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STATUS OF THE CONSERVATION AND PROTECTION OF FRESHWATER BIODIVERSITY IN CANADA, WITH EMPHASIS ON THE GREAT LAKES

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Abstract

Recognition of the world-wide impact of the decline of biodiversity led to the negotiation of the United Nations Convention on Biological Diversity in 1992. Canada was the first industrialized country to ratify the Convention. Canada's response to the Convention, the Canadian Biodiversity Strategy (CBD), was released in 1995. The goals of the CBD include the conservation and sustainable use of biological resources, improving our understanding of ecosystems, promoting awareness of the need to conserve biodiversity, developing incentives and legislation to support conservation and sustainable use of biological resources, and working with other countries in these endeavours. Terrestrial organisms and ecosystems have received most of our attention to date; however, freshwater organisms are more impacted by human activities and more vulnerable to extinction than those found in other ecosystems. The purpose of this report is to draw attention to the plight of freshwater organisms in Canada and North America and to encourage the direction of further conservation efforts towards this group. The report explains why we should be concerned about conserving and protecting freshwater biodiversity in Canada; lists the principal threats and describes several in detail (pollution, harmful alien organisms and climate change); and outlines Canada's commitments to the Convention (e.g., the CBD, Accord for the Protection of Species at Risk, U.S.-Canada Framework for Cooperation in the Protection and Recovery of Wild Species at Risk, legislation). The report also discusses how Canada is meeting these commitments with respect to freshwater biodiversity, including the roles of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Recovery of National Endangered Wildlife program (RENEW), the General Status of Wild Species in Canada initiative, the new Species at Risk Act, the Federal Biosystematics Partnership and Biodiversity Knowledge and Innovation Network, and the North American Commission for Environmental Cooperation. Finally, the report provides a brief assessment of how we are doing, including several accomplishments and some of the work that remains to be done.

Résumé

La reconnaissance de l'impact mondial du déclin de la biodiversité a mené à la négociation de la Convention sur la diversité biologique des Nations Unies en 1992. Le Canada a été le premier pays industrialisé à ratifier la Convention. La réponse du Canada, la Stratégie canadienne de la biodiversité (SCB), a été lancée en 1995. La SCB a pour objectifs la conservation et l'utilisation durable des ressources biologiques, une meilleure connaissance des écosystèmes, la promotion de la sensibilisation au besoin de conserver la biodiversité, l'élaboration d'incitatifs et de lois favorisant la conservation et l'utilisation durable des ressources biologiques, et la collaboration avec d'autres pays. Jusqu'à maintenant, notre attention s'est portée principalement sur les organismes et les écosystèmes terrestres; or, les organismes dulcicoles sont plus affectés par les activités humaines et plus vulnérables à l'extinction que les organismes d'autres écosystèmes. Le présent rapport a pour objet de souligner la situation critique des organismes dulcicoles au Canada et en Amérique du Nord et d'encourager la coordination d'autres efforts de conservation. Le rapport explique pourquoi nous devrions nous préoccuper de la conservation et de la protection de la biodiversité des milieux dulcicoles du Canada; énumère les principales menaces et en décrit plusieurs en détail (pollution, organismes exotiques nuisibles et changement climatique); donne un aperçu des engagements du Canada aux termes de la Convention (SCB, Accord pancanadien pour la protection des espèces en péril, Cadre de coopération entre l'U.S. Department of the Interior et Environnement Canada pour la protection et le rétablissement des espèces sauvages en péril, lois). Le rapport analyse également la démarche adoptée par le Canada pour respecter ses engagements touchant la biodiversité des milieux dulcicoles et étudie les rôles du Comité sur la situation des espèces en péril au (COSEPAC), de Rétablissement des espèces canadiennes en péril (RESCAPE), de l'initiative Situation générale des espèces au Canada, de la nouvelle *Loi sur les espèces en péril*, du Partenariat fédéral en biosystématique, du Réseau de connaissances et d'innovation pour la biodiversité et de la Commission nord-américaine de coopération environnementale. Enfin, le rapport fournit une courte évaluation de nos progrès, de plusieurs de nos réalisations et de travaux qu'il reste à accomplir.

Status of the Conservation and Protection of Freshwater Biodiversity in Canada, With Emphasis on the Great Lakes

What is Biodiversity?

Biological diversity or "biodiversity" is not a new term to ecologists, having first appeared in the literature in the mid-1980s. Usage of the term has since increased among scientists, policy-makers and members of the public, especially following the successful negotiation of the United Nations Convention on Biological Diversity in 1992 (Ghilarov 1996). Many variations of the term biodiversity have been published (Callicott *et al.* 1999), as the term can mean different things depending on the focus and goals of the individual (Noss 1990). However, the most widely used definition of biodiversity is the variety of life and its processes, encompassing genetic, species, assemblage, ecosystem and landscape levels of biological organization and their structural, compositional and functional components (Hughes and Noss 1992).

Conserving and Protecting Freshwater Biodiversity – Why should we be Concerned?

According to the Canadian Biodiversity Strategy (Environment Canada 1995), the decline of biodiversity has been recognized as "...one of the most serious global environmental threats now facing humanity." Ecosystem, species and genetic diversity are being reduced, largely by human activity, at an unnaturally rapid rate. The current pace of global species extinctions is believed to be 1000 to 10,000 times greater than natural - approximating the rates that defined boundaries between geological eras when massive alterations in the Earth's biota occurred (Winter and Hughes 1997). Without intervention, 25% of species on Earth are expected to disappear within the next 100 years. Keeping in mind that only a tiny portion of the Earth's species have even been identified, and less than 1% of these have been studied (Wilson 2000), species that may be of great importance to the functioning of ecosystems or have great potential for human use (e.g., new pharmaceuticals, potential agricultural crops, genes for genetic engineering) may be lost before we even know about them. The decline in biodiversity presents a serious problem for the health of natural systems, as diversity makes up the key working parts of a functioning ecosystem (Ehrlich 1992). The loss of diversity can also affect an ecosystem's stability, predictability and resistance to invasion (see Cadmore 1999).

The loss of species from tropical rainforests has received a lot of media attention. By contrast, little attention has been given to species losses in freshwater ecosystems. Yet the popular view that terrestrial species are more at risk than aquatic species is a myth. Freshwater habitat is a precious commodity, as only 0.01% of the earth's water is available as freshwater (Stiassny 1996). According to The Nature Conservancy (2002), freshwater organisms in North America have, as a whole, been far more impacted by human activities than terrestrial organisms. In fact, a report by The H. John Heinz III Center for Science, Economics, and the Environment (2002) states that freshwater organisms in the United States are twice as vulnerable to extinction as

those found in other ecosystems. Thirty-seven percent of fishes, 51% of crayfishes and 40% of amphibians in that country are at risk of extinction, as compared with only about 15% of birds and mammals (Master *et al.* 1998). Ricciardi and Rasmussen (1999) used an exponential decay model to derive recent and future extinction rates for North American freshwater fauna. They projected the mean future extinction rate for freshwater faunas to be about 4% per decade, which is five times greater than the rate for terrestrial fauna and three times the rate for coastal marine mammals. Ricciardi *et al.* (1998) estimated that the invasion of the Mississippi River basin by zebra mussels (*Dreissena polymorpha*) has increased freshwater mussel extinction rates in that system by 10-fold, from about 1.2% of species per decade to 12% per decade. It is important to recognize the differences in biodiversity within aquatic and terrestrial systems and to develop conservation approaches appropriate for the system (Mass 2000).

In the United States, nearly half of all freshwater turtle species require conservation action, while up to a third of amphibian species exhibit or are suspected of having declines (Bury 1999). Canada's freshwaters support a rich diversity of species, over 200 of which are fish alone (N.E. Mandrak and B. Cudmore-Vokey, unpublished data), and examples of freshwater biodiversity concerns are numerous. For example, of the five cisco species endemic to the Great Lakes system, two have become extinct and the remaining three are at risk. At the present time, 77 species of freshwater fish have been designated as Canadian Species at Risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and 33 others are on COSEWIC's Candidate List for assessment as time and resources allow (http://www.cosewic.gc.ca). Freshwater mussels are the most imperiled of all aquatic organisms, with 67% of North American species vulnerable to extinction or already extinct (Master *et al.* 1998). Of the 54 freshwater mussel species native to Canada, five have been designated as endangered and one as extirpated, six are currently under evaluation, and 16 others are on the Candidate List. Thus, fully one-half of Canada's freshwater mussel species are believed to be potentially at risk

Amphibian biologists have had much success in attracting worldwide attention to the declining amphibian crisis. This attention is mostly a positive development, since "Publicity is vital to conservation efforts and the level of protective measures usually reflects the amount of public concern" (Bury 1999). However, amphibian losses in the United States, for example, are no greater than losses from other freshwater groups. As Bury (1999) emphasizes, there is no point in arguing which taxa are the best indicators, rather, we must move to protect their habitats and "...recognize the broader implication that entire aquatic faunas are in danger of collapsing."

What are the Threats to Freshwater Biodiversity?

Loss of biodiversity is usually associated with human population growth and over-consumption of resources (Winter and Hughes 1997). The principal threats to Canada's biodiversity include the continued permanent alteration of ecosystems and habitats, introduction of harmful alien species, degradation of ecosystems from pollution and other factors, global climate change and other atmospheric change, and non-sustainable harvesting practices (Environment Canada 1998).

The American Fisheries Society's position statement on biodiversity provides a detailed list of current threats to aquatic communities, including: in-channel modification; construction of dams

and reservoirs; riparian and wetland alterations; water diversion and withdrawal; point source and non-point source pollution, including siltation and nutrient loading; introduction of non-native species and stocks; hatcheries; over-harvesting; acid rain; global atmospheric change; increased UV radiation; and interactions among one or more of these stressors (Winter and Hughes 1997). The previously mentioned Great Lakes endemic ciscos were an important commercial species in the early 1900s, and their present state is an example of the dangers of over-harvesting. Allan and Flecker (1993) identified six major factors that threaten species and ecosystems in rivers and streams. Five are included in the above list (habitat loss and degradation, exotic species, chemical and organic pollution, and climate change), but to these they added secondary extinctions. Secondary extinctions occur when the removal of one species has cascading effects throughout the species assemblage such that species not directly affected by the original insult become impacted. The main mechanism is through the food web, where the removal of species will have different effects depending on the number of connections within the ecosystem (Dunne *et al.* 2002). This phenomenon may be more likely to occur in temperate and northern climates, such as those in Canada, where there are fewer species to begin with and, thus, less redundancy and fewer food web connections in the system.

According to The Nature Conservancy, three of the many threats to freshwater species and their habitats stand out at the present time: non-point source pollution, primarily sedimentation; competition from and predation by non-native species; and dams, which seriously alter the flow, temperature and nutrient content of waterways, physically change river channels, and pose as barriers to species dispersal (Master *et al.* 1998). Many fish species in Canada have been seriously impacted by dams, which prevent their migration to spawning habitat. The unique landlocked population of Atlantic salmon found in Lake Ontario was decimated around the turn of the century, in part because of their inability to reach the spawning grounds (Cudmore 1999). Examples of the staggering changes that have already taken place in aquatic communities and their habitats across North America are (from Allan and Flecker 1993; Winter and Hughes 1997; and Ricciardi and Rasmussen 1999):

- 81% of fish assemblages in the United States are impaired, mainly due to agriculture.
- 25-50% of freshwater fishes caught by anglers in the United States are from introduced populations.
- only 25-46% of riparian plant communities remain in near-natural condition.
- only about 40 rivers more than 200 k long in the United States remain free-flowing.
- the total amount of diverted flow due to hydroelectric power in Canada, if combined, would constitute the third largest river in the country.
- 24-82% of lakes in heavily settled areas are eutrophic.
- the river-floodplain biotope that once supported the greatest diversity of biota in large, lowland rivers has virtually disappeared from the planet.

Three of the major threats to freshwater biodiversity are expanded upon below: pollution, the introduction of non-native invasive species, and climate change.

Pollution

During the early part of the 20th century, chemical pollution from acid mine drainage, agricultural runoff, and untreated domestic and industrial effluents, were responsible for the mass destruction of aquatic communities in North American rivers (e.g., Bogan 1993). According to Neves *et al.* (1997), eutrophication was the primary water problem in the 1980s. Sewage treatment has greatly improved over the years, such that the major threats to riverine communities today are believed to be high loads of sediment, nutrients and toxic chemicals from non-point sources, especially agriculture (e.g., Strayer and Fetterman 1999 for freshwater mussels). Neves *et al.* (1997) reported that levels of nitrates, chloride and metals in North American rivers are all increasing due to the increased use of fertilizers and road salt. It should be noted that sewage may again become a serious problem due to continuing population growth. For example, water quality in the Grand River, a major tributary to Lake Erie in southwestern Ontario, has dramatically improved in recent years as a result of improved sewage treatment. Freshwater mussel populations in the lower river have rebounded from only 6 species in the early 1970s to over 20 species at present (Metcalfe-Smith *et al.* 2000). The human population in the watershed doubled from 375,000 in 1971 to 787,000 in 1996, and is expected to grow by another 300,000 people over the next 25 years. According to the Grand River Conservation Authority (1997), "There is a serious question of river capacity to receive additional wastewater at reasonable cost in response to population growth."

Sediments are cited as the number 1 pollutant of rivers in the United States, impairing more than 40% of the country's river miles (U.S. EPA 1990, cited in Brim Box and Mossa 1999). The next most significant pollutant (not stated) is said to affect perhaps 25% of river miles. Miller *et al.* (1989) estimated that chemical pollution played a role in 38% of the known North American extinctions of fishes during this century. Allan and Flecker (1993) contend that "...it is doubtful that any river-dwelling species has been driven extinct by chemical pollution alone." However, chemical pollution can be a serious problem for species with highly restricted ranges.

Introduction of Non-native Invasive Species

According to Strayer (1999), "The movement of alien species is one of the most pervasive, most influential, and least reversible of human effects on natural communities and ecosystems." Hundreds of new species enter North American waters every year, many with devastating consequences. More than 100 aquatic species have been introduced, with varying degrees of success, in the Great Lakes basin (Winter and Hughes 1997). Approximately 10% of Canada's 230 resident species of freshwater fish are "exotic" species (CESCC 2001). Although there have been many attempts to slow or halt the introduction of non-native species into Canadian freshwaters, it can be said with some certainty that the invasion will continue. Kolar and Lodge (2002) identified 26 fish species that they predicted, through modeling, would become established in the Great Lakes if introduced. There are many vectors that bring non-native species to freshwater ecosystems, including authorized stocking, invasion (natural migration or dispersal), construction of canals, aquarium releases, ballast water, aquaculture, and bait bucket and angler releases (Cudmore 1999).

Mechanisms by which non-native species detrimentally affect native species include competition, predation, hybridization, habitat alteration, and introduction of diseases and parasites (Allan and Flecker 1993; Strayer 1999). As stated earlier, the loss of biodiversity can negatively affect the resilience of an ecosystem (Cudmore 1999). The introduction of the Pacific salmons into the Great Lakes is a case in point. There were numerous unsuccessful attempts between the late 1800s and the 1930s to introduce Pacific salmon species to the Great Lakes. Scientists have speculated that these introductions failed because the community structure was relatively stable during this period - with little change in native biodiversity – and therefore resistant to these invaders (Spangler and Peters 1995; Cudmore 1999). Following a period of significant changes to the biodiversity of the Great Lakes, including the losses of top piscivores such as the lake trout (*Salvelinus namaycush*) and the invasion of other non-indigenous species such as the alewife (*Alosa pseudoharengus*), several Pacific salmon species finally became established in the system.

Two bottom-dwelling fishes native to the Black-Caspian Seas, the round goby (*Neogobius melanostomus*) and the tubenose goby (*Proterorhinus marmoratus*), were introduced to the Great Lakes in the mid-1990s. The more aggressive round goby proliferated rapidly and now occurs in all of the Great Lakes. Resulting impacts to the Great Lakes ecosystem are significant. Concerns about round gobies include their ability to outcompete a native bottom-dwelling species, the mottled sculpin (*Cottus bairdi*), for food, space and spawning sites. Mottled sculpin populations in Lake Erie have already been decimated (Austen *et al.* 2003). Round gobies also interfere with the reproduction of other native species such as lake trout (*Salvelinus namaycush*), lake sturgeon (*Acipenser fulvescens*) and possibly the greenside darter (*Etheostoma blennoides*), which is listed as a species of Special Concern in Canada, by feeding on their eggs. Two nationally Endangered freshwater mussels, the northern riffleshell (*Epioblasma torulosa rangiana*) and snuffbox (*Epioblasma triquetra*) may be indirectly affected, as sculpins and darters are important hosts for their larval stages (Staton *et al.* 2000; Watson *et al.* 2001). The ability of the round goby to transfer energy and contaminants from the benthos into the pelagic zone by consuming large amounts of dressenid mussels is contributing to changes in the food web and community structure of Lake Erie (Austen *et al.* 2003).

The introduction and spread of the exotic zebra mussel (*Dreissena polymorpha*) throughout the Great Lakes in the late 1980s has had a dramatic ecological and economic impact on the system. Austen *et al.* (2003) summarized the major changes to one of the most impacted systems, Lake Erie, as follows: loss of energy from the pelagic community to the benthic community; increased water clarity and light penetration resulting in increased growth of aquatic macrophytes and a decline in habitat for walleye; and increased contaminant uptake and bioaccumulation through the food web. The quagga mussel (*D. bugensis*) invaded Lake Erie more recently. It is displacing the zebra mussel in the eastern basin of Lake Erie and has started to colonize the western basin. Because of their abundance and tremendous filter-feeding capacity, dreissenids strip the water column of organic matter, leaving little for other bottom-dwelling fauna such as burrowing amphipods and native fingernail clams. The most spectacular impact of dreissenids has been on native freshwater mussels (Unionidae). Zebra mussels attach to the shell of a unionid, sometimes by the thousands, effectively starving the animal to death (Haag et al. 1993; Baker and Hornbach 1997). Native mussels have been nearly eliminated from Lake St. Clair (Nalepa *et al.* 1996), western Lake Erie (Schloesser and Nalepa 1994), the upper St. Lawrence

River (Ricciardi *et al.* 1996), the Rideau River (Martel *et al.* 2001), and the Detroit River (D.W. Schloesser, pers. comm.). Small remnant communities continue to survive in a few areas, but it is unclear if they will persist (see Zanatta *et al.* 2002 for a review). The Great Lakes historically supported the largest populations of many of Canada's native unionids, and the rivers and streams of the drainage basin now remain the last refuge for these species.

North America has 390 native crayfish species, representing about 75% of the world's total. This remarkable group of freshwater crustaceans is under serious threat from the introduction of non-native crayfish species (Lodge *et al.* 2000). The restricted ranges of crayfishes relative to other freshwater organisms (according to Taylor *et al.* 1996, 20 North American crayfish species are known from five or fewer locations on the continent) make them extremely vulnerable to competition with non-native crayfish. If even a small area is invaded by a non-native species, a large proportion of the native crayfish population could be affected. One of the threats from the introduction of non-native crayfish species is the alteration of ecosystem structure and function. Crayfish are an important part of the freshwater ecosystem, as they are significant consumers of benthic invertebrates, detritus, macrophytes and algae and are important forage for fish. Thus, the addition or removal of a crayfish species could lead to changes in fish populations, losses of biodiversity through food web connectivity (e.g., reduction in abundance or elimination of some macroinvertebrates) or other large ecosystem effects such as changes in the abundance of algae and macrophytes (Lodge *et al.* 2000). There is also the potential to introduce disease, as has already occurred in Europe with the introduction of North American crayfish and the accompanying crayfish plague (Lodge *et al.* 2000). Predation (consumption) and hybridization (reproductive interference) are also threats to native crayfish populations. Some non-native crayfishes are able to outcompete native species for food and shelter and are less susceptible to fish predation. The introduction of non-native crayfish has already contributed to the global extinction of at least one native North American crayfish species (Lodge *et al.* 2000)

Most other environmental problems in North America have been at least partly controlled, but this is not true for non-native invasive species. The development of effective prevention and control measures for non-native species will be a major challenge for the future.

Climate Change

Effects of climate change on aquatic biota are unpredictable due to the uncertainty regarding future climate scenarios and their ecological effects (Allan and Flecker 1993). Adverse effects are likely to be most serious at middle latitudes, where the greatest climate change is expected to occur. Increased temperatures will lead to reduced stream flows, drier soils and lower water tables, which in turn will result in less allochthonous organic material entering freshwater systems. As lower concentrations of dissolved organic carbon (DOC) are associated with clearer water and therefore greater UV light penetration, thermoclines in small lakes will deepen – changing the stratification of habitats in these systems (Schindler 2001). Although this scenario would mean more opportunities for warm-water fishes, the combined effect of the loss of summer refugia for cold-water species and competition for space with warmer water species may result in significant changes in the distributions of fishes and ultimately a loss of fish biodiversity. According to Schindler (2001), less precipitation, and therefore less ice formation

in the north, will result in lower water levels and the loss of habitat (no re-flooding of perched basins in the northern delta areas). Less dilution of pollution can also be expected with decreased water levels. As the distributions of many freshwater species are limited by thermal boundaries, species' zoogeographic ranges will likely shift towards higher latitudes (Jackson and Mandrak 2002). Biota from warmer waters downriver will expand into headwaters, replacing coldwater species whose environmental requirements can no longer be met and resulting in a general reduction in diversity within watersheds (Jackson and Mandrak 2002; Shuter *et al.* 2002). Jackson and Mandrak (2002) have estimated that more than 25,000 Ontario populations of four cyprinid species, the northern redbelly dace (*Chrosomus eos*), finescale dace (*C. neogaeus*), fathead minnow (*Pimephales promelas*) and pearl dace (*Semotilus margarita*) may be lost due to unsuitable thermal conditions and the negative impact of competition with other species.

The ranges of many species in the northern United States will expand into Canada as a result of climate change, presenting us with further alien species problems. Nine fishes have already entered the Great Lakes system by moving north from the United States, these being the lake chubsucker (*Erimyzon sucetta*), bigmouth buffalo (*Ictiobus cyprinellus*), smallmouth buffalo (*Ictiobus bubalus*), black buffalo (*Ictiobus niger*), spotted sucker (*Minytrema melanops*), northern madtom (*Noturus stigmosus*), flathead catfish (*Pylodictic olivaris*), warmouth (*Lepomis gulosus*) and orangespotted sunfish (*Lepomis humilis*) (Crossman and Cudmore 1999; Cudmore 1999). All but two of these species (smallmouth buffalo and flathead catfish) already have established, albeit restricted, populations in Canada. Results of recent fish surveys in the Canadian waters of the Great Lakes basin show that the bigmouth buffalo and black buffalo have become more widely distributed and abundant than in the past, with warmer water temperatures believed to be a contributing factor (N.E. Mandrak, pers. comm.). Mandrak (1989) and Mandrak and Crossman (1992) identified 41 species of freshwater fish as having the proximity and ecological characteristics to potentially invade the Great Lakes and push further north into Canada as a result of global warming. In order to predict the impacts of climate change on Canadian biodiversity, a detailed knowledge of historical species distributions will be needed.

Hogg *et al.* (1998) maintain that the long-term response of natural systems to large-scale atmospheric changes will depend on species diversity and on the genetic diversity found within their populations. Populations of benthic invertebrates in lotic systems may become genetically distinct at the race, subspecies and even species levels due to the fragmentary nature of their habitats. Species having a high level of genetic variability and a low level of differentiation (high gene flow among populations) will be in the best position to adapt to climate change, thus genetic structure must be taken account when predicting the effects of climate change on aquatic organisms and ecosystems. Hogg *et al.* (1998) found that the majority of stream invertebrate species studied to date have moderate to high levels of differentiation. Implications of these findings are that the ability of North American stream invertebrates to respond to climate change may be limited.

What are Canada's Commitments for the Conservation of Biodiversity, with Emphasis on Freshwater Biodiversity?

Canadian Biodiversity Strategy

Canada is one of 176 countries that signed the Convention on Biological Diversity (CBD) at the United Nations Conference on the Environment and Development in Rio de Janeiro in June 1992. With support from the provincial and territorial governments, Canada became the first industrialized country to ratify the Convention that came into effect on 29 December 1993. The three objectives of the Biodiversity Convention are: the conservation of biodiversity; the sustainable use of biological resources; and the fair and equitable sharing of benefits resulting from the use of genetic resources. Canada's response to the Convention, the Canadian Biodiversity Strategy (CBS), was released in 1995. The goals of the CBS are:

> GOAL 1. To conserve biodiversity and use biological resources in a sustainable manner.
> GOAL 2. To improve our understanding of ecosystems and increase our resource management capacity.
> GOAL 3. To promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner.
> GOAL 4. To maintain or develop incentives and legislation that support the conservation of biodiversity and the sustainable use of biological resources.
> 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.

Governments agreed to report within one year of Ministerial endorsement of the CBS on policies, programs, strategies and actions that are or will be undertaken to implement the strategy, and to continue to report publicly on progress at regular intervals.

Legislation

The main federal agencies responsible for managing and conserving aquatic biodiversity in Canada are Environment Canada (EC) and the Department of Fisheries and Oceans (DFO). Several other departments, such as Health Canada (Pest Control Products Act) and Parks Canada (National Parks Act), also have some involvement. Environment Canada has a mandate to protect and conserve wildlife and aquatic ecosystems under the Department of the Environment Act, Canada Water Act (1970), Canadian Environmental Protection Act (1999), Canada Wildlife Act (1995), Migratory Birds Convention Act, Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act, and Great Lakes Water Quality Agreement (1978) as amended by protocol in 1987. The Department of Fisheries and Oceans administers several pieces of legislation related to the protection of the aquatic environment, including the Fisheries Act, Oceans Act, Coastal Fisheries Protection Act, Department of Fisheries and Oceans Act, Arctic Waters Pollution Prevention Act, Canada Shipping Act, and Canadian Environmental Assessment Act.

Whereas much of the legislation listed above protects biodiversity in part or indirectly, several new initiatives arose from the signing of the Biodiversity Convention. In 1996, the Government of Canada joined with the provinces and territories in supporting the Accord for the Protection of Species at Risk, which committed all of Canada's jurisdictions to prevent species in Canada from becoming extinct as a consequence of human activity (Environment Canada 2000a). Under the Accord, they have agreed to:

- participate in the Canadian Endangered Species Conservation Council (CESCC) in order to coordinate activities and resolve issues for the protection of species at risk in Canada;
- recognize the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as a source of independent advice on the status of species at risk nationally; and,
- establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada by:
    - legally designating threatened and endangered species,
    - protecting species and their habitats,
    - planning and implementing the recovery of species and habitats,
    - ensuring cooperation for protecting species that cross borders, and
    - encouraging preventive measures such as stewardship programs, information campaigns and voluntary action.

On 7 April 1997, the Minister of the Environment and U.S. Secretary of the Interior signed a "Framework for Cooperation Between Environment Canada and the U.S. Department of the Interior in the Protection and Recovery or Wild Species at Risk." The Framework recognizes that Canada and the U.S. must work together to identify species at risk and determine the best ways to conserve them and their habitats (Environment Canada 2000b). Species listed as endangered or threatened under the U.S. Endangered Species Act that also occur in Canada, and species listed by COSEWIC as nationally at risk in Canada that also occur in the United States, are considered for conservation efforts (Environment Canada and the U.S. Department of the Interior 2001). The Framework will be implemented jointly by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service. Since these two organizations have different jurisdictions, the Framework does not currently consider issues involving marine mammals, fish, or sea turtles. Freshwater species on the list include several species of amphibians, the spiny softshell turtle (*Apalone spinifera*) and four species of freshwater mussels.

In the Speech from the Throne of October 1999, the Government of Canada committed itself to bringing in a new Species at Risk Act and stewardship programs "...as one of its first environmental priorities for the new millennium" (Environment Canada 2000c). A three-part strategy was developed to:

- build on the Accord for the Protection of Species at Risk;
- promote stewardship and incentive programs to assist citizens, organizations, Aboriginal peoples, land users and private landowners who are helping to protect species and habitat; and
- introduce a new Species at Risk Act.

How is Canada Meeting these Commitments, with Particular Reference to Freshwater Biodiversity?

Canada's National Reports to the Conference of the Parties to the Convention on Biological Diversity

The objective of national reporting, as specified in Article 26 of the Convention, is to provide information on measures taken for the implementation of the Convention and the effectiveness of these measures. National reports are called for every four years. Canada's First National Report, entitled "Caring for Canada's Biodiversity", describes some of the initiatives that have been taken by governments, non-government organizations (NGOs) and the private sector to implement the Convention in Canada (Environment Canada 1998). Major activities under the heading "science and information for decision making" include state of the environment reporting (e.g., State of the Great Lakes Report) and improving biological inventories and data management and distribution (e.g., Federal Biosystematics Partnership and Biodiversity Knowledge and Innovation Network, see below). In 1996, the Canadian Environmental Assessment Agency released "A Guide on Biodiversity and Environmental Assessment" to assist in assessing the impact of proposed projects on biodiversity. Federally, plans and reports on the implementation of the CBS within the context of wildlife diversity, protected areas, agriculture and forestry have been prepared, and reports on aquatic diversity, ecological management, education and awareness, and international cooperation are to follow. Canada's Second National Report was released in 2001 and is available on the Biodiversity Convention Office website (http://www.cbin.cc.gc.ca). This report describes progress made towards the goals outlined in the First National Report, including the development of a national strategy and action plan. Canada has made some progress with respect to protecting freshwater biodiversity and considers the implementation of a biodiversity work program in inland water ecosystems a high priority. However, the resources available for meeting these obligations and recommendations are limited.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC)

COSEWIC was created in 1977 to develop a single, official, scientifically sound, national list of wildlife species at risk, and to prepare status reports on them (COSEWIC 2002). COSEWIC members are appointed by the Minister of the Environment and include representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada, Department of Fisheries and Oceans, Federal Biosystematics Partnership), three national NGOs (Canadian Nature Federation, Canadian Wildlife Federation, and World Wildlife Fund Canada), and the chairs of the Species Specialist and Aboriginal Traditional Knowledge Subcommittees. Mammals, birds, reptiles, amphibians, fish and terrestrial plants were initially considered for listing (Cook and Muir 1984). COSEWIC has assessed nearly 600 species to date and designated 415 of these species as extinct, extirpated, endangered, threatened, or of special concern (COSEWIC 2002). In the past, COSEWIC's list had no legal status; however, this will change when the Species at Risk Act is proclaimed.

COSEWIC expanded its mandate in 1994 to include invertebrates, forming a Lepidoptera and Mollusca Subcommittee. To date, 12 species of freshwater molluscs (mussels, snails, limpets) have been evaluated and nine have been listed. Unsolicited status reports on Crustacea (primarily crayfishes) and Odonata have also been submitted to this Subcommittee, indicating that concern is growing about the conservation status of freshwater invertebrates in Canada. A total of 77 species of fishes have also been designated as Canadian Species at Risk, and over 90% of these are freshwater species (COSEWIC 2002).

Recovery of Nationally Endangered Wildlife (RENEW) Program

The RENEW program, was established in 1988 to implement a national strategy to oversee recovery efforts for all species, subspecies and populations of terrestrial vertebrates designated as endangered, threatened, and extirpated by COSEWIC (CWS 1994). It provides for the preparation of recovery plans to "...guide all Canadian research and management of a particular species." RENEW's mandate has since evolved to include plants, fish, marine mammals, some species of invertebrates, and multi-species or ecosystem recovery plans. The annual report for 2002 lists 101 recovery plans, including 18 for aquatic and semi-aquatic species and four for freshwater ecosystems (CESCC 2002). Parks Canada, the Department of Fisheries and Oceans, and the Canadian Wildlife Service of Environment Canada are identified as the, or one of the, responsible jurisdictions for over 60% of these plans. Under the Species at Risk Act, federal agencies will be required to participate in recovery planning for species that occupy federal lands or waters.

Assessing the General Status of Wild Species in Canada

The provinces, territories and federal agencies represented in the Accord for the Protection of Species at Risk made a commitment to "monitor, assess and report regularly on the status of all wild species and emphasize preventative measures to keep species from becoming at risk" (Provincial/Territorial/Federal Working Group on Endangered Species 1998). The objective of this exercise is to identify species that may be in trouble, those for which more information is needed, and those that should be placed on COSEWIC's candidate list for formal assessment. Each jurisdiction agreed to assess the general status of all wild species within its jurisdiction, and produce a report every five years. The CESCC would be responsible for producing a national report on the known status of Canadian assemblages. The first national report, Wild Species 2000: The General Status of Species in Canada, was released in 2001 (CESCC 2001; http://www.wildspecies.ca). This first report included information on mammals, birds, reptiles, amphibians, freshwater fish, butterflies, orchids and ferns. Jurisdictions are committed to an ongoing and comprehensive assessment of wild species. Thus, the next Wild Species report, which is due in 2005, will aim to incorporate new data for those species already assessed, address gaps in coverage for those species groups already assessed, and report on several other groups of species for the first time. It is anticipated that Wild Species 2005 will include national status assessments for marine fishes, crayfishes, odonates (dragonflies and damselflies), ephemeropterans (mayflies), tiger beetles, a subset of the vascular plants, and freshwater mussels. These reports "...will provide a powerful tool to prioritize future research, inventory and management programs."

The Species at Risk Act

The Species at Risk Act (SARA) was first introduced into the House of Commons in February of 2001. After deliberations by the Standing Committee on Environment and Sustainable Development, SARA was given Third Reading in June of 2002 and passed by the House of Commons. Senate deliberations began in the fall of 2002, followed by Royal Assent on December 12, 2002. The new Act will come into force in 2003 following nine years of consultation and previous legislative proposals.

The overall goal of SARA is to prevent wildlife species from becoming extinct or lost from the wild, and to help in the recovery of species that are at risk as a result of human activities. The Act will cover the following elements of species preservation:

- listing (identifying which species are at risk);
- prohibitions (ensuring that species are protected);
- recovery (ensuring recovery strategies or management plans are in place for the most imperiled species); and
- habitat protection (ensuring that critical habitat is protected).

Listing – COSEWIC Species Specialist Subcommittees are charged with developing lists of candidate species believed to be nationally at risk, preparing or commissioning status reports on these species, and recommending status to COSEWIC. There are currently eight subcommittees that consider species within the following taxonomic groups: amphibians and reptiles, terrestrial mammals, birds, lepidopterans and molluscs, marine mammals, plants and lichens, marine fishes, and freshwater fishes, and a ninth subcommittee that contributes Aboriginal Traditional Knowledge. COSEWIC meets semi-annually to consider the status reports, and assigns status to assessed species based on a consensus of its members. To determine the appropriate status designation for each species, COSEWIC has adopted quantitative criteria and guidelines based on The World Conservation Union (IUCN) Red List categories (IUCN 2001). Upon proclamation of SARA, all 233 species that had been assessed or re-assessed by the end of 2001 using the new criteria will be included in Schedule 1 – the legal list of wildlife species at risk. Additional COSEWIC assessments will be published in the SARA public registry as they become available, and the Governor-in-Council will have nine months to decide whether to add these species to the legal list.

Prohibitions – As soon as a species is added to the legal list, a number of binding provisions take effect, such as automatic prohibitions against killing or harming aquatic species, migratory bird species and all species on federal lands, and against destruction of their residences.

Recovery – A recovery strategy must be developed within one year of listing for each Endangered species and within two years of listing for each Threatened species (i.e., those on the legal list). An action plan then lays out the specific measures to be undertaken in each year of a five-year period to recover the species. Management plans are required within three years of listing for species of Special Concern.

Habitat protection – Habitat loss is identified as an important threat for about 75% of the species currently listed as endangered or threatened by COSEWIC. Critical habitat on federal lands will be protected under SARA, and there will be a safety net to prohibit the destruction of critical habitat on non-federal lands where the measures of other jurisdictions have failed. There will be provisions for compensating landowners for economic hardship related to the application of critical habitat prohibitions.

Federal Biosystematics Partnership and Biodiversity Knowledge and Innovation Network

It is well recognized that Canada is losing its expertise in biosystematics. The previous generation of curators, university professors, and government experts are retiring, and since they are not being replaced there is no one available to teach the next generation. There are only three graduate-level biosystematics programs left in Canada, compared to approximately 20 programs during the 1970s. According to Goodfellow *et al.* (1999), "If we don't maintain current inventories of species occurrence and distribution patterns, we cannot hope to understand the evolutionary and ecological relationships of the organisms and ecosystems that support the emerging bioeconomy" and, of course, meet our obligations under the Biodiversity Convention.

The Federal Biosystematics Partnership (FBP) was recently created to promote and support biosystematics research in Canada. The partners are the Canadian Wildlife Service and Biodiversity Convention Office (representing Environment Canada), Department of Fisheries and Oceans, Agriculture and Agri-Food Canada, the Canadian Museum of Nature, Natural Resources Canada (Forestry Service), Parks Canada, and Health Canada. The FBP identified a national program in bioinformatics as a key requirement. The Biota of Canada Information Network (BCIN) Working Group was formed in 1999 under a Memorandum of Understanding among the five Natural Resource Departments, with the aim of exploring new options for improving the organization, exchange, correlation and application of primary data on species of interest to Canadians (Speers and Smith 2000). The first objective of BCIN was to develop a distributed network of biodiversity databases linking all data through a taxonomic core. This is an enormous challenge because most data are fragmented among various institutions, and most collection-based data are not computerized, geo-referenced or taxonomically verified. The Working Group held its inaugural workshop in March 2000 to develop an action plan and business case for their project. They agreed to develop some proof-of-concept demonstration projects for a number of taxonomic groups (e.g., the butterflies).

In the spring of 2001, BCIN was rolled into Biodiversity Knowledge and Innovation Network (BKIN), to "create an electronic knowledge base of all life forms important to Canadians for sustainable use of our biological resources based on understanding and conserving our biodiversity knowledge" (http://www.cbif.gc.ca/bkin). The main objectives of BKIN are to:

- build the Canadian biodiversity network by increasing consultations, communications and co-ordination among all interested creators and beneficiaries of biodiversity knowledge;
- strengthen Canada's human and infrastructure capacities in the biodiversity sciences to meet the needs of society; and

- manage Canada's biodiversity knowledge base by developing means to equitably share genetic, species and ecosystem data nationwide among all sectors of society.

The participants of BKIN include representatives of government, universities, zoological and botanical gardens, museums, environmental and wildlife non-governmental organizations, aboriginal groups and sectoral and high-technology industries. The Biodiversity Knowledge and Innovation Network is a pilot Canadian node of the Global Biodiversity Information Facility (GBIF). The goal of GBIF is to make the world's biodiversity data available to all. The North American Biodiversity Information Network (NABIN) was created after the North American Free Trade Agreement (NAFTA) in response to concerns that the Agreement might have detrimental environmental impacts. As a contributing partner, Canada will have access to data on Canadian species that are currently held in facilities in other countries.

North American Commission for Environmental Cooperation

In order to build environmental safeguards into NAFTA, the Commission for Environmental Cooperation (CEC) was created by the North American Agreement on Environmental Cooperation. The CEC is an international organization (Canada, United States and Mexico) that includes a Conservation of Biodiversity Program. In 2001, a Biodiversity Conservation Working Group was established to develop a "Strategic Plan for North American Cooperation in the Conservation of Biodiversity" and provide advice for its implementation. This plan will be updated every five years. The conservation and sustainable use of North America's freshwater biodiversity is included in the strategic plan as part of the exercise of identifying and developing freshwater protected areas of continental ecological significance (CEC 2002).

How are We Doing?

Inventorying and monitoring for the conservation of freshwater biodiversity is of vital importance (Biro 2001).

Canadians are stewards of 9% of the world's renewable fresh water supply. Achieving a Canada where freshwater resources and ecosystems are clean, productive and secure for present and future generations is a collective desire of all Canadians. Considerable progress has been made towards the conservation of freshwater biodiversity in Canada, but there is still much work to be done. The following are some examples of accomplishments and areas for improvement that were identified in Canada's Second National Report to the Convention on Biological Diversity:

In September 2001, intergovernmental Ministers of Wildlife, Forests and Fisheries and Aquaculture jointly released a report entitled Working Together: Priorities for Collaborative Action to Implement the Canadian Biodiversity Strategy 2001-2006. This report outlined implementation priorities for four national biodiversity issues on which the Ministers agreed to collaborate. These priorities are to: develop a biodiversity science agenda, enhance capacity to report on status and trends, deal with invasive alien species, and engage Canadians by promoting stewardship. A national business plan for each of these priority areas will follow Ministerial endorsement of the report.

Canada has many important collections of aquatic organisms held at various institutions around the country. These collections are an invaluable resource that allows us to recreate historical patterns of distribution and abundance of native species that "...help calibrate present expectations regarding the productivity, diversity, and stability of the natural systems upon which humans depend" (Steedman *et al.* 1996). The Canadian Museum of Nature recently completed the computerization of its holdings of Canadian freshwater mussel material in response to an urgent need for information on this particularly imperiled group.

In 1984, the federal, provincial and territorial governments established the Canadian Heritage River Systems (CHRS) to conserve and protect the best examples of Canada's river heritage, to give them national recognition, and to encourage the public to enjoy and appreciate them. Once a river has been nominated, a management plan must be prepared within three years before the river can be officially designated. Management plans describe the actions that will be taken to ensure the long-term conservation of the outstanding resources - whether natural, cultural or recreational – for which a river was nominated. Many rivers have been severely impacted by dams, diversions, pollution and development, and the CHRS is a means of ensuring the preservation of Canada's most outstanding rivers. There are currently 39 rivers designated as Canadian Heritage Rivers, with more being added every year.

Parties to the Biodiversity Convention are expected to take an ecosystem approach to the management of aquatic and terrestrial ecosystems. Canada has been involved in many activities to clean up, recover, and protect aquatic ecosystems, the largest of which are the six Ecosystem Initiatives established by Environment Canada (Great Lakes 2020, St. Lawrence Vision 2000, Atlantic Coastal Action Program, Northern Ecosystem Initiative, Northern Rivers Ecosystem Initiative, and Georgia Basin Ecosystem Initiative). It is significant to note that during the renewal of the Great Lakes Program (Great Lakes 2020), biodiversity was considered as a component in the planning process for the first time (Environment Canada 1999). The federal government's targets were listed as: rehabilitation and protection of habitats needed for the recovery of federally-listed species at the Great Lakes basin; on a priority basis, assess the biodiversity of all life forms in the basin; coordinate government and private programs to study and conserve biodiversity and integrate monitoring programs; and provide federal leadership on impacts of biotechnology to biodiversity. Work is also underway to develop an aquatic biodiversity module that will outline existing and planned work in the area of aquatic (marine and freshwater) biodiversity.

There are still things that need to be done. As noted in the Second National Report, resources for conserving and protecting freshwater biodiversity in Canada are limited. In all Environment Canada project assessments under the Canadian Environmental Assessment Agency, impacts on biodiversity are identified and recorded and some mitigation measures suggested. However, there is insufficient capacity to undertake comprehensive surveys of baseline conditions and engage in follow-up activities. Canada is not currently participating in the River Basin Initiative as outlined in the Joint Work Plan of the Convention on Biological Diversity. This initiative operates under the framework of the Joint Work Plan between the Convention on Biodiversity and the Ramsar Convention (international treaty for the conservation of wetlands). The goal of

the River Basin Initiative is to "establish a global network to share information and links and support activities where the principles of integrated management of biodiversity of wetlands and river basins are demonstrated" (http://www.riverbasin.org). Another area that Canada could direct more attention to with respect to freshwater biodiversity is the identification of risks, prevention, control, and eradication of non-indigenous aquatic invasive species. At the present time, only major species are being looked at and typically only within the Great Lakes basin.

According to Harvard scientist E.O. Wilson, who is credited with being the first to bring awareness of biodiversity issues to public attention, "...community ecology...is about to emerge as one of the most significant intellectual frontiers of the 21st century, standing in the front ranks with astrophysics, genomics and neuroscience" (Wilson 2000). Advances in community ecology will depend on a detailed knowledge of species and their natural history. At the present time, the ecology, functional roles and habitat requirements of most freshwater species are poorly known (e.g., Minns 2001; Vaughn and Hakenkamp 2001). While most developed countries are adopting biodiversity science plans that recognize the implications of biodiversity issues for the health of their ecosystems and human populations as well as their future competitiveness, Canada has yet to develop such a plan (Biodiversity Science Board of Canada 2000). As the species composition, structure and dynamics of Canada's ecosystems are unique, Canada will require its own biodiversity science capacity. Our current level of biodiversity expertise may seriously impair our ability to develop inventories of native species and their distributions, detect and manage pest and disease organisms, assess and interpret impacts of climate and other environmental changes, monitor and manage species at risk, and respond to threats from invasive alien species.

Addressing knowledge gaps, conducting inventories and monitoring the freshwater biodiversity of Canada is a start. This report has emphasized legislation, programs and activities that focus on species at risk – the most vulnerable of our native organisms. Although biodiversity is much more than species at risk, the plight of endangered species is an issue that many people empathize with and is therefore a useful approach for gaining public support for broader issues. For example, as a result of their success in gaining public concern for the amphibian crisis, amphibian biologists are now moving into the second phase of their research: hypothesis testing, identification of factors causing declines, and debate of the results (Bury 1999). We need to get the message out that many other freshwater organisms are just as imperiled and in need of our conservation efforts.

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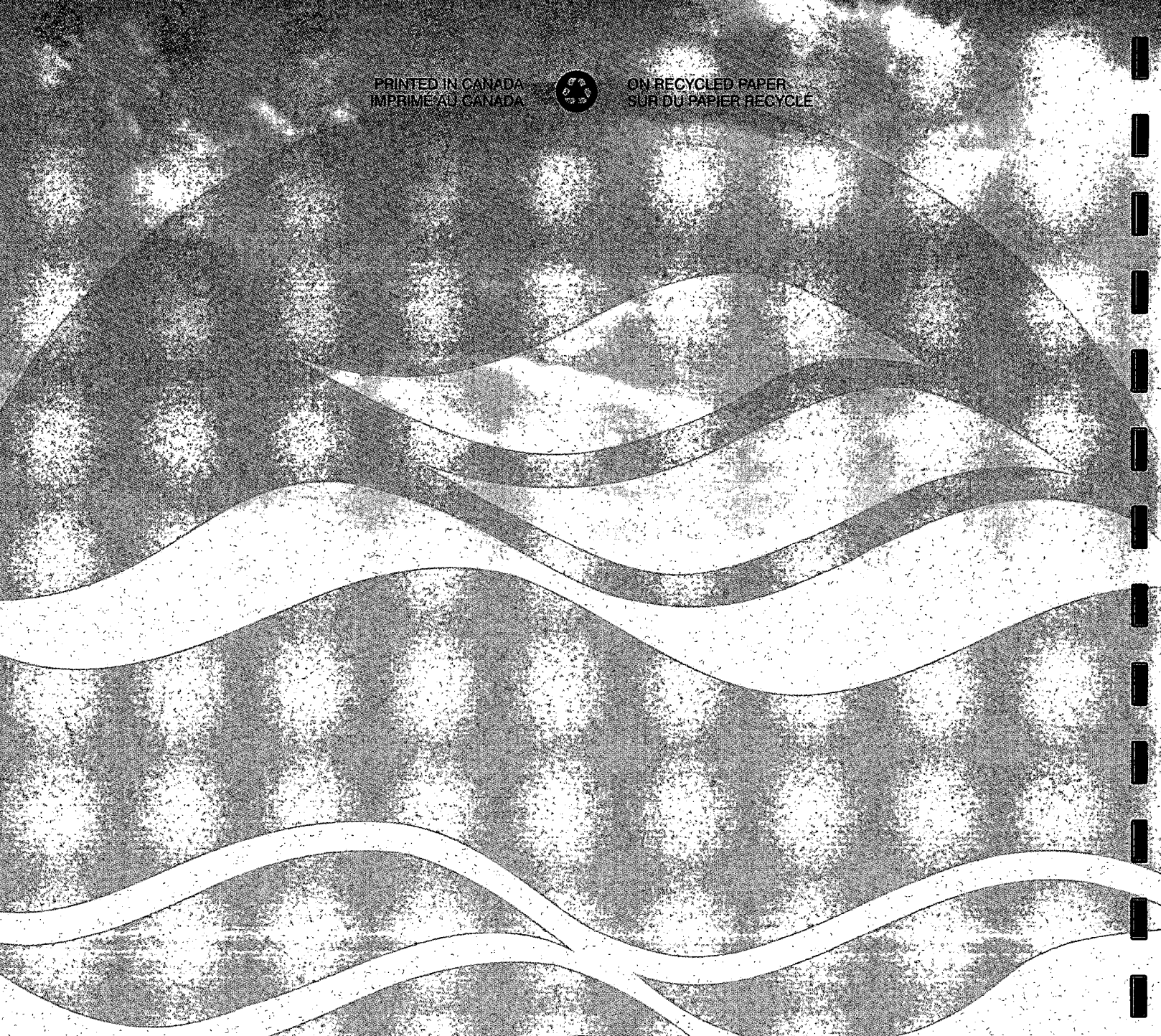

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