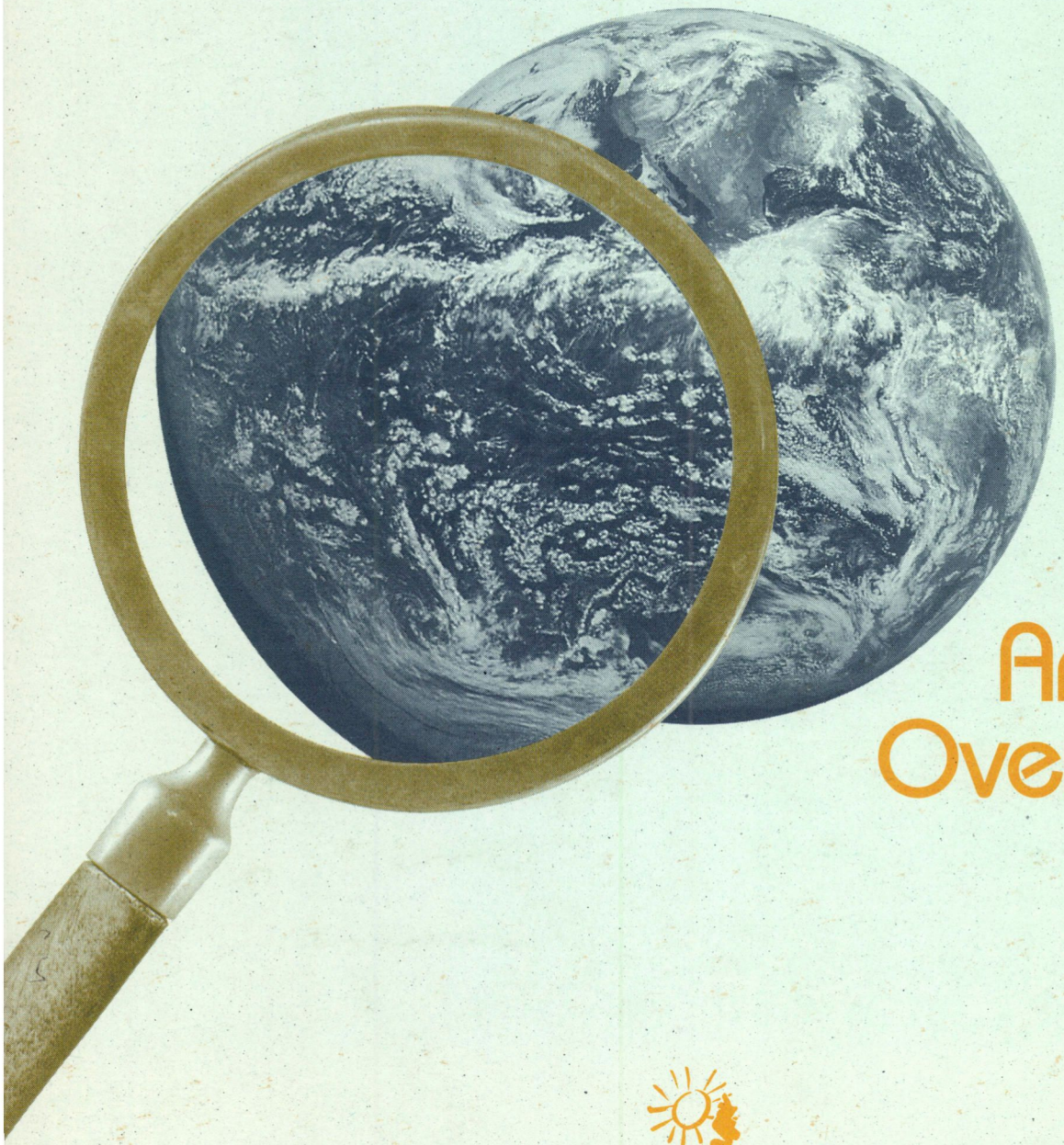
Environment Canada Environnement Canada

ENVIRONMENTAL SCIENCE & TECHNOLOGY



An Overview

Canada

Environmental Science and Technology: An Overview

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Science and technology have been at the heart of Environment Canada's activities since the Department was established in 1971. This key role is recognized and reaffirmed with substantial new resources in the Green Plan. Many existing environmental science initiatives have been reinforced; and new science initiatives have been introduced to improve our understanding about human impacts upon the environment. These activities involved range from monitoring the state of the environment and identifying environmental problems to the development of solutions through remedial actions and innovative technologies.

I am pleased to introduce this report which is intended to provide an overview of the scientific and technological effort to meet the environmental goals identified in the Green Plan. The report will give the reader a sense of the range of scientific and technological efforts that are being devoted to issues as diverse as conserving our wildlife and national parks and developing innovative technologies to clean-up polluted sites.

Through this report I am delighted to acknowledge the crucial role of all our dedicated scientific staff. I hope that you, the reader, will be able to share, as I have, some of the enthusiasm and excitement felt by our researchers as they work to contribute to achieving a better environment for ourselves and our children.

Jean Charest,
Minister of the Environment

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Table of Contents

Table A

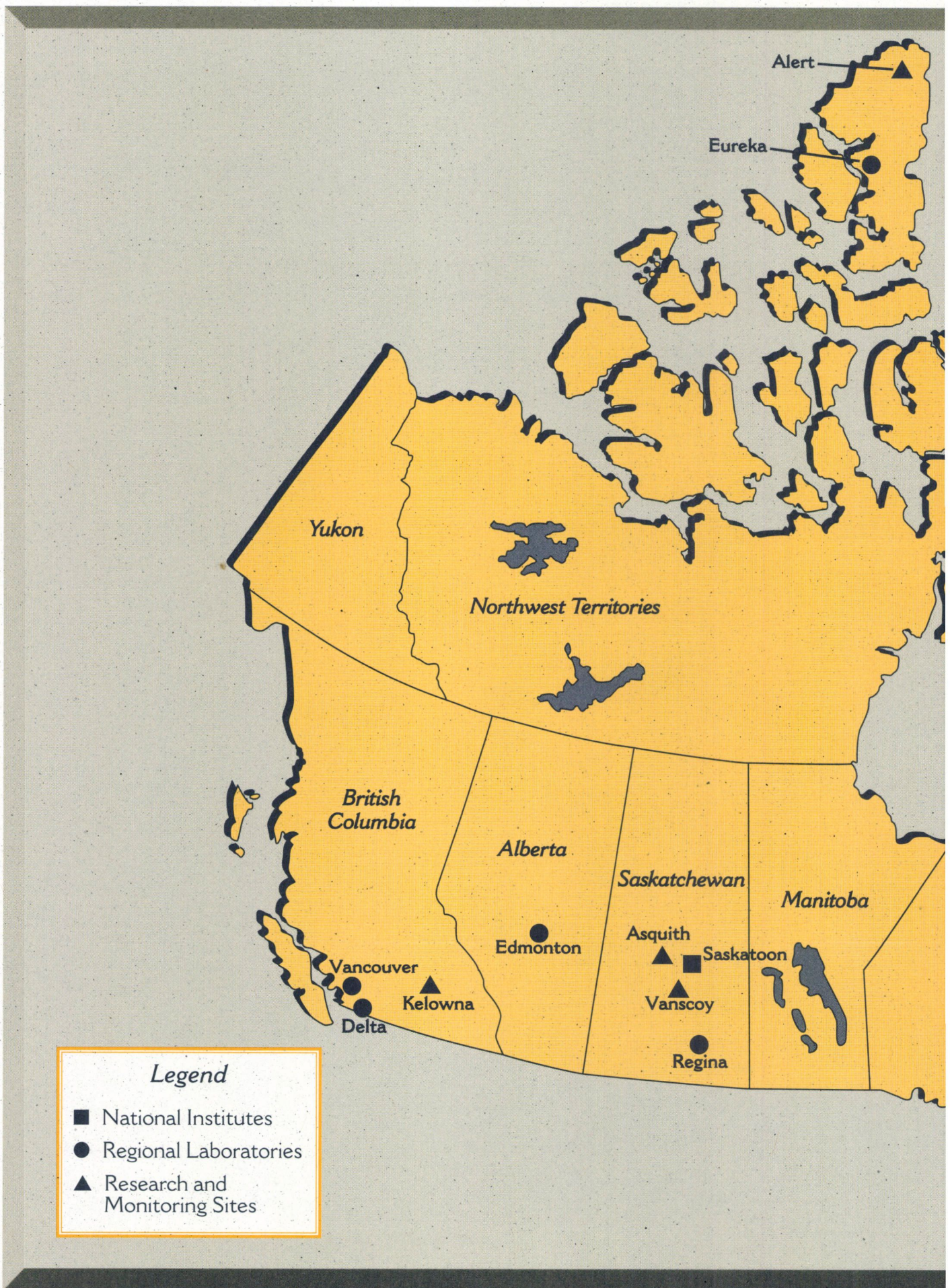
Key Issues

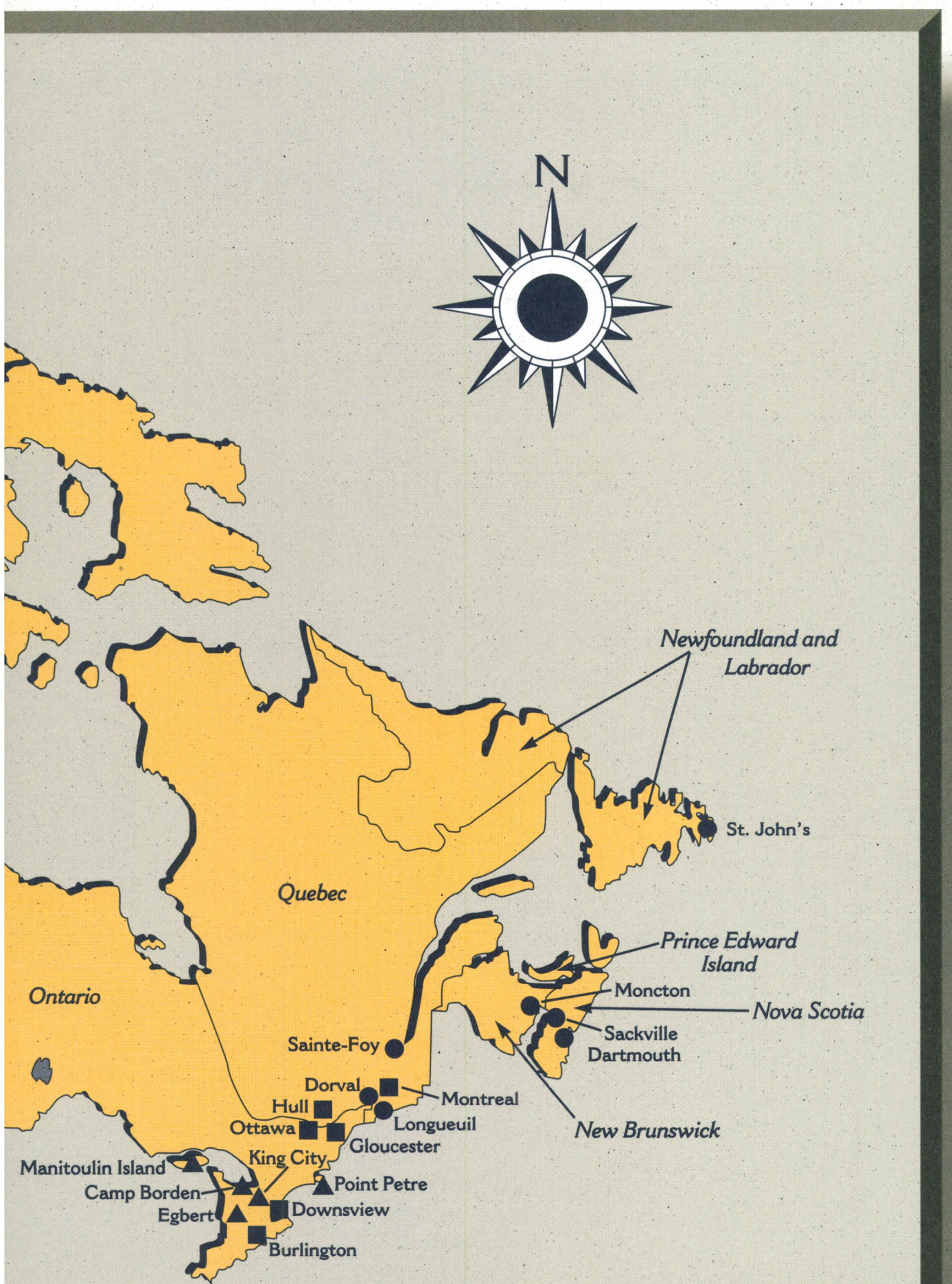
	NATIONAL INSTITUTES							
	National Water Research Institute	National Wildlife Research Centre	Centre Saint-Laurent	National Hydrology Research Institute	River Road Environmental Technology Centre	Wastewater Technology Centre	Canadian Climate Centre	Atmospheric Research Directorate
Wildlife		●	●					
Weather Forecasting								●
Waste Management	●		●	●	●	●		
Global Warming and Climate Change	●	●		●			●	●
Water Quality and Quantity	●		●	●		●		
Environmental Technology	●		●		●	●		●
Stratospheric Ozone Depletion	●			●				●
Acid Rain	●	●	●	●				●
Toxic Chemicals	●	●	●	●	●	●		●
Environmental Emergencies					●			●
The Arctic	●	●		●			●	●

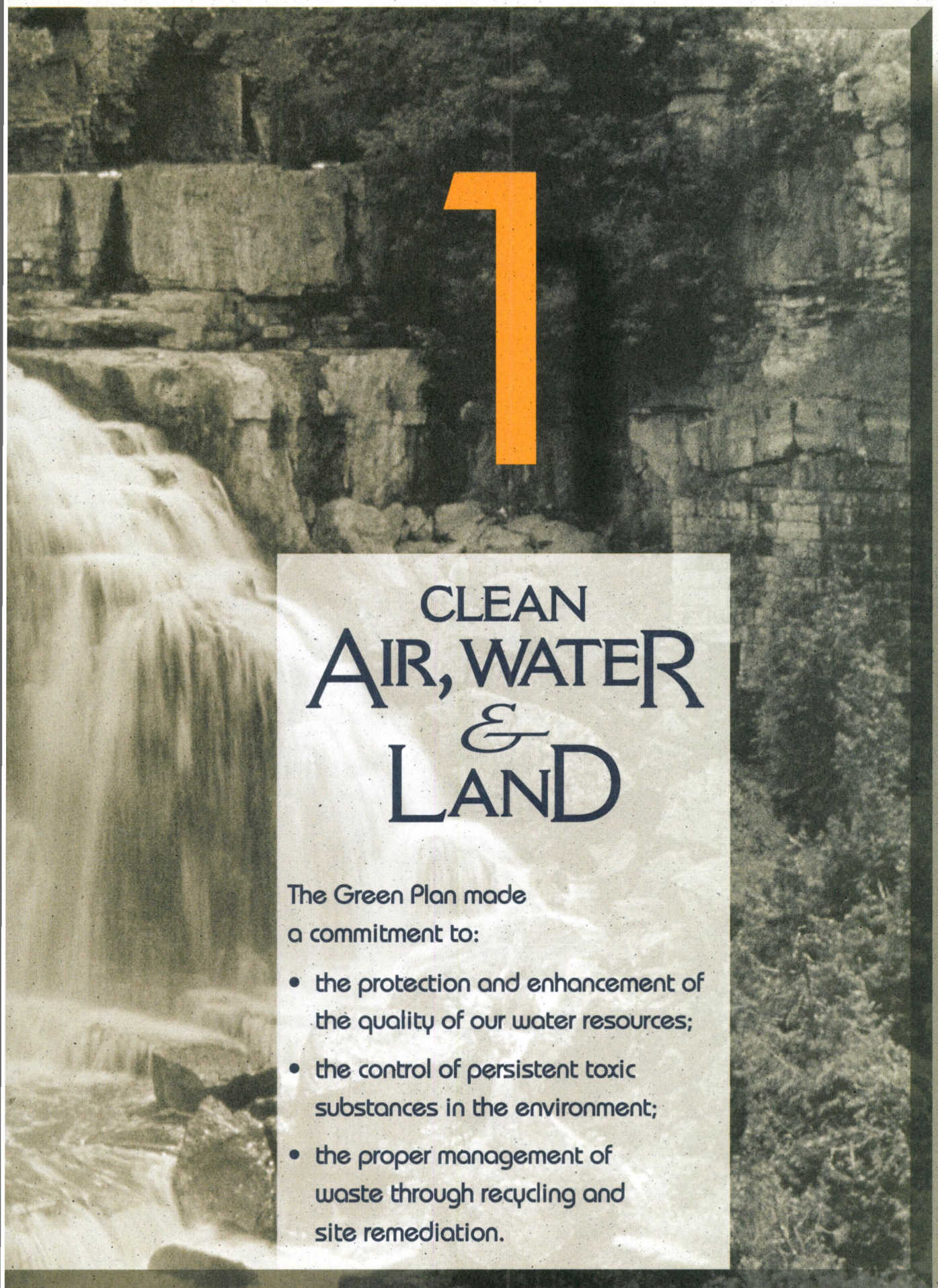
TABLE B

Environment Canada's Institutes and Laboratories

	LABORATORY	PROVINCE	LOCATION
National Institutes	National Water Research Institute	Ontario	Burlington
	Wastewater Technology Centre		Burlington
	Atmospheric Research Directorate		Downsview
	Canadian Climate Centre		Downsview
	River Road Environmental Technology Centre		Gloucester
	National Wildlife Research Centre	Quebec	Hull
	Centre Saint-Laurent		Montreal
	National Hydrology Research Institute	Saskatchewan	Saskatoon
Laboratories	Newfoundland District Laboratory	Newfoundland	St. John's
	Canadian Wildlife Service – Atlantic Region	Nova Scotia	Sackville
	Environmental Protection Laboratory		Dartmouth
	Water Resources Directorate		Dartmouth
	Monitoring and Evaluation Branch	New Brunswick	Moncton
	Canadian Wildlife Service – Quebec Region	Quebec	Sainte-Foy
	Capitaine-Bernier Laboratory		Longueuil
	Numerical Prediction Research		Dorval
	National Laboratory for Environmental Testing	Ontario	Burlington
	Canadian Wildlife Service – Ontario Region		Ottawa
	Archaeological Research		Ottawa
	Historic Resource Conservation		Ottawa
	Toxic Monitoring Laboratory		Point Petre
	Dry Deposition Research Laboratory		Camp Borden
	King Radar Research Facility		King City
	CARE Laboratory		Egbert
	Toxics Monitoring Laboratory		Manitoulin Island
	Prairie and Northern Research Centre	Saskatchewan	Saskatoon
	Inland Waters Directorate – Western and Northern Region		Regina
	RAGS Radiation Monitoring Laboratory		Asquith
	Stratospheric Launch Facility		Vanscoy
	Canadian Wildlife Service – Western and Northern Region	Alberta	Edmonton
	Environmental Protection Laboratory		Edmonton
	Ecotoxicology Laboratory		Edmonton
	Canadian Wildlife Service – Pacific and Yukon Region	British Columbia	Delta
	Environmental Protection Service		West Vancouver
	Environmental Conservation Directorate		North Vancouver
	Arctic Stratospheric Observatory	Northwest Territories	Eureka
	BAPMON Monitoring Laboratory		Alert


Alert
Eureka
Yukon
Northwest Territories
British Columbia
Alberta
Saskatchewan
Manitoba
Edmonton
Asquith
Saskatoon
Vancouver
Kelowna
Vanscoy
Delta
Regina
Legend
National Institutes
Regional Laboratories
Research and Monitoring Sites


N
Newfoundland and Labrador
St. John's
Quebec
Prince Edward Island
Moncton
Nova Scotia
Sackville
Dartmouth
Ontario
Sainte-Foy
Dorval
Montreal
Hull
Ottawa
Longueuil
Gloucester
New Brunswick
King City
Manitoulin Island
Point Petre
Camp Borden
Downsview
Egbert
Burlington

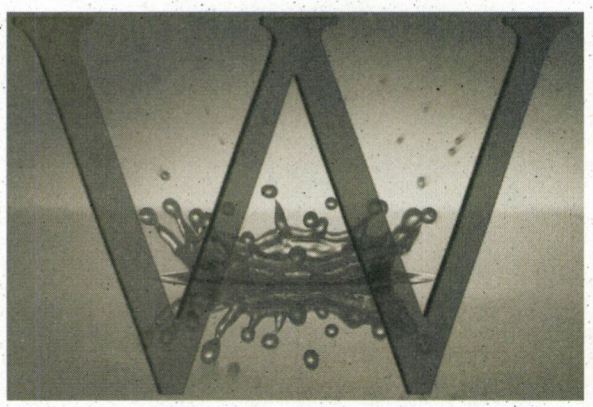


1

CLEAN AIR, WATER & LAND

The Green Plan made a commitment to:

- the protection and enhancement of the quality of our water resources;
- the control of persistent toxic substances in the environment;
- the proper management of waste through recycling and site remediation.



Water

The Green Plan recognizes the key role that water plays in the development of Canada. For example, the Great Lakes, which form the largest freshwater system in the world, are vital to our economic development and provide a source of drinking water for millions of Canadians. These freshwater supplies, along with those of other Canadian rivers and lakes, are not, however, inexhaustible. Furthermore, our waters continue to be threatened by contaminants from municipal, industrial and agricultural sources. This has led to high public concern over the supply and quality of our water resources. In Western Canada, especially, concern over supply is of great importance because of the use of water for irrigation, power generation, and household and industrial use.

Canada's Federal Water Policy, announced in 1987 and re-affirmed in the Green Plan, responds to these concerns by promoting measures to protect and enhance the quality of our water resources. Environment Canada's aquatic research program generates the scientific knowledge and expertise essential to ensure that water of sufficient quality and quantity is available for us and future generations of Canadians.

Researchers at Environment Canada actively support national efforts to find effective, enforceable regulations that will protect our aquatic ecosystems from damage due to pollutants. For instance, multidisciplinary teams at the National Water Research Institute in Burlington, Ontario, are conducting research to determine the effects of toxic chemicals on aquatic systems. Toxic chemicals of particular environmental concern are identified on the Priority Substance List of the Canadian Environmental Protection Act. Contaminant research at the Institute is focused on the effects of pesticides, the effluent from mining, pulp and paper and petrochemical industries, and future testing of priority substances.

At the Centre Saint-Laurent, scientists are focusing on testing indices of the integrity of fish and invertebrate communities in various parts of the St. Lawrence River. These indices reflect the variety of species that are present and their overall health. They identify the species that can tolerate specific levels of pollutants and those that can only survive in clean water.

Groundwater provides many Canadians with an essential source of water for drinking, agriculture and industry. Groundwater resources, however, are susceptible to contamination from chemical pesticides, landfill or dumpsite seepage, and various naturally occurring metals and chemicals. Environment Canada's groundwater research program provides sound advice on managing these groundwater resources as well as developing methods to assess and remediate groundwater contamination. For example, the National Hydrology Research Institute in Saskatoon is currently developing technologies to protect and enhance groundwater quality through the use of biological barriers. In addition, scientists at the National Water Research Institute are investigating the movement of toxic chemicals in groundwater aquifers, used as drinking water sources, in order to improve protocols for groundwater monitoring.

Research on these and many other water-related environmental issues forms the basis for many Green Plan initiatives to eliminate pollution problems in such areas as the St. Lawrence, the Fraser river, the Red-Assiniboine system, the Atlantic coast 'hot spots', and the Great Lakes Basin. Both the River Road Environmental Technology Centre and the Wastewater Technology Centre are active in contaminated groundwater remediation. For example, the River Road Environmental Technology Centre has cleaned up over 8,000 tonnes of contaminated groundwater during demonstrations and clean-ups.

Case Study:

The Great Lakes Remedial Action Plans

Excessive algae build-up on Lake Ontario shoreline

Research on the impacts of pollution on the Great Lakes has heightened since the early 1970's when excessive phosphorus was identified as the cause of the over abundance of algae and low oxygen levels in Lake Erie. Scientists at the National Water Research Institute played a key role in confirming this important finding. Recommendations by these and other Environment Canada researchers led to phosphorus reduction programs which will help to restore the ecology of the lake.

Since then, researchers have identified contamination by many toxic substances, including PCBs, DDT, mercury and alkylated lead. A binational program identified a number of highly polluted "Areas of Concern" within the Great Lakes, including the Toronto waterfront and Hamilton Harbour. These areas fail to meet the general or specific objectives of the Great Lakes Water Quality Agreement. In each case, this failure has impaired, or is likely to impair, the beneficial uses of the area or its ability to support aquatic life.

As a result, Remedial Action Plans (RAPs) are being developed to restore these areas and protect them from further damage. Under the Canada-Ontario Agreement, the federal and provincial governments work together, with local stakeholders, to develop and implement the Remedial Action Plans.

Scientists at the National Water Research Institute contribute to the action plans by improving our knowledge of the sources, pathways and effects of contaminants in the Great Lakes Basin Ecosystem, and by identifying remedial options to clean up existing problems. By successfully carrying out remedial action, Areas of Concern will be delisted when ecosystem conditions have improved sufficiently.

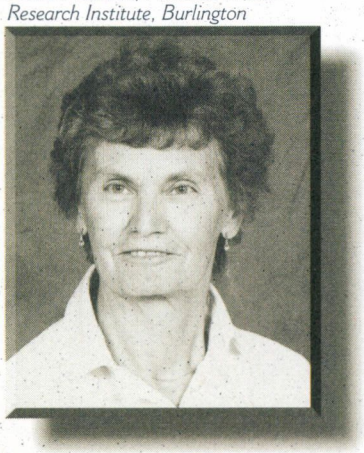
In addition, research has shown that pathways of contaminants are not limited to water and that a major source of toxics in the Great Lakes Basin is the atmosphere. Consequently scientists from the Atmospheric Environment Service are implementing an Integrated Atmospheric Deposition Network to monitor air toxics around the Lakes.

Pollutants in Water Ecosystems

Over the past two years, one of the most exhaustive studies conducted on a body of water in Canada has been underway in Lac Saint-Pierre, Quebec. Isabelle Goulet and Lynn Cleary of the Centre Saint-Laurent, in co-operation with those at L'Institut national de la Recherche scientifique - Eau, have worked on the development of a hydrodynamic model of the lake, as well as computer software, to show the flow of industrial pollutants into the lake and measure their effects on water ecosystems. This work will provide the basis for subsequent studies of other priority areas of the St. Lawrence.

Isabelle Goulet and Lynn Cleary, Centre Saint-Laurent, Montreal

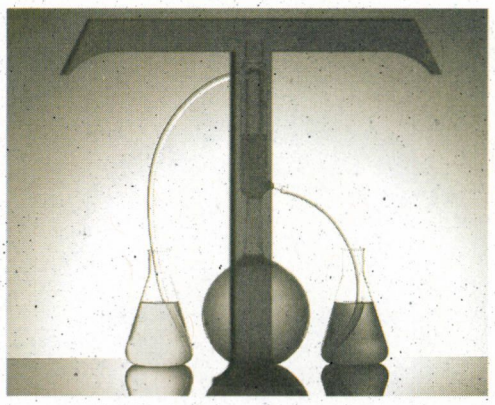
Alena Mudroch, National Water Research Institute, Burlington



The Nepheloid Layer

Evaluating the quality of lake sediments and the potential of polluted sediments to recontaminate the water is crucial to developing effective cleanup strategies. Alena Mudroch leads a group of scientists at the National Water Research Institute who study various aspects of contaminated sediments, including a phenomenon called the nepheloid layer.

The nepheloid layer is a cloud of fine particles which moves in suspension above the bottom of Lake Ontario. Mudroch's research has shown that the nepheloid layer forms naturally in the summer and becomes contaminated with various pollutants such as lead, zinc and copper and some polychlorinated biphenyls (PCBs). With the autumn turnover, the suspended matter circulates from the surface to the bottom and contaminants may be recycled into the water column and bottom sediments.



Toxic Chemicals

Public concern over the presence and movement of toxics in the environment has been growing since the early Sixties, when it was realized that toxic contaminants were accumulating in plants, animals and people. This concern led to research to identify and assess toxic substances and to develop strategies to control how they are produced, used, transported and, ultimately, disposed. About 100,000 chemicals are now in commercial use around the world and approximately 1,000 are added to the list every year. In Canada, we regularly use about 20,000 of these chemicals and introduce a hundred to two hundred new ones annually. While many of these chemicals, such as pesticides and pharmaceuticals, have proved of great value to Canadians, their use has often involved undesirable environmental consequences. In certain cases, such as DDT, this has led to banning of their use in Canada. However, even chemicals which have not been available for use in Canada for many years, may still enter the country as residues in food, imported from countries where they are still used.

Initially, scientific research focused on the detection and measurement of heavy metals as, for example, their presence in seabird eggs. With the development of more sophisticated measurement systems, it has now become possible, not only to measure heavy metals, but also to monitor very complex organic chemicals which are toxic at extremely low levels. New analytical techniques now allow levels of parts per trillion to be determined in water and air samples. The long-term goal of these increasingly sophisticated technologies is the virtual elimination of toxic substances from our environment, a major Green Plan goal.

Man-made chemicals are present in all the ecosystems which are being studied by Environment Canada's scientists. The aim of this research is to enhance our understanding of the way in which these chemicals pass through air, water and land; to develop new technologies for the measurement of toxic pollutants in rivers, lakes, groundwater, air and contaminated land sites; and to assess their impact on people, wildlife and plant species.

As a result of this research, Canada will be able to meet its obligations, domestically and internationally, for the assessment of toxic substances in the environment. Domestically, this is managed through the 1988 Canadian Environmental Protection Act and the Pest Control Products Act. There is also close international collaboration with the Organization for Economic Cooperation and Development and with the United Nations. Through this international network, a "new chemical", i.e. a chemical which has not been previously used in commerce, is tested before its use is permitted. There are, however, some 1,500 chemical substances, already used by industry and widely traded, which require examination, and possibly testing, to determine their level of toxicity. Canada is responsible for the assessment of thirty of these substances on behalf of the international community.

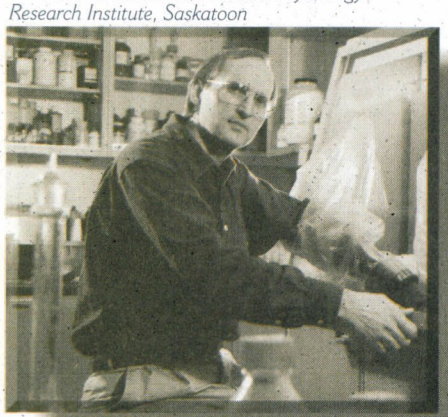
Research on the hazards posed by contaminants is being pursued in several areas by Environment Canada's scientists. At the National Water Research Institute in Burlington, scientists conduct bioassays to assess the impact of industrial effluents on the waters into which they are discharged. Industries of interest include the pulp and paper, petrochemical, chemical, and metal and mining sectors.

Toxics not only move through bodies of water, they are also transported through the air. Hence, a major area for research by Environment Canada scientists is on trends in ambient air levels of airborne toxics and on the ways in which they travel through the environment. Scientists at the River Road Environmental Technology Centre measure the contaminants caused by emissions from motor vehicles and conduct research on alternative fuels, which would reduce the

degradation of air quality and the formation of ground-level ozone (smog). Since 1988, air monitoring programs have been in place in over twenty-five sites in fifteen cities to measure air toxics and to help identify the principal sources of pollution. The results of this research have been used to develop technologies to reduce emissions. Moreover, on-going work on alternative fuels is anticipated to reduce these further.

In addition, sites contaminated from industrial development represent a major problem. Scientists at the Wastewater Technology Centre, the River Road Environmental Technology Centre and the Centre Saint-Laurent have been working with industry to develop and commercialize innovative technologies for the treatment of such sites and expert systems are being developed to assist industrial users in selecting appropriate clean-up technologies. Research at these centres is also continuing on the options for pumping out or excavating polluted landfill sites and treating the residue to remove toxic contaminants.

Dr. John R. Lawrence, National Hydrology Research Institute, Saskatoon



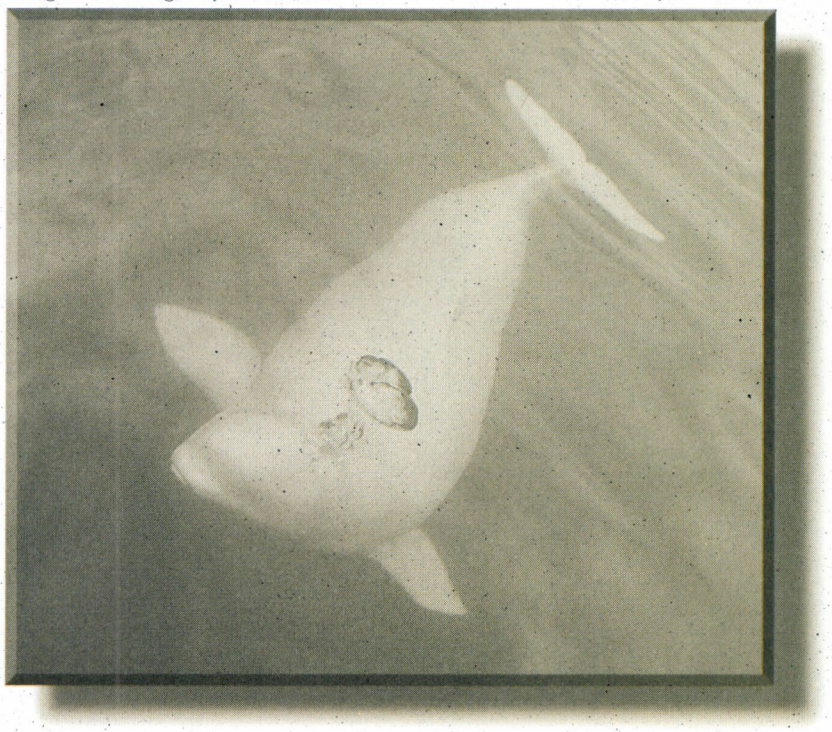
What Happens to Pesticides Applied to Soil?

Pesticides applied to soil threaten the purity of drinking water, by infiltrating the soil and subsequently polluting groundwater or through run-off into lakes and rivers. At the National Hydrology Research Institute, Dr. John R. Lawrence and his colleagues are using a large-scale model of a typical soil profile and aquifer to trace the breakdown of pesticides and determine the quantity that penetrate to the aquifer. This model consists of a 4.6 metre, 65 tonne column of soil and aquifer materials, which is fully instrumented to facilitate monitoring of the progress of pesticides. Samples of sediment and groundwater are analyzed to determine the distribution and level of contamination.

Case Study:

Toxic Contaminants in the St. Lawrence River

Beluga whale in Saguenay Marine Park



One of the tasks of the Centre Saint-Laurent is to assess the impact of toxic contaminants on the quality of the water in the St. Lawrence River and, then, work with industry and other governments on preventive strategies. For example, the beluga whale population has already suffered from active commercial fishing operations in the river during the first half of the century. More recently, a study revealed that chemical contamination from heavy metals and other pollutants, as well as overfishing, had contributed significantly to the decline of beluga whales in the St. Lawrence from an estimated population level of ten thousand at the turn of the century to fewer than five hundred today. What are the major sources of contaminants in the river and which contaminant source produces what class of toxic chemicals? What is the relative importance of these sources? These are some of the questions that a team of researchers and technicians are trying to answer, in order to improve the decision-making process for identifying areas in the river that require clean-up.

Research scientists at the Centre are also working on the biological testing of bacteria, small animals and fish tissue, in order to measure the toxic effects of various contaminants upon the life forms which inhabit the river. The development of the technology for such testing is essential to understanding the potential impacts of chemicals and complex liquid wastes on the aquatic environment. This will make it possible to identify the polluting agents and to develop plans to restore the quality of the water in this major river.

Waste and Wastewater Management

As the Green Plan noted, Canadians produce over thirty million tonnes of garbage annually, only ten percent of which is recycled. Of even more concern, twenty percent of this garbage consists of wastes, which present special problems for handling, storage, disposal and destruction. Landfill sites for the dumping of domestic waste are becoming harder to find and the environmental impact of the discharge of waste into sewers, rivers and lakes is a growing problem.

In the management of wastewater, effective sewage disposal is a major concern. Experts at the Wastewater Technology Centre have provided advice on how the operation of sewage treatment plants could be improved. Solutions include such technologies as computerized process audits, which enable municipalities to defer capital spending by making more efficient use of facilities currently in place. In one instance, modifications to old aerator cones, made at a cost of approximately half a million dollars, deferred proposed plant expansion costs estimated at twenty million dollars. Similarly, the Centre is developing technologies for converting sewage sludge into fuel oil.

One option for the disposal of solid municipal waste is incineration. This has the advantage of reducing the burden on scarce landfill sites, while offering the potential for an alternative energy source. The National Incinerator Testing and Evaluation Program has been a major Environment Canada initiative to address the municipal waste disposal problem. As part of the Program, a study was conducted by scientists at the River Road Environmental Technology Centre and the Wastewater Technology Centre to investigate combustion, computer control, ash characterisation, stock measurement and emission control technologies for waste incinerators. One of the three incinerators studied was located in Hartford, Connecticut, where the research was directed to addressing the waste disposal problems of large cities.

In support of waste reduction and recycling programs, Environment Canada scientists are also working on the development of recycling technologies, which explore ways in which recycled materials can be put to new uses. For example, a product with properties similar to hardwood, has been developed for commercial application. This substance has a variety of commercial applications and has, in fact, certain advantages over conventional wood products.

The management of industrial wastes provides an opportunity to work co-operatively with industry. In addition, as the Green Plan recognized, the development of an environmental technology industry in Canada provides the potential for cleaning-up and preventing the pollution caused by industry. For example, research is being conducted on emission control technologies for industrial boilers using fossil fuels. This research is also providing government and industry with information to assist in developing cost-effective emission control strategies and standards.

Hazardous wastes from industrial operations are currently being managed through disposal centres or storage at industrial sites, until environmentally safe and acceptable technologies become available. However, Environment Canada scientists are studying some promising options. These include the use of micro-organisms, which can break down toxic chemicals in contaminated areas, as well as the development of advanced liner technologies for the complete containment of hazardous wastes in conventional land sites.

Case Study:

Controlling Pollution in the Pulp and Paper Industry

Pulp and paper mill, Elk Falls, British Columbia

The multi-billion dollar pulp and paper industry is an important sector of our economy, a significant generator of jobs, and an export industry. Unfortunately, wastewater, discharged from pulp and paper mills, contains a variety of toxic chemicals and biomass which reduce the oxygen in the water of many important rivers and lakes. In addition, the kraft bleach process used in the mills produces solid waste and air emissions, which further contaminate the environment.

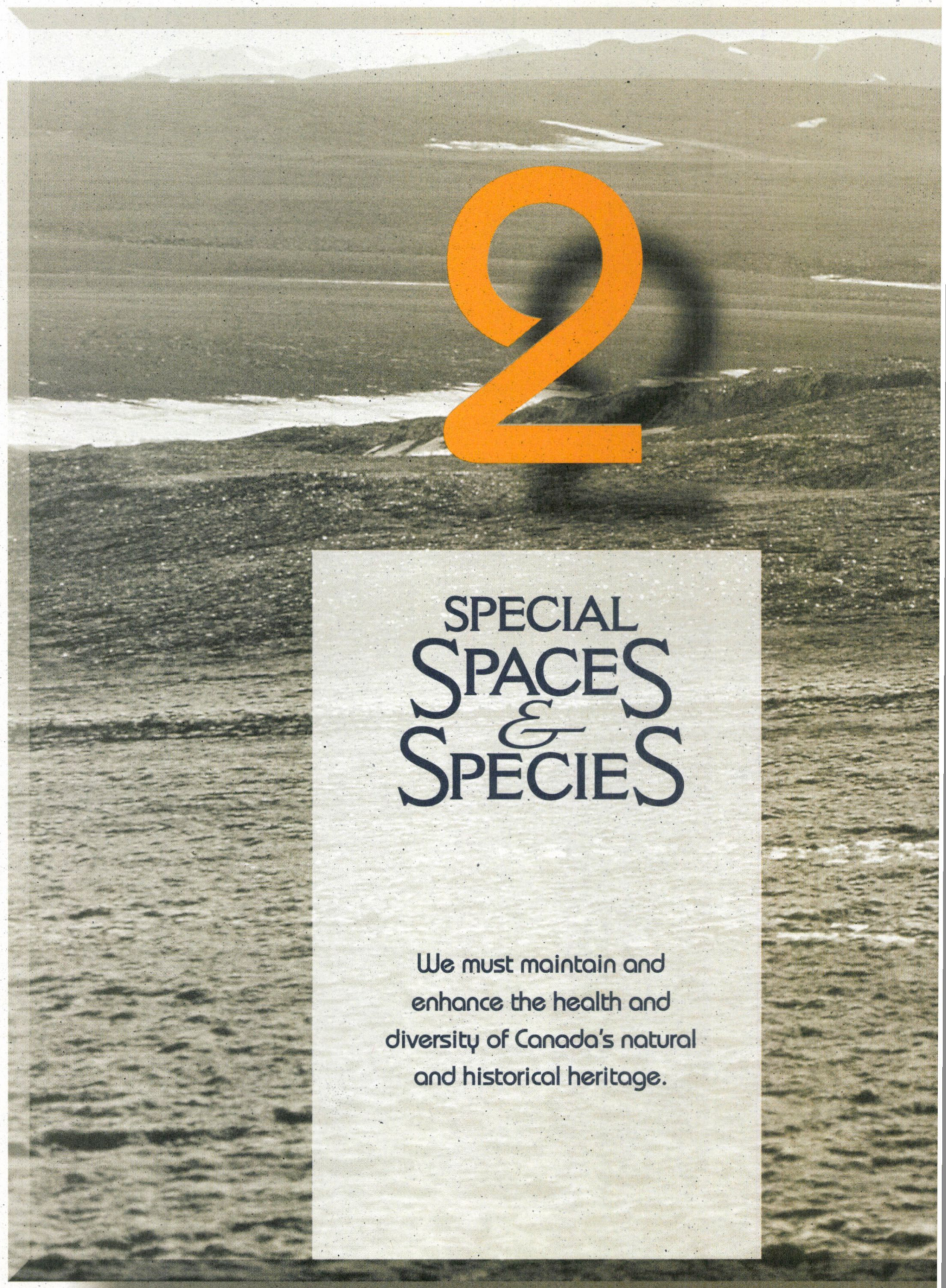
Environment Canada's scientists are working to identify the major chemicals involved and measure their degree of toxicity. Research at the National Water Research Institute, in co-operation with scientists from the Department of Fisheries and Oceans, has revealed that proposed controls on AOX (Adsorbable Organic Halogens) in pulp mill effluents may not be effective in eliminating the sub-lethal effects these effluents have on fish. Research is ongoing to identify the chemicals in the effluents that are responsible for these detrimental effects. Environment Canada scientists are also searching for process changes or waste treatment technologies to reduce this toxicity, and for means to monitor the effects of this contamination on human and environmental health.

Several of Environment Canada's scientific centres are involved in research programs that, together with research and development efforts in the industry itself, aim to assess and control the pollution which results from the operation of pulp and paper plants. At the Wastewater Technology Centre in Burlington, Ontario, a joint project with the National Water Research Institute is developing cost-effective solutions to the toxicity problem. These include research on the possibility of employing anaerobic technology, which cleans up organic pollution through the use of bacteria which do not require air or free oxygen. Another avenue being explored is the use of membrane technologies, that use the properties of the animal or vegetable tissues, which form a lining around animal organs or plant cells, to remove pollutants. The Centre Saint-Laurent in Montreal is also making a contribution by investigating a new pollution control technology using carbon filters.

Chung Chiu, River Road Environmental Technology Centre, Gloucester

Special Sampling and Analysis

There is considerable concern about the level of dioxins and furans released into the air and water by pulp mills. Furans, like dioxins, are a toxic by-product, formed during bleaching of pulp using chlorine, and result from the synthesis of organic materials. Special sampling and analytical techniques are being developed at Environment Canada's River Road Environmental Technology Centre near Ottawa by a team of scientists including Chung Chiu. These techniques are designed to ensure the accurate measurement of dioxins, furans and sulphur compounds found in the effluents and atmospheric emissions from pulp mill stacks.

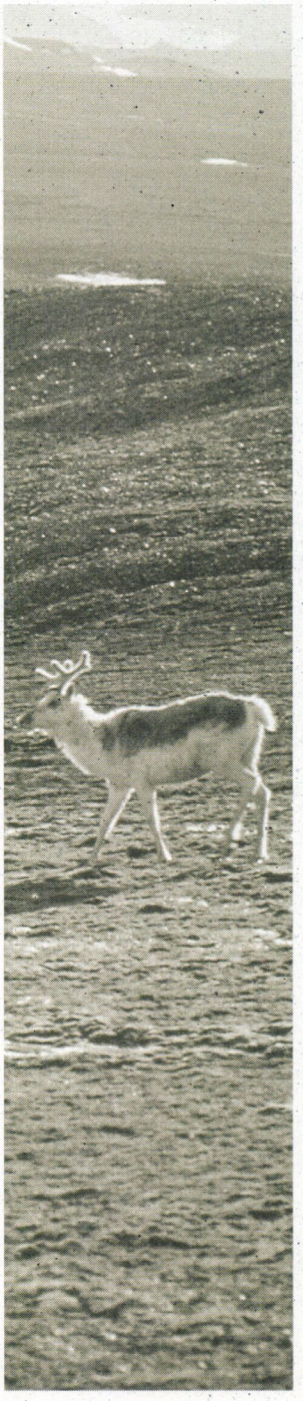


2

SPECIAL SPACES & SPECIES

We must maintain and enhance the health and diversity of Canada's natural and historical heritage.

Wildlife



Scientists at the Canadian Wildlife Service focus on the study and management of wildlife, especially the many species of migratory birds over which the federal government, rather than the provinces, has jurisdiction. Traditionally, wildlife science focused on the protection of game species because of their obvious value to people and their vulnerability to overhunting. In recent years, however, it has expanded to include other species and the habitats they require for survival. This is attributable to the realization that all species contribute to the healthy function of ecosystems. When ecosystems are degraded by human activities like agriculture, forestry, or urbanization, many species decline, some increase, and others disappear. For example, the almost complete removal of the Carolinian forest in southwestern Ontario has threatened the survival of about 25 species of plants found nowhere else in Canada. At the same time, a number of new plant species, including some serious pests, have been introduced. It is clear that, as human activities intensify across Canada, pressure on natural areas and their wildlife will inevitably increase. A major challenge facing wildlife scientists is to determine how the impact of these activities can be avoided or reduced, and how the production of healthy wildlife populations, with their important benefits, can be maintained or even enhanced.

Because the problems are not all within Canada's jurisdiction, there is also a need to work co-operatively with other countries. The conservation of migratory birds, for instance, is a matter of concern to the country where they breed, the countries through which they pass on their journeys north and south, and the countries where they winter. Large numbers of some twenty-seven species of shorebirds that breed in Canada winter in a relatively small number of sites along the South American coast-line. Aerial surveys, conducted by Canadian Wildlife Service scientists, identified these sites, and an atlas showing the main wintering areas has been published. This research has led to the creation of the Western Hemisphere Shorebird Reserve Network through which governments in both South and North America are co-operating to protect key sites.

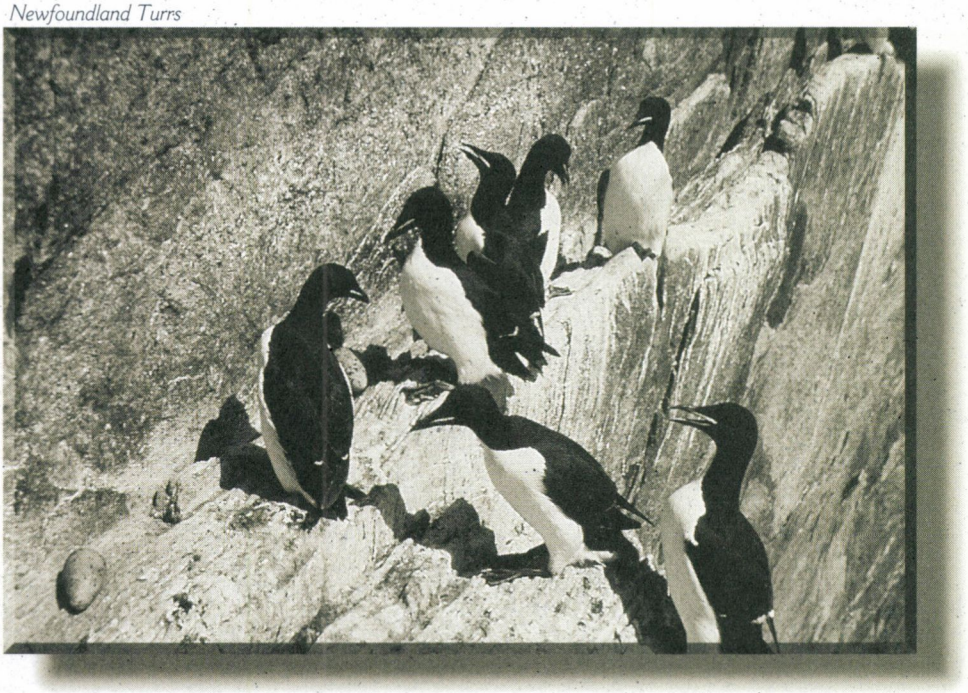
The ways in which changes in agricultural practices or climate change affects wildlife habitats are surveyed by scientists, using satellite imagery and computer techniques for mapping data. This enables programs to be designed to improve the availability of good habitat. A particular area of concern in recent years has been Canada's wetlands, some of which have been drained for agricultural and other development purposes. These complex ecosystems play an important role in maintaining not only waterfowl but a great variety of other wild animals and plants as well as in maintaining water quality and quantity. The 1991 Federal Policy on Wetland Conservation, strongly endorsed by the Green Plan, commits the federal government to include wetland conservation as a fundamental part of all federal land-use decisions.

Toxic chemicals affect people and animals. Often a decline in the diversity of species, or in the numbers of a single species of wildlife, is the first indication that a pollution problem exists. The collapse of the peregrine falcon populations of eastern North America in the middle of the century led to research both in the United States and by the Canadian Wildlife Service which established that DDT was the key causal agent. The discoveries that DDT, PCBs, dioxins and mercury were widespread and damaging to the environment have led to major restrictions on their uses or releases. Problems caused by these compounds in wildlife have proved to be efficient indicators of hazards to people.

Case Study:

Sustainable Yield: The Case of the Newfoundland Turr Hunt

Newfoundland Turrs



Known locally as turrs, Thick-billed Murres are traditional favourites of Newfoundland hunters during the winter, and represent a valuable source of meat in outport communities. An estimated five million Thick-billed Murres winter around the province's coastal regions. About eight hundred thousand Murres are harvested each year. There are currently no bag limits to restrict the harvest and there have been suggestions that this practice has contributed to population declines in the species.

The Thick-billed Murres are migratory and those that spend their winters near Newfoundland breed in the eastern Arctic and Greenland. During each breeding season since 1981, a team of Environment Canada's biologists has studied the Murre colonies at the mouth of Hudson Bay to observe the birds and to band both chicks and adults. They have found that Murres, which only lay one egg a year, do not usually breed until they are five years old. Banding results indicate that most of the birds shot in Newfoundland waters are younger than this.

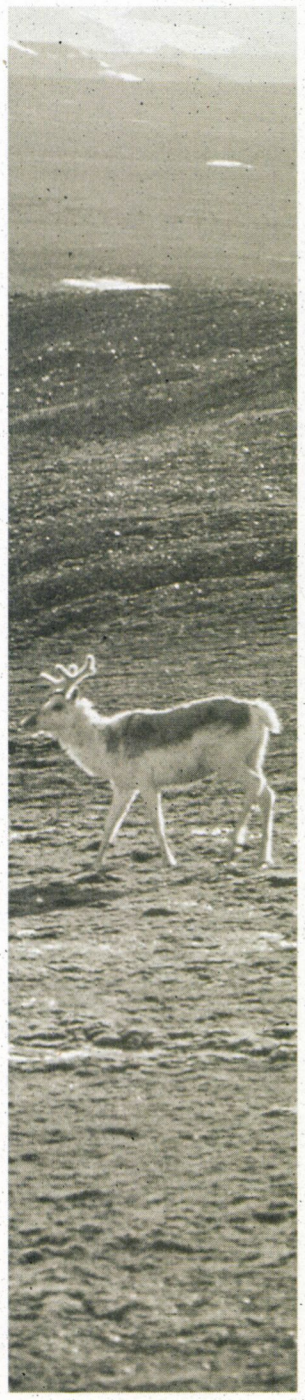
Unregulated hunting in Newfoundland could severely affect the population levels of this slow-reproducing species. Now that the nature of the problem has been determined, Canadian Wildlife Service scientists in Newfoundland are working on solutions. Through visits to the many small communities involved, they are providing information to hunters and their families on the issue and discussing possible ways to regulate the hunting, so that the harvest can continue without irreversible depletion of the stock.

Dr. Ross Norstrom, Canadian Wildlife Service, Hull

Chemical Contamination in Polar Bears

Dr. Ross Norstrom of the Canadian Wildlife Service is studying the potential effects of contamination of polar bears by organochlorines. He has discovered that the patterns of contamination found in the polar bears correspond to the patterns of contamination found in the air and is pursuing further research into time trends and circumpolar distribution. Relatively high levels of PCBs and the pesticide metabolite oxychlordane were detected in bear liver and fat. Pregnant females and cubs appear to be most at risk from these toxic substances because of the bear's dependency on its accumulation of fat during gestation and lactation.

Unique Ecological Areas and our Heritage



The first national park was established in Banff in 1885 by Sir John A. Macdonald. Today, there are thirty five national parks and park reserves, distributed throughout the country, each representing distinctive characteristics unique to its region. For instance, Wood Buffalo National Park, on the border between Alberta and the Northwest Territories, is a nesting area for whooping cranes and peregrine falcons, while Point Pelee in southern Ontario is world-famous as a refuge for many migratory birds and butterflies. This Canadian network of parks serves to preserve our special places from the pressures of urban or economic development and to ensure the conservation of essential wildlife habitats. In recognition of the vital role that the parks and other protected areas play, the Green Plan identified a long-term goal of completing the national park system by the year 2000, as well as setting aside 12 percent of the country as protected space.

National parks have always been focal points for scientific research. Initially, the emphasis was on wildlife and forest resources. In recent years, the research focus has shifted to an ecosystem perspective, which recognizes that our parks are, in fact, living laboratories. Investigations are conducted on the genetic biodiversity contained within the parks, with special attention to such species as bison, elk, pine marten, mountain goats, bighorn sheep, deer, wolves, grizzly and black bears and trout. Rare and endangered plant species are inventoried and ecosystem research, such as the Greater Fundy Ecosystem Study, is conducted in partnership with universities and provincial land managers. This approach ensures that the Canadian Parks Service responds to biological and physical changes in the conditions of each park with the appropriate management action.

The national parks contain examples of both our ecological and historical heritage. The Canadian Parks Service conducts an archaeological research program, which enables it to identify cultural resources of national significance. For instance, it maintains one of the largest and most experienced marine-archaeology units in North America. At Fathom Five National Marine Park in Ontario, experiments have been conducted with a new technique (the Sonic High Accuracy Ranging System) which has the potential to provide more accurate mapping of underwater archaeological sites. Projects such as these offer the opportunity to give Canadians a better understanding of our history.

In addition, enhanced material conservation science is helping the Canadian Parks Service to prolong the life-span of a wide variety of historic materials, ranging from artifacts recovered from archaeological sites and marine wrecks, to fine art and furniture. This activity ensures that cultural resources of national significance, which are at risk due to environmental degradation or increased human activities, are adequately protected and significant archaeological loss is prevented or mitigated.

Case Study:

Fire and the Ecology of Natural Parks

Forest fire in a national park

Fire history research indicates that, under natural conditions, fire plays a major role in the evolution of ecosystems in and around most national parks. While most people tend to think of fire as a destructive element, it is, in fact, a natural process which regulates forest growth and nutrient flows. It destroys old trees, clears ground for new growth and provides open spaces where species, such as elk and bighorn sheep, can browse.

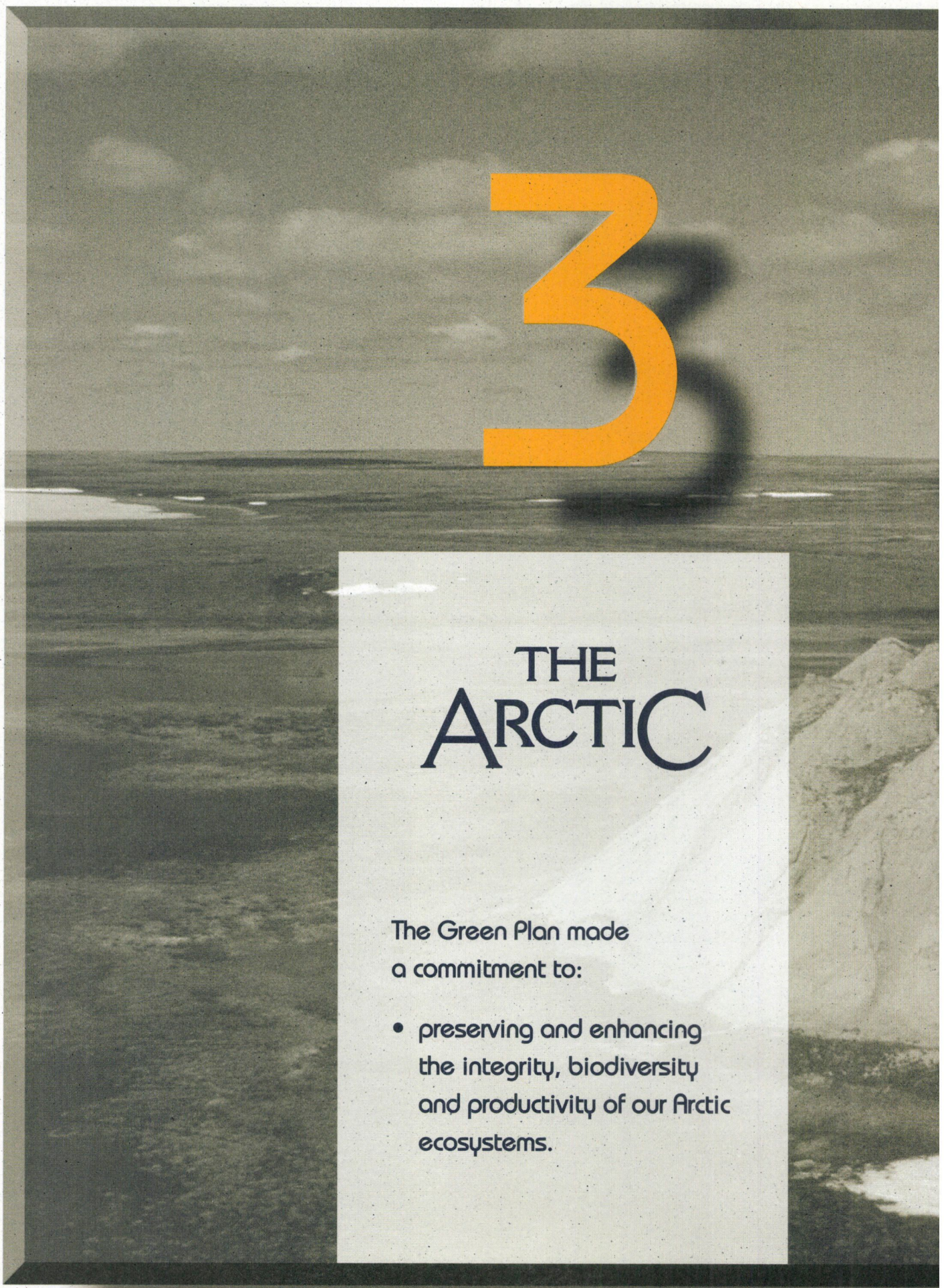
When this natural process does not occur, there can be problems. For example, in Kootenay National Park, studies have shown that there have been significantly fewer fires in recent decades. As a result, there are more older trees which will eventually fall as a result of wind, of the activities of insects or of the effects of disease. The replacement species are likely to be those adapted to these kinds of natural processes and fire-dependent species are unlikely to be favoured. Moreover, the consequent increases in accumulated deadwood and ground debris make the area readily combustible and may result in fires of greater severity. The decrease in open foraging space will mean that species, such as elk, will move closer to roads and recreation areas, where they are both at risk themselves and a danger to highway traffic.

The Canadian Parks Service has developed comprehensive fire management plans for many of our national parks, in order to return them to a more natural state. In 1991, Kootenay, Pukaskwa and La Mauricie were added to the list of parks that have fire management programs. While these programs include provisions for the rapid suppression of naturally-occurring wildfires, they also include a series of carefully controlled fires set by Parks staff. These fires ensure that the natural structure and balance of park ecosystems is preserved, while the threat to life and property, resulting from wildfires, is greatly diminished.

Robert Grenier, Canadian Parks Service, Ottawa

Underwater Archaeology

A team of Environment Canada scientists, led by Robert Grenier, head of marine archaeology for the Canadian Parks Service, has been utilizing heated suits which triple the time a diver can spend underwater in the near-freezing waters of Labrador's Red Bay. Using these suits which are warmed by water fed from a central boiler on the diving barge, they have been investigating the wreck of what is thought to be the San Juan, a Basque galleon sunk in a violent storm in 1565. In addition, two of the Canadian Parks Service scientists, Lorne Murdock and Tom Daley, have developed a revolutionary new method of making rubber casts underwater in temperatures hovering near the freezing point. These discoveries have enabled them to produce moldings of the wrecked ship, the oldest so far discovered in the New World north of Florida. The results of their investigation are helping to rewrite the history of shipbuilding in the age of discovery of the New World.



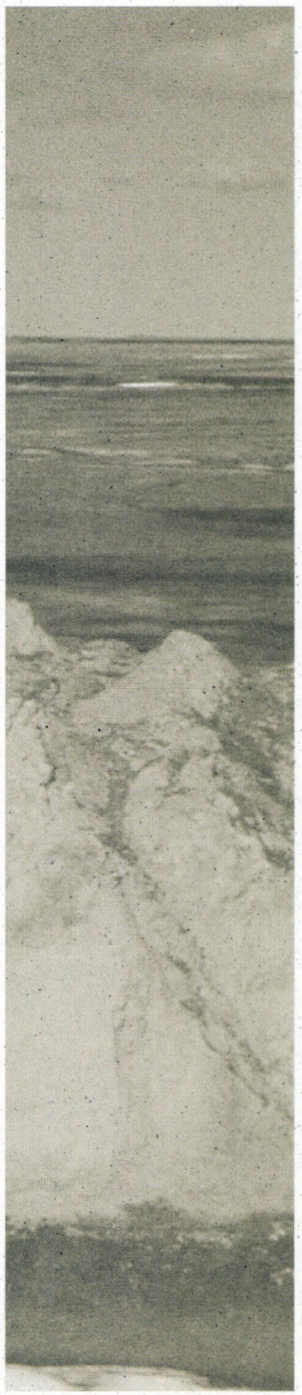
3

THE ARCTIC

The Green Plan made a commitment to:

- preserving and enhancing the integrity, biodiversity and productivity of our Arctic ecosystems.

The Arctic



Canada's Arctic includes 40 percent of Canada's total land mass. It is surrounded by two-thirds of Canada's coastline and contains more than 30 percent of our freshwater resources. In addition, 84 percent of the Canadian land mass is drained by rivers that flow northward into either the Arctic Ocean, Bering Sea or Hudson Bay. Consequently, many upstream developments will eventually impact on northern river ecosystems.

Canadians tend to think of the Arctic as an area that is remote and untouched. Indeed, it does provide a home for aquatic, terrestrial and marine species of plants that are not found elsewhere in Canada. Nevertheless, the area is no longer so remote that it can remain untouched by the environmental problems plaguing more heavily populated areas. Not only is it increasingly threatened by the industrial activities of the more developed regions of southern Canada, it is exposed to the consequences of activities in other northern nations.

The Arctic is affected by airborne pollutants from outside Canada, as well as the detrimental effects of local development. The Canadian North is directly influenced by atmospheric circulation from Eurasia; there contaminants have tended in recent years to be less rigorously controlled than in Canada and from the U.S. However, not all the Arctic pollution is derived from the air. The Arctic Ocean, partly because of the shallow sill at its margin, has difficulty expelling polluted water once it is received. Disposal of industrial and radioactive wastes in the Arctic Ocean may well be another source of contamination for the Arctic food chain. Moreover, the Arctic is one of the areas thought to be most at risk from the consequences of climate change since its extreme climatic conditions mean that any damage to its ecosystems is slow to heal. To preserve this huge and beautiful area of Canada requires a specific strategy.

The Green Plan announced the implementation of an Arctic Environmental Strategy to deal with the environmental challenges particular to the North. This strategy is being developed in partnership with governments of other northern countries. Environment Canada's scientists are working with them to gain a better understanding of the impacts of local and transported pollutants on Arctic ecosystems, to determine the implication of global warming for the northern environment, and to improve the quality of northern water resources. For example, scientists from the Atmospheric Environment Service have completed three major laboratory construction projects in the Arctic in the last 18 months to work on determining the movement of contaminants through the environment.

The Canadian Climate Centre is conducting a six year study to determine the impact of global warming on the Mackenzie River Basin and the constraints that climate change will bring to agriculture, forestry and energy in the region. In addition, potential climate changes in the Beaufort Sea ice regime may have significant implications for the development of the huge oil and gas reserves in this area. Studies are being conducted on the probable length of the open water season and the maximum winter nearshore ice thickness. The results of such research will be significant in ensuring that economic development in the area is carried out with a full awareness of the environmental impacts it may have.

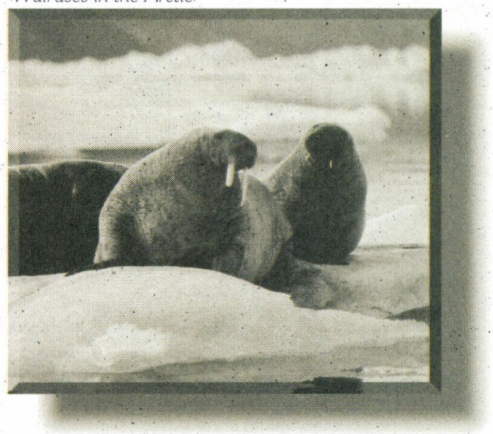
In the area of toxic pollutants, the National Water Research Institute is studying contaminants in snowfall in the Yukon and in the Northwest Territories to determine the fate of airborne contaminants in northern ecosystems and the extent of contamination in the Yukon River Basin from local and long-range sources. The National Hydrology Research Institute, together with researchers from other northern

nations, is working to develop improved environmental forecasting in the North, while the National Wildlife Research Centre is conducting research to determine the extent to which Arctic wildlife species are being exposed to toxic contaminants. Species under study include polar bears, waterfowl, and shorebirds which breed in the Arctic.

Ecological studies of many Arctic mammals, birds and fish have been pioneered by Canadian scientists. The knowledge gained is vital to the management decisions now taken co-operatively by governments and the Arctic communities that rely for their subsistence on the sustainable use of many of these species. The value of maintaining this research over long periods has recently been demonstrated by Dr. Ian Stirling of the Canadian Wildlife Service. His studies of the polar bears of western Hudson Bay show that the weights of adult bears and the productivity of females have declined steadily since the mid-Seventies. This trend in this top predator appears to indicate that something significant is happening in the ecosystem of Hudson Bay. The research challenge is to understand what that is.

The knowledge gained from such research will better enable us to manage and conserve the habitat and the population of migratory birds, transboundary mammals, such as polar bears and caribou, and endangered species of plants and animals. The aim is to ensure both sustainable economic development in the North and protection of the integrity and biodiversity of this unique environment.

Walruses in the Arctic



Case Study:

The Movement of Toxic Chemicals Through the Environment

The image of the Canadian Arctic is of a remote, vast, pristine and untouched environment. However, it is becoming increasingly apparent that toxic substances can contaminate even wilderness areas far from the places where these chemicals originate. For example, at Alert on the tip of Ellesmere Island, traces of toxaphene have been measured in the air. Until 1983, toxaphene, a pesticide, was widely used in the cotton fields of the southern United States, but was scarcely used at all in Canada. It has certainly never been used in the Arctic region.

Understanding how toxic substances travel, or are conveyed, over such large distances is a significant part of the research carried out by Environment Canada scientists. Using a model to simulate probable weather conditions in the past, they have determined that toxaphene probably travelled through the atmosphere from the southern United States to the Canadian North. Other chemicals, for example metals and radioactive elements, are thought to have reached the Arctic from Western Europe and the Commonwealth of Independent States, the former Soviet Union.

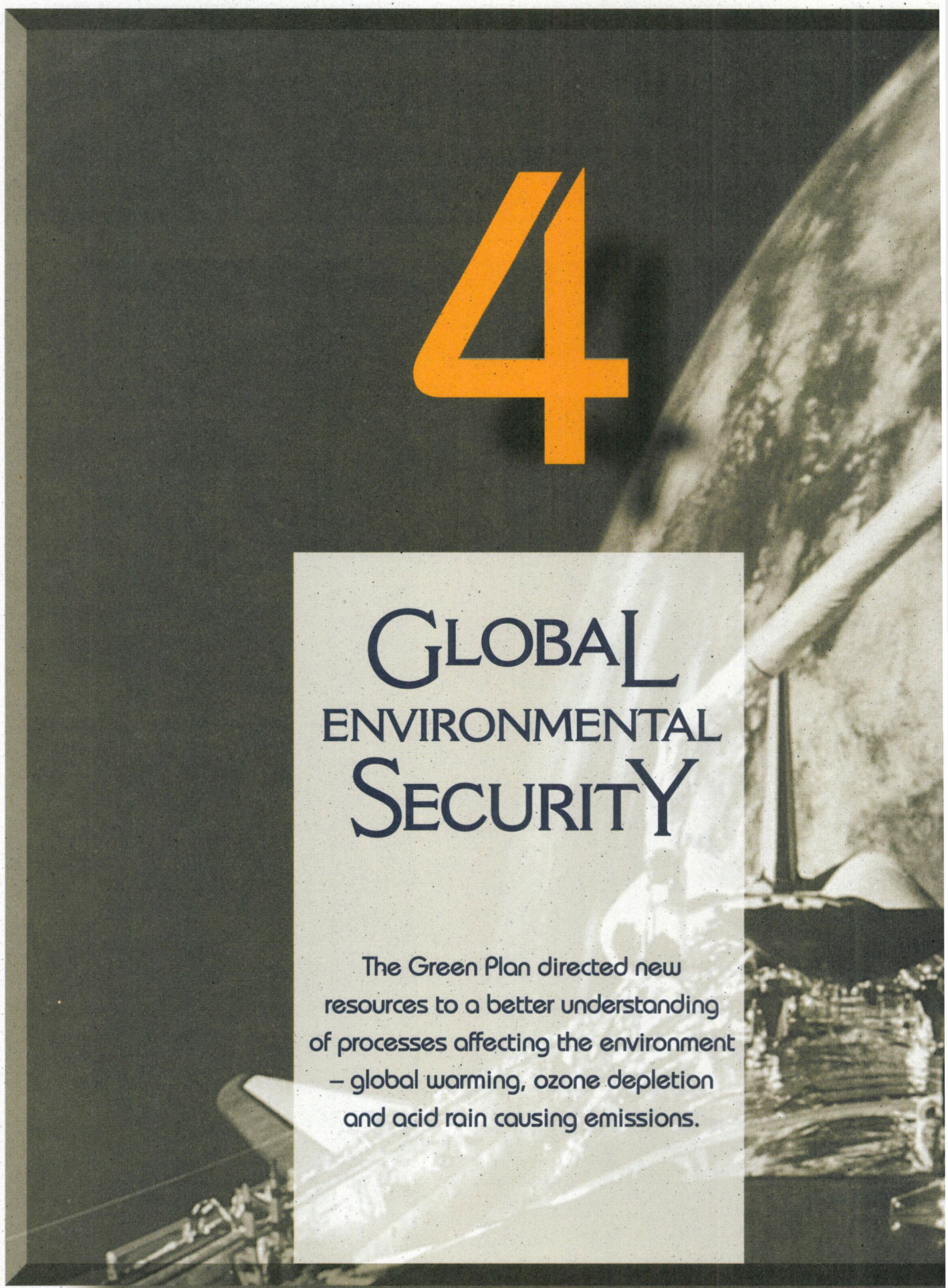
Environment Canada scientists are now investigating the possibility that toxics, travelling through the atmosphere, are being deposited in significant amounts in the Arctic. Since these substances tend to accumulate in the food chain, the threat they pose to wildlife and to human health is considerable. To determine the extent of the problem, the scientists are developing sampling procedures and analytical methods for the accurate measurement of organic chemicals in air, rain, snowfall and water. In co-operation with international colleagues and with the Department of Indian and Northern Affairs, scientists from the Atmospheric Environment Service are working to determine the sources of such contaminants, their concentrations in the Arctic and their pathways through the atmosphere. Such research will increase our understanding of the effects of long-range transport of persistent contaminants upon the health of ecosystems. It will also assist in the development of strategies for the international control of long-range, transboundary air pollution.

Lynne Dickson, Canadian Wildlife Service, Edmonton

Monitoring Loons in the Beaufort Sea

Lynne Dickson, a scientist in the Canadian Wildlife Service, has been studying the Red-throated Loon to find ways to measure the potential effect on birds of the offshore oil and gas development, proposed for the Beaufort Sea in the Canadian Arctic. She has collected five years of data on the abundance of adult pairs of loons and their breeding habits.

The Red-throated Loon is particularly well-suited for a study of the impact of oil and gas development on environmental quality. The bird is widespread in the area and its position in the food chain makes it a useful indicator of pollution in the costal sea, while disturbances in its onshore habitat are rapidly reflected in its breeding behaviour.



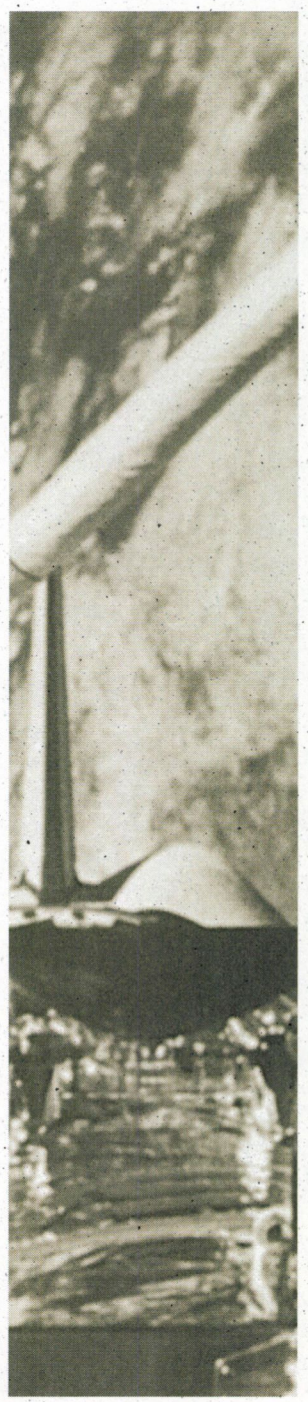
4

GLOBAL ENVIRONMENTAL SECURITY

The Green Plan directed new resources to a better understanding of processes affecting the environment – global warming, ozone depletion and acid rain causing emissions.


Canada

Global Warming



The earth's climate affects us all. The sun provides us with energy and the earth's atmosphere provides us with warmth. It is a natural greenhouse, without which life as we know it on our planet would be impossible. Carbon dioxide, methane and other gases in the atmosphere provide much of this warmth by absorbing the heat that is re-radiated from the surface.

However, scientists are becoming increasingly concerned about the impact of human behaviour on the environment and the way in which our actions are changing the world's climate. Human beings are, in a variety of ways, releasing more and more greenhouse gases into the air and increasing the natural greenhouse effect. The consequent global warming is likely to mean profound changes to aspects of our lives.

The main source of humanity's greenhouse gas emissions is energy use; in particular the burning of fossil fuels. In Canada each of us produces a disproportionate share of these gases, due to the energy-intensive resource extraction nature of our economy, our transportation needs and the requirement to keep warm in the winter. Concentrations of greenhouse gases in the atmosphere have increased dramatically in recent years and their presence may have important consequences for the earth's climate.

Here in Canada, these impacts will be different from place to place. Patterns of agriculture are likely to be affected, water supplies will become scarcer in some areas, forests may move northwards and sea levels rise. As yet unforseen impacts may occur as well. Other areas of the world are also likely to experience varied effects – devastating floods, heat waves and drought are likely to become more common in many regions.

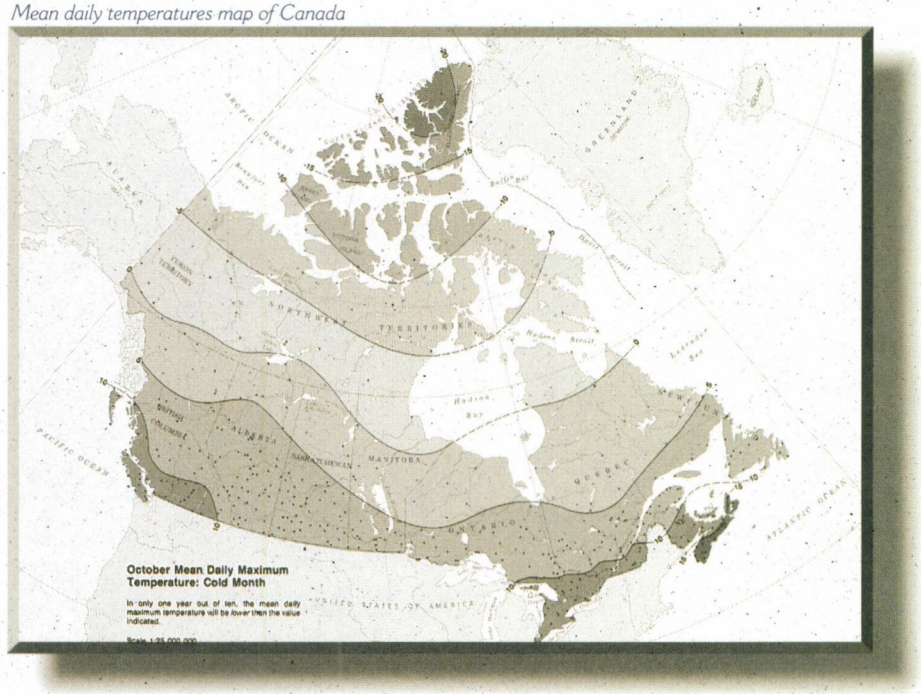
Even though Canadians produce more greenhouse gases per capita than most other people, global warming is not simply a made-in-Canada problem. This country's approach is therefore two-fold. On the one hand, we have made a special effort to stimulate international action by taking a leading role in negotiating the Framework Convention on Climate Change, as agreed upon at the United Nations Conference on Environment and Development in June 1992. Canada is also continuing to work hard to get the Convention's provisions implemented as quickly as possible. On the domestic front, a National Action Strategy has been developed, in concert with the provinces and territories and with the input of Canadians from all walks of life. The Federal Government, in the Green Plan, has laid out its program for action. A number of provinces and territories are responding in their jurisdictions. Individual Canadians are taking action as well.

There are three main thrusts to this National Action Strategy – limiting emissions of greenhouse gases, improving our scientific understanding of global warming and helping Canadians prepare for and adapt to the changes in climate which may occur as a result of global warming. Programs to limit net emissions include an Energy Efficiency Act, alternative energy programs, initiatives to encourage more energy efficient building practices, a community tree-planting program and programs to reduce methane and nitrous oxide emissions from agriculture. In order to improve scientific understanding, Canada is participating in large-scale international experiments, modelling atmospheric and ocean processes and developing an expanded greenhouse gas monitoring program. We are also putting in place an enhanced climate change detection network which will form the basis for production of regular reports on the state of the Canadian climate. To help Canadians prepare and adapt, socio-economic impact studies are being carried out to assess sensitive areas; policies are being developed to deal with changes in sea level; and we are working on ways to factor the effects of climate change into major projects such as the fixed link to Prince Edward Island.

Case Study:

The Global Climate Change Model

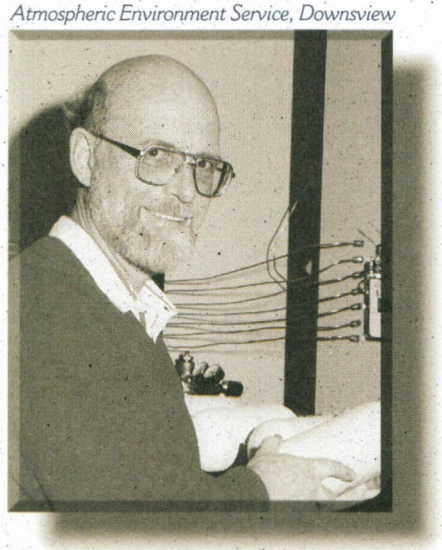
Mean daily temperatures map of Canada



The Canadian Climate Centre in Downsview, Ontario is continuing work on a large-scale mathematical simulation of the earth's climate. This General Circulation Model or GCM is based on the best scientific understanding of the processes which influence climate. By changing some of the assumptions made in the model, it is possible to use it to describe what future climates might be like as a result of global warming and other natural processes such as the El Nino phenomenon. Ultimately, models of this type may be used for predicting next year's weather conditions.

Understanding the causes of climate change allows us to better model present and future climates. Information gained from the enhanced research program, Canada's participation in large-scale international experiments such as the Boreal Ecosystem-Atmosphere Study and from the enhanced greenhouse gas monitoring effort will improve this understanding and result in better simulations of the changes that will result from global warming. This in turn will mean that Canadians will be better able to prepare for the impacts those changes will have.

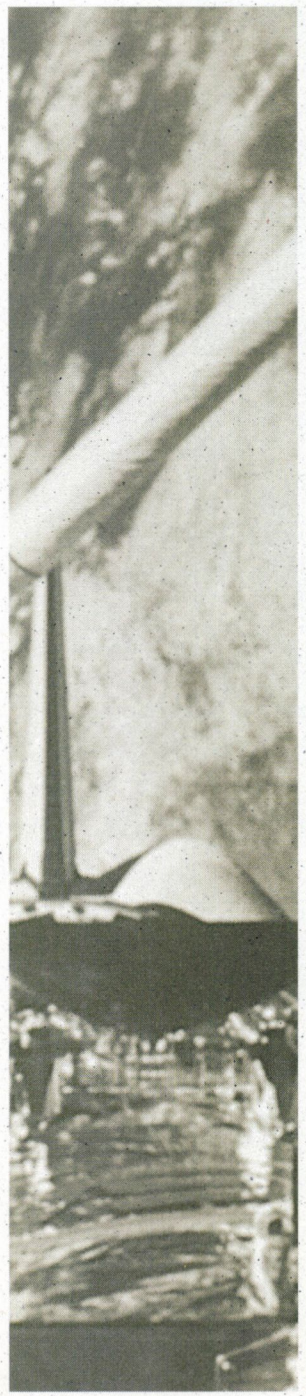
Dr. Neil Trivett, Atmospheric Environment Service, Downsview



Measuring Greenhouse Gas Concentrations

In 1986, Environment Canada started an observation program at Alert in the high Arctic, aimed at monitoring greenhouse concentrations in the atmosphere. This program has been carried out continuously since that time and is being expanded to other sites across the country. Flask samples of air are analysed by the Atmospheric Environment Service for many trace gas species in addition to the major greenhouse gases of carbon dioxide and methane. Those samples are also sent to laboratories in Australia, Germany and the United States for study. Analysis of greenhouse gases and gas species is undertaken by Dr. Neil Trivett, a scientist at the Atmospheric Environment Service in Downsview, Ontario, who was one of the pioneers of the Alert observation station. The results of this analysis for Alert have revealed a significant increase in concentrations since the start of the sampling program.

Stratospheric Ozone Depletion



The ozone layer is a naturally-produced chemical layer in the stratosphere that serves as the earth's shield against over-exposure to the sun's ultraviolet rays. The presence of this protective layer is crucial to the environmental health of the planet, since ultraviolet radiation is known to cause skin cancer, reduce crop production, increase atmospheric instability of the stratospheric ozone layer and kill the plankton at the base of the marine food chain. A global meteorological network was set up in the Thirties to monitor stratospheric ozone. Regular monitoring began in Canada in 1957 as part of the International Geophysical Year. The use of balloons to probe the layer was introduced in 1966. The Green Plan proposed that research be conducted to improve our understanding of the causes and effects of ozone depletion as part of the Ozone initiative.

Thinning of the ozone layer is producing a hole above Antarctica equal to the size of Canada. In addition, smaller reductions in the ozone layer have been occurring over the Canadian Arctic. Environment Canada, has developed an active research program on this problem. It operates the World Ozone Data Centre which, for over 20 years, has collected data from the global network and distributed it to scientists all over the world.

Scientists from the Atmospheric Environment Service are responsible for monitoring the ozone layer regularly, using instruments on the earth's surface, or carried by balloons, rockets, satellites, or the space shuttle. In addition, a network of ultraviolet radiation monitoring sites is being established to provide data for health and ecosystem studies and a permanent Arctic observatory is being built at Eureka, as part of an international network to determine the nature of Arctic ozone depletion. Canada's scientists have also played a leading role in international research on the identification and control of ozone-depleting substances, such as chlorofluorocarbons (CFCs). The use of CFCs in a variety of products, along with other chemicals, have a demonstrably harmful effect upon the ozone layer. One of the consequences of the ongoing scientific research effort was the development of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer.

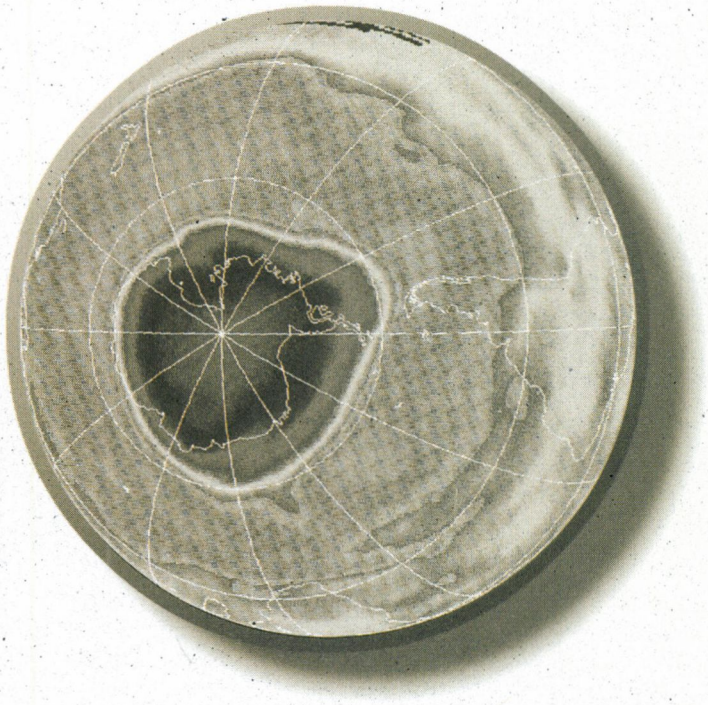
In March 1992, Environment Canada announced the establishment of an Ozone Watch. This is to be a weekly update on the state of the ozone layer over Canada. It will be issued every Friday for most of the year in the same manner as a regular weather report. It will indicate if the sun's rays are more intense as a result of ozone thinning and if, consequently, there is any increased health risk.

Subsequently, in May 1992 an Ultraviolet (UV) Advisory Program was launched to provide information to help Canadians make informed decisions about the amount of time they spend in the sun. The Program provides a daily index which points to the expected UV strength under clear sky conditions. The index is based on a scale from 0 to 10. Ten reflects the typical intensity of UV on a clear summer day in the tropics. UV rays occur naturally, but excessive exposure is considered a health concern, especially for children. The UV Advisory and Ozone Watch programs are part of the Green Plan ozone initiative, committed to increasing scientific research and monitoring effects related to ozone depletion.

Case Study:

The Ozone Hole

Ozone hole over the Antarctic

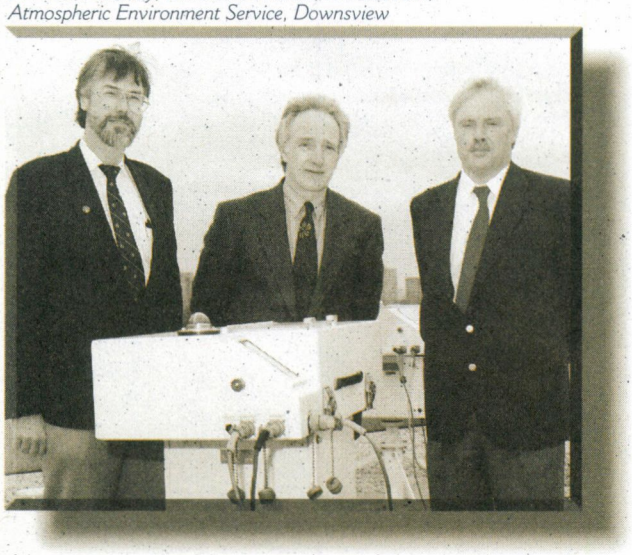


Research on the thinning of the ozone layer at the poles in the springtime shows promise of providing a sensitive indicator of its overall "health" but more research is needed to validate this. A few years ago, scientists discovered a progressive thinning of the ozone over the Antarctic in September and October. Its intensity varies from year to year due to weather conditions and the overall cause has been shown unequivocally to be the emission into the atmosphere of man-made chlorofluorocarbons (CFCs).

After the discovery of the Antarctic ozone hole, Canada became the first country in the world to focus scientific research on the Arctic ozone layer. Environment Canada began an intensive study of the far north in 1986 from the AES station at Alert. Since then, atmospheric scientists have found evidence of some ozone loss in the Arctic – but much less than that over the South Pole. In some years, ozone thinning over the Canadian Arctic is only about 4 percent. In other years, slightly greater losses of about 10 percent may occur. The area of the Arctic thinning is about the size of Greenland, and moves as the Arctic air circulates.

Additionally, Environment Canada scientists have tracked a significant thinning of the ozone layer over southern Canada over the past ten years. This depletion is greatest during the spring. Fortunately, this is also the time when the ozone layer is naturally at its thickest. Some scientists, however, feel that increased depletions may be expected over North America, due to a combination of industrial chemical use and the volcanic eruption of Mount Pinatubo in the Philippines in 1991.

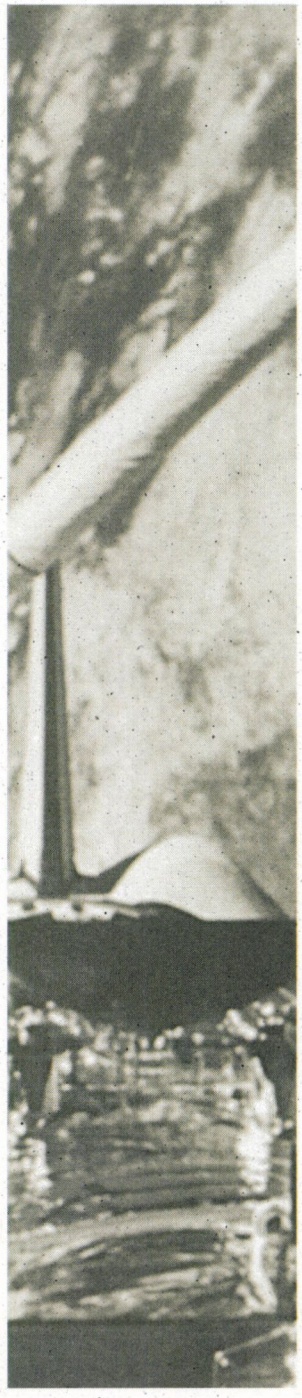
Dr. Tom McElroy, Dr. David Wardle, Dr. Jim Kerr, Atmospheric Environment Service, Downsview



The Brewer Ozone Spectrophotometer

Scientists from the Atmospheric Environment Service designed and developed the Brewer Spectrophotometer and transferred the technology to a Canadian manufacturer, Sci-Tec Inc. of Saskatoon. The inventors, C.T. McElroy, D.I. Wardle and J.B. Kerr, named their instrument after Professor A.W. Brewer with whom they all worked at the University of Toronto in the early 1970's. Since the Brewer Spectrophotometer was first put into production in 1980, it has been continually improved by the Atmospheric Environment Service and Sci-Tec. It is the world's most accurate ozone measuring instrument and the most recent models also measure sulphur dioxide, nitrogen dioxide and ultraviolet radiation. Currently, a total of fifty of these instruments have been exported and are now operating in about thirty countries around the world.

Acid Rain



Acid rain results from discharges into the atmosphere of sulphur dioxide and nitrogen oxides, produced by the consumption of fossil fuels for a variety of purposes, industrial and domestic. When these gases combine with atmospheric water vapour, they form sulphuric and nitric acids and return to the earth in the form of acid rain, snow, fog or dust. This phenomenon represents a threat to important economic sectors, such as forestry, agriculture and tourism; it causes major damage to lakes and fish populations as well as to forests; and it is partly responsible for extensive damage to historic buildings and monuments. In addition, it poses a threat to human health, contributing to respiratory problems in particular.

Intensive research on the impact and control of acid rain has been conducted in Canada since the mid-Seventies and is still ongoing. The research has been a team effort led by Environment Canada, and involves federal and provincial government scientists, as well as scientists in university laboratories. In 1985, with the commencement of the Canadian Acid Rain Control Program, Canadian research efforts were refocused to convince the United States of that country's significant contribution to the acid rain problem. In addition, a major federal-provincial agreement was reached which committed both levels of government to reducing by 50 percent the emissions from the mining and energy sectors in Eastern Canada, which are the main Canadian sources of pollutants causing acid rain.

The impacts of acid rain on water, agricultural and forestry resources, wildlife and human health, have been assessed by specialists; as well as the options for reducing emissions from various industrial sectors. A major step forward has been the development of sophisticated computer models, that trace the manner in which pollutants are transported through the atmosphere and indicate where those that cause acidifying problems will be deposited. This can assist in identifying lakes and particularly rivers that appear to be at risk.

The initial thrust of the Acid Rain Control Program was in the research, development and demonstration of technologies, in collaboration with Energy, Mines and Resources and other departments and provincial governments, to reduce SO_2 emissions from smelters and coal burning power plants. Research on such techniques as fluidised bed combustion, sorbent injection and safe disposal of wastes assisted Canadian industries to become more efficient and has dramatically reduced SO_2 emissions.

The signature of the Canada-U.S. Air Quality Agreement in March 1991, signalled a joint effort by both countries to impose control programs on transboundary airborne pollution. With the success of programs to control SO_2 emissions, the emphasis of research has now shifted to the investigation of the impacts on human health, wildlife and aquatic ecosystems of other acid rain depositions and, in particular, nitrogen deposition. Monitoring programs are also in place to determine the rate and extent of recovery of forests and lakes from degradation caused by acid deposits and to identify areas and species potentially still at risk from acid rain contamination.

Case Study:

Acid Rain Impacts on Water Resources in Eastern Canada:

Impact of acid rain on water

Canada possesses vast surface water resources, many of which are potentially at risk from acid deposition. A major research project in Eastern Canada is working to count and measure all surface water bodies and produce a data base to identify which of those resources is most at risk from acidification. Most of these surface waters consist of small lakes, whose size makes them particularly sensitive to acid precipitation, but which provide valuable habitat for fish, waterfowl and other wildlife. A size of five hectares or less is particularly valuable as breeding habitat for waterfowl that are found in acid-sensitive regions.

This detailed inventory of surface water in Eastern Canada has been conducted in two stages. In the first stage, digital images from equipment on the Landsat orbiting satellite were selected and analyzed and the geographic location, area and perimeter were computed for each surface water body larger than 30 square metres.

In the second stage Geographic Information Systems technologies were used to integrate information about surface water into an ecological framework. This enabled researchers to determine which lakes were most at risk from acid deposition, based on geological principles.

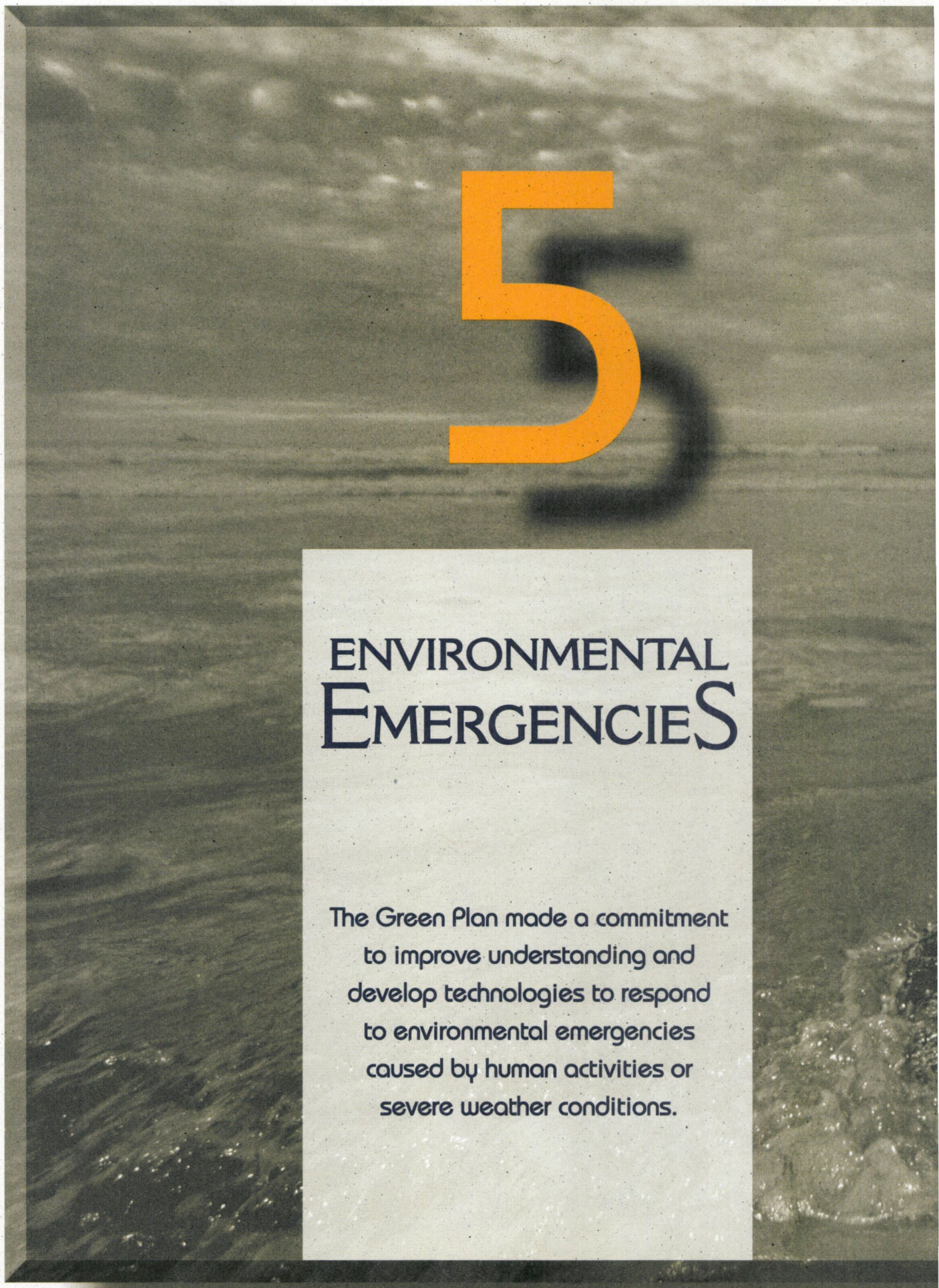
The study resulted in the identification and measurement of as many as 881,634 bodies of surface water in Eastern Canada. 73% of all surface water in this study area are in areas sensitive to acidification. It should also be noted that approximately 88% of the surface water in the Maritimes are in areas which are considered to be moderately or highly sensitive to acidification.

While most of the surface water resources are small lakes, these play a major role both as wildlife habitat and as recreational areas. Consequently Environment Canada scientists continue to operate a monitoring network to assess the health of this precious resource.

Dr. Tom Brydges, Bill Hart and Sue Milburn-Hopwood, Atmospheric Environment Service, Downsview

Long Range Transport of Air Pollutants (LRTAP)

Environment Canada has been conducting a research program into the Long Range Transport of Air Pollutants (LRTAP) and the assessment of the effect of acid rain controls on the health of our lakes and rivers. The results of this research, which will form the basis for future federal and provincial government policy, are contained in a 1990 eight volume report (the LRTAP National Assessments), whose production was coordinated by Dr. Tom Brydges, Bill Hart and Sue Milburn-Hopwood of Environment Canada.



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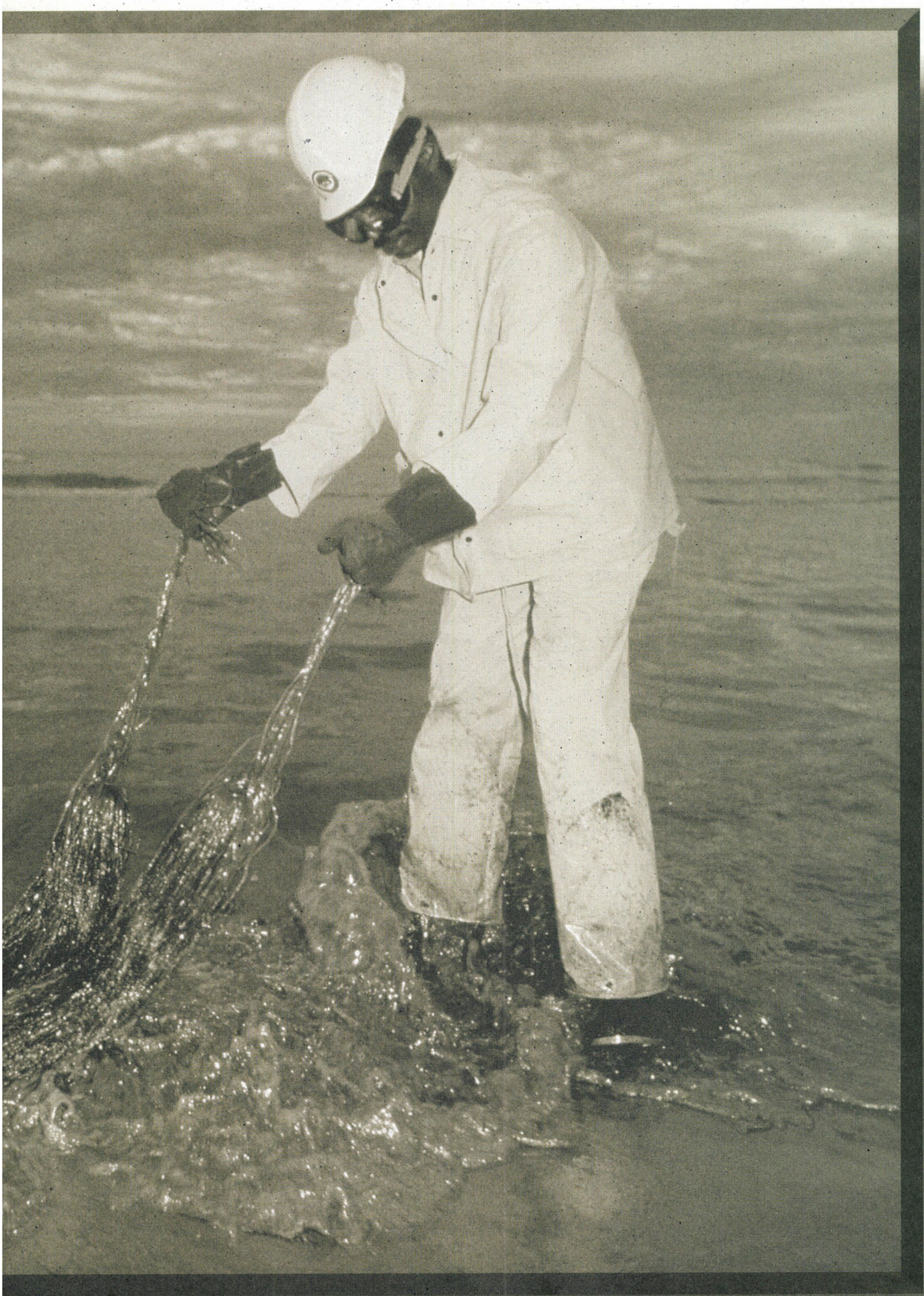
ENVIRONMENTAL EMERGENCIES

The Green Plan made a commitment to improve understanding and develop technologies to respond to environmental emergencies caused by human activities or severe weather conditions.



mergencies Caused by Human Activities

Environmental emergencies by their very nature are unpredictable and potentially highly dangerous events for both people and the environment. Two decades ago, in 1970, Canadians were awakened to the enormous damage that an environmental emergency can cause, when a fully-loaded oil tanker, the Arrow, ran aground in the environmentally sensitive waters of Chedabucto Bay, off Nova Scotia's northeast coast. The results were miles of beaches fouled by millions of litres of oil, dead and injured wildlife, threats to the inshore fisheries, millions of dollars for clean-up operations; and the birth of the Arctic and Marine Oilspill Program, which established Canada as a pioneer in the science of oilspill clean-up in Arctic and marine environments.

Through the Seventies and early Eighties, oilspills were the major focus of the scientific efforts devoted to environmental emergencies. Scientists at the River Road Environmental Technology Centre in Gloucester, Ontario, developed state-of-the-art expertise in fields as varied as remote sensing and clean-up technology. The results have included commercial success stories, like the Morris oil skimmer and the Orion tracking buoy. Major scientific projects were also conducted, such as the Baffin Island Oil Spill Project. This multi-disciplinary project, conducted in the remote coastal environment of northern Baffin Island during the early Eighties, advanced the scientific capacity to assess the impacts of oil spills in Arctic waters and determine the effectiveness of shoreline clean-up technologies.

Oilspills caused the major environmental emergencies and were the focus of scientific effort during the early Eighties. As the Eighties progressed, however, the major threats increasingly became chemical in nature. This trend developed, within Canada, as in the St-Basile-le-Grand PCB warehouse fire and the Hagersville tire fire, and abroad, as in Bhopal and Chernobyl. The dangers posed by oilspills still continued to be a problem, however, as the Gulf War and the Exxon Valdez were to demonstrate.

Canada has developed special expertise in protecting the environment during emergencies caused by human activities. This capacity includes both scientific research and an operational role. Extensive scientific studies are conducted at the River Road Environmental Technology Centre on all aspects of spills, including the behaviour of spilled oil, studies of its effects on wildlife, the extent of pollution it can cause, and the manner in which it ultimately disperses. Similar studies are conducted on spills of hazardous material, using computer modelling and remote sensing techniques. In addition, work is conducted to develop, assess and demonstrate equipment and technologies for cleaning up spills and for remediation of waste sites and landfills.

Operationally, when an environmental emergency occurs, the response effort is supported by a team of Environment Canada personnel across the country, who have been trained and equipped to work in contaminated environments. For instance, at the 1988 St-Basile-le-Grand fire, a specially equipped van was provided, managed by a team of specialists who provided on-the-spot analyses for PCBs and assisted the Province of Quebec to determine the extent and level of contamination.

Case Study:

The Deployment of the Gulf Oil Assessment Team

Capping a damaged wellhead in Kuwait

The Gulf War presented Canada with both military and environmental emergency situations. Canadian military personnel were based, during the war, in Quatar and Bahrain. This meant that Canada was uniquely well-placed to respond when a major oil spill in Kuwait threatened to devastate the coasts of Quatar and Bahrain. A Gulf Oil Assessment Team, coordinated by Environment Canada, went into action. The six-person team, including staff from the River Road Centre, was sent to assess the threat and to provide recommendations on how Canada might help. As a result of the team's recommendations, two internationally renowned Canadian experts surveyed the coasts of the two states and developed detailed response programs; Canadian off-shore containment and recovery equipment was sent to the Gulf; a mobile bird-cleaning equipment trailer was provided by the Canadian Wildlife Service. Computerized maps of the area were prepared; and a remote sensing aircraft was chartered and dispatched to the Gulf.

Fortunately, the oil slick never reached the coastlines of Quatar and Bahrain, as a result of changes in the prevailing winds. However, the speed, efficiency and completeness of the plan with which the team prepared to meet the anticipated emergency is a tribute to the federal specialists involved. It should also reassure Canadians of our ability to respond, should we ever be faced with a comparable oil spill or other pollution emergency within Canada.

Harry Whittaker and Merv Fingas, River Road Environmental Technology Centre, Gloucester

Action in Environmental Emergencies

The staff of the River Road Environmental Technology Centre is regularly called upon to deal with potential environmental emergencies. Centre staff, headed by Merv Fingas and Harry Whittaker, have worked on a diversity of problems across the country. In 1991, when a warehouse in Saskatchewan, used to store pesticides, laboratory chemicals, abandoned chemicals, and radioactive materials, burnt down, an Environment Canada team analyzed samples, defined and located the contamination and made recommendations for the subsequent clean-up.

In 1992, another team coordinated a joint project with industry to contain and clean up a potentially major source of contamination at the site of a spill of methylene-chloride from a leaking underground storage tank in north-west Toronto. The task involved the use of a prototype mobile steam stripper developed at the River Road Environmental Technology Centre.

Naturally Occuring Disasters

As part of its environmental strategy for the Nineties, the Green Plan announced a five-year program to improve the early detection, prediction and warning of extreme weather events. The ability to forecast weather has always been a crucial skill. It has developed over time into a complex scientific effort, involving highly sophisticated analysis, using state-of-the-art equipment. Today meteorologists are faced with an increasing body of knowledge, collected from all over the world, which must be analyzed in order to provide Canadians with reliable forecasts.

In normal circumstances, this capacity is used mainly to provide Canadians with accurate and timely forecasts, which enable them to plan business and personal activities with a reasonable assurance of the weather that can be expected. Weather forecasts which can predict conditions for up to five days in advance are produced, using the supercomputer installed at the Canadian Meteorological Centre in Dorval, Quebec. This computer receives and analyzes weather data from weather balloons, surface stations, ships, radar satellites, aircraft and drifting buoys all over the world. Output from this computer is then forwarded to Environment Canada weather offices across the country where forecasts, tailored to regional needs, are produced.

There are segments of the Canadian economy for which accurate weather forecasting is especially critical. Farmers depend heavily upon weather forecasting to manage crops, where frost, drought or excessive rainfall have serious consequences. Similarly, prolonged drought and excessive heat have serious implications for forest management and the protection of valuable forestry resources through emergency fire control measures.

Environment Canada's scientists maintain an on-going research program to improve the accuracy of the weather forecasts available to the Canadian public. Current research by the Atmospheric Research Directorate of Environment Canada is directed toward the development of technologies which will most effectively utilize data obtained from satellites and Doppler radar facilities and also toward the enhancement of computer models of the atmosphere. Together these should reduce the cost of weather monitoring and provide improved advance warning of severe weather. While naturally occurring environmental disasters cannot be prevented, research of this kind can at least enable earlier detection of the threat and ensure we move quickly to mitigate their consequences.

Case Study:

New Advances in Meteorological Science

Tornado funnel outside Saskatoon

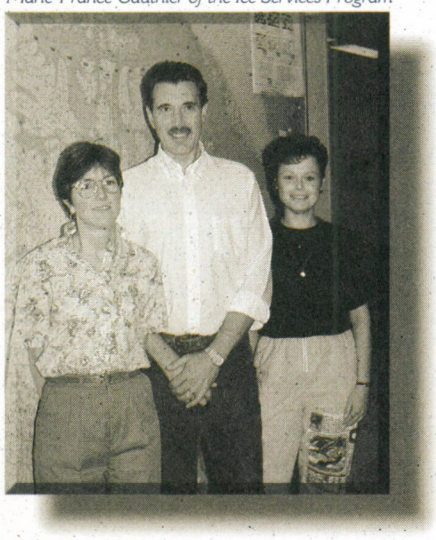
Environment Canada scientists, using research methodologies at the forefront of scientific knowledge in this field, have introduced a significant improvement into weather forecasting capabilities at the Canadian Meteorological Centre in Dorval, Quebec. In 1991, the previous hemispherical forecast model was replaced by a global model, on which data from monitoring stations all over the world are processed.

Comparisons have shown that, the new model provides the same accuracy for day five of the forecast as the old model provided on day four, an improvement of 24 hours. This is due to improvements both in the method used to analyze the data set and the way in which the mathematical solution of the equations is derived. Further improvements under development will enable the grid pattern to be modified to allow closer study of areas of particular meteorological interest, for example those in which severe weather is expected.

In addition, because of the extreme climatic conditions which Canada experiences as a northern nation, there is a need for research and development to improve our capacity to understand and predict the nature of severe winter storms. Several research projects have been directed towards a better understanding of severe weather conditions in order to provide the capacity for ready response to them. One such project is the Canadian Atlantic Storm Program (CASP), which was led by Environment Canada scientists but included scientists from universities, other government departments, the United States, Japan and the commercial sector. The aim of CASP is to gain a better understanding of rapidly intensifying cyclones over the Atlantic. Two field experiments have already been held, the first in 1986 off Nova Scotia and the second off Newfoundland in 1992.

Weather has a strong influence on the formation and movement of sea ice and icebergs. For that reason the Atmospheric Environment Service has developed and maintained a world class ice information service for Canadians. It is important to be able to predict ice conditions since the effect of ice and ice movement on the safety of Canadian shipping in northern waters is a matter of serious concern. This issue is becoming increasingly important, as we develop our offshore oil resources and seek to avert marine oil spills and the consequent environmental devastation. An added benefit of research in this area is that it enhances our understanding of the effect which the interaction of the sea and the atmosphere have upon the processes of global climate change.

Bernie Wyer, Laurie Weir and Marie-France Gauthier of the Ice Services Program



Ice Services Program in Environment Canada

Ice covers most of Canada's extensive coastal and inland waterways for at least part of the year, and in the Arctic for all the year. Ice interferes with marine operations and can be a cause of damage, resulting in loss of vessels and equipment, loss of life and major ecological disasters.

The Ice Services Program of the Atmospheric Environment Service is responsible for the provision of ice and iceberg information in Canadian waters. The Ice Services Team participates in the monitoring, analysis and forecasting of the ice and iceberg regimes and the provision of ice information to the "decision makers" in the marine community.

Bernie Wyer, an ice services specialist, is involved in the collection of ice data from aircraft and ships and provides support to Canadian Coast Guard icebreaking operations. Laurie Weir, an ice analyst, provides support to our clients through the ice analyses and integration of various data sets including satellite imagery and remotely sensed radar data from aircraft. Marie-France Gauthier, a senior ice forecaster, prepares forecasts on the growth, decay and movement of ice fields and the distribution of icebergs affecting marine operations.

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