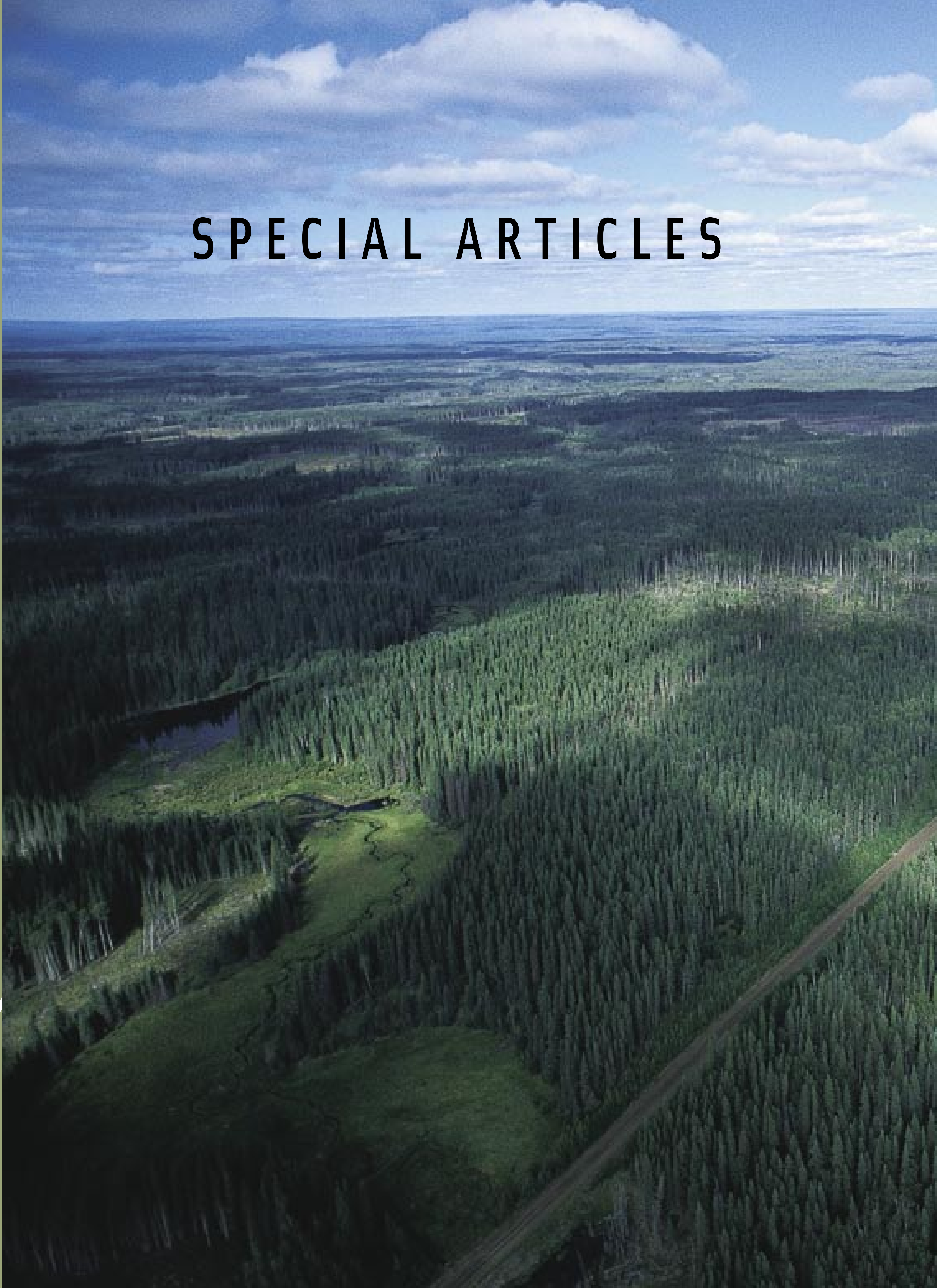
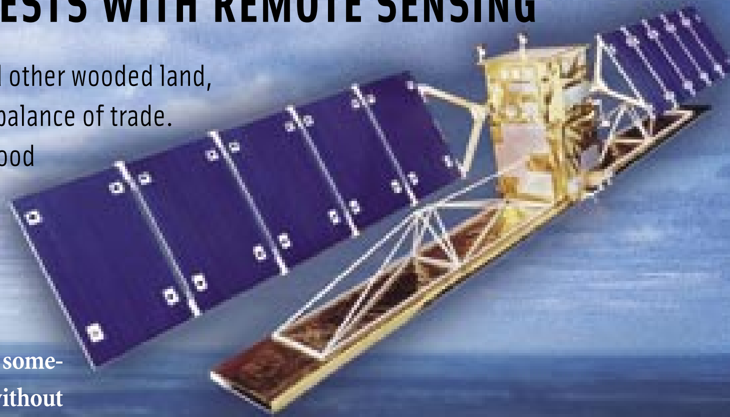
SPECIAL ARTICLES



MONITORING CANADA'S FORESTS WITH REMOTE SENSING

Canada has over 400 million hectares of forest and other wooded land, and this vast area contributes $34.5 billion to the balance of trade. To ensure that our country continues to exercise good stewardship of this valuable renewable resource, we need current and reliable forest information.



Remote sensing is the collection of information about something, such as the Earth's surface, from a distance without coming into physical contact with it. Examples of remote sensing are aerial photography and Earth observation satellites. Canada has a long history of using remotely sensed data to help monitor and address the sustainability of our forests. In a large nation, remote sensing is sometimes the only way to obtain information on remote locations. Also, remote sensing allows us to apply standardized methods for gathering data across Canada. Remote sensing is being used in many areas of forestry, including forest inventory (http://nfi.cfs.nrcan.gc.ca), forest health, wildland fires (http://cwfis.cfs.nrcan.gc.ca), forest chemistry, forest carbon accounting (http://carbon.cfs.nrcan.gc.ca) and land cover mapping.

Interpreting aerial photographs is a primary information source in the monitoring of Canada's forests, and this is increasingly done digitally. Remote sensing instruments collect data from airborne or space-borne platforms, and images are formed according to the characteristics of the sensor: spatial (size in pixels), spectral (wavelengths), temporal (revisit frequency, or how often a platform passes over a given location) or radiometric (data depth in bits per pixel). By including all of these characteristics, remotely sensed data capture unique information to meet a wide range of information needs.

Data that have low spatial resolution but high temporal resolution are ideal for the creation of map products at frequent intervals to portray the land cover characteristics of Canada; the local detail, however, is often not sufficiently captured. Medium spatial resolution data may be used to map the land cover of large areas while still capturing enough local detail to be generally representative of stand-level conditions, as exemplified by the Earth Observation for Sustainable Development of Forests (EOSD) project. High spatial resolution data allows accurate depiction of individual trees or groups of trees, but typically is only acquired on demand.

Just as differing spatial resolution is an advantage in collecting data, differing spectral resolution also allows for the capture of unique characteristics. Sensors that collect a range of spectral wavelengths or channels can isolate wavelengths specific to particular vegetative conditions. Microwave data, such as that collected by Canada's RADARSAT, can provide information on the structural characteristics of forests.

Provincial and territorial mapping agencies are largely focused on meeting operational needs. Canadian Forest Service (CFS) research is positioned to develop, test and transfer suitable technologies to meet the operational needs of provincial and territorial governments. The CFS pays particular attention to the boreal forest, which is an extensive and important ecosystem. In this region the impact of the new technology is particularly high, since disturbances such as burns and harvest can be more easily monitored, and are often outside of the managed forest areas of the provincial jurisdictions. The CFS remote sensing research projects and applications that follow are applicable to all of Canada's forests.

EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT OF FORESTS

To meet national and international reporting requirements, the CFS works with the Canadian Space Agency to use space-based, earth observation technologies to monitor the sustainable development of Canada's forests. The EOSD initiative is producing a land cover map of the forested

area of Canada using Landsat satellite data. To conform to existing standards, the products generated by this project are based on the National Topographic System (see figure on page 68). A project of this magnitude benefits from working with provincial and territorial agencies that have ongoing land-cover mapping programs.

The short-term goal of EOSD is to complete, during 2006, a land cover map representing forested area conditions present around year 2000. Over the longer term, EOSD aims to produce land cover products (such as maps) that capture changes in forest conditions over time to support national and international reporting requirements. EOSD also conducts research to estimate biomass and develops forest monitoring tools and systems that enable easy access to this rich source of digital information.

INDIVIDUAL TREE CLASSIFICATION

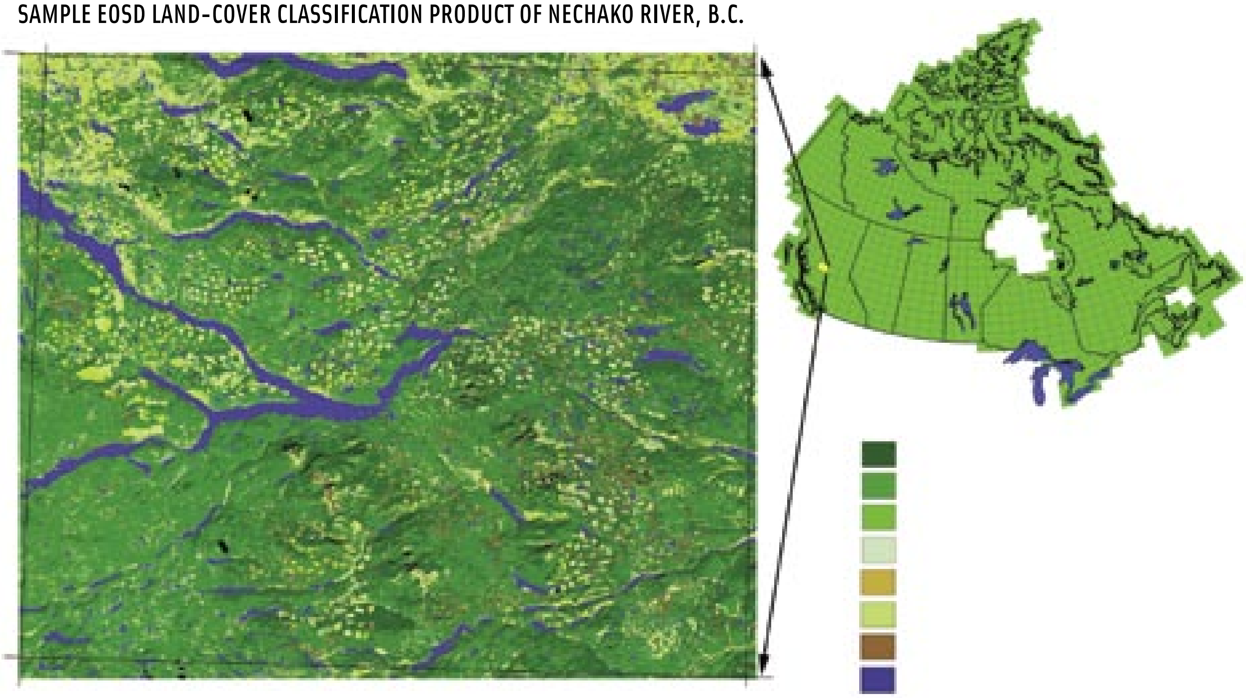
The CFS has developed a range of automated techniques to interpret high spatial resolution images in support of forest management. One of these technologies, an integrated software package called the Individual Tree Crown (ITC) suite, uses high-spatial-resolution, remotely sensed digital images (30-100 cm/pixel) to develop precise stand-based information. This software automatically delineates individual tree crowns, classifies species, aggregates trees into forest stands and generates reports. In addition, the ITC suite gathers new information on crown sizes, gap distribution and stem location. Once trees are located and delineated, further analysis may be undertaken to assign additional attributes such as species or indication of health.

Tested and developed using airborne imagery, the ITC approach is now using new high-spatial-resolution satellite imagery. This technology, which is still being refined, is used commercially by geomatics and forestry companies, as well as provincial governments and international collaborators. The technology has been successfully transferred to the private sector for commercialization.

RADAR REMOTE SENSING OF FORESTS

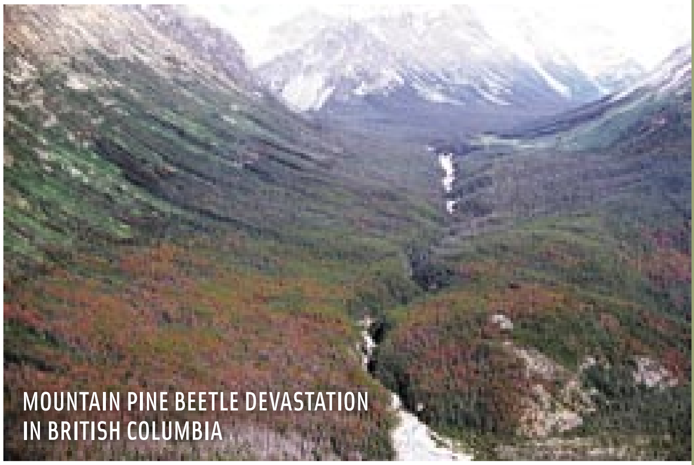
Canada is not only a forest nation, but also a world leader in the development of remote sensing technologies and applications. In radar remote sensing, microwave signals transmitted from an aircraft or satellite towards the earth interact with and are altered by characteristics such as the shapes, structures and moisture conditions present. These signals are reflected back, recorded at the sensor, and processed into digital imagery. Since radar is an active sensor providing its own illumination (as opposed to relying on the sun), it can acquire imagery under low-light conditions (such as those in Canada's north during the winter) and through clouds. The Canadian Space Agency and industry have partnered to build and operate Canada's first remote sensing satellite, RADARSAT-1. Building upon this first satellite technology, RADARSAT-2, to be launched in the coming years, is a significant advancement in technological

SAMPLE EOSD LAND-COVER CLASSIFICATION PRODUCT OF NECHAKO RIVER, B.C.



capability, with better resolution and multiple polarizations. Its advanced capabilities will require new and more sophisticated analysis methods.

An objective of research into radar by the CFS is to aid the Canadian forestry community in receiving the maximum benefit possible from radar satellites. The forest sector has potential for the application of radar data for forest management (e.g., for mapping land cover and forest change). The advanced capabilities of RADARSAT-2, if developed and transferred appropriately, may play a role in biomass estimation and forest mapping, especially in conjunction with optical satellite sensors.


MOUNTAIN PINE BEETLE DEVASTATION IN BRITISH COLUMBIA

SATELLITE APPLICATION: MAPPING OF MOUNTAIN PINE BEETLE INFESTATION

The current mountain pine beetle outbreak in British Columbia has reached historic proportions (http://mpb.cfs.nrcan.gc.ca). The extent of the outbreak, the rapid rate of its spread and the associated economic impacts have prompted research into new techniques and data sources for reconnaissance and mapping of the infestation. Trees in the red attack stage of infestation have a distinctive red colour, which facilitates their detection by remote sensing instruments. Currently available commercially, high-spatial-resolution satellite data presents opportunities for cost-effective collection of accurate, consistent and timely information on mountain pine beetle impacts. IKONOS multispectral imagery has been used to detect mountain pine beetle red attack at a study site near Prince George, British Columbia. Independent calibration and validation data were collected from 1:20 000 scale aerial photography and used to assess the accuracy of a resulting red attack map. When the results were compared to the independent validation data collected from the aerial photography, it was found that 70 percent of lightly infested and 92 percent of moderately infested red attack sites were correctly identified through the classification of the IKONOS imagery.


RED ATTACK AS SEEN FROM AN IKONOS 4-METRE MULTISPECTRAL SATELLITE IMAGE.

HYPERSPECTRAL REMOTE SENSING OF FORESTS

Whereas multispectral sensors typically record reflected light in several broad channels, hyperspectral sensors collect data over a broad spectrum of hundreds of narrow channels. On Canada's west coast, the CFS has demonstrated that hyperspectral imagery can be used to derive maps of forest species (such as Douglas fir and hemlock) where multispectral data can typically only distinguish between forest types (conifer, deciduous, mixedwood). Methods of assessing forest health are being developed by mapping leaf chlorophyll and water content. Foliar nitrogen is also an indicator of forest health: strong relationships have been demonstrated between ground measurements of foliar nitrogen and estimates derived from hyperspectral sensing.

The detailed spectrum of hyperspectral data adds a new dimension to forest mapping by making it possible to generate new products in the areas of forest inventory, forest chemistry and forest health.

BOREAL FRESH WATERS

Canada's boreal landscape contains more lakes and rivers than any equivalent land mass on earth. Although the boreal forest has been estimated to include over 1.5 million lakes with surface areas larger than four hectares, no actual inventory has been done. Many of Canada's major river systems pass through the boreal region, including the Athabasca-Peace-Slave-Mackenzie system, and the Churchill and Nelson rivers along with many of their tributaries. The surface area of some parts of the boreal is more than 25 percent water. The world's boreal region also contains vast tracts of wetlands.

The boreal region of Canada contains both soft-water and hard-water lakes and rivers. Soft-water lakes are set in ancient igneous rock of the Canadian Shield, where mineral weathering is low, and the water is similar to rainwater in its chemistry. The soft-water ecosystems occur east of a line that roughly connects the centres of Canada's largest lakes: Great Bear Lake, Great Slave Lake, Lake Athabasca and Lake Winnipeg. All of these lakes have important cold-water sport fishing or commercial fisheries.

To the west of the line, lakes and rivers are set in limestone or sandstone, and generally have hard water. These lakes are shallower than the soft-water lakes, and some are much more productive. Most of the soft-water lakes are oligotrophic (unproductive and low in plant nutrients) in their pristine condition, although many are slightly yellowish in colour as the result of receiving water that has passed through extensive peatlands. Hard-water lakes tend to be eutrophic (productive and rich in plant nutrients), even without human nutrient sources.

There is a strong gradient in precipitation across the boreal region, from very dry conditions in western Canada to humid conditions in the east. In the west, where the Rocky Mountains provide a rain shadow, precipitation can average as little as 400 millimetres per year. The amount increases gradually eastward—1 000 to 1 500 millimetres falls in some parts of eastern Canada. On average, about a third of all annual precipitation falls as winter snow. As a result, river flows and lake levels are usually highest in spring, when the snowpack melts.

FISH POPULATIONS

Most boreal systems contain cold-water species, such as the glacial relicts lake trout, several species of whitefish, and cisco. A number of glacial relict invertebrates share cold-water habitats, including some large crustaceans. In southern parts of the boreal region, where surface waters reach summer temperatures of over 16 degrees Celsius, these species are confined to cold deep waters during the summer. Through much of the southern region of the boreal, warm-water species occur as well. Sport fish include walleye, northern pike, muskellunge and smallmouth bass. In the western boreal streams, mountain whitefish, arctic grayling and bull trout are found.

Boreal aquatic systems contain simple communities. Production of fish is limited by cold water for much of the year and is generally low; many species require 6 to 10 years or more to reach reproductive size. However, some sport fish can reach large sizes by living 20 to 50 years or even longer. As a result of the slow growth rates, boreal fisheries are susceptible to over-exploitation.

DISTURBANCES AND THEIR EFFECTS

Boreal lakes and streams are threatened by a number of human-initiated activities and events, including climate warming, acid precipitation, over-exploitation, nutrient pollution (eutrophication), pollution with mercury and pesticides, and chemical discharges from pulp mills, oilsands developments, base metal mining and other industries.

Climate warming

In western Canada, boreal lakes are threatened in several ways by climate warming. Many of the glacial relict species are near their thermal limits under normal conditions, and a few degrees of warming could cause them to decline or disappear, particularly in large, shallow, windswept lakes where no thermoclines (colder layers of water) develop to provide midsummer cold-water refuges. The watersheds of western lakes become much more susceptible to fire under warmer, drier conditions, and increased fire can cause increased run-off of nutrients and of mercury and other chemicals that are normally sequestered by terrestrial vegetation.

Temperature increases in the western boreal regions as predicted by global climate models could cause an increase in evapotranspiration (evaporation from the land and transpiration from the plants) beyond the level of precipitation, so that the western boreal could be warmer and drier in the future. This would cause river flows and lake levels to decline, and consequently retain more of the chemical substances that enter them. In dry southern parts of the western boreal, the warm climate and drought of the 1990s has already caused some lake outlets to cease flowing, resulting in increased salinity of the lakes.

Acid precipitation

Acid precipitation is a threat largely in eastern Canada, where prevailing winds carry sulphur and nitrogen oxides from industry and transportation in southeastern Canada and the northeastern United States over the soft-water lakes of the Canadian Shield, which have little resistance to acidification. Thousands of lakes and streams were acidified in the late twentieth century, resulting eventually in the regulation of sulphur oxide emissions. The regulations have allowed some lakes to recover. However, many lakes remain acidified, and soil fertility in some areas is threatened by the combination of forest harvesting and acid precipitation, both of which cause the loss of critical calcium from forest soils and fresh waters. In order to recover significant additional lakes, both sulphur oxides and nitrogen oxides must be reduced further. This will require reducing emissions from power plants, smelters and automobiles.

In western Canada, acid rain may become a regional problem downwind of the Alberta oil sands, where rapid development of bitumen extraction industries is expected to cause large increases in the emission of sulphur and nitrogen oxides in the next 20 years. The soft-water lakes and streams of northern Saskatchewan are most vulnerable.

Other disturbances

Industrial pollution, over-exploitation and eutrophication are still confined largely to the southern boreal, near large human populations and industrial developments.

Effluents from the many pulp mills in the southern boreal were poorly regulated until the mid-1990s, and resulted in contamination of fish in nearby rivers. However, recent regulations and technological developments have lessened this problem.

Greater ease of access to remote lakes has exposed boreal lakes to increased exploitation. The problem is especially acute in Alberta, where over 3 million people share only a few hundred fish-bearing lakes. In many lakes walleye fisheries have collapsed, and pike fisheries are greatly overfished. Lake trout have been totally eliminated from some lakes, including huge Lesser Slave. The proliferation of roads, seismic lines and trails, and the development of modern four-wheel-drive vehicles, all-terrain vehicles and snowmobiles, allow easy access for fishermen all year. Technological developments such as GPS, SONAR, underwater cameras, improved fishing lines, more powerful outboards and better lures also contribute to the increased exploitation.

Eutrophication (overfertilization) of lakes occurs when nutrients from the land flow into lakes, and the resulting abundance of plant life deprives animal life of oxygen. Eutrophication of boreal waters is occurring as a consequence of nearby land clearing, cottage development, changing land use and urbanization. Where cleared lands are turned into pastures or agricultural fields, manure and commercial fertilizers cause even greater run-off of nutrients. Typically, drainage of wetlands and destruction of riparian areas allow more of the mobilized nutrients to reach lakes and streams. Within a few hours' drive of major population centres like Toronto, Montréal, Winnipeg and Edmonton, extensive cottage developments on lakeshores can also cause eutrophication problems. Poorly installed and poorly maintained septic tanks, as well as lawn fertilizer, pet excrement and the destruction of natural shoreline vegetation, allow increased nutrient inputs to lakes.

Boreal lakes, rivers, streams and wetlands provide key ecological functions for wildlife in the boreal region. To protect the future of boreal waters and communities, stronger national and provincial water policies are needed to manage and mitigate disturbances such as climate warming, acid precipitation, over-exploitation and pollution.

Dr. David Schindler
University of Alberta

BIRDS IN CANADA'S BOREAL FOREST: NEW PARADIGMS FOR PARADISE FOUND

At the dawn on a late May morning, the air in the boreal forest is cool and still. As the sun begins to filter through the trees, the voices of sparrows and flycatchers, warblers and thrushes begin to build to a glorious cacophony of song. This is the bounty of the boreal forest, home to as many as five billion landbirds. The mosaic of habitats that constitute the boreal forest stretches over half of Canada, creating one of the most diverse areas for forest birds in North America. With the largest area of wetlands of any ecosystem in the world, the boreal forest is also breeding ground for 12 to 14 million waterfowl and untold millions of shorebirds.

Most of these birds arrive each spring, taking advantage of the flush of insects available to feed their young. Coping with sometimes harsh weather and predation pressures, they raise one or two clutches of young before flocking up to return south to the United States and beyond. Other species—woodpeckers, chickadees and nuthatches—live in the boreal forest year-round. These resident species have unique physiological adaptations that allow them to withstand the extremes of winter. For instance, Black-capped Chickadees can survive an eight-degree Celsius drop in body temperature during cold winter nights by entering nocturnal hypothermia, a sort of temporary hibernation. In spring they breed earlier than their migratory counterparts, giving their young more time to develop before the onset of winter.

Canada's boreal is one of the last large intact forested ecosystems on earth. Given its vast size and relative remoteness, little scientific work has focused on boreal birds. From the limited information available on population status of boreal birds, it appears that at least 40 species are experiencing widespread population declines. These declines are distributed across species of landbirds, waterfowl such as Lesser Scaup and American Black Ducks, and shorebirds such as Solitary Sandpipers and Short-billed Dowitchers. One species associated with forested wetlands, the Rusty Blackbird, has declined by a spectacular 85 percent over the last 40 years. Identifying the causes of declines in species that breed in boreal forests but migrate south of the Canadian border is difficult. Human activity in boreal forests may be a contributing factor, and this is cause for concern among forest managers and conservationists.

While many Canadians may immediately think of forestry as the largest source of pressure on boreal forests, the sources actually vary across its geographic extent. In the western sedimentary basin, the area of timber cut annually by the oil and gas industry during exploration and extraction activities approaches that harvested by forest companies. Agricultural conversion eats away at the southern fringe of the boreal. In other areas, mining and hydro-electric power generation can create long-term sources of forest loss. The institutions established to manage these sectors were never designed to deal with the cumulative effect of all these activities, much less longer-term uncertainties such as the impacts of climate change. This burden adds to the challenge of environmentally constraining the efforts from which we expect continued economic growth.

BLACK-CAPPED CHICKADEE © J. David Andrews

Boreal forests are generally resilient systems, continually regenerating from natural disturbances such as fire and insect outbreaks. Researchers currently have little sense of how much human activity the boreal forest can withstand over time. Some habitats for boreal birds are more vulnerable to human activity, particularly those that require time and natural processes to create. Old-growth mixedwood forests hold the most diverse communities of forest birds of all forest ages, but current forest management encourages younger stand ages. Newly burned forests have a unique complement of bird species owing to the abundance of standing burned timber and resulting beetle infestations, but these stands are also targeted for salvage harvesting operations. Wetland and bog complexes have a complement of species very different from the upland; such areas are important for myriad waterfowl, waterbirds and shorebirds. These are all habitats that must be thoughtfully managed; however, conservation of boreal forests will not be achieved through protection of local "hotspots." If the wealth of the boreal is in its spatial extent and the natural disturbances that maintain it, we cannot rely solely on areas of locked-up land to protect it. The boreal forest challenges us to think holistically about conservation planning, beyond the bounds of any one tenure, park or political jurisdiction.


AMERICAN BLACK DUCK ©Ducks Unlimited

Within the working landscape, some forest managers are adopting harvesting practices that attempt to emulate natural disturbances such as wildfire. This affects the size and shape of areas harvested, as well as the pattern of trees and vegetation that are left to grow within those areas. Retaining live trees and patches of trees within cutblocks may provide some habitat value for forest birds immediately following harvest. Greater value is achieved as these tree patches age and provide "old-growth" characteristics in younger, regenerating stands. Riparian areas are another area of increasing research interest. Fires can burn to the edge of a waterbody; thus, in some jurisdictions, the desire to emulate natural disturbance has spurred the creation of new regulations for harvesting in riparian areas.

Success of the natural disturbance paradigm for harvesting will come from recognizing that not all aspects of wildfires can be emulated. Harvesting to emulate the action of wildfire suggests larger cutblocks and harvesting in riparian areas, but it also means retention of trees, both within a cutblock and as whole stands, where the interval between harvests is extended or the stand is removed from harvesting for a rotation. This paradigm is best applied using active adaptive management—management strategies that test new practices and maintain flexibility to apply new insights as they are acquired.

As we move towards conservation planning for boreal forests and the birds that live there, certain core information needs must be addressed. Environment Canada's Western Boreal Conservation Initiative (WBCI) was launched to engage with stakeholders and others interested in conservation of boreal biodiversity. (For more information, visit http://www.pnr-rpn.ec.gc.ca/boreal.) WBCI is supporting the development of a national boreal bird monitoring program that will work in partnership to provide information on species distributions, status, population trends, and habitat associations over a landscape that has historically been difficult to access.

In the shorter term, modelling techniques can estimate where birds are located and which habitats they rely on. A national-scale project is being developed in partnership between WBCI and Boreal Ecosystems Assessment of Conservation Networks (BEACONs), the science platform for the Boreal Conservation Framework developed by the Canadian Boreal Initiative and its partners. Key to this project's success is cooperation and collaboration with avian ecologists working in boreal forests across Canada. With further work, this project will also test management scenarios and their implications for boreal bird populations. In addition, it will inform a conservation framework that BEACONs is developing for Canada's boreal forest.

The challenges facing the boreal forest and its avian populations are widespread and pressing, but the opportunity to effect change is unprecedented. And the bird songs in the dawn forest should serve to remind us why our efforts will be worthwhile.

Samantha J. Song, Ph.D. and Kevin C. Hannah, M.Sc.
Western Boreal Conservation Initiative
Canadian Wildlife Service, Environment Canada

NON-TIMBER FOREST PRODUCTS AND SUSTAINABLE DEVELOPMENT IN THE BOREAL FOREST

Non-timber forest products (NTFPs) are botanical products, excluding wood, that grow in forests and that can be used as food, medicine or ornaments or for industrial purposes. Examples of these products include maple sap, mushrooms, herbs, pine cones, resins and natural dyes. Some definitions include services that forests provide (such as recreation and tourism); still other definitions consider the scale of the operation and whether the product originates from natural forests, plantations or agroforestry operations.

Today, nearly 500 types of NTFPs are commercially traded in Canada. These products differ widely in their characteristics and in where they come from, how they are produced and how they are used. Generally, NTFPs fall into four categories: food, natural materials and manufacturing, health and personal care, and decorative and aesthetic (see table on page 76 for examples of products from each category). In Canada maple syrup, mushrooms and berries dominate—although the demand for nutraceuticals (natural dietary supplements), ornaments (such as pine cones) and other products from boreal forests is growing.

CHANTERELLES

According to researchers at the Canadian Forest Service (CFS), traditional NTFP industries have the potential to contribute $1 billion to the Canadian economy (see table on page 75 for current economic value of selected products), although the exact value of Canada's NTFPs is not known. There is also huge potential for growth in value-added industries. Edible mushrooms provide another example—exporting this product could, in the future, contribute as much as $115 million to the Canadian economy.

CONSERVATION AND SUSTAINABLE USE

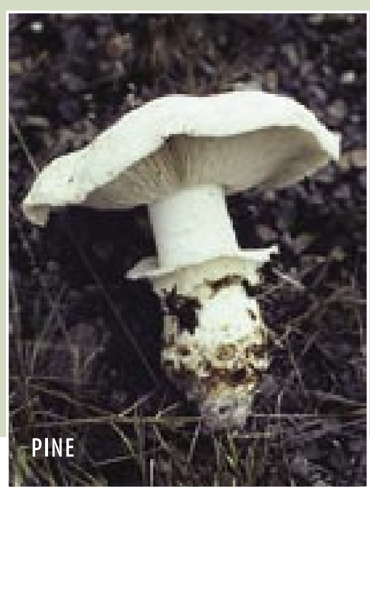
Until the 1992 Rio Conference on Environment and Development focused attention on the need for forest products other than wood and for ecosystem-based management and sustainable development, management of boreal forests was concerned almost exclusively with wood values. Ongoing efforts to link conservation of

MOREL

Wild Mushrooms: A Developing Resource from Boreal Forests

The moist floor of a boreal forest is an ideal habitat for mushrooms. Pine mushrooms, chanterelles and morels are most often collected in boreal forests. These mushroom species have the best-established commercial markets, ranging from local restaurants to commercial operations, where harvesters pick the mushrooms for grading and shipping to markets across Canada and internationally, notably in Europe and Asia. In Japan, the pine mushroom is a delicacy, known for its aromatic odour, particular texture and taste, and can command a price of about $400 per kilogram.

Many of the important commercially hunted forest mushrooms form a symbiotic association with the roots of some tree species to form a new structure, called mycorrhiza (fungus-root). It may be possible to enhance the growth of mycorrhizae through the inoculation of seedlings (or other forest management practices), and in this way combine wood fibre and non-timber production.



PINE

Estimated Current Output of Selected Non-Timber Forest Products in the Canadian Economy*		
NTFP	**Output in tonnes or litres (thousands)**	**Current economic value (thousand $)**
Honey	37 072	160 805
Tree saps	34 761	163 968
Berries	149 373	278 654
Mushrooms	1.14	43 000
Understorey plants	2.30	75 321
Wild rice	1 013	3 492
Total		

* Calculations based on extrapolated data from S. Wetzel et al., *Bioproducts from Canada's Forest: New Partnerships in the Bioeconomy*. In preparation.

biodiversity and economic development have also helped stimulate interest in NTFPs both in Canada and internationally.

There is much we do not understand about the shrubs, herbs and fungi that are being considered for development as NTFPs. This lack of knowledge makes it difficult to assess the sustainability of harvest and to develop management plans. Any harvesting has some effect on an ecosystem, but the extent of the impact depends on many factors. These factors include the amount of material harvested, the intensity and frequency of harvesting, the plant part used (effects are more severe when roots, fruits or reproductive structures are harvested), and how well the habitat and the plant recover following harvesting (some habitats are more fragile than others). Experience with NTFP harvesting in tropical forests has shown the importance of careful management, regeneration and a sustainable level of harvest. Climate change and other effects from pollution and anthropogenic activities can also increase the impacts of harvesting.

Monitoring the harvested species and their interactions with other species is important in determining the harvesting impact. Monitoring also ensures that commercial harvesting does not lead to declines in availability of wild stocks. For example, field studies to determine the potential yields from wild ginseng found that ginseng populations of less than 170 plants could not be harvested sustainably at all, and populations larger than 170 plants have a sustainable yield of only 30 to 90 plants. Since most patches of wild ginseng are smaller than 170 plants, the research showed that harvesting wild ginseng is not ecologically or economically viable.

MARKETS AND ECONOMIC POTENTIAL

Widespread economic interest in NTFPs of boreal forests in Canada is relatively new, but the National Forest Strategy is committed to stimulating the development of these products and services. CFS researchers have reported that, over the last couple of decades, exports of non-timber and value-added products have increased more than exports of conventional wood and paper products.

Economic analysis plays a major role in determining whether a new NTFP has the potential to be harvested profitably in an environmentally sustainable setting. The evaluation must address issues surrounding harvesting methods and time frames, prices, markets, their locations and access to them. To add to the challenge of the analysis, many non-timber products have no defined market value, and the prices assigned to the products may not reflect true economic values.

SOCIAL AND CULTURAL ASPECTS

Non-timber forest products offer social benefits and sometimes represent culturally significant activities for local communities. For many Aboriginal and rural communities, the harvest of medicines, berries, bark and other forest goods is an integral part of life. Traditional ecological knowledge and management approaches—such as the use of fire and traditional harvesting techniques—are a part of their culture.

The Northern Forest Diversification Centre (NFDC) in Northern Manitoba has identified the development of an NTFP industry as a realistic, practical, income-generating opportunity that expresses local values, is based on local resources, and benefits local people. This opportunity is especially attractive for marginalized forest communities with the requisite local skills and knowledge. The NFDC model is working with the Centre for Non-Timber Resources at Royal Roads University in British Columbia to develop a Western Canadian NTFP Network from Manitoba to the Yukon. Future plans include expanding this community development model across the Canadian boreal forest, as a small but positive step in fighting poverty and developing a sustainable economy for many small forest communities in the north.

Examples of Food Products	Examples of Natural Materials and Manufacturing Products	Examples of Health and Personal Care Products	Examples of Decorative and Aesthetic Products
Berries	Adhesives	Aromatherapy oils	Christmas trees
Beverages	Alcohol	Cosmetics	Cone crafts
Essential oils	Candles	Drugs	Bark crafts
Flavouring agents	Cloth	Essential oils	Wood crafts
Herbs and spices	Essential oils	Herbal health products	Carvings
Honey	Fragrances	Nutraceuticals	Floral arrangements
Maple/birch saps—syrups, sugars, taffy, jelly, butters	Incense	Perfumes and fragrances	Wreaths, garlands, swags
Mushrooms	Resins	Pet care products	Natural dyes
Nuts	Specialty wood products	Shampoos	
Seeds	Stuffing material	Soaps	
Teas	Thread and rope		
Vegetables	Turpentine		

THE FUTURE

While NTFPs may be marginal forest resources, they have an array of benefits that are particularly attractive for boreal forests:

- **They are important both culturally and economically for the people who harvest them.**
- **Their harvest may lead to the formation of harvester co-ops or processing facilities.**
- **They may be complementary to other industries centred on the forest, such as eco-tourism.**
- **They may lead to the establishment of multi-species plantations providing enhanced value to forest owners through non-destructive harvesting coupled with fibre production.**

Realizing these benefits will require improved knowledge about NTFPs, their economic importance, their potential as a resource, and the science to manage the resource in a sustainable manner.

FOREST-ASSOCIATED SPECIES AT RISK: WHAT IS THE STATUS?

Approximately two thirds of Canada's estimated 140 000 species of plants, animals and micro-organisms are found in the forest. Each forest-associated species plays a unique role in forest ecosystems, but over 400 of them are currently at risk. In response to this threat, Canada's National Forest Strategy has identified the conservation of forest biological diversity as a priority. The revised Canadian Council of Forest Ministers' framework of Criteria and Indicators of Sustainable Forest Management (2003) provides eight indicators to assess the state of biodiversity within Canada's forests. One of the core indicators in this framework is the status of forest-associated species at risk.

A forest-associated species is one that is measurably dependent on a forest ecosystem for any aspect of its life history (included are indirectly dependent species which consume forest-based or derived resources). The status of forest-associated species is often used to monitor ecosystem and genetic diversity, forest structures and patterns, and key ecological processes. The status of these species serves as a barometer, since a decrease in a species population can signal an imbalance in a biological system that may damage the long-term health of our forests and lead to productivity losses.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent scientific committee, evaluates species suspected of being at risk. COSEWIC assigns national status designations to these species based on the best scientific information available. The COSEWIC national list of species at risk is divided into five categories, from "extinct" to "special concern." The current list includes 467 species (as of November 2004) and can be viewed at http://www.cosewic.gc.ca.

When a species is put on the COSEWIC List of Wildlife Species at Risk, the federal Cabinet consults with stakeholders and other groups before deciding whether it should be legally protected under the national *Species at Risk Act* (SARA). Currently, 306 species are on this Legal List in Schedule 1 of the act. Recovery strategies are prepared within a year after listing for the threatened species, and within two years for endangered and extinct species.

COSEWIC Status Categories

Category	Definition
Extinct	A species that no longer exists
Extirpated	A species no longer existing in the wild in Canada, but occurring elsewhere
Endangered	A species facing imminent extirpation or extinction
Threatened	A species likely to become endangered if limiting factors are not reversed
Special concern	A species that may become threatened or an endangered species because of a combination of biological characteristics and identified threats

Of the 467 COSEWIC-designated species, 305 (65 percent) are considered to be forest-associated, and 219 of these are protected under SARA's Legal List (as of January 2005). Of the forest-associated species reassessed by COSEWIC since 1999:

- 60 percent have the same COSEWIC status
- 17 percent have been moved to a higher risk category
- 1 percent moved to a lower risk category
- 22 percent are new species assessed by COSEWIC for the first time

COSEWIC does not currently document why species are transferred between categories, and therefore the data showing changes from one status category to another must be interpreted very carefully. Changes in status could be the result of new information rather than an actual improvement or deterioration in the status of the species.

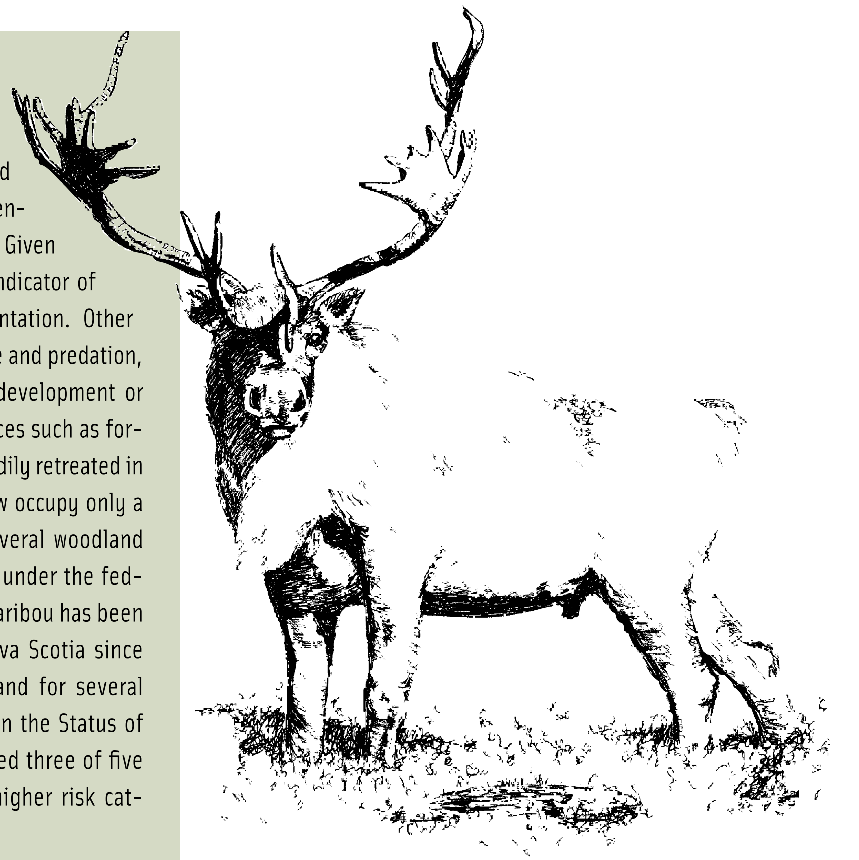
The map on page 79 shows the number of forest-associated species at risk protected under SARA in each of Canada's ecozones. The largest concentrations of these species are in the coastal forests of British Columbia (Pacific Maritime ecozone) and in the Carolinian forest of southern Ontario (Mixedwood Plains ecozone).

The map also shows that Canada's vast boreal forests (Boreal Cordillera, Boreal Plains and Boreal Shield ecozones) have relatively few species at risk. However, these evergreen forests provide habitats for some of Canada's best-known species, such as the grizzly bear, whooping crane and woodland caribou (see text box). Maintaining and recovering these boreal species is a prime objective of sustainable forest management.

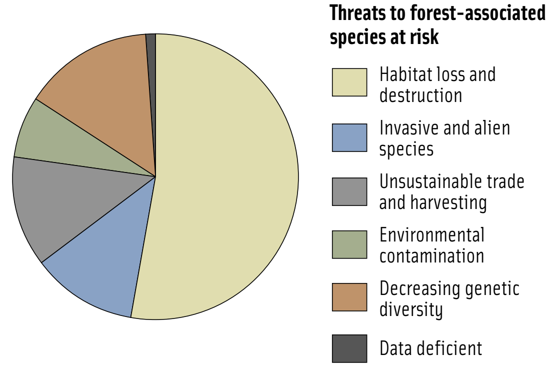
Woodland Caribou

The woodland caribou relies on relatively large and healthy areas of mature and old-forest habitat, making this species sensitive to fragmentation and habitat loss. Given such characteristics, this species is an indicator of forest connectivity and habitat fragmentation. Other pressures include illegal hunting, disease and predation, human disturbances such as industrial development or land use changes, and natural disturbances such as forest fires. The woodland caribou have steadily retreated in the face of human development, and now occupy only a small portion of their former range. Several woodland caribou populations are currently listed under the federal *Species at Risk Act*. The woodland caribou has been extirpated from New Brunswick and Nova Scotia since the 1920s and from Prince Edward Island for several centuries. Since 1999, the Committee on the Status of Endangered Wildlife in Canada has placed three of five populations of woodland caribou in a higher risk category following reassessments.

Provincial, national and international efforts to protect significant populations of the woodland caribou have been ongoing for over a decade. Many provinces have developed or are in the process of developing recovery and conservation strategies for this species. Conserving some of the most susceptible populations has proven to be challenging because they face numerous threats. Finding the right balance between environmental and socio-economic factors is key to the survival of woodland caribou.



Threats to forest-associated species at risk



Source: COSEWIC Status Reports

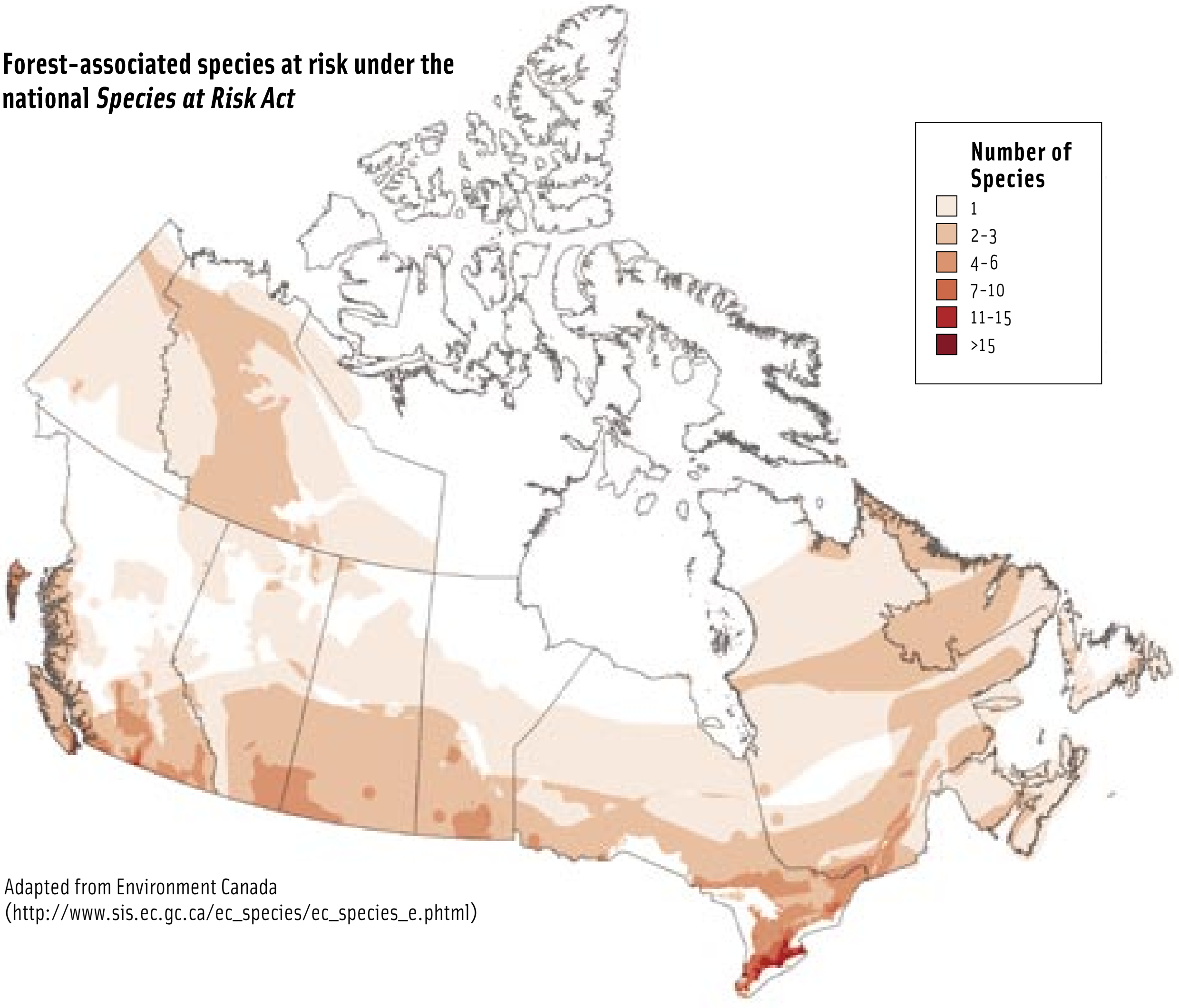
Management strategies need to be integrated and adaptive, ranging from strict protection (such as ecological reserves) to sustainable forest management (such as harvesting in a way that leaves individual trees or groups of trees for wildlife). To be successful, these strategies require support for monitoring, information managing and reporting.

There are many threats to species at risk, and sometimes particular species or populations decline because of a combination of these threats (see figure above). According to the COSEWIC status reports, the main threat to forest-associated species at risk is habitat loss or destruction. The protection of "critical habitat" under SARA brings a legislative tool to mitigate this threat. The act aims to protect places where a species at risk lives, feeds, breeds and raises its offspring. SARA's intent is to legally protect critical habitats as much as possible by supporting voluntary actions, stewardship measures and management practices that minimize habitat destruction.

Another major threat to biodiversity is decreasing genetic diversity, often called the invisible extinction. Genetic diversity allows species to adapt to changing environmental conditions, such as climate change, or to compete with an introduced invasive alien species. Despite increased detection efforts at Canada's ports of entry, these species are entering more frequently and their number is growing. The increased global movement of people and commodities is breaking down the major bio-geographical barriers that have, in the past, kept the flora and fauna from different continents distinct. Many aggressive species are now widely distributed around the world, and in some areas they exist in very high densities.

Canada, as a signatory country to the Convention on Biological Diversity, is committed to working towards significantly reducing, by 2010, the current rate of biodiversity loss at the global, regional and national levels. This initiative will help to alleviate poverty and benefit all life on earth. Tracking species at risk is only one aspect of monitoring biodiversity to determine whether we are approaching this target.

Forest-associated species at risk under the national *Species at Risk Act*



Adapted from Environment Canada
(http://www.sis.ec.gc.ca/ec_species/ec_species_e.phtml)