidelines which protect unique biological or physical resources such as old-growth forests, riparian zones, wildlife habitat, and unique ecological or cultural sites. Provincial forest practices requirements apply on all provincial lands. Some have statutory or regulatory force, while others are contained in standards, manuals and guidelines. In recent years, several provinces have revised their practices or formally adopted codes of practice to achieve their sustainable forest management policy objectives.

Three provinces have adopted comprehensive guidelines which protect genetic, species and habitat diversity. The protection of non-timber resource values is achieved notably by restrictions over harvesting (e.g., location, size and design of cut blocks), the imposition of modified silvicultural systems (e.g., selection cutting rather than clearcutting), and careful road design and location. British Columbia has adopted a system that classifies forests as special management zones, enhanced zones, and zones for general forest use.

In addition to these government measures, some forest industry associations and individual forest companies have developed their own codes of practice or sustainable forest management standards. For example, the Ontario Forest Industries Association reports annually on its members' adherence to its code of practice, and the Alberta Forest Products Association has adopted a code of practice called "ForestCare". The latter provides for outside audits of company operations every three years.

Professional and technical forestry associations have also adopted codes of ethics, practice and professional conduct. The Canadian Federation of Professional Foresters Associations developed national "Codes of Ethics, Principles and Standards of Practice" that have been adopted by most provincial professional foresters associations. The Canadian Institute of Forestry has also adopted a code of practice.

7.2.e. Enforcement of laws, regulations and guidelines

Without proper enforcement, no legal regime can ensure the conservation and sustainable management of forests. Effectiveness of enforcement is measured not only by institutional capacity, but also by provisions in forest legislation which define offences, penalties and the overall enforcement regime.

Responsibility for monitoring compliance and enforcing forest-related laws and regulations and the terms and conditions of tenure agreements is assumed by forest departments and ministries, while environmental departments and ministries are usually responsible for the enforcement of environmental regulations. A system of inspections or field evaluations is in place in all provinces and territories, although effectiveness is directly related to the number of inspectors available. Periodic performance reports are usually requested from industry.

British Columbia and Ontario laws require independent audits of industry compliance and government enforcement. In both of these provinces, the public can report violations or raise concerns with the administering department. The provincial Ombudsman may also be approached to deal with disputes or concerns involving the actions of a government department or agency. British Columbia has established a special board to review complaints from the public as well as compliance and effectiveness of forest practice legislation.

In all Canadian jurisdictions, remedies for contravention may be administrative or judicial, varying from loss or suspension of harvesting rights to financial sanctions to legal prosecution or requirements for remedial measures.

7.2.c. Development and maintenance of human resource skills across relevant disciplines

Silvicultural workforce

Between 30 000 and 50 000 silviculture and forest workers are employed by logging companies, contractors and government forest services for reforestation and the management, improvement and conservation of forest lands.

In almost every province, universities and community, technical and vocational colleges provide some forestry courses. Approximately 600 students graduate annually as forest technologists or technicians from community, vocational and technical schools. Private institutions and trainers also provide short courses. In addition, industry provides both on-the-job training and other short courses. Equipment manufacturers also give courses on the safe and efficient use of their equipment. Total enrolment in all silviculture and forestry courses is unknown.

As of 1994, there were some 70 certification and training programs available for the silviculture and forest workforce. Mandatory provincial courses tend to address health and safety issues, while voluntary courses usually deal with work productivity and quality.

Canada's 1994 *Agreement on Internal Trade* provides for the reduction or elimination of barriers to the free movement of goods, services, persons and capital within Canada. The Agreement provides mechanisms for achieving mutual recognition and harmonization of occupational qualification standards.

Standardization in the forestry profession

Canada's forest sector has taken a number of steps to ensure the quality of stewardship of the country's forests by professional foresters. All eight university forestry faculties are accredited according to the criteria established and applied by the five provincial professional associations, the Canadian Institute of Forestry and the universities. The forestry profession is in the process of reviewing and revising the accreditation process and requirements in light of recent changes to the priorities and scope of forestry education and new demands being put on practicing foresters.

Registered Professional Forester (RPF) associations are reviewing the possibility of standardizing their admittance requirements. Each now recognizes graduates from any accredited university in Canada. They are reviewing other requirements for membership such as years of experience and successful completion of an exam on forest policy.

Professional forester associations exist in five provinces: British Columbia, Alberta, Ontario, Québec and New Brunswick. Total estimated membership of professional foresters remained relatively unchanged between 1992 and 1996 (Figure 7.2.c.1).

Figure 7.2.c.1
Professional foresters (numbers)

Provincial Association	1994	1995	1996	1997
Association of British Columbia Professional Foresters	2 521	2 639	2 788	2 927
Alberta Registered Professional Foresters Association	375	382	382	392
Ontario Professional Foresters Association	749	694	727	733
Ordre des ingénieurs forestiers du Québec	1 625	1 622	1 633	1 662
Association of Registered Professional Foresters of New Brunswick	231	340	232	232
Total	5 501	5 677	5 762	5 946

7.2.d. Develop and maintain efficient physical infrastructure to facilitate the supply of forest products and services and support forest management

Statistics on areas planted, seeded or prepared for regeneration can serve as a rough indication of trends in the capacity of the reforestation infrastructure. The REGEN component of the *National Forestry Database Program* indicates that the area harvested between 1975 and 1992 increased by 33%. This contrasts with a 263% increase in the area planted or seeded during the same period. More than 417 000 hectares were either planted, seeded or scarified in 1992, whereas only 115 000 hectares were treated in 1975. The increase in planting and seeding was prompted by problems observed in the late 1970s in the regeneration of forests harvested since the early 1960s. See Indicator 2.c. (The area and growing stock of plantations of native and exotic species) for a more detailed discussion of this trend.

Today, forest managers rely on advance regeneration techniques to ensure that at least two thirds of harvested forest areas will regenerate naturally. If necessary, the remaining third is restocked by planting, seeding or scarification to yield a desirable number of trees at maturity. Additional planting or seeding takes place if regeneration is inadequate.

Forest tree seed plants and seedling nursery capacity are currently concentrated in establishments located in the warmer southern and western parts of Canada. Seed is shipped to the nurseries and seedlings shipped back to source locations for planting.

c) Sources for information

1. Canadian Institute of Resources Law, *Forest Management in Canada* (1995).
2. Canadian Institute of Resources Law, *Criterion 7 questionnaire to government forestry agencies* (June, 1996).
3. Canadian Council of Forest Ministers, "Forest Regeneration in Canada, 1975-1992", *The National Forestry Database Program* (1996).
4. Canadian Council of Forest Ministers, *Mid-Term Evaluation Report on Canada's 1992 National Forest Strategy* (1994).
5. T.J.B. Boyle, *Forest tree genetic conservation activities in Canada,* Inf. Rep. ST-X-4 (Natural Resources Canada–Canadian Forest Service, 1992).
6. P. Janas, *Canadian conifer forest tree seed statistics, 1982-83: Survey results,* Inf. Rep. PI-X-56 (Canadian Forestry Service, Petawawa National Forestry Institute, 1985).
7. D.F.W. Pollard, *Canadian national list of seed orchards,* 1981, Inf. Rep. DPC-X-13 Canadian Forestry Service, Environment Canada, 1982).
8. *National Forest Strategy 6.5 - Committee Report to the CCFM* (August 1994).
9. J.H. Smyth, A.J. Brownwright, *Forest tree production centres in Canada - 1984,* Inf. Rep. O-X-378 (Canadian Forestry Service, Great Lakes Forestry Centre, 1986).

7.3 Extent to which the economic framework (economic policies and measures) supports the conservation and sustainable management of forests

a) What are we measuring?

This indicator examines the role that economic policies and the regulatory environment play in influencing choices about how forests are used and managed. Policies related to investment, taxation, trade and incentives for use of forest bioenergy are discussed. As well, the regulatory environment as a whole is considered in terms of its potential to reflect changing public and private values and goals related to forests.

b) Factual Description

7.3.a. Investment and taxation policies

The development of the Canadian forest sector reflects a history of regulated private access, with most of the resource resting with provincial governments. Investment in the forest resource is therefore influenced predominantly by provincial arrangements in which the private sector uses the publicly owned forest resource under various forms of volume- or area-based tenure. This is described further in Indicator 7.1.

The current system was originally designed to accommodate timber resources rather than multiple forest benefits, and historically did not generally provide incentives for the provision of non-timber values. Although timber production is the predominant use of forest land under tenure, in recent decades tenure arrangements have also provided for access by other users in areas designated for integrated or multiple-use management. As discussed under 7.1.a., access to and use of non-timber forest resources (eg., wildlife, water and minerals) are often granted by different government departments. Provincial forest management policies strive to maintain the long-term sustained yield of the timber supply through reforestation requirements and limits on the annual allowable cut. As well, all forest tenures are subject to timber harvesting regulations designed to protect various non-timber values such as fish habitat.

In general, tenures grant few rights which might act as incentives for voluntary sustainable management. Other than through allowable cut effect policies, tenures do not generally guarantee rights to the results of silvicultural activity, and therefore provide little incentive to do more than what is required contractually. The allowable cut effect is designed to encourage voluntary silviculture over and above tenure requirements. Under this policy, tenure holders can increase their annual allowable cut in direct relation to the increased future forest yield resulting from voluntary silviculture. Seven provinces use allowable cut effect policies, but with minimal response.

Some provinces have begun to experiment with new investment instruments directly aimed at increasing long-term sustainability of the forest resource. In British Columbia, a new Forest Renewal Fund, using a portion of forest revenues, is available to companies, communities, First Nations, workers, researchers and government agencies to support improved forest ecosystem health, research, watershed restoration and sustainability activities.

There are no specific Canadian tax provisions to encourage private investment in management for all forest resources, on either private or public land. The income tax system makes little distinction between the forest products sector and other manufacturing activity, and is consequently not used to provide explicit incentives for conservation, silviculture or reforestation. However, general tax regulations do seem to have other effects which could influence operations on public land. For example, capital cost provisions may pose a disincentive to forestry investments on public lands by companies not already operating there. In addition, while capital cost allowances may lower the cost of producing forest products, they do not appear to provide incentives for forest management.

Both income and property taxes affect private woodlot owners. While the income tax system does not provide specific regulations for forest land ownership or forest management, it does have special provisions for farm income, including that derived from growing and harvesting timber on private land. These rules provide no clear incentive for investment in woodlot management, however. Four provinces offer property tax incentives for active forest management by woodlot owners through lower tax rates or tax rebates for managed woodlots. There are also provisions under the federal Income Tax Act to encourage contributions of land for conservation purposes.

Incentives for bioenergy use

The *National Action Plan on Climate Change* prepared by the federal, provincial and territorial governments includes a variety of measures designed to ensure that Canada fulfils the requirements of the United Nations Framework Convention on Climate Change. Among these is a commitment to promote greater use of bioenergy as an alternative to fossil fuels. Bioenergy currently represents about 7% of Canada's energy use, and almost all of it comes from the forest. The forest industry itself uses the largest share of this bioenergy, mainly in pulp and paper mills where it provides space heat, steam and electricity.

Governments at all levels encourage reductions in greenhouse gas emissions through policies which provide economic incentives for bioenergy use. All but one of the provincial and territorial governments offer programs directed at promoting alternative energy sources, including forest biomass. However, most of the programs focus on information awareness, technology transfer and promotion of research and development to overcome information or technology barriers to greater bioenergy use. Five governments also have programs that could provide financial incentives for forest biomass use. More information is needed to determine the extent to which this wide variety of programs actually results in greater forest biomass use in energy production.

The federal government recently released its *Renewable Energy Strategy* to increase the role of renewable energy in Canada's energy mix through financial, technology and market initiatives. The strategy expands the applicability of measures that allow companies to claim a capital cost allowance for investments in energy-producing equipment that uses renewable energy, including forest biomass, in industrial processes. As well, the ENFOR (Energy from the Forest) program funds research and development aimed at increasing the contribution of forest biomass to Canada's energy supply. Current funding, which averages about $1 million per year, supports work that addresses such issues as how to increase the biomass supply for energy purposes, the environmental effects of increased biomass production and removal, technology transfer to increase biomass use, and socioeconomic constraints to biomass use. The federal government announced in its 1997 budget that it will set aside $20 million per year for three years, beginning in 1998, to promote investments in both energy efficiency and renewable energy for new and existing commercial buildings.

Regulatory environment

The impact of the regulatory environment on sustainable forest management is broad and complex. In addition to taxes, tenure and forest management policies, regulations in such areas as the environment and fisheries also have an important effect. The growing emphasis on sustainable management and non-timber forest goods and services is increasingly reflected in the regulatory environment governing forest tenure holders. Most provinces have enacted new laws, or have adopted new forest management policy frameworks, all with the objective of strengthening sustainable forest management practices. Indicators 7.1 and 7.2 describe this activity.

The complexity of the regulatory environment makes it difficult to provide a comprehensive assessment of the extent to which the wide variety of rules at various levels of government affects choices about the use and management of Canadian forests. One way to examine the issue is to assess how consideration of evolving public and private interests and values is built into public policy and regulatory mechanisms. The extent of public participation provides some indication of the extent to which new or revised regulations may reflect socially efficient choices. Indicators 7.1 and 7.2 describe processes for public participation in forest management and decision making.

7.3.b. Trade Policies

Forest products trade plays an important role in Canada's economic well-being. In 1995, forest product exports reached approximately $39 billion, representing almost 16% of Canada's total exports, and about 19% of world forest product exports. Lumber, pulp and newsprint account for about 80% of the Canadian export value, with the major markets being the United States, Japan and the European Union.

As a country reliant on trade, Canada has consistently pursued a system of non-discriminatory and rules-based trade, both multilaterally through the GATT and the WTO, and bilaterally. The federal government attempts to ensure that its trade policies do not contribute to environmental degradation and that environmental policies do not restrict trade any more than necessary to achieve their objectives. Canada also promotes international rules to define sustainable forest management, such as an international forest convention.

Canada adheres to GATT requirements on non-discrimination as they apply to forest product imports. As a result of the Uruguay Round, Canada and other major industrialized nations agreed to eliminate tariffs on all pulp, paper and paper products by the year 2004. As well, existing Canadian tariffs on solid wood products will be reduced by an average of one third by 1999. Tariffs on continuously shaped wood products will be reduced to a range of 0 to 3.7%, those on plywood to 5.3 to 9.7%, and those on builder's joinery and carpentry products such as windows and doors to 0 to 8.2%.

The increasing need to manage the forest resource for multiple goods and services can have negative implications for employment and the economic well-being of forest-dependent communities. To help mitigate such effects, the federal and provincial governments attempt to encourage domestic processing and greater value-added processing of the timber resource. Logs have been placed on the Canadian Export Control List and provincial tenure arrangements include provisions dealing with log exports. Logs in excess of domestic requirements can be exported.

c) Sources for information

1. Natural Resources Canada, Renewable and Electrical Energy Division, Energy Sector, *Renewable Energy Strategy: Creating a New Momentum* (Ottawa, Ontario: October 1996).

7.4 Capacity to *measure and monitor* changes in the conservation and sustainable management of forests

a) What are we measuring?

This indicator describes the scope, frequency and statistical reliability of forest inventories, monitoring systems and other relevant information. This section also discusses the compatibility of Canada's information with that of other countries in terms of monitoring and reporting on indicators in the Montréal Process framework and other international resource assessments.

b) Factual description

7.4.b. Forest inventories

The management of most forest resources is a provincial or territorial responsibility. Forest inventories in Canada have generally developed in response to local or regional needs. Until relatively recently, the term "forest inventory" was applied to a survey of a forested area to acquire information such as area, condition, timber volume and species, for the purposes of planning, purchase, evaluation, management or harvesting. Forest management agencies have only recently begun to broaden the scope of forest inventories to encompass non-timber values.

There are three classes of inventories used in compiling Canada's *National Forest Inventory* shown in *Figure 7.4.b.2*:

Reconnaissance: An exploratory, extensive forest inventory with no detailed estimates obtained. A formal sampling design is generally not used, and no precision estimates are obtained.

Regional: A detailed, extensive forest inventory for planning on a regional or provincial basis. Major forest types are usually mapped, with estimates given for each type. Precision estimates are given for total inventory volume.

Management: A detailed, intensive forest inventory for management of an area managed as one unit. The forest types are usually mapped in detail with estimates given for each type. Precision estimates are given for total inventory volume.

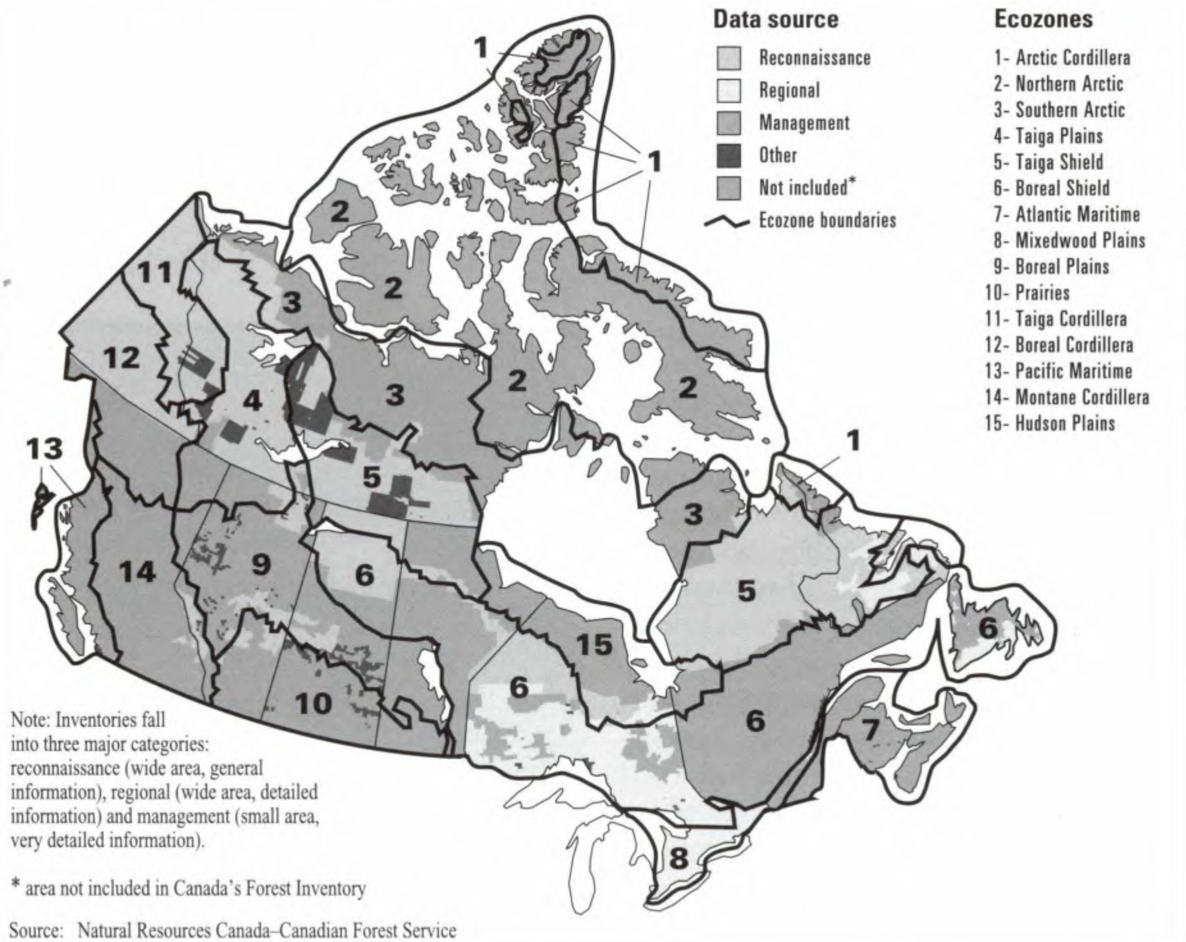
Other: Includes Canada Land Inventory, satellite coverage, and other information

Figure 7.4.b.1 Inventory classes for *Canada's Forest Inventory*

Canada's Forest Inventory 1991 is the authoritative national statement on the distribution and structure of Canada's forests. It is a spatially referenced database containing the best information available in 1991. Because it is spatially referenced, *Canada's Forest Inventory* can be overlaid with other information for further analysis, and the characteristics of Canada's forests can be presented in thematic maps.

All major forest areas are included in the inventory, which was compiled from many sources and existing inventories (see Figure 7.4.b.1). Over the years, the coverage of forest inventories has become more complete, and most jurisdictions now have programs to periodically renew them for areas under active forest management. The oldest inventories used in compiling Canada's Forest Inventory, and those having the most data gaps, tend to be those for remote areas. The extent of forest inventory coverage is illustrated in Figure 7.4.b.2. Canada's Forest Inventory does not yield meaningful information on changes over time because previous national forest inventories were not as comprehensive. Inventories are generally designed not for monitoring forest condition, but as one-time surveys.

7.4.b.2 Forest inventory coverage by data source



Note: Inventories fall into three major categories: reconnaissance (wide area, general information), regional (wide area, detailed information) and management (small area, very detailed information).

* area not included in Canada's Forest Inventory

Source: Natural Resources Canada–Canadian Forest Service

Information about non-timber attributes

Most forest management agencies in Canada have stated their intention to develop resource inventories to provide information on a variety of values. British Columbia's Resource Inventory Committee (RIC), established in 1991 to address the issues of standardizing and integrating all the province's resource inventories, serves to illustrate the enormity of this task. The committee's mandate was expanded beyond forest lands to include resources related to the atmosphere, cultural heritage and coastal waters. RIC established a number of task forces to study issues such as biodiversity, culture, recreation and tourism, fisheries, timber, water and watershed, and wildlife habitat and range. These task forces were comprised of over one hundred experts and volunteer technical specialists representing a full range of resource disciplines. They were drawn from provincial and federal agencies, First Nations, academia, industry, and interest groups. Within each task force, working groups addressed specific types of inventories or topics.

A new vegetation inventory design incorporating a vastly improved timber inventory design as well as information on soils, other ecological factors, range and wildlife habitat, was field tested in 1993. In addition, specialists, in cooperation with the Ditidaht Tribal Council, (First Nation) tested methodologies to assess cultural heritage and archaeological potential.

Development of standards and methodologies continued in 1993, with large-scale field testing in 1994. Following the field trials, task forces fine-tuned their standards and developed training packages. Manuals have now been published and distributed. All future inventories in the province will be developed using the inventory procedures and standards prepared by RIC and its task forces.

Another approach employed in Canada to document non-timber attributes involves mapping "traditional land use and occupancy". This is the term used to describe Aboriginal people's reliance on the land for hunting, fishing, gathering edible plants, trapping, and generally living and travelling in the forest. Knowledge of traditional land use and occupancy resides largely in the memories of residents, band elders and all contemporary users of the resources of a region. Very little information exists in standard printed form. The information gathered encompasses physical inventory attributes (e.g., trails, food, animals, birds, fish, berries); an evaluation of the comparative value of "bush-economy" supplies such as meat and wood, and lifestyle values such as arts and crafts made from the forest resources; and spiritual places. These land use and occupancy studies are being undertaken to map environmental knowledge for the future. The information prepared in this way supports comprehensive land claims, treaty entitlement negotiations, and resource development planning.

Monitoring forest changes

Although Canada has a national program to monitor forest health, it does not yet have a program to monitor changes to its forest cover. In the past, there was little need for monitoring changes in land use and forest cover due to the reproductive resilience of disturbed forests in Canada, the low rates of conversion to other land uses, the size of the forest, and the concentration of effort on map-based inventories for the areas of most active forest management. Data on destructive agents and activities affecting Canada's forests are reported by jurisdiction rather than area.

Statistics Canada has authoritative time-series data for most economic indicators related to timber-based industrial activity. New data sets and monitoring systems will be required for most of the indicators related to cultural, social and spiritual needs and values, both in terms of resources and benefits. The Canadian Council of Forest Ministers has identified the data gaps and is developing an implementation plan to acquire the data needed to report on all indicators for sustainable forest management.

7.4.c. International forest assessments

Canada responds to requests for information from international organizations such as the OECD's periodic survey on the state of the environment and FAO's decennial Forest Resource Assessment (FRA). However, the marked differences between Canada's forests and forest management and those in Europe make it difficult to respond appropriately to international surveys. Canadian specialists continue to participate in international fora to encourage the development of universally meaningful sets of questions to assess global forest resources.

An independent review panel from the OECD released an assessment of Canada's environmental performance in November 1995. The report made several positive observations regarding forest renewal, pollution reduction, use of clean technologies and involvement of all social actors. The review panel also urged Canada to continue efforts in specific areas. Canada is the ninth OECD country to under an environmental audit since the program began in 1991.

7.5 Capacity to conduct and apply *research and development* aimed at improving forest management and delivery of forest goods and services

a) What are we measuring?

This indicator describes Canada's capability to conduct forest biology and socioeconomic research and development. The forest biology research assessed in this indicator is aimed at improving the understanding of forest ecological processes and the ability to predict the impacts of human activities, including the consequences of climate change on forests. The socioeconomic analytical capability assessed is that which focusses on methods to integrate socioeconomic and environmental factors in private and public decision making. This includes the incorporation of the value of the state of forest resources into national accounting. Also described is the capability to adopt new technologies in forest management, harvesting and forest product manufacturing. This report is restricted to research capability that is primarily directed at forest industry and forest resource issues. It is possible to touch on only some of the key mechanisms for conducting and promoting science and technology in the forest sector. The trends in research and development expenditures are reported under Indicator 6.3.b. (investment in the forest sector).

b) Factual description

Forest research infrastructure

As discussed in Indicator 6.3.b., expenditures on forest-related research in Canada in 1994, for which the latest complete data are available, totalled approximately $285 million. This was almost evenly split between forest products and forest management R & D.

The bulk of industry research is conducted by three industry research cooperatives: FORINTEK Canada Corp., which is engaged in wood-based products research; the Forest Engineering Research Institute of Canada (FERIC), which addresses harvesting, road construction, transportation and silvicultural issues; and the Pulp and Paper Research Institute of Canada (PAPRICAN), which supplements and complements the pulp and paper technology development of member companies. Federal and provincial governments, along with industry, contribute to funding for FERIC and FORINTEK. Some integrated forest products companies maintain in-house research capability, but most rely on the three research institutes and research purchased from other agencies and universities.

Most forest-based research in Canada is performed by government and universities. NRCan–CFS is the primary forest research agency. Other federal bodies involved in forest R & D include Industry Canada, Environment Canada and the National Research Council.

The provincial and territorial governments provide funding for the Silvicultural Operations and Small Scale Operations programs of FERIC. Provincial governments also support research councils, some of whose programs include research into forest-related matters.

In addition to funding its own laboratories, the federal government supports the development of research infrastructure at universities and elsewhere. The recently announced Canada Foundation for Innovation is an independent agency that will provide approximately $180 million annually over five years for research infrastructure at universities and research hospitals in the areas of science, health, engineering and the environment. This could include forest-related challenges. The federal government also provides financial support through two granting councils–the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council–for the establishment and operation of National Networks of Centres of Excellence. One such centre is devoted to pulp and paper research and sustainable forest management. In addition, the Industrial Research Assistance Program (IRAP) of the National Research Council provides technology assistance to small- and medium-sized firms in all sectors of the Canadian economy. IRAP also puts firms in touch with the people and financial resources to help them undertake research, development and technology adaptation projects. The federal government will also partner with the private sector through the Technology Partnerships Canada Program, a cost-sharing investment approach to developing and commercialising high technology, including environmental, enabling, aerospace and defence technologies. Finally, federal and provincial research tax credits help industry to underwrite research and development investments.

7.5.a. Development of scientific understanding of forest ecosystem characteristics and functions

7.5.d. Enhancement of ability to predict impacts of human intervention on forests

Most provincial and territorial funding is directed at applied forest research, whereas federal forest research, primarily situated in NRCan–CFS, is focussed more on enhancing the basic knowledge needed to solve applied and operational forest management problems. Provincial and territorial expenditures vary greatly, with tens of millions of dollars spent by those provinces where forests dominate the economy and landscape.

With the growing recognition that forests must be managed as ecosystems and landscapes in order to achieve sustainable forest management objectives, much of the focus of forest research in Canada has shifted from timber production towards understanding forest ecological processes, biodiversity, and the impacts of human activities (including forest practices and the use of fossil fuels) on the health of the forest. Drawing on this improving knowledge about forest ecosystems and their response to disturbances, silviculture research is emphasizing the development of sustainable forest management techniques, including techniques to adapt to the effects of climate change, to conserve biological diversity, and to provide for integrated forest management objectives. It is difficult to disentangle the lines of scientific enquiry to report on individual areas such as climate change research.

NRCan–CFS is the prime federal forest agency and provides scientific and policy advice to other departments and agencies in the fulfilment of their respective mandates. The Service is well known as a source of advanced knowledge about the forest and the forest sector and as an active participant in initiatives to ensure the integrity of Canada's and the planet's forests. As Canada's foremost forest research agency, it has historically aimed its research towards fostering a scientific approach and long-term outlook to forest management in Canada. Most NRCan–CFS research activities address strategic or fundamental national and international forest management issues. The main purpose of this agency is to provide tools to accomplish sustainable forest management.

The NRCan–CFS Science and Technology (S&T) program is based largely on a network approach. Ten networks are formed around strategic policy issues and associated research priorities. These are: forest health, climate change, forest biodiversity, forest ecosystem processes, effects of forest practices, landscape management, fire management, pest management methods, tree biotechnology and advanced genetics, and socioeconomic research.

7.5.e. Ability to predict impacts on forests of possible climate change

Canada's climate change activities, including research, are coordinated through two major committees. The *Canadian Climate Program (CCP) Board* deals with global climate modelling, data sharing and coordination of work on analyses of socioeconomic impacts of climate change. It has representation from government, industry and universities. The *Canadian Global Change Program (CGCP) Board* is an independent non-governmental coordinating body which brings together scientists to plan interdisciplinary research, assess the policy significance of this research, and communicate the implications.

These two bodies are Canada's link to international climate change programs–the CCPB to the World Climate Research Programme (WCRP) and the Intergovernmental Panel on Climate Change (IPCC); and the CGCP to the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions of Global Environmental Change Programme (IHDP). Hundreds of researchers in federal and provincial government departments and in universities across the country participate in the three core international programs and in the IPCC.

Most of the funding for global climate change research in Canada comes from a small number of federal departments and granting councils. In 1994-95, seven federal organizations budgeted some $55 million in support of climate change research, both by federal scientists and others. More than $10 million per year is in support of forest-based climate change research, including the Boreal Ecosystem-Atmosphere Study (BOREAS), which is a collaborative effort on the part of the United States, the NRCan–CFS Climate Change Network, other federal departments, and 13 Canadian universities. As well, at the federal level climate change research activity is coordinated under a memorandum of understanding among the four natural resource departments–Agriculture and Agri-Food, Environment, Fisheries and Oceans, and Natural Resources–by the Climate Change and Variability Working Group.

The NRCan–CFS Climate Change Network has a base of seven scientists and a budget of $1 million. The network is involved in BOREAS and works in partnership with other researchers in NRCan–CFS, other federal and provincial agencies and universities. Its activities address four key issues:

* How will climate change affect forests and what will be the economic, social and environmental consequences of these changes?
* Are Canada's forests part of the problem or part of the solution?
* Are effects of climate change on forests discernable now?
* Are forest sequestration and sink enhancement options environmentally sound, cost-effective and socially acceptable?

c) <u>Sources for information:</u>

1. Canadian Global Change Program, *Understanding our changing planet: An overview of global change research in Canada* (Ottawa: 1996).

7.5.b., 7.5.c. Research capabilities in integration of socio-economic and environmental analysis in forest policies and programs

Figure 7.5.b.1 indicates the distribution of the focus of socioeconomic work by issue area. The categories overlap to some extent, but provide a summary of the broad areas of research expertise. Most researchers have interests in two or more of these issue areas.

Broad categories directly related to measuring and integrating environmental and social costs and benefits into markets and public policies include the study of communities and the forest resource, non-timber values, public decision making, natural resource accounting, and socioeconomic analyses of forest management. Approximately one third of

Figure 7.5.b.1
Focus of Socioeconomic Expertise

Research Category	*Percent of Researchers*
Communities and the forest resource (e.g., community stability and change, dependency, community sustainability, etc.)	33
Non-timber values (e.g., demand for and value of non-timber goods and services, valuation methodologies, value estimates, etc.)	32
Public decision making (e.g., public participation in decision making, how to reflect changing public values, techniques for considering multiple objectives in decision making, conflict resolution, etc.)	25
Natural resource accounting (e.g., methods for including forest resources in national accounting frameworks)	6
Socioeconomic analysis of forest management (e.g., economic components of forest management activities such as regeneration, effect of forest management on supply and economic value of forest goods and services, resource management decision-support systems, etc.)	38
Timber resource analysis (e.g., economic supply of timber at various scales of analysis)	28
Forestry sector analysis (e.g., wood product demand analysis, competitiveness, productivity, industrial structure, trade, employment, industry models, etc.)	44
Forest policy analysis (e.g., economic implications of forest sector policies, tenures, economic incentives for sustainable forest management, etc.)	44

Source: NRCan–CFS, 1996

all respondents are involved in research related to communities, and one third have research interests related to non-timber values. One quarter study forest-related public decision making as part of their research. Although each of these research foci is relatively new, they are among the key areas for measuring and integrating environmental and social costs.

Traditional timber resource, forest sector and forest policy analyses are focussed more directly on forest products sector issues, but have relevance for the objective of integrating social costs and benefits into markets and public policies. Close to half (44%) of the researchers identified devote at least part of their research efforts to forest sector or forest policy analysis. Just over one quarter consider issues related to timber supply analysis. Few economists are working on developing methods to integrate the state of natural resources into national accounting frameworks.

Almost 45% of Canada's socioeconomic expertise can be found in its universities. Provincial governments and other organizations (including industry and consulting firms) each account for about 20%. The remaining 15% of expertise resides in the federal government.

iii) Summary

While each level of government has its own responsibilities, there is a tradition of cooperation between the federal and provincial governments in forestry matters. All provinces and territories have forest legislation in place. The legislation primarily addresses the allocation of rights to harvest timber on publicly owned land and conditions for forest planning and operations. Private forests are increasingly being subjected to regulations to ensure that they are also soundly managed.

In Canada, all timber harvested on publicly owned land is harvested under some form of tenure. The ownership of the land is retained by the government, with only the right to harvest and grow the timber and occupy the land for these purposes being granted to third parties. Long-term tenure arrangements account for the bulk of the cutting rights to publicly owned timber.

Federal and provincial governments all involve the public to some degree in public policy and regulatory processes, and this should help to ensure that changing public and private interests are reflected in the regulatory environment. In general, Canadian tax and investment policies were not designed to provide incentives for voluntary pursuit of sustainable management of forests. Tenure arrangements do require basic harvesting and reforestation investments, however, and are subject to regulations designed to protect non-timber values.

Canada encourages the use of bioenergy as part of its response to the Framework Convention on Climate Change. The federal government provides economic incentives through the tax system for greater industrial bioenergy use, and also funds research and development on forest bioenergy. Most provincial and territorial governments have programs to encourage use of forest biomass, although few of these programs provide economic incentives for bioenergy use.

Canada adheres to the requirements of GATT to prevent discriminatory trade practices. It also encourages international action on reducing market access problems related to forest products through the development of international rules to define sustainable forest management.

Existing forest inventory systems in Canada are not well suited to measuring and monitoring, on a consistent and national basis, changes in the conservation and sustainable management of forests. The adoption of national protocols to enhance and ensure consistency in Canada's forest inventory system would improve the capacity to measure and monitor most of the indicators associated with ecological criteria.

Responsibility for monitoring compliance and enforcing forest-related laws and regulations and the terms and conditions of tenure agreements is assumed by forest departments and ministries. Environmental departments and ministries are usually responsible for the enforcement of environmental regulations. A system of inspections or field evaluations is in place in all provinces and territories. Periodic performance reports are usually requested from industry.

In addition to legislation to protect special places and values, many government agencies, private companies, and industry and professional foresters associations have adopted voluntary codes of best forestry practice.

Canada's capability in forest-related research and development is well established, although it is currently being re-evaluated in response to changing needs, both domestic and international. There is recognition of the need to more sharply focus scientific capability and to work within partnerships to develop and implement the needed scientific and technological information as rapidly and cost-effectively as possible.

IX. SUMMARY

Summary of indicator data

In addition to being a dominant feature of the Canadian landscape and an important part of the economy, forests are part of our heritage and a vital aspect of Canadians' identity, quality of life and culture. Even those who never actually visit forests attach a great deal of importance to their existence and the need to conserve them for future generations.

Canada is home to diverse ecosystems and species. Eleven of the country's 15 ecozones have 15% or more forest cover, and eight have at least 15% productive forest. Three quarters of the Boreal Shield's 195 million hectares are forested, although the greatest species diversity can be found in the Mixedwood Plains ecozone. Forests are vital to the survival of two thirds of Canada's known species, and are home to 180 tree species. Two forest-dependent species in Canada became extinct prior to 1940, while 78 are currently considered at risk at the national level.

While age class data are not available for all of Canada's forests, it is known that most are even-aged stands that arose after disturbances such as fire or insect infestations. Stand age declines from west to east, due mainly to rates of natural disturbance and harvesting.

In 1995, 7.6% of Canada's forest land was in protected areas. This figure is increasing steadily as the federal government, provinces and territories work to protect biodiversity and the many benefits derived from forests. Between 1986 and 1991, the area of national parks in Canada increased by 28% and the area of provincial parks by 14%. It is not possible at this time to determine species or age classes within protected areas.

There is no agreement on how to measure forest fragmentation. Road density has been used in some provinces to measure human disturbance of the natural environment. Road density in Canada ranges from sparse in areas of British Columbia to moderate in the Atlantic Maritime ecozone.

Of Canada's 417.6 million hectares of forest land, some 234 million are classified as commercial forests. The total area that is non-reserved, economically accessible and actively managed for timber production is approximately 117 million hectares. Most commercial forest land is managed by the provinces and the Northwest Territories, all of which have enacted policies to prevent or restrict its sale for conversion to other uses. It is not currently possible to report on changes in growing stock over time.

The silvicultural systems used to manage even-aged forests for timber production are clearcutting and seed-tree and shelterwood harvesting. Clearcut harvesting is the most widely used silvicultural system in Canada. Planting and seeding programs in the 1980s eliminated most of the backlog of unregenerated sites that had been accumulating. Since that time, provinces have scaled back these operations somewhat and begun to rely more on natural regeneration. Plantations are therefore becoming less important in the Canadian context.

Over the past 20 years, the national harvest rate for both hardwoods and softwoods has been consistently below the AAC (annual allowable cut). The AAC may decline somewhat in coming years to accommodate other requirements such as protected areas, wildlife reserves and stricter forest regulations.

Two of the primary disturbances shaping Canada's forests are insects and diseases (including exotic species of both) and fire. Canada has been collecting data on forest pests for the past 50 years. Losses appear to be evenly divided between those caused by insects and those by diseases, although there are regional variations. Depletion of Canadian forests caused by diseases is estimated to exceed 50 million m^3 annually. Many of the exotic species of insects and diseases now in Canada were introduced in the past 100 years, and have altered ecosystem diversity. An average of 9 600 fires have burned 2.9 million hectares annually in Canada over the last 10 years. Approximately 0.4% of the commercial forest area is burned every year.

Pollution data have been gathered from 11 sites in Canada for over 13 years, and hourly ozone concentration levels have been available since 1980. The most common air pollutants in Canada are sulphur dioxide and nitrogen oxides. Their presence in acid deposition remains a threat to forest ecosystem condition and productivity in portions of the Boreal Plain, Mixedwood Plain and Atlantic Maritime ecozones.

Codes and guidelines for forestry practices have been designed to mitigate their potential impacts on soils and aquatic systems. This is particularly true for ground disturbance, which has been reduced through an understanding of the importance of slope and the use of transportation methods other than skidding to the roadside. Conventional forest practices do not appear to have long-term effects on stream flow rates and timing, or soil properties. No national statistics are available on the compaction of forest soils, although there are now guidelines in place to limit it. Results of catchment studies show that harvesting increases nutrient levels in water and soils for three to five years, and that the return of the stream flow to near background levels usually takes at least 20 years.

A carbon budget model is being developed for Canada, for which data are available for the boreal and subarctic forests covering the period 1920 to 1989. Results indicate that after being a net sink for atmospheric carbon for much of the twentieth century, these two forest types have become a net source of atmospheric carbon emissions, apparently as a result of changes in fire and insect disturbance rates. Harvesting, an important human disturbance contributing to changes in the forest, does not appear to be a major cause of the change in the forest carbon budget. The role of Canada's forests in the carbon cycle is difficult to predict.

In addition to timber, Canada's forests provide society with a great many benefits, including maple products, Christmas trees, recreational and subsistence opportunities, and spiritual and cultural values. Many of these are currently difficult to quantify. National parks are receiving more visits, while consumption activities such as hunting are on the decline. Estimates suggest that as much as 60% of the area of Canada's boreal forest is used for subsistence purposes, as well as some areas of the coastal and mountain ecosystems and portions of eastern Canada. In 1995, the forest sector contributed $20.38 billion to the country's $776 billion gross domestic product.

Despite the importance of the forest sector to the economy, Canadians recognize that the forest is a finite resource, and now recycle 42% of all paper consumed. Wood products are also increasingly being recycled and reused, and great strides have been made by sectors such as the construction industry.

There appears to be a trend emerging for forest managers to invest more in general stewardship activities than in traditional silviculture, protection and resource access. This may reflect a move towards ecosystem-based management systems that are more information intensive and that emphasize natural regeneration of harvested lands. The industry invested $143 million in research and development in 1995, while research funding from all sources, including government, totalled approximately $285 million in 1994. The Canadian forest products sector is traditionally cyclical and suffered extreme losses in the early 1990s. Earnings were again positive by 1994.

Direct employment in the forest products industry was 369 000 in 1995. With advances in technology, the forest sector is becoming more and more an employer of skilled and highly paid workers. Average pay in this sector is higher than for the manufacturing sector as a whole. The spin-off effects of forestry employment create jobs in other sectors of the economy as well. It is estimated that the total number of forestry-related jobs is 880 000, or 1 in 15 Canadian jobs. Information on injury rates is not available at the national level. In 1991, 337 communities in Canada were heavily forest-dependent. While some have one other resource on which they depend for employment, a study in the Prairie provinces suggests that heavily forest-dependent communities could not be considered diversified.

In Canada, 94% of forest land is under government control. Various tenure arrangements have been developed across the country for the harvesting of timber on publicly owned land. All provinces and territories have forest legislation in place, and involve the public to some degree in policy and regulatory processes. The provinces and federal government use tax policies or spending programs to encourage the use of bioenergy, although the tax system is not generally used to encourage management, conservation, silviculture or reforestation. Overall, the legal and regulatory framework supports the sound stewardship of forest resources through mechanisms which recognize clear property rights, comprehensive planning processes and effective enforcement of laws, regulations and guidelines.

Capability to report on criteria and indicators

Canada has been able to report reasonably well on the indicators found in **Criterion 1 (Biological diversity)**, although some proxy data were used (for example, road density to report on forest fragmentation). Efforts are currently underway to develop a standard land cover classification for Canada, without which it is not possible to accurately measure the extent of the country's forests. Many issues have to be resolved such as the development of definitions for forest types and standardized measuring methodologies. *Canada's Forest Inventory 1991* is largely drawn from provincial inventories and contains little or no information on areas of non-commercial forest. While data exist on the current status of dominant species in Canada's forests, it is difficult to report on historical forest composition.

Since age class data are not available for all forest regions, "maturity" has been used instead. It appears that data in *Canada's Forest Inventory 1991* underestimate the proportion of younger-aged and uneven-aged stands in Canada. Because most jurisdictions cease forest inventory activities once an area has been set aside for protection, it is not possible to provide a detailed analysis of how well different forest types and age classes are represented in Canada's protected areas.

It would be helpful to more precisely define "forest-dependent species" to clarify, for example, whether to include aquatic species which benefit from tree shade, or find spawning habitat or food in fallen trees.

Canada maintains data on endangered species, although provincial and national data do not always correspond. Work is underway to develop a definitive list of species to be monitored for the various forest age classes and ecozones. Not all Canadian species have been identified (particularly invertebrates) and historical data for most are not available.

The preservation of species diversity is the first goal of the *Canadian Biodiversity Strategy.* Conservationists worldwide agree that humans have a responsibility to maintain all life forms. An important objective of sustainable forest management is ensuring that populations of species are not put at risk as a result of forest harvesting, regeneration, and other uses.

For **Criterion 2 (Productive capacity)**, Canada is able to report on the proportion of total forest land which is productive. *Canada's Forest Inventory 1991* is not designed, however, to provide measures of changes in growing stock over time. Data are available to report on the extent of successful regeneration on provincial forest land, but not on the growing stock of plantations of native species. The annual allowable cut is used as a proxy to determine the sustainability of the timber harvest; however, similar information is not available for non-timber forest products.

By measuring the productive capacity of its landbase, Canada can trace the effects of human intervention and monitor the state of its forests, while evaluating their ability to provide society with a continuous stream of benefits.

Data exist to report on the aspects of **Criterion 3 (Ecosystem health and vitality)** dealing with insects, diseases, fires and pollution. For insects, diseases and fire, data cover only area affected, and not severity or impact. Statistics have been gathered on forest pests at the regional rather than national level. Information on fire disturbance is available by agency dating back 75 years, although data prior to 1975 are incomplete. Recent data have been used to compile a preliminary report on the impacts of wildland fire on sustainable forestry. Pollution levels have been monitored for 13 years, while ozone levels have been tracked since 1980. Reporting is, and will remain, more difficult on forest lands having diminished biological components. Plot-based monitoring systems for the impact of acid deposition on soil exist, and could be expanded to include insects, fungi and flora. Data do not exist to quantify the impact of floods, storms, land clearance or domestic animals.

Measuring disturbance and stress provides a basis for sustainable forest management. This is because greater predictive power and knowledge of the effects of disturbance and stress on forest condition and productivity allow for improved decision making and the development of sound policies for Canada's forests.

Much of **Criterion 4 (Soil and water resources)** is difficult for Canada to quantify. Some case studies have determined appropriate guidelines to minimize ground disturbance, and general information is available to determine the impact of harvesting on soil and water. Quantitative data are not available for these indicators. Because soil and water conservation authorities are usually local, it is not known how many exist in Canada, nor how much forested area they protect. Recent data reflecting current codes of practice are not available to measure whether biological diversity in water in forested areas has significantly changed from historical norms in Canada.

Physical soil disturbance impacts on forest sustainability by decreasing the land area suitable for forest growth. Monitoring can ensure that appropriate planning and construction techniques are employed to minimize the losses. Elevated nutrient levels and flow rates in forest streams over long periods clearly indicate a major forest ecosystem malfunction because water and nutrients that should be utilized in forest growth are instead moving rapidly into drainage systems. This threatens not only sustainability of forests, but also the aquatic systems themselves through eutrophication, and downstream agricultural and urban areas through flooding.

Data for **Criterion 5 (Global carbon cycles)** are available through a proxy: a carbon budget model for Canada with information for the period 1920 to 1989. The most up-to-date section of the model deals with the boreal and subarctic forests, which represent 75% of Canada's total forest area. Work is nearing completion for estimates for Canada's entire forest area.

Forests occupy 4 000 million hectares globally, and Canada's forests represent 10% of this total. Because of their size, forests play a major role in the functioning of the Earth's biosphere, and contribute to and help regulate the carbon cycle. Depending on whether they are a sink or a source for atmospheric carbon, forests can either mitigate or contribute to climate change. At the same time, assessment of the status of the carbon budget is a relatively good indicator of the sustainability of forest management.

For **Criterion 6 (Socio-economic benefits)**, there are varying levels of data availability. It is possible to report on the contribution of the forest products sector to GDP, as well as direct and indirect employment, consumption of wood products, recycling, and to a lesser extent, investments in management, research and education. Information is also available for certain non-wood products such as wild pelts and maple products. For the most part, proxies and case studies must be used to report on subsistence and non-consumptive use of forests; and social, cultural and spiritual needs and values.

As with Criterion 2, the continued capacity of Canadian forests to provide a flow of goods and services to society is an essential component of sustainable development. A reduction in this capacity may be indicative of unsustainable harvesting. The focus of research and education efforts, as well as the level of recycling, are important indicators of Canadians' attitudes towards and commitment to sustainability.

Information is available to discuss the **legal, institutional and economic frameworks** found in **Criterion 7,** and for measuring and monitoring changes in the conservation and sustainable management of forests. Data are incomplete for reporting on forest research and development. In Canada, much of the framework discussed in this criterion is the responsibility of provincial governments, and therefore approaches may vary across jurisdictions.

Laws, policies, organizational structures, and codes of ethics and practices are also indicators of Canadians' attitudes and priorities. Reviewing the legal, institutional and economic frameworks in the context of sustainability provides an opportunity to identify areas where more can be done to use, protect and enhance Canada's forests.

Utility of the criteria and indicators for Canada and future directions

A key initiative in Canada's efforts to develop comprehensive information bases on status of and trends in its forest **biodiversity** could involve an analytical framework describing enduring features of ecosystems: topography, climate, soils, and surficial geology. This framework could be used to synthesize data on more rapidly changing ecosystem properties such as vegetation cover, land use, and species populations. By integrating remote sensing and ground-based monitoring approaches, it would facilitate a preventive approach to conserving biodiversity, providing detailed and consistent information to all people whose actions influence Canada's forests.

Indicators on the maintenance of **productive capacity** of Canada's forest ecosystems are partly found in *Canada's Forest Inventory* and the National Forestry Database Program (NFDP). The inventory provides detailed information on Canada's forest land area and the growing stock associated with it. Data collected under the CCFM's NFDP provide accurate and relatively complete information on AAC, harvest and the regeneration status of Canada's forests. The indicators provided with this information are as complete and accurate as can be expected. Information on non-timber forest products, is, in general, scarce and fragmented, although site-specific studies do provide some useful information. The NFDP is pursuing the possibility of expanding the scope of the database to include **non-timber values**. This would involve identifying common measurement protocols between the federal and provincial/territorial governnments and collecting and synthesizing the data.

The term "non-wood products" is used under some indicators of Criterion 6, while under Criterion 2, the term "non-timber forest products" appears to have the same definition. The two were combined in Canada's country report under Indicator 2.e. It may be advisable to revise the indicators and definitions to eliminate repetition.

Canada will continue to maintain the databases on processes and agents impacting on **forest ecosystem health and vitality.** These include insects, diseases, fire and air pollutants. Work will be carried out to enhance reporting on forest land having diminished biological components. Research has been proposed which would serve to quantify fire indicators which cannot currently be measured or modelled.The role of wildland fire in the Canadian Criteria and Indicators and the Montréal Process is currently being examined. Framework and design specifications have been developed for fire C&I. Ten fire criteria have been proposed: environment, disturbance, ecosystems, biochemistry, forestry, society, fire management, atmosphere, soil and water, and balance. The importance of each criterion has been quantified. Seventeen of twenty-six proposed indicators can be measured or modelled with existing data; these form the basis of a prototype C&I process for fire. Six criteria have been combined into seasonal fire severity, which indicates "good" and "bad" years and the relative importance of each criterion. Research has been proposed to quantify what cannot currently be measured.

All jurisdictions in Canada have implemented guidelines and codes of practice to reduce or eliminate potential negative impacts of forest harvesting on **soil and water resources.** Additional data will become available to measure the effects of these new practices.

Estimation of the **carbon budget** and its various components depends heavily on, and builds upon, the information utilized in Criteria 1, 2 and 3. The carbon budget is in essence a cumulative effect of the impacts of each of these criteria. Monitoring of forest composition and age class structure is critical to the success of carbon budget estimates. The current inventorying approach does not allow for the assessment of change in forest biomass over time and consequently is inappropriate for assessing the status and change of the forest carbon budget over time. The same is true of the monitoring of disturbance impacts over time.

Data relating to **GDP, employment, wages, consumption of wood products, recycling and expenditures on industrial R & D** are available through official sources and are national in scope. Proxies and case studies must be used to report on **subsistence and non-consumptive use of forests** and other **social, cultural and spiritual needs and values.** Some indicators, such as the area of forest land managed for general **recreation and tourism,** offer little information given that virtually 100% of the public forest landbase is managed for these and an array of other uses. NRCan–CFS is a partner in a major national survey to evaluate the level of participation of Canadians in **outdoor forest-based activities** and their general connection with nature. Results of this survey will be available toward the end of 1997. A major focus of the NRCan–CFS socioeconomic network is to develop methodologies for valuation of **non-market forest-related outputs,** a better understanding of the relationship of **Aboriginal peoples** with forests, and an improved understanding of the role and contribution of forestry-related activities to **community economic development** and of the impacts of forest dependency on social stability and social interactions. NRCan–CFS will continue to analyse and assess structural changes in forest products markets of importance to the Canadian **forest sector,** and to develop the capability to predict the sector's response to external changes. This capacity will provide an improved basis for understanding the linkages and interrelationships between economic benefits generated by forests and resource status.

Much of the **institutional, legal and economic frameworks for forest conservation and management** fall under provincial or territorial jurisdiction. Canadian governments will continue to cooperate with one another and share information and data in order to ensure reporting on these important areas at a national level. Efforts will be made to develop more complete data on trends in R & D related to forest conservation.

Conclusion

Within the lifespan of a single tree, Canadians' focus has shifted from timber production to managing forests for a variety of uses. The goal is to manage the vast forest resource such that it continues to provide benefits to Canadians, and is able to meet the needs of future generations. Canada looks forward to working with its partners in the Montréal Process and other international bodies to ensure the sustainable management of all the world's forests.

GLOSSARY

Abiotic: Concerning the non-living component of the environment (e.g., climate, ice, soil and water).

Aboriginal: As defined by the Constitution Act, 1982, Section 35(2), "Aboriginal peoples of Canada" includes the "Indian, Inuit and Metis" peoples of Canada.

Age class: A category into which the average age or age range of trees or other vegetation is divided for classification or use.

Annual allowable cut (AAC): The amount of timber that is permitted to be cut annually from a specific area; AAC is used as the basis for regulating harvest levels to ensure a sustainable supply of timber.

Aquatic: Pertains to both marine and freshwater ecosystems.

Biodiversity/Biological diversity: The total variability of life on Earth, including the diversity of genes, species and ecosystems.

Bioenergy: The kinetic energy released from biomass when it is eaten, burned or converted into fuel; the potential energy embodied in biomass.

Biogeochemistry: A science that deals with the relation of earth chemicals to plant and animal life in an area.

Biomass: The dry weight of all organic material (i.e., animals, plants and microorganisms) living or dead and above or below the soil surface.

Biosphere: Regions of the planet where life is found, ranging from the oceans to the lower atmosphere.

Biota: All of the living organisms in a given ecosystem, including bacteria and other microorganisms, plants and animals.

Bogs: Peatlands that are generally unaffected by nutrient-rich groundwater. They are acidic and are often dominated by shrubs and mosses; they may also include open-growing, stunted trees.

Buffer: A strip of land where disturbances are not allowed, or are closely monitored, to preserve aesthetic and other qualities adjacent to roads, trails, waterways and recreation sites.

Carbon cycle: The cycle of carbon in living things in which carbon dioxide is fixed by photosynthesis to form organic nutrients and is ultimately restored to the inorganic state by respiration and protoplasmic decay.

Carbon sink: An area where the rate of carbon uptake by living organisms exceeds the rate of carbon release, so that carbon is actively sequestered in organic or inorganic forms.

Catchment studies: Studies carried out on the area tributary to or draining to a lake, stream, reservoir or other body of water.

Clearcutting/clear-cut harvesting: A forest management method that involves felling and removing a stand of trees. Clearcutting may be done in blocks, strips or patches.

Climate change: An alteration to measured quantities (e.g., precipitation, temperature, radiation, wind and cloudiness) within the climate system that departs significantly from previous average conditions and is seen to endure, bringing about corresponding changes to ecosystems and socioeconomic activity.

Commercial forest: Forest land that is able to grow commercial timber within an acceptable time frame.

Commodity: A general term referring to primary-level manufactured products (e.g., dimension lumber, plywood and market pulp) that are sold in bulk. These products are often used to produce products of greater value-added (e.g., structures, furniture and fine papers).

Compaction: A reduction in soil volume (usually caused by repeated passes of heavy equipment) leading to poor soil aeration, impeded drainage and root deformation.

Cutover: An area of forest from which some or all of the timber has recently been cut.

Decomposition: The breakdown or decay of organic materials by the action of bacteria, fungi and other minute organisms.

Deforestation: Clearing an area of forest for another long-term use.

Detritus: Loose material that covers the soil surface, consisting of decomposing plant matter and resulting directly from disintegration.

Diminished biological components: Refers to a reduction in the diversity of biological species.

Direct and Indirect employment: Direct employment is the number of jobs created by firms in the process of producing a good or service. However, in the process of producing the good or service, the primary firm also generates secondary economic activity in other sectors of the economy. The jobs created by the secondary economic activity are referred to as indirect employment.

Displacement: The removal of soil, including the forest floor, from one location to another, causing a change in the natural microtopography.

Ecosystem: A dynamic system of plants, animals and other organisms, together with the non-living components of the environment, functioning as an interdependent unit.

Ecosystem-based management: Management systems that attempt to simulate ecological processes, with the goal of maintaining a satisfactory level of diversity in natural landscapes and their pattern of distribution. The goal is to ensure the sustainability of forest ecosystems and forest ecosystem processes.

Ecozone: A broad-scale ecological unit that is based on patterns that include climate, geography and ecological diversity.

Erosion: To wear away a material by the action of water, wind or glacial ice.

Eutrophication: The process by which a body of water becomes-either naturally or by pollution-rich in dissolved nutrients (e.g., phosphates), often accompanied by a seasonal deficiency in dissolved oxygen.

Evapotranspiration: Loss of water from soil and vegetation, both by evaporation and by transpiration from plants.

Exotic species: Any organism that enters an ecosystem beyond its normal range through deliberate or inadvertent introduction by humans.

Fire behaviour: Ignition, flame development, spread and intensity of a forest or wildland fire.

Fire environment: Weather, fuels and topography that affect forest or wildland fires.

Fire severity: Negative effects of a forest or wildland fire on other ecosystems.

Firewood: Trees that will yield logs suitable in size and quantity for the production of fuelwood; also the logs of such trees.

First Nations Canadians: Aboriginal peoples who have occupied the territory now called Canada for several thousand years. Many diverse and autonomous First Nations lived in the territory as hunters and gatherers for most of that period. The term "Indian," which European immigrants long used to refer to First Nations peoples, is now considered a misnomer (an error in naming). Canada's two other Aboriginal peoples are the Inuit and the Métis. Inuit are Arctic people. They have lived along the coastal edge and the islands of Canada's far North for thousands of years. Métis are people of mixed ancestry, the descendants of Aboriginal peoples who intermarried with European fur traders and settlers.

Forest-dependent community: A community that is dependent on forests for its survival; due to data availability, dependence is usually measured with timber-sector data.

Forest-dependent species: Any species that needs forest conditions for all or part of its requirements of food, shelter or reproduction.

Fossil fuel: Oil, gas, coal and other fuels that were formed under the Earth's surface from the fossilized remains of plants and tiny animals that lived millions of years ago.

Fragmentation: The division of a continuous block of forest or other wildlife habitat into disconnected units as a result of human or natural disturbances.

Fuelwood: Trees that will yield logs suitable in size and quality for the production of firewood logs or other wood fuel; also the logs of such trees.

Gross domestic product (GDP): A measure of national income-the amount paid to Canadians, including governments, including wages, profits, taxes and royalties.

Habitat (wildlife): The environment in which a species population lives; includes not only the place, but also the particular characteristics of the place (e.g., climate or availability of suitable food and shelter) that make it especially well suited to meet the life-cycle needs of that species.

Hardwood(s): Broad-leaved trees; also refers to the wood produced by these trees. Hardwoods belong to the botanical group angiospermae and are dominant in the deciduous forests.

Heavily forest-dependent community: A forest-dependent community that relies on the forest sector for more than 50% of its economic base.

Indian: Means a person who, pursuant to the Indian Act, is registered as an Indian or is entitled to be registered as an Indian; see "First Nations Canadians".

Indigenous: Having originated in and being produced, growing, living or occurring naturally in a particular region or environment.

Integrated forest management: Forest management that incorporates timber and non-timber values.

Landfill site: Low-lying land that has been built up by the disposal of waste buried between layers of earth.

Litter: The uppermost, slightly decayed, layer of organic matter on the forest floor.

Merchantable tree species: A species that has known commercial wood uses. Merchantability is usually judged with respect to the suitability of a species for pulp, paper, lumber or specialty wood products. Both native and exotic tree species can be considered merchantable tree species.

Moderately forest-dependent community: A forest-dependent community that relies on the forest sector for 10-50% of its economic base.

Non-commercial tree species: A tree species for which there is currently no market.

Non-consumptive use of forests: Uses that do not lead to the taking of physical products from the forest. They include recreation, photography, birdwatching, education, and contemplation or meditation.

Non-timber forest products: Includes game animals, fur-bearers, nuts and seeds, berries, mushrooms, oils, foliage, medicinal plants, peat and fuelwood, forage, etc.

Non-timber values: Includes all forest-related values that are not derived from timber harvesting and the subsequent production of forest products.

Off-cut(s): A piece cut off when cutting material to size. The term "offcut" has been standardized by ISO.

Old-growth forest: A forest dominated by mature trees and that has not recently been significantly influenced by human activity. The forest may contain trees of different ages and various species of vegetation.

Outfitter: Small commercial operation where the owner or operator provides the necessary equipment and supplies to individuals or groups so that they can have an outdoor experience in a particular area. In some cases, the outfitter guides or accompanies the individual or group, providing outdoor skills and knowledge of local sites, conditions, trails, and wildlife or fishing locations.

Ozone: A form of oxygen (O_3) formed naturally in the upper atmosphere by a photochemical reaction with solar ultraviolet radiation; one of the elements present in smog.

Particulate: Of or relating to minute separate particles.

Passerine birds: The largest order of birds, which includes more than half of all birds and consisting chiefly of songbirds that have perching habits.

Peatland: Terrain that is covered by an accumulation of partially decomposed plant matter, due to excessive moisture.

Protected area: An area protected by legislation, regulation or land-use policy to control human occupancy or activities. Categories of protected areas include protected landscapes, national parks, multiple-use management areas, and nature or wildlife reserves.

Pulp: Wood chips that have been ground mechanically into fibres and used for the production of paper, such as newsprint, or that have been chemically treated to remove the lignin and used to manufacture higher-quality papers.

Recycling: The processes used to reclaim — as a material input to a product or service system — material that would otherwise be disposed of as waste.

Reforestation: The re-establishment of trees on deforested land by natural means or by planting or seeding.

Regeneration: The renewal of a forest stand following disturbance. Natural regeneration occurs from roots, stems or seeds that are already present or that are brought in by wind or animals. Alternative regeneration methods involve direct seeding or planting.

Renewable resource: A natural resource that is capable of regenerating itself. If properly managed, renewable resources can essentially never be exhausted, usually because they are continuously produced (e.g., tree biomass, fresh water and fish).

Seed tree cutting: Leaving a number of scattered trees on a site to provide a portion of the seeds needed for regeneration.

Shelterwood (even-aged) cutting: A method of harvesting that involves two cuts; the first cut leaves stems or groups of trees at intervals to provide the crown closure and species required for regeneration; the second removes the remaining mature stems, leaving the regeneration to develop.

Siltation: Loose sedimentary material with rock particles.

Silviculture: The practice of controlling the establishment, composition, growth and quality of forest stands; can include basic silviculture (e.g., planting and seeding) and intensive silviculture (e.g., site rehabilitation, spacing and fertilization).

Skidding: The process of dragging logs from the forest to a landing or a road-side using a large tractor-like machine.

Sludge: A soft, thick mixture, deposit or sediment. Often a by-product of sewage treatment processes.

Softwood: Cone-bearing trees with needles or scale-like leaves; also refers to the wood produced by these trees. Softwoods belong to the botanical group *gymnospermae* and are dominant in coniferous forests.

Species-at-risk: A wildlife species that is facing extirpation or extinction if nothing is done to reverse the factors causing its decline or that is of special concern because it is particularly sensitive to human activities or natural events.

Standing biomass: The amount of biomass that occurs on a given site at a particular time, without reference to the rate of accumulation (i.e., kg/ha).

Stewardship: The science, art and skill of responsible and accountable resource management.

Stocking: A qualitative expression of the adequacy of tree cover on an area, in terms of crown closure, number of trees, basal area, or volume, in relation to a pre-established norm.

Subsistence activities: Harvesting or growing products directly for personal or family livelihood.

Succession (successional trends): Changes in the species composition of an ecosystem over time, often in a predictable sequence.

Sustainable forest management: The management of forests to meet current needs without prejudice to their future productivity, ecological diversity, or capacity for regeneration.

Trophic (web/status): Of or relating to nutritional relationships.

Turbidity: Reduced clarity or purity of water.

Ungulates: Any species of the hoofed mammals, of which most are herbivorous and many are horned.

Unspecified broadleaves: A group of hardwood trees not identified to the genus or species level.

Use values: Activities (e.g., subsistence food gathering, outdoor recreation, and hunting and trapping) where the individual directly uses or consumes a good or service from the forest.

Vitality: Capacity for an ecosystem to maintain energy flow and demonstrate endurance.

Vulnerable species: A species that is particularly at risk because of low or declining numbers, a small range, or some other reason, but is not immediately threatened.

Watershed: An area of land that is drained by underground or surface water bodies into another waterway.

Wetland: Land that is seasonally or permanently covered by shallow water, or land where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic (water-tolerant) plants.

ABBREVIATIONS / ACRONYMS

AAC	Annual Allowable Cut
ARNEWS	Acid Rain National Early Warning System
BOD	Biological Oxygen Demand
BOREAS	Boreal Ecosystem-Atmosphere Study
CAPMON	Canadian Air and Precipitation Monitoring Network
CCFM	Canadian Council of Forest Ministers
CCP	Canadian Climate Program
CFS	Canadian Forest Service
CGCP	Canadian Global Change Program
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
FERIC	Forest Engineering Research Institute of Canada
FIDS	Forest Insect and Disease Survey
FRA	Forest Resource Assessment
FRDA	(Federal-Provincial/Territorial) Forest Resource Development Agreement
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
IGBP	International Geosphere-Biosphere Programme
IHDP	International Human Dimensions of Global Environmental Change Programme
IPCC	Intergovernmental Panel on Climate Change
IRAP	Industrial Research Assistance Program of the National Research Council
ISO	International Organization for Standardization
IUCN	World Conservation Union
MtC	million (mega) tonnes of carbon
NAMP	North American Maple Project
NAPS	National Air Pollution Surveillance Network
NFDP	National Forestry Database Program
NRCan	Natural Resources Canada
OECD	Organization for Economic Cooperation and Development
OMNR	Ontario Ministry of Natural Resources
PAPRICAN	Pulp and Paper Research Institute of Canada
R & D	Research and Development
RIC	(British Columbia's) Resource Inventory Committee
RPF	Registered Professional Forester
S & T	Science and Technology
TSS	Total Suspended Solids
UNCED	United Nations Conference on Environment and Development
WCRP	World Climate Research Programme
WTO	World Trade Organization

Natural Resources Canada / Ressources naturelles Canada
Canadian Forest Service / Service canadien des forêts

Terrestrial Ecozones of Canada

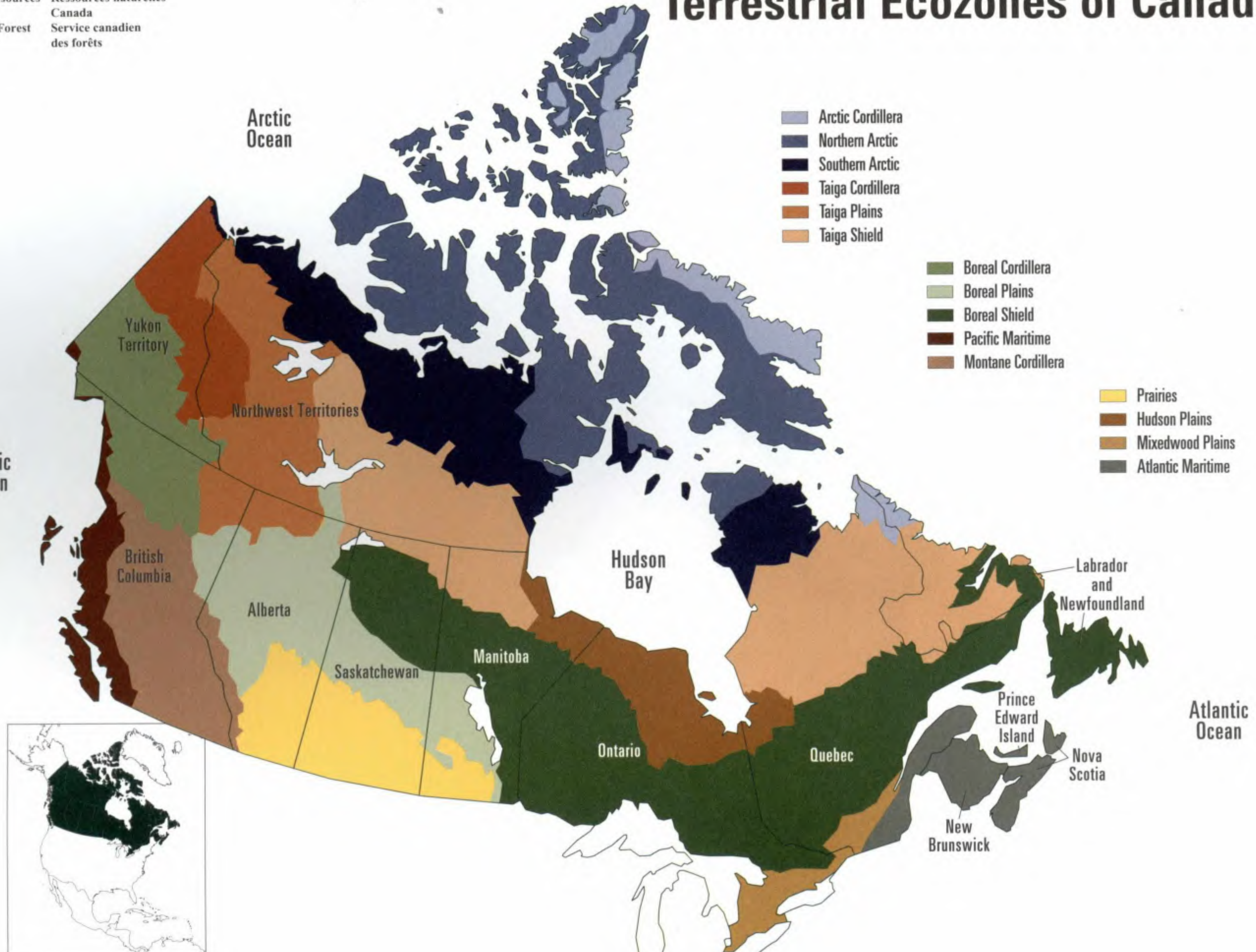
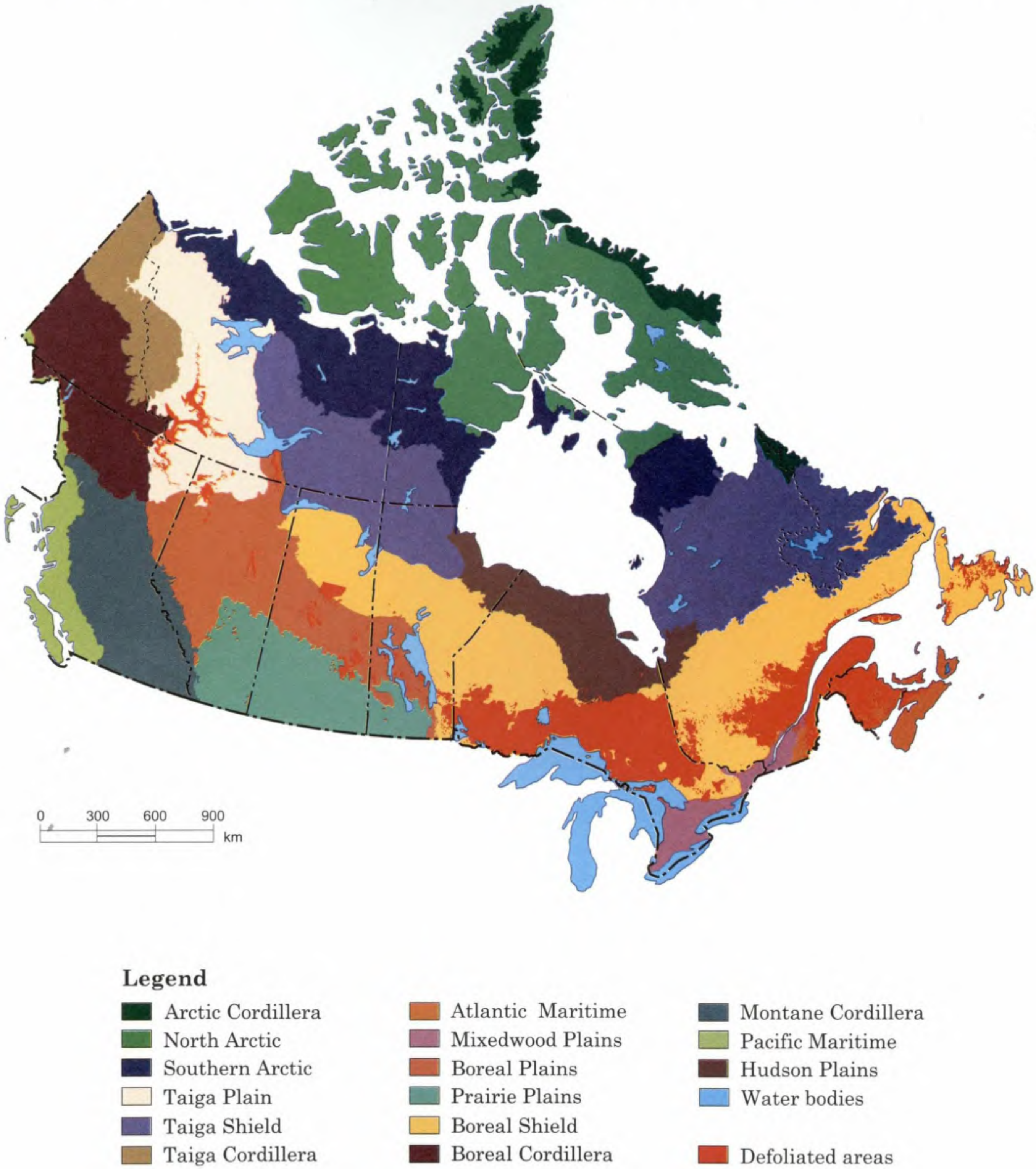


Figure 3.a.2

Areas of Defoliation by Forest Tent Caterpillar, 1980-1995



Data compiled by Forest Health Network, Atlantic Forestry Centre, Canadian Forest Service, Natural Resources Canada.
Map co-produced by ***GeoAccess*** Division, Canada Centre for Remote Sensing, Geomatics Canada, Natural Resources Canada.