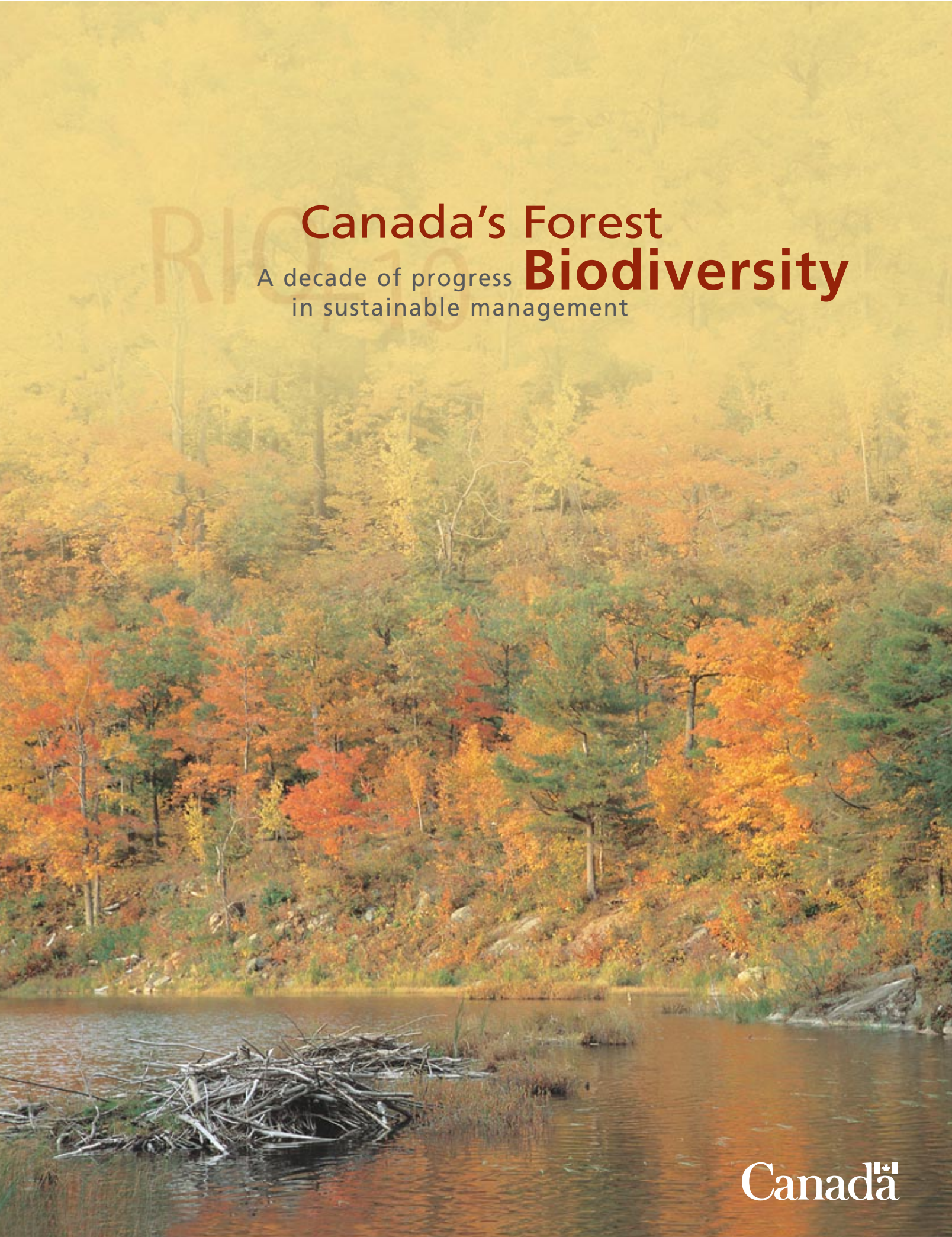
Canada's Forest Biodiversity

A decade of progress in sustainable management



Canada

Message from the Minister

I am pleased to present the publication *Canada's Forest Biodiversity: A decade of progress in sustainable management.* This report profiles Canada's success in conserving forest biodiversity. It also assesses our progress in meeting commitments under the Canadian Biodiversity Strategy (CBS).

Canada takes its responsibility in this area very seriously. We are steward of 10 percent of the world's forests, which provide habitat to about 66 percent of species in this country. Maintaining biodiversity is a basic criterion of sustainable forest management, and our CBS commitments mirror the fundamental commitment in our National Forest Strategy to maintain the extent, diversity and health of our forest ecosystems.

I am proud of what we have accomplished in the past 10 years. We have been successful because we worked together—federal, provincial and territorial governments, organizations, industry and individuals from the forest community. Our very successful Model Forest Network is being emulated in Asia and North and South America, and the innovative First Nation Forestry Program has been recognized as one of the Government of Canada's outstanding programs.

Canada is also living up to its international commitments under the United Nations Convention on Biological Diversity, an agreement that was reached at the Rio Earth Summit in 1992. We were recently instrumental in achieving a ministerial declaration regarding, among other things, a work program for forest biological diversity. We also continue to pursue the adoption of a legally binding instrument on all types of forests that would provide a common definition of sustainable forest management and include a compliance regime.

Ongoing assessment of our performance is essential to ensure biodiversity and sustainable use of our forests. Canada now has a framework and the tools to monitor its progress. The report will also help us set objectives for the next 10 years, and it will be extremely useful in helping us further integrate biodiversity in the next National Forest Strategy, which is under development.

Our work on biodiversity builds on our commitment to ensuring a clean, healthy environment and preserving our natural spaces, which are essential elements of our quality of life. As a world leader in sustainable forest management, Canada will continue to take effective action to ensure that its forests maintain their ability to provide an array of benefits for future generations.

I look forward to working with both the national and international forest communities in the journey to advance biodiversity in the 21st century.

Herb Dhaliwal

The Honourable Herb Dhaliwal
Minister of Natural Resources Canada

RIO+10

Canada's Forest Biodiversity

A decade of progress in sustainable management

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Introduction

This report addresses Canada's custodial responsibilities in retaining the wealth of its natural heritage: the biodiversity of the forested regions. Canadians are proud to be stewards of a large portion of the world's temperate and boreal forests–stewards of forests that include:

- 10% of the world's forest;
- 20% of the world's remaining wild areas; and,
- the source of 25% of the world's fresh water supply (Natural Resources Canada 1992-2001 (annual)).

In addition, Canada, Russia and Brazil together contain approximately one-half of the world's remaining closed forests (those with greater than 40% canopy closure) (United Nations Environment Program 2001). Canada is home to some of the largest free-ranging wildlife populations in the world, including more than a million barren-ground caribou.

This report assesses the progress of the forest community toward meeting its commitment to the Canadian Biodiversity Strategy (Canada's response to the Convention on Biological Diversity) to maintain the extent, diversity and health of Canada's forests. Very simply, it examines the state of forest biodiversity and the range and success of the current programs to maintain biodiversity within forests. This maintenance strategy is fundamental to retaining the breadth of biodiversity across the nation. Canada is in the enviable position of retaining and managing its vast forest as a result of a high degree of public ownership of forests, the wilderness nature of most of the northern forests and the limited development within the forest.

By maintaining the integrity of its natural forests and positioning its wealth of biodiversity as an asset, Canada will continue to benefit from the array of opportunities associated with sustainable management.

The Canadian Biodiversity Strategy: Canada's Response to the Convention on Biological Diversity

Vision

A society that lives and develops as a part of nature, values the diversity of life, takes no more than can be replenished and leaves to future generations a nurturing and dynamic world, rich in its biodiversity.

Goals

conserve biodiversity and use biological resources in a sustainable manner;

improve our understanding of ecosystems and increase our resource management capability;

promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner;

maintain or develop incentives and legislation that support the conservation of biodiversity and the sustainable use of biological resources; and,

work with other countries to conserve biodiversity, use biological resources in a sustainable manner and share equitably the benefits that arise from the use of genetic resources.

Forest Biodiversity in Canada

The conservation of biodiversity emerged as the key ecological concept of the 1990s and has provided a public focus on the disappearance and impoverishment of the earth's biota. Conservationists have effectively expressed their concerns that current approaches to land-use and resource management are eroding the earth's biodiversity. In response, governments have adopted appropriate public policy measures, and resource managers have had to rethink their fundamental assumptions about management objectives and standard methods of planning and implementing activities.

Biodiversity conservation became the main element of Canada's environmental policy agenda during the 1990s. At the United Nations-sponsored Rio Earth Summit in June 1992, Canada played a leadership role in the development of the United Nations Convention on Biological Diversity. In December 1992, Canada became one of the first industrialized countries to ratify the convention, and three years later released the Canadian Biodiversity Strategy (1995) as the agenda to implement the convention in Canada. This strategy built on elements of the 1992 National Forest Strategy and subsequently influenced the development of the 1998 strategy (Canadian Council of Forest Ministers 1992, 1998). At the same time, Canada agreed to the UNCED Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests, which embodies the objectives of the convention as it applies to the conservation of forests.

Embedded in all these commitments is the recognition that the conservation of biological diversity preserves the resilience of ecosystems and maintains a "natural" landscape that ensures the continuing existence of species. Each level of diversity (genetic, species and ecosystem) has its own management challenges as well as being directly linked to the other levels. Each ecosystem provides a unique set of habitats, which in turn supports a variety of species at different densities. The maintenance of the integrity of ecosystems has a direct bearing on the diversity of species within a landscape or region. Species diversity refers not only to the actual number of species in an area, but also to their distribution across the landscape. And genetic diversity provides the variation in characteristics of individuals within a population and of populations within a species range, allowing species to respond to changes in environmental conditions.

Within the context of recognizing the complexity of biodiversity, Canada's approach during the 1990s evolved from a species focus to an emphasis on conserving ecosystems, particularly in its forested landscapes. This approach also ensures appropriate focus on changes to habitats, and on their degradation, as the major threat to biodiversity. As Canada still has almost its entire original complement of forest ecosystems and forest species, a proactive conservation program of maintenance rather than restoration was successful during the 1990s.

Before reviewing program achievements, a brief examination of Canada's natural forest ecosystems is provided to highlight specific issues relating to conservation and sustainable use of forest biodiversity.

Ecosystem Diversity

The current state of biodiversity within the Canadian forest is the product of three very different forces on the landscape—recovery from the last glacial period, the effect of continual large-scale natural disturbances and the result of man's intervention. The first two are natural and are the overriding forces affecting all the forested landscapes in Canada.

Canada's forest originated 10 000 to 12 000 years ago, after the retreat of the Wisconsin ice sheet. The slow process of soil formation, colonization by a variety of species and adaptation to post-Ice Age change in the world's climate is not only very evident today but is still shaping our young forests. Over this period, eight forest regions have evolved in Canada (Table 1; see also the map on the inside front cover). Each forest region is dominated by remarkably few species of trees. For example, in the boreal forest, Canada's largest forest region, black and white spruce are the dominant tree species, with jack pine, tamarack, balsam fir, poplar (trembling aspen) and birch also as common forest components.

Canadian forest ecosystems are a mixture of forest, woodlands, wetlands, lakes, glaciers and rock. Within each forest region there are a diverse variety of forest habitats made up of a variety of species. Natural disturbances add the

dimensions of time (successional stage) and space (size of stands) to Canada's forest ecosystems. The main causes of natural disturbance in Canada's forests are fire, insect epidemics and disease. These disturbances often occur in natural cycles and have shaped Canada's forests for thousands of years. Smaller-scale disturbances caused by wind and ice-loading are also common.

The area affected by wildfires in Canada each year is immense: over the decade of the 1990s, an average of 8 248 fires burned 3.2 million hectares annually (Canadian Council of Forest Ministers 2000a). This includes more than 700 000 hectares of commercial forest land, which is 74% of the annual area harvested (Natural Resources Canada 1997b). Possible explanations for the gradual increase in area burned over the past 30 years (Figure 1) include higher temperatures, dry and hot summers, fuel build-up from years of successful fire suppression and changes in fire management policies that allow more fires to burn in remote areas.

Whereas wildfires annually affect the largest area of our forest, insect defoliation has a major impact in wetter areas. For example, in the wetter eastern Boreal Region insect defoliation is the major disturbance on commercial forest land, whereas in the drier western Boreal Region fires are the main cause of disturbance (Natural Resources Canada 1993). Some of the predominant insect pests in Canada are spruce budworm, hemlock looper, mountain pine bark beetle, gypsy moth and forest tent caterpillar. Figure 2 shows the area defoliated by two of the most widespread species, the spruce budworm and the forest tent caterpillar. Currently, populations of the mountain pine bark beetle have reached epidemic levels in the central interior of British Columbia.

Tree diseases do not have the same visible impact in shaping our ecosystems. However, the average tree mortality and growth loss from diseases in Canada is equivalent to 29% of the annual timber harvest in Canada each year (Natural Resources Canada 1997b).

The area harvested annually in Canada is relatively constant, at approximately 1 million hectares. This is 0.4% of Canada's commercial forest, substantially lower than the area affected by fire (Figure 3). It should be noted that harvest statistics include "salvage logging" of forests affected by fire and insect epidemics. Clearcutting is the most common harvesting and regeneration system used in Canada. It is applied in areas affected by large-scale disturbances such as fire and insect outbreaks to emulate the natural disturbance patterns. Eighty-five percent of Canada's forests are predominantly

Figure 1. Annual variability of forest fires in Canada (CCFM 2000a)

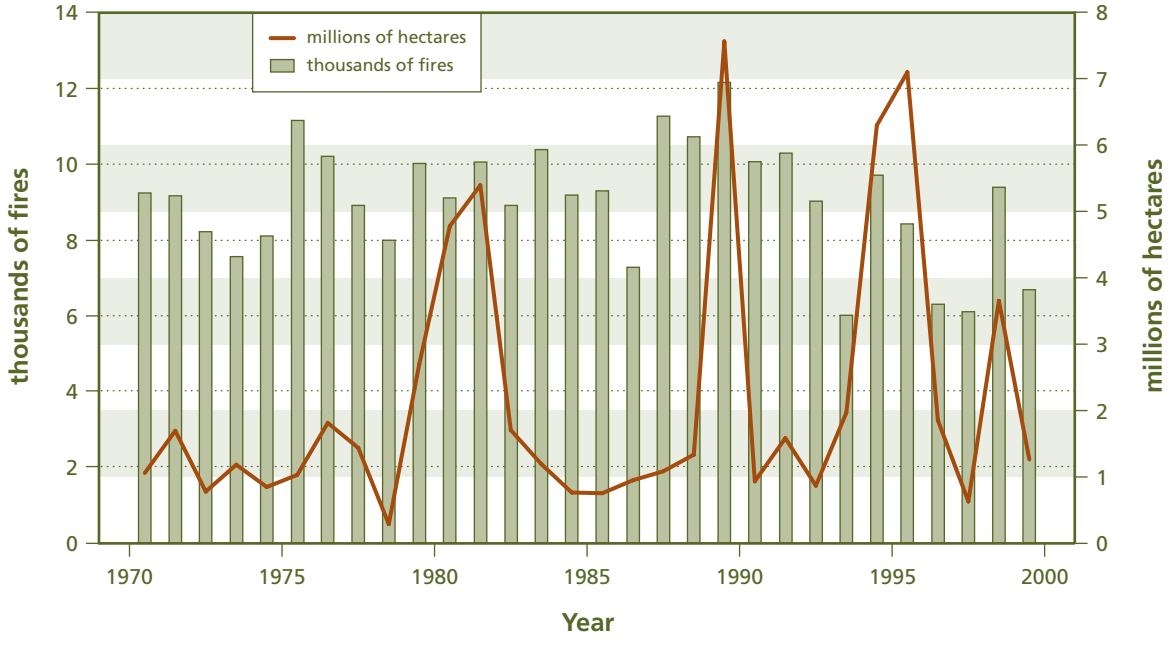


Table 1. Forest Regions of Canada*

Forest region	Total area (ha)**	% of total area***	Timber-productive forest land (ha)**	Principal tree species	Examples of characteristic wildlife species
Boreal					
Predominantly forest	289 438 000	29.0	140 784 000	white and black spruce, balsam fir, jack pine, white birch, trembling aspen	black bear, caribou, white-tailed deer, moose, wolf, beaver, hairy woodpecker, cedar waxwing, common garter snake, wood frog, chorus frog, Labrador tea, lowbush blueberry, pitcher plant, sphagnum, Canadian tiger swallowtail butterfly
Forest and grassland	21 911 000	2.2	2 324 000	white spruce, black spruce, tamarack	
Forest and barren	218 613 000	21.9	23 546 000	trembling aspen, willow	
Subalpine	25 139 000	2.5	14 794 000	Engelmann spruces, alpine fir, lodgepole pine	grizzly bear, moose, coyote, lynx, hoary marmot, bighorn sheep, red-tailed hawk, mountain chickadee, red crossbill, western toad, white rhododendron, grouseberry, feather moss, twinflower, bunchberry, Rocky Mountain Parnassian butterfly
Montane	14 996 000	1.5	11 751 000	Douglas-fir, lodgepole pine, ponderosa pine, trembling aspen	caribou, grizzly bear, mallard, white-tailed ptarmigan, blue grouse, western terrestrial garter snake, western toad, russet buffaloberry, wild gooseberry, common juniper, nodding onion, woodland skipper butterfly
Coast	12 574 000	1.3	1 096 000	western redcedar, western hemlock, Sitka spruce, Douglas-fir	coast deer, black bear, long-eared bat, mountain quail, bald eagle, rough-skinned newt, Pacific tree frog, Alaska blueberry, red huckleberry, step moss, deer fern, Hydaspe fritillary butterfly
Columbian	5 456 000	0.6	3 619 000	western redcedar, western hemlock, Douglas-fir	mule deer, Columbia ground squirrel, grizzly bear, chestnut-backed chickadee, gray jay, Steller's jay, rubber boa, black huckleberry, bunchberry, oak fern, Perseus dusky wing butterfly
Deciduous	5 184 000	0.5	403 000	beech, maple, black walnut, hickory, oak	eastern fox squirrel, muskrat, opossum, raccoon, great blue heron, kingbird, eastern milk snake, five lined skink, spotted salamander, smooth serviceberry, white trillium, yellow lady's slipper, giant swallowtail butterfly
Great Lakes/ St. Lawrence	46 583 000	4.7	24 549 000	red pine, eastern white pine, eastern hemlock, yellow birch, maple, oak	white-tailed deer, otter, red fox, black bear, snowshoe hare, loon, black-capped chickadee, blue jay, golden-eye, wood turtle, eastern garter snake, gray tree

(Continued)

Table 1. *(Concluded)*

Forest region	Total area (ha)**	% of total area***	Timber-productive forest land (ha)**	Principal tree species	Examples of characteristic wildlife species
					frog, red-spotted newt, beaked hazel, prickly gooseberry, trout lily, spinulose wood fern, West-Virginia white butterfly
Acadian	12 168 000	1.2	8 817 000	red spruce, balsam fir, maple, yellow birch	American marten, moose, black bear, porcupine, white-tailed deer, great blue heron, Lincoln's sparrow, bay-breasted warbler, eastern painted turtle, American toad, northern dusky salamander, green frog, alternate-leaf dogwood, mountain maple, harvester butterfly

*References for table include CCFM 2000a, Layberry et al. 1998, Behler 1996, Chambers et al. 1996, NRCan 1993, Scotter and Flygard 1986, Young 1985, Blouin 1984, DeGraaf and Rudis 1983.

**The Grasslands and Tundra Regions, not included in this table, have 1 230 000 and 6 405 000 ha respectively in timber-productive forest land, a relatively small portion of their total areas of 30 159 000 ha and 314 840 000 ha.

***Based on a total area of 997 061 000 ha, including the Grasslands and Tundra Regions (3.0% and 31.6% of the total area).

coniferous and subject to frequent and severe fires. Many of these natural stands are composed of "pioneer" tree species like jack pine, lodgepole pine, aspen and white birch. These species typically regenerate after disturbance and require full sunlight to grow. Over the past decade clearcutting has become less uniform, with many experimental designs aimed at more closely mimicking natural disturbance patterns.

Some forests do not fit the natural disturbance model associated with clearcutting practices. The mixed deciduous forests of southern Ontario and Quebec, and the coastal forests of British Columbia, have a pattern of small patch disturbances often caused by the loss of one tree. The use of selection or uneven-aged management strategies accounts for about 10.7% of the current wood harvested in Canada (CCFM 2000a), which appears to be more appropriate for these forests.

Approximately 45% of Canada's land base is forested, just over one-quarter of which is actively managed to supply wood for the manufacture of forest products. In Canada, 94% of the forest is publicly owned. Forest land is allocated to forest companies through a variety of licensing and tenure arrangements. These areas are subject to government regulation with respect to timber management and conservation. The other 6% is privately owned and managed by approximately 425 000 landowners (CCFM 2000a).

The extent of "old growth" in Canada has been difficult to estimate based on traditional inventory categories, and because old-growth definitions do not apply well to most of Canada's forests. Although old-growth forests are described using a combination of structural characteristics, there are expectations of tree size and perceptions of self-sustaining species mixes. Historically, forest stands fitting these criteria have been very rare in Canada's boreal forests because of the regular large stand-replacing disturbances and the predominance of younger age classes. Most patches of old-aged stands are small in this region and the result of islands of forest remaining after a large fire. Clearly these areas have significant importance for biodiversity, but they do not meet the expectations associated with some definitions as "frontier" or "ancient" forest. In British Columbia's Coast Forest Region, where there is no history of frequent large natural disturbances, stands fitting the general "old-growth" definition are often present.

Formal estimates of area in old growth have been generally inconsistent, because of the lack of a standardized old-growth definition in Canada. Based on age category, estimates

Figure 2. Area of moderate to severe defoliation by spruce budworm, forest tent caterpillar and all insects (includes area of beetle-killed trees) (CCFM 2000a)

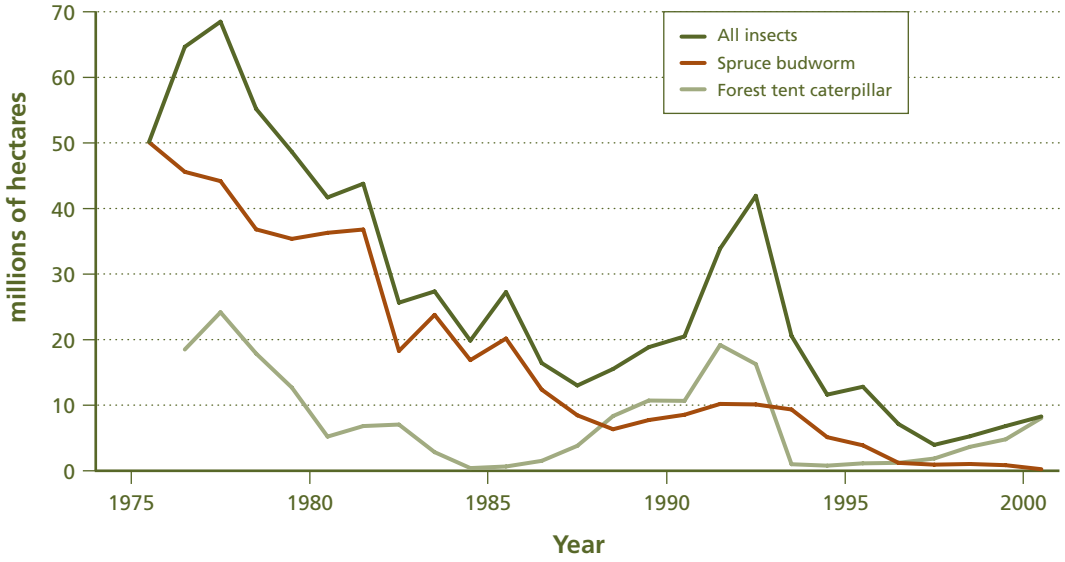
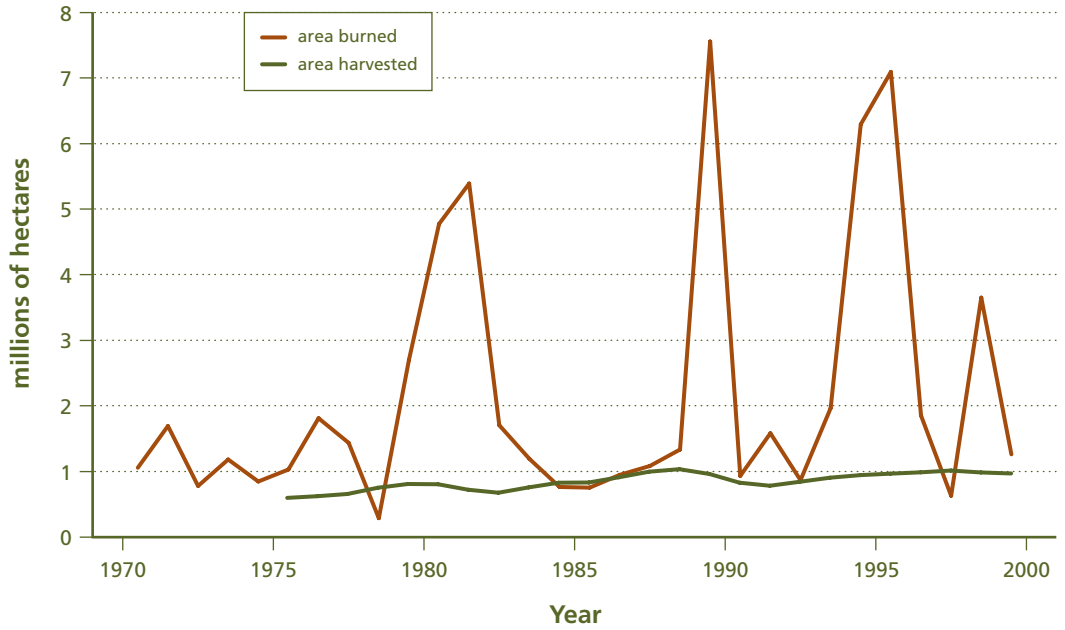


Figure 3. Area burned versus harvested each year in Canada (CCFM 2000a)



as high as 19% of Canada's forest regions have been reported (Natural Resources Canada 2000b). In British Columbia, old growth accounts for 40% of the forests overall, and 54% of the coastal rainforests (MacKinnon 2001).

At present, Canadian forest inventory data show that 45% of Canada's forest area is in mature and over-mature age classes. This is considerably higher than reported in historic records, and is due to Canada's successful fire control programs

There is a public focus on "old-growth" forests and the habitat that they provide for wildlife. However, the value of other age classes cannot be ignored. This is demonstrated in the analysis of two **habitat suitability matrices** in Ontario. These matrices, for eastern Ontario in the Great Lakes/ St. Lawrence Forest Region (Bouvier and Howes 1997), and for northeastern Ontario in the Boreal Forest Region (D'Eon and Watt 1994), show habitat suitability for mammals, birds, reptiles and amphibians by forest cover type and age class. Each use of a habitat type by a species was recorded as a habitat use unit in the analysis (as in Neave and Neave 1998). The analysis of habitat use of different age classes is summarized in the following tables for each matrix. Clearly, all age classes are heavily used by many wildlife species in all forest cover types.

Summary of habitat use by age class in eastern Ontario

Age class	Percent habitat use for breeding	Percent habitat use for other needs
Regeneration	11	9
Sapling/polewood	14	10
Small sawlog	15	11
Large sawlog	15	11
Uneven-aged	2	2

Summary of habitat use by age class in northeastern Ontario

Age class	Percent of habitat use units	
	preferred habitat	used habitat
Forest initiation	1	9
Regeneration	2	9
Young	4	17
Mature	8	22
Old growth	7	21

over the past 50 years. Figure 4 shows the changing age class distribution in the Boreal Forest Region over this period. The average age of the boreal forest increased from 60.9 to 82.5 years from 1920 to 1969 (Natural Resources Canada 1997b). This increase suggests a lower rate of disturbance during this period. An apparent increase in natural disturbances since 1970 lowered the average age to 76.4 years by 1989 (Natural Resources Canada 1997b).

Harvesting of trees is a forest disturbance that occurs at the scale of the stand or tree. There are important differences between logging and fire or insect epidemics that need to be considered when practising sustainable forest management at the scale of the stand. These include the level of soil disturbance, amount of material or nutrients removed from the site, number of residual trees, volume of downed woody debris and impact on the composition of regenerating species. At a landscape level, differences include the degree of habitat fragmentation, size of disturbance (patch size), connectivity and configuration of remaining patches, the replacement of conifers with deciduous stands and incidence of disturbance. Applying the concepts of ecosystem diversity to forest management remains a challenge in Canada, but considerable effort is being made by forest managers from industry and government to address these complex issues.

Species Diversity

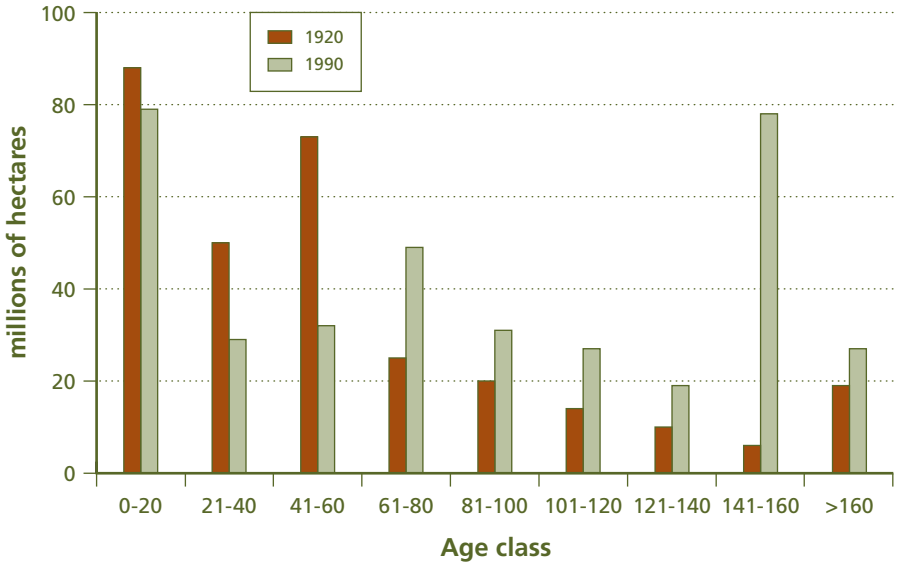
Canada's forest ecosystems provide habitat for a great variety of plants, animals, fungi and other organisms. Of the estimated 140 000 species in Canada, approximately two-thirds are thought to occur in forests (Mosquin 1995).

Forest ecosystems provide a variety or patchwork of habitats on the landscape, each supplying a variety of resource needs to species. All species require food, water, cover and home range (space). Sufficient amounts of these resources must be available both spatially and temporally. Habitat must also provide for seasonal needs such as reproduction and overwintering.

Wildlife habitat management in Canada is generally accomplished with a coarse filter approach that maintains an array of representative ecosystems on the landscape. As most Canadian forests have evolved under natural disturbance regimes, forest species have evolved to utilize an array of successional stages and forest cover types. As a result, habitat requirements of most species can be met in areas with a diverse mix of successional stages, forest types and patch sizes.

Some species have special habitat requirements that may not be available using only a coarse filter approach. These species require special management considerations, or a fine filter approach, where requirements of individual

Figure 4. Age class distribution of Canada's boreal forest in 1920 and 1990 (modified from Kurz and Apps 1996)



species are used to establish management guidelines in forested landscapes.

Over the past decade, wildlife managers have utilized the coarse and fine filter approaches to effectively deal with a number of habitat issues, including:

a) Species within fragmented habitats: In areas of severe fragmentation caused by clearing for agriculture, such as the Deciduous Forest Region of southern Ontario, management for forest interior species and their complex interactions with competitors, predators and disease is an extremely challenging task. A large portion of Canada's forest species at risk can be found in this region.

b) Species depending on old-growth or mature forest habitats: A number of species in Canada are dependent on the specialized features provided by old-growth and mature forests. Some examples include woodland caribou, American pine marten, marbled murrelets and spotted owls. Management for access and connectivity of these habitats, along with continuous habitat supply over time, is critical for survival of these species.

c) Species with large home range requirements: Species like grizzly bears, wolves, cougars and black bears require extensive areas to supply their habitat needs. Movement across the landscape tends to coincide with changing weather conditions and reproductive needs. Forest management and conservation efforts must consider these movements.

d) Species requiring specific structural habitat features: Special management for features such as vertical structure, dead and dying trees, fallen logs and debris on the forest floor and in streams is required for some species in managed forest stands. Many forest vertebrates and invertebrates use these features for cover, reproductive habitat and overwintering. Examples of boreal forest species using snags for nesting, perching and roosting include northern flying squirrels, fishers, hooded mergansers, pileated woodpeckers, barred owls and northern hawk owls (Natural Resources Canada 1994).

Many species currently occupy only a portion of their former range, largely as a result of modifications of their habitat. Early logging practices affected the distribution of white pine throughout eastern Canada, hemlock and black spruce in Ontario, and garry oak in British Columbia (Natural Resources Canada 1997b). Many provinces monitor this indicator as

an early warning signal that a species is in trouble. In British Columbia, for example, 44% of the 36 forest-dwelling mammals with known range trends have contracting ranges (BC Ministry of Environment, Lands and Parks 2000).

The current number of forest-dwelling species at risk in Canada is 30 endangered, 25 threatened and 37 of concern (Natural Resources Canada 2001b). Most provinces and territories have regional lists of species at risk.

Genetic Diversity

Genetic diversity is the variation in characteristics of individuals within a population of a species. Conserving genetic diversity is key to ensuring that species survive and retain their capacity to evolve and adapt to change, especially under changing environmental conditions. Two aspects of genetic diversity are important in monitoring the health of forests. The first is ensuring species are adapted to the natural range of conditions (fitness) and the second is ensuring that species can survive and evolve under environmental stress (diversity). Genetic diversity occurs at the population level with variation across its range, at the stand level and within individuals (Nielsen 2001).

Most Canadian tree species have high levels of genetic diversity. Trembling aspen is one of the world's most genetically diverse plants and white spruce, black spruce, balsam fir and lodgepole pine all have high levels of genetic diversity (Natural Resources Canada 1997b). A few species such as red pine, with very low levels of genetic diversity, are thought to have gone through a "genetic bottleneck" during their evolutionary history (Natural Resources Canada 1997b). Many of Canada's threatened and endangered species of forest ground vegetation are found in the Carolinian zone of the Deciduous Forest Region and have very restricted ranges. As forest cover has been reduced from 80% to 11% of the total area (Larsen et al. 1999), continuing conservation initiatives are essential to retain this genetic stock.

Determining the genetic makeup of plants and animals has been useful in population modeling and determining migration patterns, ranges of specific populations and the extent of gene flow among populations. Recent genetic studies using DNA techniques determined that Dolly Varden trout and bull trout are different species with different habitat requirements that affect restoration efforts. Similar studies have shown that a small population of wolves in central Ontario's Algonquin Park is linked to the endangered red wolf in the United States.

Woodland caribou require mature and old-aged coniferous forests, which are disappearing in many areas of their range. Ironically, the decline in caribou populations appears to have been affected as much by an increase in moose populations as the decline of suitable habitat. The amount of harvesting in many southern regions of the caribou's range has provided young stands which are suitable moose habitat. The expansion of the moose population has facilitated the expansion of wolf populations, resulting in higher rates of predation on woodland caribou in the region.

Assessing Canada's Performance in Conservation and Sustainable Management of Forest Resources

Canada reinforced its commitment to retaining the biodiversity found within each of the forest regions with the signing of the Biodiversity Convention in 1992 and the release of the Canadian Biodiversity Strategy in 1995. During the past two decades, forest managers have adopted a paradigm of sustainable forest management which recognizes that biodiversity can and must be maintained within natural levels of variation. Underlying this commitment is the recognition that protecting forest ecosystems is the priority not only for biodiversity conservation, but also for the continuing supply of economic and social benefits.

The Canadian Biodiversity Strategy presents a vision for Canada of:

A society that lives and develops as a part of nature, values the diversity of life, takes no more than can be replenished and leaves to future generations a nurturing and dynamic world, rich in its biodiversity.

The goals of the Canadian Biodiversity Strategy are to:

- conserve biodiversity and use biological resources in a sustainable manner;
- improve our understanding of ecosystems and increase our resource management capability;
- promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner;
- maintain or develop incentives and legislation that support the conservation of biodiversity and the sustainable use of biological resources; and,
- work with other countries to conserve biodiversity, use biological resources in a sustainable manner and share equitably the benefits that arise from the use of genetic resources.

This strategy was formally endorsed by federal, provincial and territorial governments in April 1996 after extensive public consultation. The forest community has therefore been challenged to demonstrate that forest management practices maintain both site integrity and landscape configuration within the range of variation of our natural disturbance regimes.

The following chapters examine Canada's performance in working toward the goals of the Canadian Biodiversity Strategy and address the range of issues involved in biodiversity conservation.

Canadian Biodiversity Strategy

Goal 1

To conserve biodiversity and use biological resources in a sustainable manner

Use of forest resources has been a central focus in Canada since the early development of the fur trade. The first national conference on the state of Canada's forests was held in 1906 and was addressed by the Prime Minister. During the past century, forest management paradigms have largely focused on the management of forests to supply wood in Canada. With the recognition that Canadian forests provide a broad range of values including wilderness, recreation and wildlife habitat as well as economic benefits and water supply, the federal, provincial and territorial governments, under the Canadian Council of Forest Ministers, subsequently became committed to strategies of sustained yield, multiple use, integrated resource management, sustainable development and the emerging ecological approach to forest management. The national commitment within the forest community during the 1990s to an ecosystem approach has resulted in significant progress towards the achievement of Goal 1.

1A. Maintaining populations of wild flora and fauna and other wild organisms in their functioning ecosystems, landscapes and waterscapes

Canadian forest managers have the unique opportunity to retain the diversity of species throughout their natural range.

"Results of conservation biology research indicate that the key to conserving species is to maintain viable populations across their natural range" (Canadian Biodiversity Strategy 1995). While the entire Canadian Biodiversity Strategy deals with the mechanisms required to ensure adequate habitat for all species, the first step is to understand the status of wild flora

An Ecosystem Approach

During the 1990s the sustainable forest management paradigm evolved to more fully incorporate the principles associated with biodiversity conservation. Principles include the conservation of ecosystem structure and function; recognition of the limits of natural productivity and sustainable use; spatial and temporal scales; and the recognition that ecological change is inevitable. The full adoption of this ecosystem approach requires multi-disciplinary teams and the use of adaptive management practices.

In British Columbia, **8% of 1 079 known species of forest-dwelling animals and vascular plants are provincially red-listed**—either threatened or endangered, or else candidates for these designations. Over 80% of the more than 5 400 known salmon stocks are healthy. Yet a third of forest-dependent native freshwater fish are threatened or endangered in British Columbia. Grizzly bear populations are excellent or good in 81% of their historical range, threatened in 8% and extirpated in 11% (BC Ministry of Environment, Lands and Parks 2000).

Table 2. Forest-dwelling species at risk (Natural Resources Canada 2001b)

Mammals	Birds	Plants	Reptiles/Amphibians
Endangered			
American marten (NF population) Vancouver Island marmot (BC) Wolverine (eastern population) Woodland caribou (QC)	Acadian flycatcher (ON) Kirtland's warbler (ON) Northern spotted owl (BC) Prothonotary warbler (ON) White-headed woodpecker (BC) Western yellow-breasted chat (BC)	American ginseng (ON, QC) Bashful bulrush (ON) Blunt-lobed woodsia (ON, QC) Cucumber-tree (ON) Deltoid balsamroot (BC) Drooping trillium (ON) Heart-leaved plantain (ON) Large whorled pogonia (ON) Nodding pogonia (ON) Prairie lupine (BC) Purple twayblade (ON) Red mulberry (ON) Seaside centipede (BC) Small whorled pogonia (ON) Spotted wintergreen (ON) **Tall bugbane (BC)** Wood-poppy (ON)	Blue racer (ON) **Night snake (BC)*** Rocky Mountain tailed frog (BC)
Threatened			
Ermine, *haldarum* subspp. (BC) Pallid bat (BC) Wood bison (AB, BC, NT, YT) Woodland caribou (Boreal and southern mountain populations)	Hooded warbler (ON) Marbled murrelet (BC) Queen Charlotte goshawk (BC)	American chestnut (ON) Birdsfoot violet (ON) Deerberry (ON) Goldenseal (ON) Kentucky coffeetree (ON) **Lyall's mariposa lily (BC)** Phantom orchid (BC) **Purple sanicle (BC)** Round-leaved greenbrier (ON) **Scouler's corydalis (BC)** White wood aster (ON, QC) Whitetop aster (BC) Yellow montane violet (BC)	Black rat snake (ON) Blanding's turtle (NS) Eastern massasauga rattlesnake (ON) **Jefferson salamander (ON)** Pacific-giant salamander (BC)

(Continued)

Table 2. *(Concluded)*

Mammals	Birds	Plants	Reptiles/Amphibians
Of Special Concern			
Eastern wolf (ON, QC)	Bicknell's thrush (NB, NS, QC)	American columbo (ON)	Coeur d'Alène salamander (BC)
Fringed bat (BC)	Cerulean warbler (ON, QC)	Blue ash (ON)	Five-lined skink (ON)

*Boldface indicates species added to the list in 2001.

and fauna in each of the forest ecosystems. In 1996, the federal, provincial and territorial ministers responsible for wildlife became committed "to monitor, assess and regularly report on the status of all wild species" in order to identify those species that may be threatened or for which more information or management attention is required. *Wild Species 2000: The General Status of Species in Canada* was the first national effort in this regard, providing an assessment of over 1 600 of Canada's known 70 000 species. In the report, a broad cross-section of species from all provinces and territories were classified as extirpated or extinct, or at risk, maybe at risk, sensitive, secure, undetermined, not assessed, exotic or accidental. The results of the assessment allow species to be prioritized based on their management and protection needs. Provincial agencies also publish their own status reports on species and many provinces have recently started to assess species distributions within their historic ranges.

The Committee on the Status of Endangered Wildlife In Canada (COSEWIC) annually publishes a list of Canadian species at risk which comprises five categories from "extinct" to "of special concern". The number of forest-dwelling species on this list has steadily risen, to 93 (Table 2). The increase is the result of the additional species examined by COSEWIC, the concern for specific populations within the species range and the number of naturally rare species on the periphery of their range in Canada. During the 1990s, an emphasis on the need for complementary legislation with provincial governments to provide a legal safety net for all endangered species in Canada led the ministers responsible for wildlife to agree in principle to the National Accord for the Protection of Species at Risk. This common approach committed all jurisdictions to ensure that legislation and habitat programs meet 14 specific criteria that provide base protection for endangered species throughout Canada.

Although the focus of wildlife conservation in Canada is on achieving a legislative safety net for endangered species, the majority of Canada's wild species are secure (Canadian Endangered Species Conservation Council 2001). Natural and human-induced disturbances result in habitat modification affecting population stability and distribution. Some species will flourish and others will diminish in response to these disturbances in parts of their range. These responses have been monitored particularly for migratory songbirds, and examples of the status of various wildlife populations affected by disturbance are found throughout this report.

A large area of the **Central Coast Region (also known as the Great Bear Rainforest)** of British Columbia is being managed through an agreement among conservation groups, the provincial government, First Nations and the forest industry. The area has many significant valleys and habitats and also holds strong cultural significance to the First Nations people in the region. An ecologically sensitive management plan for the region is currently in development (Government of British Columbia 2001).

1B. Protected areas

Establishing protected areas is now seen as an integral component of a landscape conservation strategy.

The establishment of a network of conservation areas and protected areas representative of the diversity of Canada's forests is one element in the overall strategy to maintain forest biodiversity in Canada. Under the National Forest Strategy in 1992, the Canadian Council of Forest Ministers recognized that an approach based on protected areas within a landscape could retain intact ecosystems, contribute to the maintenance of healthy populations of native species and act as storehouses of irreplaceable genetic resources. Exploration and development of resources are generally prohibited within protected areas, with the exception of fishing, aboriginal hunting

Nova Scotia's Interim Old Forest Policy was developed in 1999 to set aside the best remaining old forests and identify opportunities for old forest restoration. The policy focuses on provincial public lands, providing tools for site identification. Regional teams are investigating sites, and selected areas will be set aside and excluded from forestry development. The final comprehensive forest policy will be a more integrated strategy addressing broader landscape objectives and the need to involve private landowners (Nova Scotia Forestry Division 2002).

Alberta's Special Places Program, established in March 1995, was a five and a half year program developed to complete a network of protected areas representative of the province's six natural regions. From 1995 to 2001, the province designated 81 new sites and expanded 13 others, adding almost 2 million hectares to Alberta's protected areas network. Including Alberta's five national parks, 12.5% of the province is now protected (Government of Alberta 2001).

The Ministère des ressources naturelles du Québec has identified a number of **Exceptional Forest Ecosystems** in three categories: rare forests, old-growth forests and shelter forests for threatened or vulnerable species. Since 1997, administrative protection has been provided for a number of these forests on public land and eventually legal protection will be attributed. More than half these exceptional forests are on private lands.

An existing objective of the **Weldwood Forest Management Agreement** at Hinton, Alberta, is that all new watercourse crossings on fish-bearing streams must facilitate unrestricted fish passage. In addition, remedial action is required for past construction of water crossings that have affected or may affect fish-bearing streams. Since 1996, Weldwood has voluntarily inspected 524 stream crossings, remediated 150 crossings and informed other resource operators within the forest management area of problem areas on their roads.

and trapping interests and fire control measures. The Canadian system of protected areas comprises a mixture of federal, provincial and territorial strategies that establish parks, wilderness areas, ecological reserves and natural areas. Since 1990 these areas have grown from 4% to more than 8% of Canada's forested landscape (World Wildlife Fund 1999). Several governments have undertaken new initiatives to legislate or reserve extensive areas for protection categories, which will further increase the area of protected forests and the representation of forest types and natural habitats. Jurisdictions have proposed a variety of target levels for protected areas across Canada. British Columbia and Alberta are the first two provinces to have achieved their goals of placing 12% of the total land base under protection (Natural Resources Canada 2000b; Government of Alberta 2001).

The emphasis on establishing parks and protected areas in Canada to maintain a large area as wilderness and protect sensitive sites has limited the appropriate recognition of other broader initiatives for landscape conservation, including:

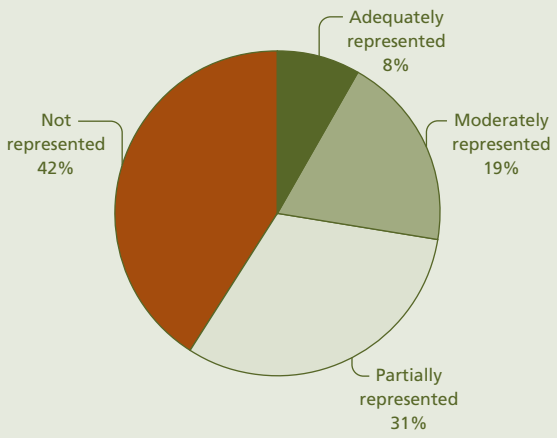
- the development of old-growth conservation strategies (e.g., in Ontario and Nova Scotia);
- the establishment of wilderness (roadless) policies (e.g., in Manitoba and Ontario);
- broad landscape protection initiatives (e.g., Yellowstone to Yukon and Algonquin to Adirondack);
- specific regional conservation agreements (e.g., British Columbia's Central Coast, also known as the Great Bear Rainforest); and,
- site-specific protection through legislation, policy and guidelines (e.g., area of commercial forest that has been protected from logging). A recent questionnaire to a random sample of forest companies in Canada indicated that the proportion of the productive area protected for biodiversity conservation through these measures was an average of 14% for the Boreal Forest Region and 8% for the Montane Forest Region (Table 3).

Although protected areas are an integral component of any biodiversity strategy, the costs and benefits of Canada's approach are only starting to emerge. The report of the Panel on Ecological Integrity of Canada's National Parks (Parks Canada Agency 2000a, b) advised that protected areas would only be successful in conserving biodiversity if they became integrated within the conservation programs of surrounding forests. The impacts of controlling forest fires, invasion of exotic flora and fauna, and human disturbance within Canadian National Parks all illustrate the inability of parks to survive as

untouched islands. In addition, the establishment of parks in Canada has been only partially successful in ensuring a network of protected areas representative of Canada's forests. Representative protected areas serve as important ecological benchmarks (particularly significant for gene conservation), but there is limited opportunity to establish adequate

World Wildlife Fund conducted an independent gap analysis to investigate ecosystem representation in protected areas for 388 forested natural regions in Canada. The results suggest that while legally protected forest areas in Canada may now cover 8.4% of the total forest area, ecological representation is still a concern.

Percentage of forested natural regions adequately, moderately and partially represented in protected areas (WWF 1999)



Ontario's Living Legacy Land Use Strategy was launched in 1999 and aims to add 378 new parks and protected areas totaling 2.4 million hectares to the current provincial network. The current planning process has identified areas that contribute to representing the range of biological and geological features of the province while minimizing the impacts on other land uses. These sites are under interim protection pending formal regulation. The addition of these areas will achieve their goal of protection of 12% of the land and water base within the planning area (Government of Ontario 2002).

The Muskwa-Kechika, one of North America's last true wilderness spots south of the 60th parallel, is a 6.3 million hectare management area defined under the ***Muskwa-Kechika Area Act*** of 1998. The act established a trust fund to support wildlife and wilderness resources through research and integrated management of natural resource development and to maintain in perpetuity the diversity and abundance of wildlife species and the ecosystems on which they depend through the management area.

Table 3. Extent of merchantable forest land retained for biodiversity conservation*

Survey question	Boreal Forest Region			Montane Forest Region
	Average	Minimum	Maximum	Average
Average size of forest management area (FMA)	2 650 000 ha	400 000 ha	12 500 000 ha	600 000 ha
Proportion of FMA considered "timber-productive" and operable	53%	37%	100%	47%
Proportion of "productive" area protected for biodiversity conservation through legislation, policy and guidelines	14%	5%	30%	8%
Proportion of FMA not accessed for harvesting	27%	0%	75%	6%
Percentage of FMA affected by fire annually	1%	-	-	< 1%
FMA has established biodiversity conservation objectives	10 of 11	-	-	3 of 3
Sample size	11	11	11	3

*Results of a questionnaire to a group of randomly selected large forest operations across Canada regarding biodiversity conservation. The questionnaire was conducted for the purposes of this report and analysis in January 2002.

protected areas in southern Canada. New proposals to establish intensive, multiple-use and protected forest management zones have not included an examination of the impacts on biodiversity.

1C. Restoration and rehabilitation

Post-harvest regeneration is focused on the re-establishment of a forest similar to the one that was harvested. Restoration and rehabilitation measures have largely been associated with riparian areas and re-establishing forests on marginal agricultural lands.

Development and Implementation of Ecosystem Restoration Programs

In Canada there has been limited need for traditional ecosystem and habitat restoration programs within forest ecosystems, with the exception of areas of southern Canada. In southwestern Ontario where the deciduous forests have been fragmented by urbanization and clearing for agriculture, management for both quantity and quality of remaining habitats is critical. Many sites in this region have protected status, and 38 others are protected through private land stewardship agreements under the Carolinian Canada Program. Restoration of fragments and corridors is ongoing in this region. In the montane forests of the Rockies, fire control has affected habitat quality and quantity. Impacts of the exclusion of frequent low-intensity fires in the region include forest encroachment into montane grasslands and structural changes in forest stands. Projects are being conducted to restore these habitats which provide critical winter range for elk and bighorn sheep.

As ecosystem restoration and rehabilitation are difficult and expensive, preventing ecosystem degradation through appropriate silvicultural practices is the main approach used by the forest industry in Canada. Reforestation following harvest is a legal requirement on nearly all publicly owned forest lands in Canada. Although reforestation is accomplished primarily through natural regeneration, seeding and planting have increased dramatically from 86 000 ha per year in 1965 to 513 000 ha per year in 1990, and have since leveled off at about 460 000 ha (Morgenstern and Wang 2001). The rapid increase in planting programs came in response to the recognition that natural regeneration was not successful on all sites, and to new provincial regulations requiring prompt regeneration of all harvested areas with site-adapted native tree species. There has also been an increase in stand tending operations to ensure vigorous growth of these young stands.

All provinces but one ensure that stand-level wildlife and habitat values are considered in preharvest ecological

A **habitat restoration project for bighorn sheep** was developed along the Lynx Creek in Alberta through a partnership between the Rocky Mountain Elk Foundation, Sunpine Forest Products Ltd. and Alberta's Sustainable Resource Development Department. Encroachment of trees along the Ram River and Lynx Creek Canyon over the past 50 years of wildfire control had reduced the quantity of forage areas for wildlife. A management strategy for the harvesting of two areas along the canyon to create wildlife habitat was developed. The blocks were harvested in frozen conditions so that lesser vegetation would not be disturbed, and shaped with irregular borders cleared away from the edge of the canyons. The project was a success as the bighorn sheep, elk and other wildlife are now using the area. Similar initiatives have taken place in the Rocky Mountain House area.

Regeneration activities in the Boreal and Montane Forest Regions*

Survey question	Boreal**	Montane**
Proportion of regeneration		
natural	63%	8%
planted	36%	92%
aerial seeding	1%	0%
Expectation to change these proportions	None	None
Number of species planted		
native	3	6
exotic	0	0
Percentage of area planted in exotic species	0%	0%
Expected change in species mix planted	None	None
Sample size	11	3

*Results of a questionnaire to a group of randomly selected large forest operations across Canada regarding biodiversity conservation. The questionnaire was conducted for the purposes of this report and analysis in January 2002.

**Values are averages of responses.

assessments. Although regeneration systems vary widely across jurisdictions, primarily because of site characteristics, success rates in reaching the "free to grow" stage (meeting stocking, height and height growth rates where regeneration is free from competition) range from 81% to 100% (National Forest Strategy Coalition 2001), with most provinces exceeding 90%. Insufficiently stocked areas require an additional silvicultural treatment. Requirements for reforestation on private lands are less formalized.

Development and Implementation of Species Recovery Plans

On a national basis, the committee on the Recovery of Nationally Endangered Wildlife (RENEW) coordinates recovery and reintroduction programs. Most of their efforts within the forested landscape are designed to improve the viability of endangered and threatened species through the protection of existing habitat. Many provincial and territorial wildlife agencies have more specific recovery plans, often with a strong research and assessment component. In summary, of 107 endangered and 76 threatened species throughout all areas of Canada in 2001:

- 64 have recovery teams in place;
- 19 have approved recovery plans and 6 more await approval;
- 25 have recovery plans or strategies in draft form;
- 68 are the focus of recovery efforts;
- 40 others are included in ecosystem recovery; and,
- 17 show stable or increasing population trends (Recovery of Nationally Endangered Wildlife 2001).

Of particular significance is the $26.6 million currently expended on recovery, with 129 salaried people and 25 volunteers working full time and with 214 organizations making financial contributions (Recovery of Nationally Endangered Wildlife 2001). In addition, in April 1997 the United States and Canadian governments signed an agreement for binational efforts on research, habitat protection and joint reintroduction activities for species at risk. Of the 10 cooperative efforts, three species, the grizzly bear, woodland caribou and marbled murrelet, are directly associated with Canada's forested landscape.

For several decades there has been a major cooperative effort to restore and rehabilitate salmon habitat on both the east and west coasts of Canada through partnerships between governments, industry and sportsmen. The removal of barriers to fish movement and the creation of spawning beds have restored a number of major salmon populations such as the one in the Quesnel River in British Columbia. In addition, a number of forest companies have restored fish populations by regulating public access on their private lands.

Over the past decade, the Government of British Columbia, working with the Department of Fisheries and Oceans, has addressed the historic degradation of the province's watersheds. Through the **Watershed Restoration Program**, the **Fisheries Renewal Program** and the **Habitat Conservation Trust Fund**, the province has directly invested more than $325 million in the restoration of forests, fisheries and aquatic resources that have been adversely affected by development. Initiatives include replanting streamside vegetation, construction of fish habitat and stabilization of riverbanks and up-slope areas.

In areas of southern Canada subject to long-term disturbance from agricultural development, a number of forest species remain only in small and scattered patches across the landscape. The **National Genetic Heritage Program** is developing conservation strategies to retain the genetic diversity of white spruce, white pine, red oak and two species at risk (pitch pine and butternut). Of particular interest is the focus on locating healthy butternut, chestnut and elm trees resistant to insects and disease in order to develop a gene conservation program.

The **Grand Lake Reserve** was established in 1999 to protect and manage habitat for the endangered Newfoundland pine marten. The reserve also provides protected areas in three ecoregions. The government of Newfoundland and Labrador acted in cooperation with Corner Brook Pulp and Paper Limited and Abitibi Consolidated on recommendations of the Western Newfoundland Model Forest's Pine Marten Conflict Resolution Working Group (National Forest Strategy Coalition 2001).

1D. Sustainable use of biological resources

Canada's forest community has made a strong commitment to maintain the extent, diversity and health of its forest; however, management agencies often have limited and declining financial resources.

The fourth strategy, a core element to retain biodiversity within Canada's forested landscape, is the implementation of resource management programs based on the sustainable use of both biological resources and ecosystems. The Canadian Biodiversity Strategy commits Canadians to a management paradigm that:

- "continues to develop and implement improved forest management practices that provide for the sustainable use of forests while maintaining the regional forest mosaic";
- "uses practices that are as consistent as is practical with natural disturbance regimes, patterns and processes"; and,
- "allows fire, disease, succession and natural forest regeneration to maintain biodiversity where they are compatible with forestry and other land use objectives and where natural regeneration can be effective."

To achieve this strategy, there needs to be a **visible commitment** by all the forest community partners followed by the ability to **establish objectives** and **monitor our success**.

Commitment

Canadians undertook a unique set of consultations in 1991 and 1992 to debate, define and reach consensus on the complex values inherent in sustainable forest management, and on ways to work toward protecting and managing forests to achieve these multiple values. Forest stakeholders agreed on the need for a shared vision, defining both their future forest and the measurable actions to achieve their goals. After seven forums held across Canada with a total of 350 participants, the National Forest Strategy (NFS) was launched in 1992 with a theme of sustainable development. The consultations were sponsored by the Canadian Council of Forest Ministers (CCFM) and advised by a National Forest Strategy Coalition that represented all forest interests. After an evaluation of progress towards achieving this strategy in 1997, a revised five-year strategy entitled *Sustainable Forests: A Canadian Commitment* was launched in 1998, retaining the overall vision of:

> "maintaining and enhancing the long-term health of our forest ecosystems, for the benefit of all living things both nationally and globally, while providing economic, social and cultural opportunities for the benefit of present and future generations"
> *National Forest Strategy 1998*

Nine strategic directions were identified in the NFS, the first two dealing with forest stewardship and the environment, and forest management practices. The mid-term evaluation in 2001 by the National Forest Strategy Coalition indicated that considerable progress had been made in achieving the six specific biodiversity commitments. The largest identified challenges to improve the understanding of forest

Significant commitments to **biodiversity and wildlife conservation in New Brunswick** since 1992:

1992 Cabinet endorses the Biodiversity Convention and approves a Protected Areas Policy
1992 Mature Coniferous Forest Habitat Objectives established on Public Land
1994 Wildlife Policy
1996 Watercourse Buffer Zone Forestry Guidelines
1996 Endangered Species Act
1997 Wildlife Council Trust Fund established
1998 Conservation Easements Act
1999 Atlantic Canada Conservation Data Centre established with regional partners
2001 Protected Natural Areas proclaimed
2002 Wetlands Conservation Policy
2002 Coastal Policy
2002 Forest Community Types objectives plus specific objectives established to sustain eight new Forest Habitat Types on Public Land

In 1997, Natural Resources Canada's Canadian Forest Service released ***Biodiversity in the Forest: The Canadian Forest Service Three-Year Action Plan*** as part of a series of federal modules that responded to the Canadian Biodiversity Strategy. The document provides a framework for the department to guide strategic directions into practical actions. It identifies the Canadian Forest Service's roles and responsibilities, current activities, gaps and future actions and partnerships (Natural Resources Canada 1997a).

ecological functions and their response to natural disturbances included broader inventories, consistent ecological classifications and the transfer of knowledge to appropriate management agencies.

Canada has made progress on many other national and international commitments for the conservation of biodiversity that are parallel to the National Forest Strategy, including:

Internationally

- United Nations Conference on Environment and Development
- United Nations Convention on Climate Change 1992 and the subsequent Kyoto Protocol 1997
- Santiago Declaration for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process) 1995
- Intergovernmental Panel/Forum on Forests 1995/1997
- United Nations Forum on Forests 2000

Nationally

- A Wildlife Policy for Canada
- A Protected Areas Strategy for Canada
- Canada's Green Plan for a Healthy Environment
- Biodiversity in the Forest: the Canadian Forest Service Three Year Action Plan
- Conserving Wildlife Diversity: Implementing the Canadian Biodiversity Strategy
- National Accord for the Protection of Species at Risk (*Species at Risk Act*)

In addition, each province and territory has amended its legislation to achieve conservation of biodiversity. They have implemented policies and strategies to change the basis of forest management from a sustainable timber yield to an ecological management approach that encompasses consultation on a broad range of forest-related values. There have been financial implications for the forest community with the tangible movement toward an ecological approach to forest management. Under partnership arrangements with government and non-government conservation interests the forest industry has assumed a great proportion of the increased costs. Whereas overall forest management expenditures rose 16% over the 10-year period from 1988 to 1998, industry expenditures have tripled (Natural Resources Canada 2000b).

New Brunswick's Forest Land Habitat Management Program, developed in 1992, facilitated the incorporation of wildlife habitat objectives into forest management plans. Habitat supply analysis indicated a future shortage of mature forest habitat that would affect 25 bird species and 4 mammal species dependent on this habitat type. The American marten, a species particularly dependent on mature forest, was chosen as an indicator species and specific habitat objectives were set to maintain a viable population. Each forest company must now maintain a specific amount of mature forest habitat over the long term (New Brunswick Department of Natural Resources and Energy 1995).

Biodiversity Objectives

The adoption of sustainable forest management in Canada has fostered the growth of voluntary certification processes, which in turn has accelerated the definition of measurable objectives for biodiversity conservation.

The pressure on forest agencies responsible for biodiversity conservation to define objectives for management units accelerated during the 1990s, partly due to the forest industry's requirements for voluntary certification programs. Very quickly the demand by forest managers for answers on "how much is enough?" changed to seeking and defining biodiversity objectives to be incorporated within forest management plans. This requirement, along with considerable progress

The **Forest Biodiversity Program** was a pilot program developed by **Wildlife Habitat Canada** with the objective of working with forest products companies to develop and implement a biodiversity conservation strategy as an integral part of their normal operations. Six Canadian forest products companies participated in the pilot phase, including Cornerbrook Pulp and Paper Ltd., Repap New Brunswick Inc., Stone Consolidated Corporation, Canfor Corporation, Weldwood of Canada Ltd., and Weyerhaeuser Canada Ltd. This program was instrumental in the development of biodiversity objectives at the operational level for certification purposes (Wildlife Habitat Canada 1998a). Recently the Nova Scotia Forest Alliance examined this model for application in all of Atlantic Canada (Wildlife Habitat Canada 2001).

Table 4. Development of biodiversity objectives within certified management systems*

Question	Yes	No
Do you have additional biodiversity objectives due to certification?	19	6
Are these objectives compatible with government objectives?	12 (5 in process)	8
Are these objectives beyond regulatory requirements?	14	11

*Results of a questionnaire to a group of 25 randomly selected forest operations across Canada with certified management systems. The survey was conducted for the purpose of this report and analysis in January 2002.

in developing criteria and indicators (to monitor change in biodiversity) and forest management guidelines (to protect genetic, species and habitat diversity), has accelerated the adoption of an ecosystem approach to forest management. By 2000, all jurisdictions based their forest management planning on defined ecosystems and most forest companies had embraced biodiversity conservation within their strategic and operational planning procedures.

The regulatory framework for biodiversity conservation during the 1990s was largely focused on reporting on the basis of specific national and local criteria and indicators, and meeting guidelines for environmental and resource management planning. The proliferation of guidelines to protect forest biodiversity at the stand level across Canada helped in the evolution of biodiversity conservation objectives. However, even the most comprehensive set of guidelines, the *British Columbia Biodiversity Guidebook* with habitat and landscape considerations, lacked objectives. The BC Forest Practices Board predicts that the success of future efforts to move to a more results-based code will depend on establishing clear and measurable objectives for managing all forest resources. Many other provinces that have evaluated the effectiveness of guidelines have moved toward an approach of emulating natural landscape patterns and away from the species-by-species protective approach.

The most significant demand for measurable objectives came from the development and adoption of certification programs in Canada. The adoption of the voluntary certification standards of the Canadian Standards Association (CSA), Forest Stewardship Council (FSC) and Sustainable Forest Initiative (SFI) clearly pushed the implementation of sustainable forest management practices across Canada with the underlying commitment to maintain biological diversity along with the host of other forest values. The CSA process has a particular focus on defining and achieving biodiversity objectives consistent with the criteria developed by the Canadian Council of Forest Ministers. A recent random survey of the forest industry, at the operational level, indicates that three-quarters of the 25 operations contacted had incorporated biodiversity and conservation objectives within their five-year management plans, in response to certification (Table 4). More than half of these companies had biodiversity objectives exceeding government

Canadian Forest Management Certification Summary–January 2002 (Abusow 2002)

Standard used	Acronym	Area certified hectares*	Area certified acres	Annual allowable cut (AAC) (m^2)*
ISO 14001 Environmental Management System Standard	ISO	91 845 000	226 857 150	93 475 000
Canada's National Sustainable Forest Management Standard	CSA	8 840 000	21 834 800	17 790 000
Sustainable Forestry Initiative Program - American Forestry and Paper Association	SFI	8 210 000	20 278 700	11 900 000
Forest Stewardship Council**	FSC	123 253	304 435	N/A
ISO, CSA, SFI, or FSC***		92 738 253****	229 063 485****	94 055 000

*Hectares and AAC are rounded to the nearest 10 000, except for FSC data which are taken directly from the FSC website.

**Data are taken from December 19, 2001, FSC website.

***If a forest has been certified to more than one standard, the area is only counted once.

****Approximately half of Canada's multiple-use forest.

regulatory requirements. In view of the rapid evolution of certification systems through the 1990s, it will be prudent to monitor the success of these programs in achieving their defined biodiversity objectives.

The situation for private woodlots is more complex. A few have applied for independent certification. The apparent lag in the development and adoption of forest biodiversity objectives within the management of private woodlots can be traced to the difficulties in implementing existing certification programs, the large number of woodlot owners, small areas, limited resources and diverse management objectives.

Monitoring of Sustainable Use

Developing and implementing a forest biodiversity monitoring program with local, regional and national criteria and indicators is a significant achievement toward sustainable forest management.

An ongoing core commitment within the National Forest Strategy has been to provide a system of national indicators to measure progress in achieving sustainable forest management. In 1995, the Canadian Council of Forest Ministers (CCFM) released *Defining Sustainable Forest Management–A Canadian Approach to Criteria and Indicators* (CCFM 1995). Concurrently, Canada participated in the Montréal Process Working Group, which resulted in the signing of The Santiago Declaration statement on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (Montréal Process Working Group 1995). Conservation of biological diversity is the first of six criteria used under the CCFM framework, and one of seven under the Montréal Process. The two CCFM publications (CCFM 1997, 2000b) are significant achievements in compiling provincial information, reporting on the status of forest biodiversity and providing a focus on information requirements and gaps. Subsequently, many provinces have developed similar criteria and indicator programs based on the CCFM framework and are publishing information under their requirements for reporting on the state of the environment. In addition, each of Canada's 11 Model Forests developed local indicators of sustainable forest management which included monitoring biodiversity conservation (Table 5).

All forest operations on public land are inspected regularly by government staff to ensure compliance with regulations. This compliance ranges from developing and instituting short- and long-term management plans to ensuring adequate forest regeneration. From a biodiversity perspective, these provincial audits of company operations are important to ensure that the companies are fulfilling their legal obligations for appropriate regeneration after harvesting and reclamation of disturbed sites, particularly watercourses. For example, the ground rules for forest management licenses in Canada normally allow about 10 years following harvest for the area to be fully regenerated and reach "free-to-grow" status. As areas are inspected by provincial foresters and declared free-to-grow, they are returned to the status of stocked and productive land. An indicator of successful management is to ensure all harvested areas achieve this regenerative stage within 10 years.

As the maintenance of biodiversity has become a key goal in achieving sustainable forest management, there has been a period of transition in establishing audit requirements and associated monitoring responsibilities. Industry has taken an increasing role, as part of its internal audit or certification process, or both, and also to support an adaptive approach to management. It is recognized that without a rigorous and adaptive monitoring program in place, it is unlikely that the public would support a flexible type of forest ecosystem management (Grumbine 1994).

Like timber, other biological resources are managed primarily by provincial governments under the same sustainable management paradigm. The exceptions include navigable waters and fish populations, which remain federal responsibilities. The decline of many fish populations under a sustained yield concept for fisheries management has demonstrated the need for a much more conservative or precautionary approach. Accessible wildlife resources (within a kilometre or less of a road), whether they are big game animals, trout or wild leeks, are often overharvested. For example, a recent research paper (Post et al. 2002) reported that sports fishery stocks are depressed in rivers and lakes within a three- or four-hour drive of Canadian urban centres. Over the past few decades there has been a substantial decline in the number of hunters in Canada, resulting from a combination of low recruitment within Canada's more urban population, increased complexity of regulations and the intensity of competition around urban centres. Wildlife in more remote areas receives limited harvesting pressure. The result is often extensive over-browsing of winter habitat by ungulates, cyclic populations supporting large carnivore populations and subsequent increased conflict with humans and crops. Fishing continues to become more popular and the commercial collecting of wild plants has accelerated, prompting a need for legislative protection for some species.

Table 5. Summary of local-level biodiversity indicators developed and currently being tested by the Canadian Model Forest Network (Natural Resources Canada 2000c)

Ecosystem diversity	Species diversity	Genetic diversity
Area of forest type by age class	Number of forest-dependent species at risk (SAR)	Adherence to seed zones
Area of forest land by land use designation	Number of recovery plans in place	Use of commercial tree genetic material in tree propagation
Percentage of forest permanently converted to non-forest land	Population indices and reproductive success for SAR	Adherence to an ex-situ/in-situ gene conservation strategy
Average area of clearcut	Proportion of SAR where actions have been taken	Distribution of tree establishment from various sources (provincial tree improvement sources, natural seed collection within seed zone and regeneration from local site seed source)
Area naturally regenerated relative to reforested area	Proportion of pre-harvest assessment crews trained to identify SAR and their habitats	Size of parent population producing regeneration seed source
Percentage of post-harvest block subject to pre-harvest assessment	Forest management activities in habitats of SAR not set out in forest management plan	Change in populations/genetic diversity for selected species
Road distribution/density	Population size and reproductive success of species dependent on forest interior habitat	Degree of range reduction of sensitive species
Change in patch size distribution and relative distribution of seral stages in relation to natural patterns of disturbance	Number of known forest species occurring in a small portion of their former range	Population size and reproductive success for select species
Changes in stand structure including vertical complexity, abundance of snags and coarse woody debris	Population levels/diversity indices for select species or guilds (e.g., songbirds, woodland caribou)	No significant change in gene frequencies in trees
Percentage and representation of forest types in protected areas	Habitat quality and quantity for select species	
Identification and protection of local sites of significance	Area and percentage of each forest stand type protected	
	Area harvested in grizzly bear habitat zones	
	Exploitation rates of natural resources	

1E. Special management issues

Future forest biodiversity conservation will largely be the result of our successes at the international and national policy levels that complement provincial and local initiatives and directly reduce the impact of human activities on the global environment.

Genetic Conservation

In Canada, the genetic resources of commercially important tree species are conserved in ex-situ gene banks and seed orchards. Natural Resources Canada's National Tree Seed Centre specializes in ex-situ conservation of Canadian tree and shrub seed and other forest genetic materials. Most provinces have their own seed banks, seed orchards, provenance trials and other in-situ facilities for commercial tree species. The genetic resources of other forest-dependent species are conserved by maintaining characteristic forest types across the forested landscape.

The approach to conserving forest genetic diversity has also focused on assessing the genetic status of rare species and populations that are isolated or at the periphery of their range (as they may be better adapted to stressful environmental

Red mulberry, an understory species found only in the Carolinian Forest Region, is designated as "endangered" in Canada. Current threats include not only habitat loss but hybridization with the alien white mulberry. Conservation strategies require DNA "fingerprinting" to provide genetic markers that differentiate the two species and allow targeting of white and hybrid trees for removal (Natural Resources Canada 2001c).

In Newfoundland, white pine was once relatively common. It is now a species in decline as a result of unregulated harvesting at the turn of the 19th century, and has subsequently been under pressure from white pine blister rust and invasive alien species. Although the historic range is intact, decreased abundance has resulted in concerns over gene flow and inbreeding depression. The Newfoundland Forest Service has established a **clonal white pine seed orchard/gene conservation garden** which houses genetic material from over 200 healthy white pines from across the island. The facility will protect against loss of genetic diversity and provide a reliable native seed source for restoration and planting.

factors such as climate change). Inventory and monitoring of tree species was traditionally accomplished through provenance trials and more recently by use of molecular markers. Methodologies based on recombinant DNA technology are being used to study population genetics, to monitor the impact of toxic contaminants and for enforcement purposes (illegal harvesting).

Some of the key issues affecting genetic diversity within the forested landscape that require further investigation include:

- the ability of long-lived tree species to adapt quickly to new threats of disease and alien species;
- the isolation of populations within fragmented habitats leading to potential population loss;
- forest management practices, including harvesting and regeneration systems, tree breeding and introduction of exotics, that have an impact on genetic viability;
- the harvesting techniques used on late successional forest types that are characterized by "gap-replacement" stands adapted to shade and moist conditions (including red spruce, eastern hemlock and balsam fir); and,
- environmental changes from introduced pest species and competitors, climate change and increased air pollution (Rajora and Mosseler 2001).

In 1993, the framework for a national strategy on forest resource conservation and management was developed by representatives of government and industry. Certain elements are in place, but most provinces and territories do not have a genetic conservation strategy, and rely on broader strategies. Parks, protected areas and reserved stands provide the basis of Canada's genetic conservation areas, although it is recognized that sustainable forest management practices can also retain this diversity.

Approximately 460 000 ha are regenerated annually by seeding and planting in Canada. There was a great improvement in seed supply of commercial native tree species during the 1990s. Superior genetic traits associated with rapid growth, wood density, fiber length, cold tolerance and pest resistance have been the focus of tree breeding experiments in Canada over the past few decades. Advances in genetic modification and biotechnology have also been made with respect to improving tree physical qualities and defense systems. However, these experiments are still in the early stages and none of the experimental trees are being used for reforestation purposes (Natural Resources Canada 2000b).

Biosafety—Harmful Alien Organisms

The spread of invasive alien forest pests is a growing concern in Canada, threatening the health of Canada's forest ecosystems, the forest sector and international trade in forest products. Alien or exotic species are considered to be invasive when they cause changes in ecosystems through competition with native species, predation, parasitism, hybridization and habitat alteration. Globally as well as nationally, the introduction of invasive alien species is seen as the most significant threat to biodiversity next to habitat loss (IUCN 1998).

Vulnerable ecosystems include areas disturbed by human activities and areas with a simple ecological structure (e.g., lack of predators, competitors or herbivores, and areas with limited biological diversity) (Natural Resources Canada 1999a). The limited species complement in the boreal forest makes the latter particularly susceptible (Natural Resources Canada 1999a). Many of Canada's southern ecosystems have been dramatically altered after the introduction of an alien species. In eastern Canada, chestnut blight and Dutch elm disease have had a devastating impact on their host species. In British Columbia, hybridization with salmon used in aquaculture has affected wild populations. In 1998, the Canadian Committee on the Status of Endangered Wildlife in Canada estimated that 25% of the endangered species, 31% of the threatened species and 16% of the vulnerable species in Canada are at risk because of alien species introductions (Natural Resources Canada 1999a).

With the continued increase in global trade of wood products, and prospect of rapid climate change, there is a projected increase in the number of alien species introductions and their establishment (Pimental et al.1999). A draft plan to address the threat of invasive alien species to biodiversity is

Significant forest pests introduced to Canada (Natural Resources Canada 1999a).

Insects

- Larch sawfly (*Pristiphora erichsonii*)
- Browntail moth (*Nygmia phaeorrhoea*)
- Poplar sawfly (*Trichiocampus viminalis*)
- Larch casebearer (*Coleophora laricella*)
- Late birch leaf edgeminer (*Heterarthrus nemoratus*)
- Balsam woolly adelgid (*Adelges piceae*)
- Satin moth (*Leucoma salicis*)
- Winter moth (*Operophtera brumata*)
- European spruce sawfly (*Gilpinia hercyniae*)
- Gypsy moth (*Lymantria dispar*)
- European pine shoot moth (*Rhyacionia buoliana*)
- Mountain-ash sawfly (*Pristiphora geniculata*)
- Birch leafminer *(Fenusa pusilla)*
- Introduced pine sawfly *(Diprion similis)*
- Birch casebearer (*Coleophora serratella*)
- European pine sawfly (*Neodiprion sertifier*)
- Elm leaf beetle (*Pyrrhalta luteola)*
- Smaller European elm bark beetle (*Scolytus multistriatus)*
- Ambermarked birch leafminer (*Profenusa thomsoni)*
- Apple ermine moth (*Yponomeuta malinella*)
- Pine false webworm (*Acantholyda erythrocephala*)
- European pineneedle midge (*Contarinia baeri*)
- Early birch leaf edgeminer *(Messa nana)*
- Pear thrips (*Taeniothrips inconsequens*)
- Pine shoot beetle (*Tomicus piniperda*)

Diseases

- Dothichiza canker (*Discosporium populeum*)
- Chestnut blight (*Cryphonectria parasitica*)
- White-pine blister rust (*Cronartium ribicola*)
- Willow scab (*Venturia saliciperda*)
- Dutch elm disease *(Ophiostoma ulmi*)
- Scleroderris canker (European race) (*Gremmeniella abietina*)
- European larch canker *(Lachnellula willkommii*)
- Beech bark disease (*Nectria coccinea*)
- Beech scale (*Cryptococcus fagisuga*)
- Butternut canker (*Sirococcus clavignenti-juglandacearum*)

The North American Forest Commission is developing an **Exotic Pest Information System** to manage and share information on exotic forest pests entering North America. The information system is a cooperative project of the member organizations for the Insect and Disease Study group, which includes the Canadian Forest Service and the Canadian Food Inspection Agency along with partners from the United States and Mexico.

in preparation in Canada under the direction of the federal, provincial and territorial Ministers of Wildlife, Forests, Fisheries and Aquaculture. The existing legislative mosaic in Canada is highly fragmented both across and within jurisdictions, and a Canada-wide strategy is clearly needed (Federal-Provincial-Territorial Biodiversity Working Group 2001).

Climate Change

During the past decade, changes in the global climate have become a public policy issue with the recognition that changes pose significant threats to biodiversity. Potential impacts include changes in species distributions (ranges), population sizes, timing of reproduction or migration events, resource availability both temporally and spatially, and habitat quantity and quality. The combination of acid rain, hazardous air pollution, ozone depletion and recent emphasis on greenhouse gases and ultraviolet radiation are predicted to affect species directly and indirectly through modification of existing habitats. Canadian forests are already under considerable short-term stress from changing weather patterns (e.g., increases in fires and pest survival). These on-going changes may lead to mid- and long-term successional changes within some forests.

The degree of stress on Canada's forests is still unclear, although research led by Natural Resources Canada's Canadian Forest Service is helping to define issues and devise management strategies. Several global climatic models suggest that the fastest, most pronounced global warming will occur in northern latitudes and that boreal forests may be the most vulnerable (IPCC 2001).

Since 1997, when Canada became a signatory to the United Nation's Framework Convention on Climate Change, the federal, provincial and territorial governments have prepared a National Action Program on Climate Change. Consistent with Canada's strategy for biodiversity conservation, the Canadian Action Plan encourages the reduction of greenhouse gas emissions, as well as monitoring and participating in research with the international community. Models, currently under development, of forest growth and survival, forest response to altered climate and disturbance regimes, and forest management options will assist forest resource managers in selecting appropriate species and management strategies to mitigate and adapt to climate change.

Human Population and Settlement

Approximately 77% of the Canadian population lives in urban centres in Canada (Redpath Museum 1999). These

The **Canadian Lakes Loon Survey** is a volunteer-based program administered by Bird Studies Canada with support from Environment Canada. Over the past 20 years, surveyors have monitored breeding success of loons on up to 800 lakes annually across Canada. Loons are a good indicator of recovery from acid rain, as they eat fish and invertebrates whose populations are heavily affected by lake acidification. Results of the monitoring efforts show that despite progress in reducing SO_2 emissions, the number of successfully breeding pairs has declined. Results also indicate that the rate of decline was more extreme in lakes with higher acid levels (Environment Canada 2000).

centres occupy 0.2% of the total land area in Canada, and are generally located within a narrow band along the United States border (Middleton 1994). Agriculture in Canada is also concentrated in the southern portion of the country, and has had considerable impacts on biodiversity. Less than 13% of the shortgrass prairie, 19% of the mixed-grass prairie, 16% of the aspen parkland and very little of the tallgrass prairie ecosystems remain in the prairie provinces (Mineau et al. 1994). The prairies are home to one-half of Canada's endangered and threatened birds and mammals (Mineau et al. 1994). Southern Ontario, with less than 15% of its native forest cover remaining, also has a high concentration of species at risk.

There has been a limited recognition of a growing "rural-urban" landscape, often dominated by small woodlots. The peripheral forest rings around urban centres are largely owned by "acreage" owners whose prime objective is to retain their natural forest community. Equally, there is forest cover found throughout most of Canada's agricultural landscape that is highly significant for biodiversity conservation. The tree cover often associated with rivers, streams, lakes and large wetland complexes provides critical habitat for most forms of wildlife (Neave and Neave 1998). Data from the Census of Agriculture in 1986 (the latest year with concise data on woodlands) show that the "proportion of farmland in woodland" was approximately 17.5% in the agricultural regions of Ontario and Quebec (Neave and Neave 1998). In association with the larger private woodlots, these forests have often been called "forgotten" forests. In recent years, government agencies have encouraged conservation and management through a mix of stewardship planning, improvement and development incentives.

Pollution generated in populated areas of North America affects the air, water and biodiversity of Canada's forest regions. The long-range transportation of air pollutants such as sulphur, nitrates, pesticides and ozone can have significant impacts on forest ecosystems, including loss of productivity, loss of resistance to forest pests and disturbances, loss of species and impacts on aquatic communities. Acid deposition has been a large problem particularly in eastern Canada where concentrations of pollutants are high and the granite bedrock has only a weak capacity to neutralize acidity. Although sulphur dioxide emissions were reduced by up to 46% in targeted areas of eastern Canada in the 1980s and early 1990s, there has been little change in NO_3 wet deposition over the same period (Canadian Council of Forest Ministers 2000b). Inland waters have responded less to the reductions than expected, with acidic conditions persisting in many lakes (Environment Canada 2000). Monitoring of forest vegetation and soils in test plots of the Acid Rain National Early Warning System, conducted by the Canadian Forest Service, found no indication of a large-scale decline in forest health that could be attributed to these pollutants; however, it is possible that trees have been weakened or stressed (Natural Resources Canada 2000a). In 1998, the federal, provincial and territorial ministers responsible for Environment and Energy signed the Canada-Wide Acid Rain Strategy, which has a goal for acidifying compounds in the environment to remain below the critical load level (Canadian Council of Forest Ministers 2000b). The concept of critical load, "the threshold level beyond which acid deposition will cause chemical changes leading to long-term harmful effect on overall structure or function of an ecosystem", was an improvement from the previous targets for concentrations, which did not consider cumulative effects (Canadian Council of Forest Ministers 2000b).

Canadian Biodiversity Strategy

Goal 2

To improve our understanding of ecosystems and increase our resource management capability

2A. Improving our ecological management capability

The synthesis of research into practical knowledge is a rare art form.

During the 1990s, the underlying sustainable forest management paradigm recognized that the health of forest ecosystems was the foundation of forest productivity and management. In this period there was considerable effort to improve our understanding of ecosystems and to apply this knowledge to forest planning and management practices. Although these efforts came at a time when government management agencies were undergoing severe budget reductions (downsizing) as a result of fiscal difficulties in Canada during the decade, considerable success was achieved by the forest community as its members worked together.

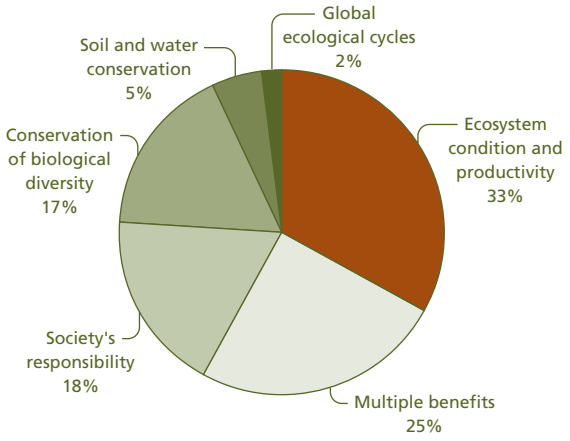
Research

The latest two National Forest Strategies have outlined extensive research commitments to advance an ecological approach to the management of Canada's forests. This priority is supported by increased financial resources, the development of new models for partnerships and work, and improved transfer of new information to forest managers. These commitments were particularly timely with the demise of substantial funding under the Federal-Provincial Forest Resource Development Agreements, and they led to a substantial increase in federal, provincial and territorial research funding during the 1990s.

A review of forest research by the Forest Coalition for the Advancement of Science and Technology (FORCAST) in 1999

A report commissioned by Wildlife Habitat Canada and the Forest Products Association of Canada in 1998 provided a comprehensive list of possible sources of funding for projects related to biodiversity conservation. This report, along with a similar review for funding of Eastern Habitat Joint Venture projects in 1998, demonstrated the inability of the conservation community to fully exploit **potential funding sources for conservation** (Wildlife Habitat Canada 1998b).

Analysis of the emphasis of current research projects within Canada's Model Forest Network addressing the CCFM criteria of sustainable forest management
(Natural Resources Canada 2001a)



ranked 25 areas of forest research by their current financial commitment. Whereas the top five included forest biology or ecology and environmental issues, two of the last three were biodiversity, and fish and wildlife. In the same questionnaire, however, biodiversity was listed as one of the top priorities requiring greater research emphasis (Watts and Kozak 2000). Although a number of very creative institutional research arrangements with biodiversity as a key objective were developed during the 1990s, the major funding still appears to be applied to silviculture and technological advancement. Some of the forementioned creative research arrangements include:

- the development of the Model Forest Program in 1992, with core funding from the Canadian Forest Service, which stimulated an array of partnership ventures within 11 model forests and developed and tested new approaches to sustainable forest management;
- the Sustainable Forest Management Network of Centres of Excellence, which has a prime focus to fund biodiversity research within the boreal forest across Canada, and more recently in adjacent forest regions;
- extensive funding under British Columbia's Forest Renewal Program;
- the Forest Ecosystem Research Network of Sites (FERNS), which promotes the multidisciplinary study of sustainable forest management practices and ecosystem processes at the stand level in all of Canada's forest regions; and,
- Ontario's Centre for Northern Forest Ecosystem Research (CNFER), which is a multi-disciplinary research unit with a mandate to study the effects of forestry practices on boreal aquatic and terrestrial ecosystems.

At this stage, one of the largest challenges facing the research community is the synthesis of information for forest managers addressing issues of biodiversity conservation. Considerable site and species information is available related to broad issues such as the definition of "old growth" within a Canadian forest disturbance regime. However, there is still a need for a common understanding and stated principles for these issues, packaged in a useful manner for the forest manager.

Traditional Knowledge

Local, long-time residents have a wealth of untapped information on biodiversity for particular sites.

There has been a growing awareness of the need for forest managers to recognize and utilize the conservation knowledge and associated suite of values of local residents within Canada's forest regions. The focus has been on aboriginal peoples, their interests and their associated treaty rights, but there are also many others who have had a long tradition of trapping, hunting and fishing in local forests.

Approximately 80% of Canada's aboriginal communities are located within the forest regions of Canada. Roughly 1.4 million hectares of forest land is directly located within Indian reserves, with 58% under active forest management (Natural Resources Canada 2001b). Although aboriginal forestry organizations and the federal government do not have a comprehensive aboriginal forest strategy, there have been a number of efforts to increase aboriginal involvement in the

Some provinces are making an effort to capitalize on the **knowledge of trappers and hunters** for monitoring the populations of small furbearers and large game. The Nova Scotia Department of Natural Resources requires a mandatory report from licensed fur trappers giving information on number of pelts harvested, number of animals released and approximate abundance estimates for fur-bearing species. Voluntary report forms are also available to hunters of waterfowl and small game (Nova Scotia Department of Natural Resources 2000).

planning and management of forest resources within areas of traditional use. Of particular note in the integration of traditional forest-related knowledge are:

- the 1996 National Aboriginal Forestry Association (NAFA) report entitled *Aboriginal Forest-Based Ecological Knowledge in Canada*;
- the 1999 document, *Traditional Ecological Knowledge within the Government of Canada's First Nation Forest Program–A Case Study*;
- the many Canadian Model Forest Program projects, including:
  - Waswanipi Cree Model Forest, which is exploring approaches to incorporate traditional knowledge;
  - Long Beach Model Forest, which documents resource management practices of the Nuu-chah-nulth people;
  - McGregor Model Forest, which is in the process of translating traditional ecological knowledge into geographical information systems (GIS);
  - a workshop on linking traditional ecological knowledge to criteria and indicators of sustainable forest management, held by the Model Forest Network; and,
- a co-management arrangement between the Cree First Nations of Saskatchewan and Millar Western.

Unfortunately there has been even less emphasis on incorporating other local knowledge. Trappers, many of whom are aboriginal, are in many ways the stewards of public land under the trapline systems throughout Canada's forests. While they are often required to report their harvest of fur, there are few mechanisms to capture their local knowledge of changes to biodiversity within a local area. Yet hunters, trappers and fishermen are normally the first to observe drastic environmental change (e.g., pollution, inappropriate harvesting levels) and report on the need to modify existing harvest of animals.

Inventories

Management of biodiversity in Canada is constrained by the lack of appropriate inventory information and a continued focus on a small set of high-profile species.

Relevant information on biodiversity is critical to the success of the forest community in implementing an ecosystem management approach. Reliable and up-to-date information is required to establish sustainable harvest rates of biological resources, to monitor the status of ecosystems, species and genetic resources, and to develop resource and landscape plans. This need is widely accepted in Canada and has led to substantial progress in the enhancement of existing forest resource inventories to include biodiversity attributes and the development of new national programs.

Traditionally, forest management inventories are conducted in cycles of 10 to 20 years, and provide stand level data and maps from interpreted aerial photography. Tree volume estimates, derived from field sampling, supplement these inventories. A national forest inventory compiles these provincial inventories periodically under a national classification scheme that includes information on site class, age, dominant tree species and forest type. This information is digitized and stored in a database management system and a geographic information system. Unfortunately, technological development and demand for biodiversity information have far exceeded the outdated inventory data that were largely collected in

The **Alberta Vegetation Inventory** was developed with the cooperation and input of government foresters, wildlife biologists, managers of grazing lands, inventory specialists and representatives of the forest sector. The data set will be used to support decision-making systems for ecosystem management and landscape planning. The inventory currently covers half of Alberta's forest lands and will provide information to address a broader spectrum of forest management issues than earlier timber inventories.

A large number of **volunteer monitoring programs** were established in the 1990s. Many have educational value only, but others, with a large number of volunteers or standardized training and protocols, or both, may provide some insight into changing populations and habitat. Some examples of these programs and other long-term volunteer monitoring efforts in Canadian forests include:

- Nocturnal Owl Surveys (British Columbia, Manitoba, Ontario, New Brunswick)
- American Woodcock Singing Ground Survey (Manitoba, New Brunswick)
- Red-shouldered Hawk and Spring Woodpecker Survey (Ontario)
- Frogwatch (Canada-wide)
- Treewatch (Canada-wide)
- Wetland Keepers and Stream Keepers (British Columbia)
- Volunteer Lake Monitoring Program (British Columbia)
- Birds in Forested Landscapes (North America)
- Canadian Breeding Bird Survey (Canada-wide, long-term program)
- Christmas Bird Count (Canada-wide, long-term program)

the 1970s. Although there have been no new national inventory initiatives, all provinces enhanced their forest inventories to add attributes describing broader ranges of vegetation, soils, hydrology and wildlife habitat. While some provinces have completed these revised inventories and assembled the information on an ecosystem basis, it is expected that it will be another decade before this coverage is complete in Canada. In addition, most jurisdictions have implemented an ecological land classification system with all forest lands classified at a variety of scales across the country.

As the level of harvest by the forest industry approaches the annual allowable cut (AAC) in some regions of Canada, it is imperative to make corresponding advances in inventory and monitoring, to ensure that the combined effects of natural disturbance and human use do not exceed the limits of sustainability. Forest biodiversity inventories are essential to detect changes in species distribution and abundance and to prevent the local collapse of populations. To address the underlying problem of existing inventory systems being unable to monitor change within the forest, a new National Forest Inventory Program was proposed in 2000, but it has not yet been implemented on a national scale. This system will monitor the status and trends over time of 25 forest resource attributes in 1% of Canada's forests, using three levels of sampling: ground-based plots, photo plots and remote sensing plots. It is currently being tested by some resource agencies across Canada.

In 1998 the Canadian Council of Forest Ministers mandated a cross-Canada exercise to try to find the points of comparison among the individual provincial Forest Ecosystem Classifications, to enable "cross-walks" and to see if national classification standards are achievable. Natural Resources Canada's Canadian Forest Service is coordinating the Canadian Forest Ecosystem Classification (CFEC) project with partners from federal, provincial, territorial and private-sector organizations to develop a nationally standardized set of definitions and descriptions for forest communities. The CFEC will provide a standard basis for identifying and delimiting habitat for the development of conservation and protection strategies, and for linking ground-derived ecological attributes to remote sensing information. The CFEC project is working with NatureServe Canada (formerly Association for Biodiversity Information Canada) to determine where there can be linkages to the International Classification of Ecological Communities.

Although there have been few new inventories of wildlife in Canada by government agencies (except in British Columbia under the Forest Renewal Program), considerable information has been collected by public interest groups and the forest industry. A proliferation of voluntary monitoring programs developed during the 1990s across Canada. Along with these programs were the inventory efforts by non-government agencies to assess conservation programs, and industry efforts to define and meet biodiversity objectives in management planning and certification programs. These developments have all helped fill the "inventory niche" left by the downsizing of provincial wildlife agencies responsible for biodiversity conservation. There is no comparable national fisheries data set,

At the **Manitoba Conservation Data Centre**, the geographic information system and database on biodiversity have grown to include over 4 000 known occurrences of species and plant communities of concern to conservation. The system stores information on more than 3 000 species and communities, occurrences of 448 managed or protected areas, 223 knowledgeable contacts and 9 594 referenced sources of information. It continues to be the most extensive source of biodiversity information in Manitoba. Similar conservation data centres are maintained across Canada.

but a large proportion of fisheries information for management is collected through voluntary creel census of recreational fishermen. Although the standards associated with wildlife inventories and biodiversity monitoring protocols have improved substantially, the gap between existing information and the needs of resource managers continues to widen, creating serious national and international ramifications.

2B. Increasing resource management capability

The lack of a common knowledge infrastructure to organize ecological information may be the greatest remaining impediment to integrating biodiversity conservation within sustainable forest management.

Data Information Management

Our technical ability to develop data storage and retrieval mechanisms for natural resource and biodiversity information evolved rapidly during the 1990s; however, there has been little progress in implementing a program for data information management. Even the existing National Forestry Database Program has not evolved to include non-timber values. The reasons for the delay include a lack of a comprehensive base inventory, the lack of clear definitions of biodiversity concepts and features such as "old growth", and the availability of existing information within a variety of often competing agencies responsible for biodiversity conservation. The 1995 Criteria and Indicators Framework of the Canadian Council of Forest Ministers could be considered the basis of a system for national reporting on the state of forest biodiversity, using the eight indicators under the criterion "Conservation of Biodiversity". Although two reports (CCFM 1997, 2000b) assemble existing information, there is no continuing mechanism for the collection and assembly of new information.

"Providing an ecological knowledge infrastructure could be the single most important step toward sustainable forest management" (National Forest Strategy Coalition 2001). There are a number of federal proposals to develop a common, GIS-based framework for storing and analyzing ecosystem-level data sets and making them available in various formats to many different users. These include the Canadian Forest Service's NATGRID initiative, the Canadian Council of Forest Ministers' National Forest Information System, Environment Canada's Canadian Information System for the Environment and the multi-stakeholder-proposed Biodiversity Knowledge and Innovation Network. These require an extensive network of distributed and inter-operable data partnerships, a much clearer definition of user needs and a broader forest inventory which provides information on all vegetative species, fragmentation, age classes and disturbances. The synthesis of biodiversity information is progressing at the operational level, often associated with the development of forest companies' operating and management plans, and by interest groups including the Forest Products Association of Canada's Biodiversity Program.

The emergence of Conservation Data Centres across Canada and the recent launch of NatureServe Canada (formerly the Association for Biodiversity Information Canada) offer a standardized mechanism for assembling information on all species and communities. Most provinces have established a Conservation Data Centre or Natural Heritage Information Program to serve as a data bank for inventory data collected by the government, universities or volunteers. The information is geo-referenced, enabling GIS applications.

The **Biodiversity Knowledge and Innovation Network** was proposed as a result of the conference Canada's Natural Capital–Investing in Biodiversity for the Information Age. The objective of the conference was to address gaps in information management related to biodiversity science, and the critical lack of taxonomic and systematic scientists in Canada. Conference delegates recommended the establishment of an electronically linked knowledge base on biodiversity at the genetic, species and ecosystem levels to facilitate conservation and sustainable use of biodiversity.

Integrated Planning and Ecological Management

While biodiversity conservation is a priority within the planning process of all parts of the forest community, management approaches continue to be evaluated and further developed.

Integrated resource management approaches have been implemented across Canada for four decades in different forms, as the process of integrating the variety of social and economic objectives on a specific landscape while protecting the environment. The planning can be provincial in scope

Biodiversity considerations in the forest management planning process of Western Forest Products Limited (WFP): North Vancouver Island Region

Landscape Ecology–WFP has initiated targets and long-term projections for seral stages (diversity of ages) and patch sizes (spatial distributions) for the entire forest management unit.

Old-Growth Management Areas (OGMAs)–WFP is participating in government planning for a geographically and ecologically representative network of OGMAs for their forests.

Riparian Reserve Zones–Timber buffers are retained along all significant fish streams throughout the forest, and prescriptions made to protect all streamside zones.

Stand Level Biodiversity–Wildlife tree patches for retention of biodiversity and habitat are established in every cutblock.

Riparian Habitat Restoration–In historically logged zones along major streams, stand treatments are being conducted to encourage the development of old-growth characteristics, wildlife habitat and fish habitat.

Salmon Enhancement Programs–WFP maintains three significant salmon hatcheries in the certified forest. Salmon are an important resource on the BC coast, and there are several major salmon spawning streams in the managed forest.

Ecological Classification–Ecological inventories, mapping and classification are the basis of WFP's forest management. Reforestation is based on native species, adapted to local ecosystems, and maintaining broad genetic diversity.

High Conservation Value Forests–These are forests with concentrations of biodiversity values, important species or ecosystems. WFP is currently funding studies to define attributes for potential FSC certification.

Long-term Projections–Sustainability of various forest-level values such as timber supply and old forest is projected over 200 years based on current management assumptions.

Wildlife Species-specific Plans–Fourteen deer winter ranges have been established or are being evaluated. A strategy report for managing wildlife is being prepared to maintain terrestrial forest-dependent organisms across the forest area.

Professional Foresters–Professional foresters are responsible by law to integrate biodiversity into all timber harvesting and forest management plans.

Assessments–Resource professionals and specialists are required by law and regularly engaged for issues such as terrain stability, fish habitat, wildlife habitat and biodiversity studies.

Indicators–A local public advisory group is helping WFP refine indicators and objectives for biodiversity within an internationally accepted framework.

Land Use Planning–The BC government launched a comprehensive land use planning process through which communities, industry, conservation groups, aboriginal people and others have helped develop land use plans and biodiversity strategies for more than 70% of the province so far, including WFP's certified forest.

Protected Area Strategy (PAS)–In 1992, BC began a concerted effort to more than double the area protected in the province to 12.5 million ha. This resulted in over 450 new protected areas, with several in or beside the certified forest.

Special Management Zones (SMZs)–Through land use planning, 14% of the province has been designated as SMZs where wildlife, recreation or other values take precedence over harvesting. WFP's certified forest contains two SMZs, in which innovative silviculture systems are implemented.

(e.g., Ontario's Living Legacy), regional (e.g., Alberta's Policy for Resource Management of the Eastern Slopes), or site specific in forest management plans. Often associated with these plans are a wide range of legislative tools and guidelines that are imposed on forest management activities (e.g., Alberta Timber Harvest Planning and Operations Ground Rules or the Watershed Planning and Biodiversity Guidelines under the BC Forest Practices Code).

During the 1990s, most regulatory agencies developed and promoted the adoption of ecological approaches to forest planning that attempted to mimic the characteristics of natural disturbances. Ontario's "Tools for Managing for Natural Disturbance", for example, are reducing the need for species-specific guidelines. The development of biodiversity objectives has greatly assisted in the planning process and subsequent monitoring and reporting procedures. The use of habitat supply models with indicator species has also helped develop these natural disturbance models. In addition, the development of multi-value inventories at the operational level, the use of ecological-based classification systems and the strong

Manitoba's Ecosystems Based Management (EBM) pilot project is a project designed to investigate how to manage whole ecosystems rather than just specific resources such as trees and wildlife. The project focuses on planning at the landscape level in Ecoregion 90 in eastern Manitoba. The region combines areas of remote wilderness, 16 communities, and forestry and mining activities (National Forest Strategy Coalition 2001).

commitment to stakeholder consultation have greatly enhanced the planning process. The Model Forest program has also provided a lead in the development of local decision support systems.

In summary, the processes are in place to ensure adequate planning for sustainable forest management that fully conserves the range of biodiversity. By 2000, all companies in Canada were using pre-harvest assessment systems that consider soil, climate, wildlife and ecological classification. However, new planning issues affecting biodiversity are emerging with proposals of large planted areas of faster-growing tree species. An analysis of the benefits of this landscape model is required before planning the next step with this approach. Similarly, there appear to be different ecological issues that need to be addressed when the forest industry operates in the northern area of the boreal forest.

Environmental Assessment

Formal environmental assessments in Canada tend to examine site-specific developments and have not had a significant impact in shaping biodiversity conservation within the forested landscape.

Although both federal and provincial governments have legislation outlining environmental assessment processes, these assessments have not been commonly applied to forest management operations, or even to the allocation of new forest management agreements. The assessment process has, however, been applied to the approval of pulp mill construction. Since the 1970s there have been a number of provincial environmental assessments on timber harvesting by new environmental departments, largely based on public hearings and testimony of experts. The results of these assessments were often a set of recommendations or considerations on ways to incorporate social and environmental objectives within timber management operations. A quasi-judicial Class Environmental Assessment on Timber Management in Ontario was completed in 1994, endorsing the forest management regime in the province with a series of terms and conditions for sustainable forest management. The decision from this assessment, ranging from adequacy of reforestation to planning and policy procedures, was adopted by the Ontario government over a very specific time period. In Newfoundland and Labrador, all five-year operating plans have an environmental assessment, including public review.

A considerable amount of federal as well as provincial environmental legislation applies to the permitting of forest harvest operations, including the federal *Fisheries Act*, the *Canadian Environmental Assessment Act*, the *Pest Control Products Act* and recent interpretations under the Migratory Bird Convention legislation. The limited herbicide and pesticide use in Canada's forest has been assessed under this form of legislation, but there are still concerns that with our limited knowledge, the effects of chemicals and the cumulative or synergistic impacts may be affecting many forms of wildlife. The jurisdictional wrangle over the administration of the federal *Fisheries Act* has limited its effectiveness in assessing the impact of major developments on fish habitat. Although there are many referrals, the current reviews of proposed separate fish habitat alterations do not deal with the incremental impacts of timber harvesting within a watershed. A recent stronger federal presence in the approval and monitoring of impacts on fish habitat, and the use of guides and planning objectives, should stimulate partnerships and provide adequate information to address development outside the legal process of environmental assessment. Similarly, Environment Canada recently released an environmental assessment

The Canadian Environmental Assessment Agency and the Biodiversity Convention Office of Environment Canada have produced **a guide on biodiversity and environmental assessment**. The document highlights the importance of biodiversity considerations in project and policy planning. It includes examples of spatial and temporal biodiversity parameters that require investigation through impact assessment, mitigation and monitoring. It also highlights the environmental assessment requirements of the Biodiversity Convention, the Canadian Biodiversity Strategy and the Canadian Environmental Assessment Act (Environment Canada 1998).

guideline to protect forest habitat of migratory birds. The guideline identifies forest company information requirements and appropriate planning approaches primarily at the landscape level.

Training

As a result of the increasing demand to implement biodiversity conservation measures in forest management planning, the forest industry is becoming a major employer of wildlife biologists.

During the 1990s all post-secondary forestry institutions revised their programs to adjust to the development of the sustainable forest management paradigm. Since then, management of biological diversity has become a standard course requirement in most undergraduate forestry programs in Canada. Many universities have undergone a divergence in their forestry faculties as well, now offering both the degree of Bachelor of Science in Forestry and a degree in natural resource conservation and environmental management. These new applied conservation programs have a large component on biodiversity conservation, and graduates gain an interdisciplinary perspective on issues facing Canadian resource managers. There is an obvious need for professionals with this training, as most graduating foresters do not have sufficient expertise in biodiversity management. By 2000, many forest companies had acquired biologists or ecologists to deal with the growing public demands associated with biodiversity conservation.

Continued forestry education has been recognized as an important element in achieving sustainable forest management in Canada. Many workshops and seminars have focused on the emerging issues associated with rapid technological changes, increased public awareness and the need for higher environmental standards. Unfortunately, in most of these workshops there has been very little involvement or participation by the traditional wildlife community or scientists involved in biodiversity conservation. Likewise, there has been very limited use of forestry journals (such as the Canadian Institute of Forestry's *Forestry Chronicle*) by biologists to distribute information to the forest community.

Professional and technical associations provide voluntary education programs, but traditionally have lacked the expertise to deal with biodiversity issues. However, there is an opportunity as forest industry associations have adopted self-regulatory codes of environmental practices with associated assessments and even audits that greatly encourage continuing training of forest practitioners.

The Western Newfoundland Model Forest developed a **sustainable forest management training program** for front-line forest workers, dealing with environmental awareness and environmentally sensitive harvesting practices. The program has been delivered to all forest workers employed by pulp and paper companies in the province, and training for workers harvesting on public land is ongoing (National Forest Strategy Coalition 2001).

The **British Columbia Forest Practices Code Guidebook** series (49 in all) directs the conservation of fisheries, wildlife, biodiversity, soil, water and other forest values. The guidebooks were prepared to help forest resource managers plan, prescribe and implement sound forest practices that comply with the Forest Practices Code (British Columbia Ministry of Environment, Lands and Parks 1995).

Forest Care is a program developed by the member companies of the Alberta Forest Products Association. It encourages members to continually improve their forest practices in target areas including forest sustainability, multiple use and environmental protection. Forest Care members must assess performance annually, as well as implementing action plans to raise performance levels. Members also undergo independent audits of their woods and mill operations every three years. The audit process is rigorous, addressing many areas not covered by government regulations and policy. Forest Care members account for more than 90% of the annual timber harvest in Alberta (Alberta Forest Products Association 2000).

2C. Monitoring our understanding of ecosystems and our resource management capability

The development of an effective national monitoring framework is hampered by the quality and quantity of existing information.

Monitoring programs have evolved rapidly in the 1990s to meet a variety of objectives, including:

- detecting changes in biodiversity that exceed natural variation (often associated with climate change, invasive species and the effects of land use and land-use changes);
- providing a public reporting system based on established criteria and indicators that both demonstrate the level of success in sustainable forest management and allow for adaptive management; and,
- providing information for specific reporting requirements (from meeting international commitments to forest certification programs).

In Canada there is no national biodiversity-monitoring program, but there are national programs that summarize related information in a useful way. Environment Canada's National Environmental Indicators Program is a national reporting system that summarizes information on timber harvest levels, natural disturbance trends and regeneration. The annual report produced by Natural Resources Canada's Canadian Forest Service entitled *The State of Canada's Forests* also reports on trends in Canada's forests. In addition, there have been two complementary documents (CCFM 1997 and CCFM 2000b) reporting on sustainable forest management using the Canadian Council of Forest Ministers' criteria and indicators.

Alberta's Ministry of Sustainable Resource Development has established performance measures that address progress and results in key areas. All of the **performance measures support the goals of the Canadian Biodiversity Strategy**. For example, the target for species at risk is to keep the percentage of species at serious risk to less than 5%. The performance measure is based on a review of the general status of wild species in Alberta conducted every five years (Alberta Environmental Protection 1998).

The **Ecological Monitoring and Assessment Network (EMAN)** reports on status and trends of species and ecosystems. The Biodiversity Science Board has recommended standardized protocols for plot-based monitoring of biodiversity. Under the Science Horizons Program, the network, in partnership with other government organizations and the private sector, is testing, in parks and other protected areas, protocols to monitor tree condition, terrestrial vegetation, soil decomposition, frogs and toads, earthworms, plant phenology, ice phenology, lichens and birds (EMAN 2002).

The goal of the **Partners in Flight Program** is to ensure the long-term viability of native Canadian landbirds across their range of habitats. The Canadian Landbird Monitoring Strategy provides the framework for coordination of landbird conservation efforts at national, regional and local levels. The goals of the strategy are to:

- monitor the status (distribution, abundance, demography, habitat) at a variety of geographic scales;
- ensure the results of monitoring are available and used for research and conservation;
- use, improve and expand on existing surveys (e.g., Breeding Bird Survey, Checklists, Christmas Bird Counts), and develop new surveys to address priority gaps;
- develop the capacity to monitor habitat to complement population monitoring; and,
- develop protocols and train volunteers.(Partners in Flight 2000).

Another national initiative is the Ecological Monitoring and Assessment Network (EMAN) that assembles monitoring information from 78 sites across the country.

For the development of the report *Wild Species 2000 – The General Status of Wildlife Species*, each provincial and territorial wildlife agency reported on the relative status of wildlife species. Many of the provincial assessments started early in the 1990s, and a published update is available every five years. These reports rank the relative status of vertebrates and other groups as at risk, maybe at risk, sensitive, not at risk, and insufficient information to determine status. They are used extensively to set priorities for conservation decisions and research. Although this effort is most prominent, universities, museums, non-government conservation organizations

The Forest Health and Biodiversity Network of Natural Resources Canada's Canadian Forest Service reports on the health of Canada's major forest ecosystems. ***Forest Health in Canada: An Overview 1998*** discusses impacts on forest health from natural influences and human-induced activities, including air pollution and land-use activities (Natural Resources Canada 1999c).

and industry also have monitoring programs, which vary in scope from the community to the regional scale.

There are a number of other initiatives that contribute to the monitoring of biodiversity in Canada, including:

- the Biological Survey of Canada;
- the Commission on Environmental Cooperation–Ecosystem Monitoring Initiatives;
- the North American Bird Conservation Initiative;
- the Model Forest Program;
- the National Centre of Excellence–Sustainable Forest Management Network;
- a broad array of species and habitat monitoring initiatives under citizen science programs; and,
- ongoing monitoring requirements under certification programs on sustainable forest management.

In summary, these initiatives provide a framework to meet a variety of monitoring objectives, but their effectiveness is limited because of the lack of adequate inventory information and the need for standardized protocols and coordination across initiatives.

Most provinces and territories publish a periodic State of the Environment report, often as a legal requirement. Their purpose is to provide accurate information about ecosystem conditions and trends and corrective actions for environmental issues. Biodiversity is an important feature throughout the reports. In addition, there are ongoing reports on the state of parks and ecozone assessments. However, there is no common framework to report nationally on the status and trends in biodiversity (i.e., common scale or integration of information). The interpretation of biological data within these initiatives is dependent on associated environmental data (such as climate and water quality). Unfortunately, with the fiscal constraints in the 1990s, there has been less effort in collecting this baseline information.

A number of initiatives have recently started in Canada to develop and test natural resource accounting models. The National Round Table on the Environment and the Economy is developing environmental and social indicators to measure progress in achieving sustainable development.

Canadian Biodiversity Strategy

Goal 3

To promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner

Even though wildlife conservation and environmental issues remain a focus for all Canadians, biodiversity within forest management is not a widely understood concept.

The Canadian Biodiversity Strategy proposes a three-pronged approach to achieving goal 3: public awareness programs, education, and interpretation and extension. The approach recognizes the need to evaluate current public understanding, to design effective programs.

Although Canada has become a more urbanized country relatively recently, most Canadians retain a close relationship with the forested landscape. Unfortunately, biodiversity conservation in national and international programs and policies is poorly understood by individuals and local communities across Canada, even though conservation solutions are normally based on community support and participation. Canadians do, however, have a consistent concern, as expressed

The **Importance of Nature to Canadians** is a survey conducted every five years that reports on the economic significance of nature-related activities in Canada. The report indirectly shows the magnitude of importance of these activities to the Canadian public. In 1996, 20 million Canadians spent $11 billion in Canada pursuing activities such as wildlife viewing and photography, camping, canoeing, cross-country skiing, backpacking, bird-watching, hunting and fishing (Federal-Provincial-Territorial Task Force on the Importance of Nature to Canadians 2000).

in public opinion surveys, about environmental issues. An Environment Canada Omnibus Survey (Environment Canada 1999) indicated that a large majority of Canadians are emotionally "upset" or very concerned (or both) about "threats" to nature and "loss" of wildlife. Although more than 8 out of 10 Canadians cannot define biodiversity, there is a rapidly growing realization that habitat destruction is the main cause of biodiversity loss. Similar results from an Environics poll in 1999 on biodiversity issues (Environics 1999) predicted a third "green wave" in the next few years related to underlying concerns about ecosystem health and natural legacy. It also noted concern for an increasing gap between perceived performance and expectations of governments and industry.

Public Awareness Programs

Canada's national public awareness strategy has focused largely on the annual release of the State of the Forest reports initiated in 1990. These reports have primarily targeted the traditional forest community. Most provinces publish similar periodic reports on the state of the forest as a legislative requirement. Government and non-government agencies publish other periodic reports on the status of parks, environment, habitats, endangered species and forest health.

Canada's Biodiversity: The Variety of Life, Its Status, Economic Benefits, Conservation Costs and Unmet Needs attempted to provide a national understanding of Canada's biodiversity and its status. The report indicated that Canada's biological resources generate an estimated monetary benefit of approximately $70 billion annually. This estimate did not consider the value-added processing of biological resources and was therefore conservative (Mosquin 1995).

The Grand River Conservation Authority and the Ontario Soil and Crop Improvement Program developed a small stewardship program involving planting of the American chestnut on farms in southern Ontario. The **American Chestnut Restoration Program** has been successful in restoring threatened chestnut trees to their native range. The program also facilitated the introduction of landowners to the local Conservation Authority and promoted awareness of the greater issue of species at risk in southern Ontario.

Perhaps the most effective public awareness programs are those associated with public consultation reviews. At the national level, the National Forest Strategy was developed after a series of consultations with stakeholder and interest groups from across the country. Subsequent evaluations by third-party auditors were available to the public. Provincial land-use strategies such as Ontario's Living Legacy have also been developed with extensive public consultation. At the operational level, nearly all companies now participate in ongoing public review during the development of management plans. In addition, the certification process of the Canadian Standards Association (CSA) has a strong public participation requirement.

Education and Interpretation Programs

The focus of Canada's education and interpretation program has been with younger groups (junior and elementary schools). Integrating themes of biodiversity conservation into the formal school curriculum is difficult, but some provinces, such as Alberta, New Brunswick and Newfoundland, already have a forest curriculum established throughout their elementary school systems (National Forest Strategy Coalition 2001). Many provinces have had success in providing professional development sessions at teachers' conferences. In addition, all provinces and territories provide schools with a mix of educational posters, fact sheets, CDs, teacher manuals and guides. Considerable information on biodiversity conservation is tailored to youth through government, industry, and non-government agency internet sites. Envirothon, a program for high-school students that focuses on forest ecosystems, has become a popular team event in some provinces. The most prominent efforts are education programs that occur during special weeks (e.g., Wildlife Week, National Forest Week and Environment Week). The programs include seminars, public exhibits and local community events that are delivered by all parts of the forest community. In addition, existing interpretation programs in parks, wildlife areas, museums and at

Alberta Education has adopted an **integrated science program for students** capturing science, technology and societal concerns. Environmental topics covered currently include diversity in forests, wetland conservation, needs of plants and animals, environmental quality, forest conservation, water quality and relationship to watershed, and sustainable development (Alberta Environmental Protection 1998).

The Bas-Saint-Laurent Model Forest covers 113 100 hectares of mixed forest in the rural municipalities of the Lower St. Lawrence region in eastern Quebec. The model forest has developed a successful **voluntary wetland conservation program** for private lands in partnership with La Fondation de la Faune du Québec, Wildlife Habitat Canada, Ducks Unlimited Canada and the North American Waterfowl Management Plan. Woodlot owners receive extension materials on the importance of protecting wetlands.

many forest company operations all have a clear focus on biodiversity conservation. The interpretive work of the Model Forest Program during the 1990s has provided both additional resource materials and the needed coordination among agencies and interests.

Extension

Even though most of the forests in Canada are in public ownership, there has been considerable educational material developed for private lands in addition to the forest management guidelines, codes of practices and procedures for dealing with biodiversity conservation on public lands. In the 1990s, landowners showed a substantial interest in learning about forest values and woodlot management. Although tax incentive schemes, tree marking courses and codes of practice are being developed that include provisions for biodiversity conservation, the distribution of biodiversity information to the 425 000 woodlot owners in Canada appears inadequate. Three Model Forests, Fundy in New Brunswick, Bas-Saint-Laurent in Quebec, and Eastern Ontario, have provided most of the new educational programs for landowners on biodiversity conservation. Provincial and regional private woodlot associations are successful in distributing information and need to be supported with biodiversity information and extension material.

Canadian Biodiversity Strategy

Goal 4

To maintain or develop incentives and legislation that support the conservation of biodiversity and the sustainable use of biological resources

The "carrot and stick" approach is only effective when legislation establishes minimum standards and incentives foster stewardship practices.

By the beginning of the new millennium, a needed balance between legislation and incentives was starting to emerge. The clear Canadian policy commitment to biodiversity required new legislative authority, but equally recognized was the need for landowners and resource managers within the forested landscape to act and be perceived as forest stewards in retaining environmental and biodiversity values. Within the forest community, the awareness and adoption of biodiversity measures were significantly enhanced by the adoption of voluntary certification programs across Canada. Although much of the sustainable development policy of governments has focused on economic, social and environmental tradeoffs, the paradigm of sustainable forest management recognizes the overarching and non-tradeable ecological attributes of the landscape. The emerging forest paradigm with an "ecosystem" approach more fully recognizes the fundamental importance of biodiversity conservation.

Incentives

Over the past decade, the conservation community has developed an array of stewardship and recognition programs across Canada, often focusing on a particular habitat associated with rare species or protection of riparian or wetland complexes. These programs, almost exclusively associated with private lands, have been a major contributor to the maintenance of tree cover on marginal farmlands as well as the main tools in retaining the remnant stands of Carolinian forest in

The **Forest Stewardship Recognition Program** was developed by Wildlife Habitat Canada, the Forest Products Association, the Ontario Ministry of Natural Resources and Natural Resources Canada's Canadian Forest Service, with the support of other forestry and conservation organizations. The program promotes awareness and appreciation of good forest stewardship and biodiversity conservation in Canada's forests. Approximately 100 forest workers, woodlot owners, conservation organizations and others working on the ground have received recognition for their efforts since the program was started in 1998 (Wildlife Habitat Canada 2001).

In Ontario, since 1988 the **Conservation Land Tax Incentive Program** has encouraged protection of provincially significant wetlands and endangered species habitat on private lands. The program has successfully secured the protection of over 166 000 ha of land with more than 15 000 participants. The **Managed Forest Tax Incentive Program** encourages landowner awareness and forest stewardship on private land. Since 1996 it has grown to include almost 9 300 properties totaling more than 610 000 ha of privately owned forest land.

The British Columbia government's enforcement staff conduct about 50 000 inspections a year to ensure that forest companies are complying with the **British Columbia Forest Practices Code**. The compliance rates are approximately 97% based on these inspections. The Forest Practices Code includes a range of conservation initiatives including rules and measures to protect old-growth habitats, ungulate winter ranges, wildlife trees and riparian areas. A major independent audit of coastal streams by the Forest Practices Board indicated that stream disturbance by logging has been significantly reduced in the past decade (Government of British Columbia 2002).

southern Ontario. Most programs, including those emerging under the Federal-Provincial Stewardship Accord, are designed to recognize landowners for their sound stewardship practices, encourage them through extension programs to adopt additional conservation measures, and where necessary provide funding for activities such as fencing cattle away from stream banks. An Environics Survey of 2 500 rural landowners, released in September 2000, confirmed their "willingness" to retain the ecological values on their properties and their need for both information and incentives (Environics 2000). With the recent infusion of federal funding into stewardship programs associated with the pending *Species at Risk Act*, and the broadening of the goals of existing conservation programs such as the North American Waterfowl Management Plan, a considerable portion of forest habitat should be affected. For sites with more singular features, Canada's new Ecological Gifts program, with tax incentives under conservation easements (legal agreements that protect ecological features on the property in perpetuity), is also expected to make a significant contribution.

There has been slow progress in developing comprehensive strategies for the sustainable development of private woodlots. A number of provinces have instituted legislative standards of practice or financial incentives that promote long-term management planning, or both. With British Columbia's development of a long-term vision for private woodlots, the government agreed to a 3.6 million dollar tax break to protect public values. Quebec, Ontario and Alberta have introduced a Managed Forest Tax Incentive Program that requires a management plan with defined objectives. Prince Edward Island provides financial assistance for reforestation and management (National Forest Strategy Coalition 2001).

Finally, the tenure arrangement for industry on public land often provides investment mechanisms, frequently in the form of tax credits to encourage long-term investment in forest management. Under these long-term tenure arrangements, investment incentives include the establishment of trust funds primarily for silvicultural purposes. Recent renewal trusts have also focused on reclamation and biodiversity research. These incentives complement an array of voluntary incentives in the forest industry, such as their codes of practice and certification programs.

Legislation

In Canada, legislation reflects national commitment and government policy. For these policies and commitments to be implemented, there needs to be both a legislative authority (and accountability) and a responsible allocation of financial resources. Until recently there was a slow evolution of legislation to protect biodiversity in Canada. However, by the late 1990s, five of the provinces and territories had additional

Figure 5. Trend in dioxin and furan levels and adsorbable organic halides (AOX) in mill effluent (CPPA 1999)

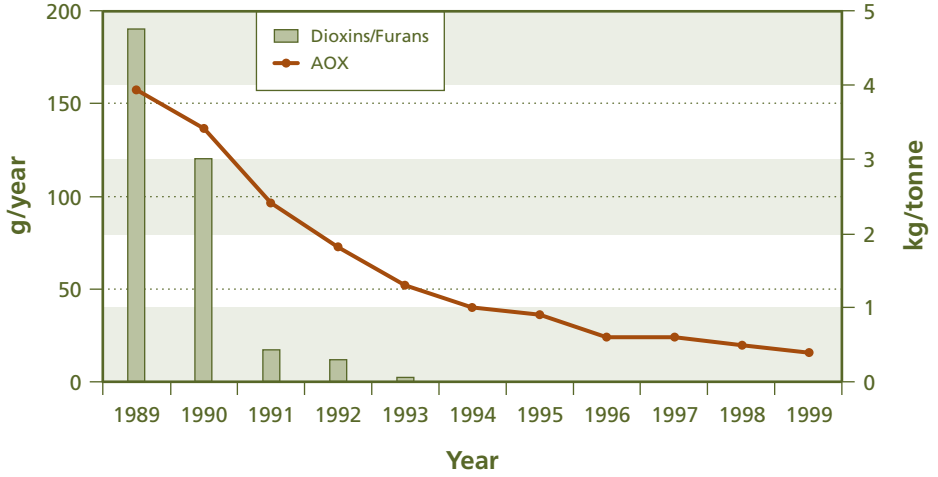
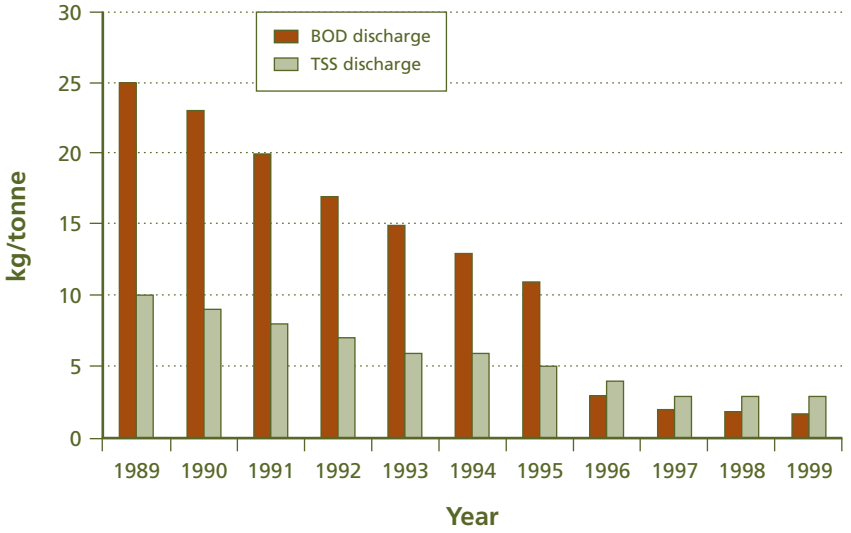


Figure 6. Reductions in BOD and TSS in pulp mill effluent

Source: CPPA Environmental Survey



specific legislation protecting endangered species. In addition to the pending federal *Species At Risk Act*, there are planned amendments to the *Canadian Environmental Assessment Act* requiring more stringent assessments on development associated with species at risk as well as a mandatory monitoring of mitigation measures. The *Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act* not only prohibits commercial trade in rare and endangered species, but is designed to prevent introduction of undesirable species to Canadian ecosystems. From a conservation perspective, regulations under resource legislation and associated policy requirements are perceived as minimum requirements and do not encourage creativity. However, the extensive use of guidelines has permitted considerable flexibility at the operational level.

Government agencies across Canada have adopted a consultative approach to developing forest policy, routinely seeking public opinion and working closely with forest industries, aboriginal groups and environmental organizations. Many provinces now require analyses of socio-economic issues as part of the planning process for forest management on public land. Natural Resources Canada's Canadian Forest Service has completed nearly 50 socio-economic studies and has developed a "choice experiment" technique to measure non-timber

values. Ontario conducted a socio-economic impact analysis for the Lands for Life land-use planning process. Although these processes are in place, the collective ability to "construct a national resource account that considers ecosystem degradation and implements standard national income accounts" is still a distant reality (Canadian Biodiversity Strategy 1995).

Amendments to federal legislation have resulted in modifications to regulations that have eliminated dioxin and furan outputs from the pulp mill production process (Figure 5); reduced biochemical oxygen demand (BOD) and total suspended solids (TSS) in effluent discharge to levels that can sustain aquatic life (Figure 6); and reduced the use of herbicides and pesticides. Although some countries require acute toxicity testing at select facilities, Canada is the only nation where these tests are required at every pulp and paper facility (Organization for Economic Cooperation and Development 1999). All facilities must have non-acutely lethal effluent, and must undertake testing of the receiving environment every three years to monitor progress in addressing subtle sublethal effects from effluent discharge. These changes will have long-term beneficial effects on the quality of both aquatic and terrestrial habitats.

With extensive budget cuts to most forest and wildlife resource agencies across Canada during the 1990s, there is a need to assess whether enforcement and extension activities can be effective in administering new biodiversity legislation and associated incentive programs. For public land management, the profusion of species-specific biodiversity guidebooks and guidelines have declined in favor of establishing specific objectives and adopting an over-arching natural disturbance model. However, extension activities are essential for this transition. With the exception of Model Forest areas, private woodlots and other privately owned forest lands remain largely unregulated by either legislation or codes of practice (National Forest Strategy Coalition 2001).

Canadian Biodiversity Strategy

Goal 5

To work with other countries to conserve biodiversity, use biological resources in a sustainable manner and share equitably the benefits that arise from the utilization of genetic resources

Recent Canadian international efforts that advocate sustainable forest management have started to include some biodiversity conservation elements.

International Cooperation

Canada is committed "to work with other countries to conserve biodiversity, use biological resources in a sustainable manner and share equitably the benefits that arise from the utilization of genetic resources" (Canadian Biodiversity Strategy 1995). Canadians are aware that we share both common resources, such as migratory animals, and responsibility in the protection of the global environment. The Canadian approach has been the forging of new partnerships to enhance activities, support the initiatives of other countries and encourage the sharing of biological resources. Since the signing of the Biodiversity Convention, there have been many new international developments within the forest community. However, it is too early to assess their benefits directly related to biodiversity conservation.

From the early 1990s, Canada was committed to developing international principles on the management, conservation and sustainable development of the world's forests. Earlier initiatives, including Caring for the Earth, A Strategy for Sustainable Living (1991); Our Common Future, the Brundtland Report (1987); and the World Conservation Strategy (1980), all provided an impetus and conservation philosophy. The UN Conference on Environment and Development (UNCED) process led to a "non-legally binding" set of principles commonly known as the Forest Principles. Canada was instrumental in developing these principles, which advocate

The **North American Waterfowl Management Plan (NAWMP)** is the largest habitat conservation initiative in North America. It is a billion-dollar landscape approach with programs designed to restore waterfowl populations to 1970s levels by enhancing or restoring wetland habitats and surrounding areas. The program also benefits other wildlife species, and considerable attention has recently been given to forested landscapes.

In 1995, international collaboration between the US Fish and Wildlife Service and wildlife managers in western Canada facilitated the first steps in **restoring the wolf populations** of Yellowstone National Park and Central Idaho. Jasper National Park in Alberta provided 29 wolves in the first release, and the province of British Columbia provided 36 more the following year. Results suggest that the relocated populations are increasing. (Alberta Environmental Protection 1998)

The Chiloe Model Forest (part of the **International Model Forest Network**) is an area of more than 900 000 ha and is home to a rich diversity of forest types and many endemic and endangered species. The UNDP-GEF is funding a large four-year project in the model forest, with the objective of conserving biodiversity. The model forest partnership approach has the potential to effectively tackle the main causes of the loss of biodiversity by enhancing local stakeholder participation in biodiversity conservation and sustainable forest management.

The Canadian government created the International Development Research Centre (IDRC) to help communities in the developing world with social, economic and environmental problems. The centre initiated the **Sustainable Use of Biodiversity Program** to promote the conservation and sustainable use of biodiversity through the application of indigenous knowledge, the development of appropriate technologies and the development of local institutions and policy frameworks.

Canada signed the **Convention on the Conservation of Wetlands of International Importance** in 1971. Sites are classified under the Convention as Ramsar Sites if they are important for the maintenance of biological diversity, support large numbers of waterfowl or aquatic birds and are good examples of a specific wetland type in the region. There are 36 Ramsar sites in Canada, of which 18 are in the forested landscape. Most are large areas such as Hay-Zama Lakes and the Peace-Athabasca Delta (Ramsar 2000).

"forests as integrated ecosystems with a whole range of different values". Subsequently, the Canadian Council of Forest Ministers has established a working group to work toward an international forest convention. Concurrently, considerable effort led to the development of *Defining Sustainable Forest Management–A Canadian Approach to Criteria and Indicators*, approved by the Canadian Council of Forest Ministers in 1995. The approach was the basis for Canada's participation in the development of the Montréal Process Working group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests. Biodiversity is a key element.

For several decades, Canada has been committed to participating in a number of international wildlife conservation initiatives including the Convention on the Conservation of Wetlands of International Importance (RAMSAR) and the Convention on the International Trade of Endangered Species (CITES). Canada has also played a leading role in the ongoing negotiations associated with the United Nations Framework Convention on Climate Change and the Kyoto Protocol (National Forest Strategy Coalition 2001), with the commitment to reduce carbon dioxide emissions and to conserve and enhance greenhouse sinks and reservoirs. Associated program measures under way, such as increasing afforestation on marginal agricultural lands, increasing urban forestry efforts and modifying forest management practices, should be complementary to biodiversity conservation measures.

In addition to advocating sustainable forest management through international agreements, Canada has built an impressive array of partnerships with other countries largely to share experiences and knowledge. For example, Canada is collaborating in an OECD project to develop biodiversity indicators. Canada has also developed cooperative biodiversity initiatives under the North American Free Trade Agreement, through the Commission for Environmental Cooperation. The Canadian Museum of Nature is assisting other countries with

The Canadian International Development Agency (CIDA) annually contributes $40 million to **developing countries for projects that combat deforestation and degradation, enhance capacity to manage and monitor forest management activities, and aid in rehabilitation of degraded areas**. Recent funding support for biodiversity conservation includes the Important Bird Areas Project in the Americas, Zambezi Wetlands Conservation Project and research on transboundary pollution from forest fires in southeast Asia.

biodiversity studies. Over the past ten years the Canadian International Development Agency has supported a broad array of biodiversity initiatives in most regions of the world. Funding projects, often in partnership with Canadian conservation organizations, have focused on developing protected areas, capacity building and ensuring biodiversity conservation is an element of sustainable development planning. Canada launched an International Model Forest Network based on the success of its national program. Now with 19 model forests in 11 countries established or in development, there is a great opportunity to focus on the coordination of research and management programs relative to biodiversity conservation. However, some of the largest and most successful continental and global conservation programs, such as the North American Waterfowl Management Plan, the North American Bird Conservation Initiative and the establishment of RAMSAR wetland sites, do not yet have a direct link to these continental forestry initiatives.

Conclusion

Has the forest community made a difference? This review has outlined the strength and diversity of Canada's forests and the efforts to align programs to meet commitments to conserve biodiversity. In many ways, this report assesses the fundamental commitment under the National Forest Strategy to maintain the extent, diversity and health of Canada's forests.

In summary, since publishing the Canadian Biodiversity Strategy in 1995 (Canada's response to the 1992 Convention on Biological Diversity), the forest community has not only embraced a sustainable forest management paradigm that recognizes the suite of biodiversity values, but has embraced an underlying ecosystem approach. It is an approach that more closely emulates natural disturbance patterns, that encourages a greater range of creative harvesting and silvicultural activities and that links protected areas and managed stands within a natural forest landscape.

To date, achievements can largely be described as building a framework, developing technical tools (such as GIS for inventories) and establishing biodiversity objectives and monitoring protocols, all in order to support planning and management at the required landscape scale. In large part, governments are meeting accountability for protecting biodiversity by developing objectives and monitoring programs. Strong partnerships between governments, industry and non-government interests continue to flourish under the National Forest Strategy Coalition. Over the past decade the forest community has addressed three fundamental issues:

- ensuring that biodiversity conservation is an integral component within forest management programs;
- ensuring that there is adequate protection for all wildlife (flora and fauna); and,
- ensuring that forest management addresses landscape considerations that foster multi-sectoral partnerships.

The future holds new challenges, as forests and management programs continue to evolve. Canada's forest community has the opportunity to build on this framework by addressing the biodiversity issues and opportunities identified in each section of the report, with the preparation of the new National Forest Strategy in 2003. There are a number of overarching issues that require attention, including:

- ensuring the full understanding and adoption of an ecosystem management paradigm;
- ensuring that there is a monitoring program to assess progress and allow adaptive management processes;
- ensuring that adequate financial resources are committed to fulfill conservation commitments (particularly for inventory, monitoring and data management programs);
- defining conservation threshold levels within landscapes, and setting targets and benchmarks;
- developing temporal as well as spatial plans, to ensure the maintenance and representation of stands of all ages on the landscape;
- integrating watershed management goals into forest management plans;
- ensuring that there is a standardized definition of "old growth" and appropriate inventory information to monitor and maintain all ecological features;
- ensuring that the existing and new protected areas fill the role of maintaining genetic diversity through adequate representation in all forest areas of Canada; and,
- ensuring that forest research activities increase the understanding and awareness of biodiversity conservation in forest management.

Most promising was the breakdown of jurisdictional barriers in 2001, with meetings between the Councils of Ministers Responsible for Wildlife, Fisheries and Forests. Their stated priorities include addressing the threat of invasive alien species; building a foundation of biodiversity science and information; monitoring and reporting on biodiversity status; and engaging Canadians in biodiversity stewardship (Federal-Provincial-Territorial Biodiversity Working Group 2001). During the 1990s, there was clearly substantial progress in the conservation of biodiversity across Canada. The level of commitment and the extent of programs demonstrate that biodiversity conservation is an achievable goal.

The recent decade was devoted to setting the stage for an ecosystem management paradigm that will ensure the maintenance of biodiversity within the forested landscape. The future challenge will be to monitor and where necessary adapt the paradigm in order to effectively conserve biodiversity.

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Canada's Seven Forest Management Paradigms

Prior to colonization, land use and range management activities were consistent with the cultural values of aboriginal peoples. Since 1500, driven by changes in public needs and values as well as increased knowledge of forest science, Canada's forests have been managed under seven forest management paradigms (Apsey et al. 2000).

1500–1750 — **Subsistence and Early Colonization**: A small population of European settlers cleared land for agriculture and cut trees to meet their needs for building materials and fuel wood.

1750–1850 — **Colonial Growth**: Settlers continued clearing for agriculture and established sawmills to supply building materials for the construction of villages and towns. Timber was exported to the United States and Europe. During this period there was no organized forest management.

1850–1920 — **Forest Resource Exploitation**: During a steady increase in Canada's population and the size of the forest industry, wood flowed to sawmills and paper mills from land clearing and forest harvesting. Governments developed agencies to administer timber cutting. This was a period of small-scale resource exploitation.

1920–1960 — **Sustained Yield Management**: Canada became an urban industrial society and the forest industry grew in size. Provincial governments granted long-term forest management licenses to ensure a steady supply of wood for industry and they required sustained-yield management.

1960–1970 — **Multiple Use Management**: The forest industry continued to grow and lumber and paper were exported to meet the needs of customers around the world. Public use of the forests for outdoor recreation increased. Forest management plans included the needs of these other users.

1970–1990 — **Integrated Forest Resource Management**: This important change required a team of foresters, wildlife biologists and hydrologists to develop forest management plans that integrated timber management planning with provisions for wildlife habitat and water quality conservation.

1990–Present — **Sustainable Forest Management**: Perhaps the most fundamental of the forest management paradigm shifts. Conservation of biodiversity and forest ecosystem health and productivity became a foundation stone in the management of forests.