PRESSURES ON THE ARCTIC ECOSYSTEM FROM HUMAN ACTIVITIES

Although once considered pristine because of its remoteness and small population, over the last 50 years the Canadian Arctic has been subjected to contaminants from local community, mining, oil and gas, and military activities as well as pollutants transported over long distances from industrialized regions of the world. Although there are generally lower levels of these contaminants in the Arctic than in Southern Canada, they are often of greater concern because of their persistence in the arctic environment and their potential to accumulate in the tissues of wildlife species that constitute a substantial portion of the diet of arctic residents.

This environmental scan briefly describes the various human activities that are currently placing pressures on the ecosystem. It has been divided into two broad categories, those activities which occur in the Northwest Territories and those that occur in other parts of the world but still affect the Arctic.

Activities Occurring in the Northwest Territories

A. Urban Residential Settlements

Communities in the Northwest Territories are generally small, producing small quantities of liquid, solid and hazardous waste. Regardless of the quantities, there exists a potential impact on the local ecosystem and this impact is likely to become greater as populations and industrial activity increases.

Liquid pollutants from communities are primarily the result of direct discharges of treated and untreated human sewage. Some communities continue to discharge raw or primary-treated sewage directly or indirectly to the aquatic environment. Others operate sewage lagoons or holding ponds, but these sometimes overflow or wastes leach into surface drainage systems. Other sources of liquid-based pollutants include non-point source runoff and leachate from solid waste sites. This waste may contain concentrations of disease-causing bacteria, organic materials including oil, grease and petroleum hydrocarbons, nitrogen and phosphorous nutrients and heavy metals such as lead, zinc and cadmium.

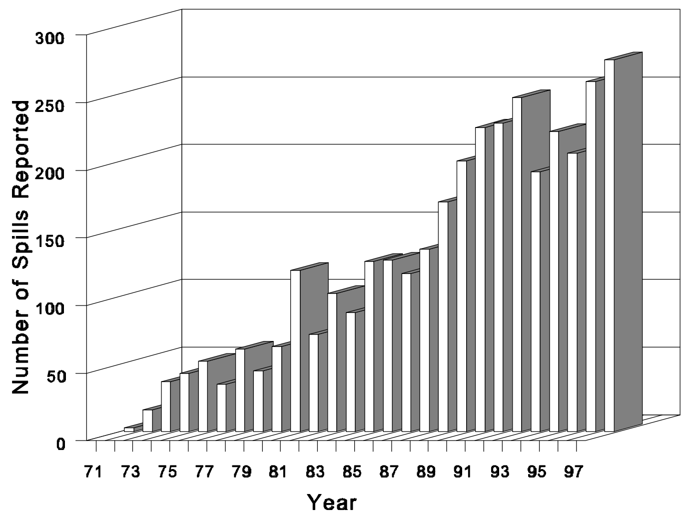
Solid waste disposal facilities in arctic communities are often rudimentary as a result of the lack of staff and funds, climatic restrictions and the presence of permafrost which forces many communities to dispose of their wastes in open sites. These wastes take decades to degrade because of the extremely slow rate of decomposition in the Arctic environment. Recent water and sediment studies confirm that concentrations of heavy metals and organic pollutants can be found downhill of these facilities. Many communities also continue to open burn their solid waste as a means of reducing volume. This practice results in metals, organic pollutants, ash and other contaminants to be discharged directly to the atmosphere where they are distributed by wind to locations many kilometres away.

Hazardous Waste	Kilograms/year
Used oil & waste fuel	est. 2 million litres
Antifreeze	60200
Batteries	56000
Solvents	54500
Paint containers	33600
Filters	27800
Misc. chemicals	10800
Misc. solids	8700
Waste paints	3500
Degreasers	3100
Cylinders	1400
Sharps (needles)	790
Pathogens	340
Caustic cleaners	12
Mercury	0.13

Community residents, businesses and institutions also generate quantities of hazardous wastes which must be properly managed and disposed. The most common types include used lubricating oils and waste fuels, antifreeze, batteries, solvents, paint and oil filters. Recent surveys indicate that more than two million litres of waste oil and fuel, and approximately 260 tonnes of other hazardous wastes, are produced annually by northern communities (refer to table).

B. Petroleum and Chemical Shipment, Transfer and Storage

The risk of petroleum spills is associated primarily with the transport and storage of fuels for community and industrial needs. To service the needs of remote coastal and river communities, barges and other large marine vessels provide bulk fuel and supplies. Communities located along highway systems are provided with petroleum by tanker truck. Once delivered to communities, mine sites and other locations, the large volumes of petroleum must then be stored for eventual use in vehicles, furnaces and electrical generators. Between 1971 and 1997, there were 2742 accidental spills of petroleum reported to the Northwest Territories' 24-Hour Spill Report telephone line involving a total of 23.4 million litres of diesel oil, jet fuel, gasoline, crude and lubricating oil (refer to figure).



At present, technology for cleaning up spilled petroleum is not adequate to remove oil from ice-covered waters and there is the potential for a major environmental disaster within arctic fresh and marine waters if a barge or tanker was to spill its petroleum cargo. Although highway tanker trucks carry a significantly smaller volume of fuel than do barges or tanker ships, the increasing volume of truck traffic along northern highways and ice roads continue to threaten terrestrial and aquatic environments located adjacent to these roads. Between 1971 and 1997, a total of 143 accidental spills were reported to the 24-Hour Spill Report Line involving trucks travelling on northern highways and ice roads.

Petroleum in the Arctic environment degrades very slowly. Arctic plants and animals may be exposed to spilled petroleum for a longer period than in temperate climates. In terms of potential biological effects, the short term exposure of animals to oil in the water column is considered most significant although spilled oil can also affect the health of terrestrial vegetation. Certain species of waterfowl could also face population depletion if a spill happened on their arctic breeding grounds at the wrong time.

C. Mining and Concentrating Industry

Mining and concentrating are defined as the activities associated with mineral exploration, extraction and milling. Although the mining industry remains a major source of employment for northerners, it also has the potential to impact the northern environment in a number of ways.

One of the main impacts of mining on terrestrial ecosystems is thought to be habitat loss associated with construction and operation of the mine and its access roads. These roads can also increase access to adjacent areas by resource harvesters and recreational users. Access roads can also cause permafrost degradation and sediment inputs from runoff to adjacent streams and lakes. These effects are generally confined to local areas.

Depending upon the size and number of years a mine operates, many thousands of tonnes of waste rock and tailings may be produced. Unless mining companies carefully control the discharge of water from their tailings ponds, metal and sediments from these ponds can affect the aquatic environment downstream for many years. If a tailings pond is allowed to become dry, tailings dust can also be distributed to surrounding land and water by the wind.

There are also significant potential impacts from mining operations as a result of the release of metal-bearing wastes. The potential for contamination comes from the weathering of waste rock and rock exposed during the mining activities as well as accidental spillage of mill tailings. Exposure of iron pyrite and other sulphur-bearing minerals to atmospheric oxygen in the presence of moisture leads to acid weathering reactions. These reactions could lead to “acid mine drainage” and the continual dissolving of metals from waste rock and tailings. This leachate is a potential long-term source of metals to the environment where they can be taken up by plants and animals.

D. Oil and Gas Exploration and Development

Oil and gas activities in the Canadian Arctic have centred primarily on exploration. In the past, more than 140 exploratory wells have been drilled in the Mackenzie Delta-Beaufort Sea region with 49 significant discoveries. In the Arctic Islands area, more than 100 wells have been drilled on-shore with 15 discoveries. Although exploration has now largely ceased in these areas, significant exploration continues in the Sahtu and Deh Cho regions of the western Northwest Territories. Oil and gas is currently produced at two locations, Norman Wells and Pointed Mountain where oil and gas are transferred by pipeline.

The main emissions associated with oil and gas activities are the discharge of drilling wastes, atmospheric emissions and accidental spills of petroleum. It is common industry practice to dispose of waste drilling fluids on land into sumps adjoining the oil rig. These wastes contain various pollutants ranging from metal salts to petroleum hydrocarbons. It has been estimated that approximately 20,000 tonnes of solids contaminated with various drilling additives and more than 250,000 litres of oil have been discharged over the years to land sumps in the Arctic. During offshore drilling activities, water based drilling fluids are often discharged directly to the marine environment and have resulted in local elevated concentrations of mercury, lead and cadmium along with other heavy metals within the sediments.

E. Wastes from Abandoned Sites

Prior to 1972, there were largely no rules or regulations in place to govern land use in the Arctic. This has resulted in wastes being scattered throughout the Arctic including abandoned exploration and mine sites and government facilities. During the 1950's, 42 Distant Early Warning Line stations and several other military related sites were constructed across the Canadian Arctic. In the mid 1960s, 21 of these intermediate DEW Line sites were abandoned “as is” in accordance with the practices at that time. Since then, efforts have been made to assess the abandoned sites and begin cleanup of the buildings, fuel and other wastes. The remaining 21 DEW Line stations are being phased out and cleaned up as part of the North American Air Defence Modernization project. In addition to these facilities, there are hundreds of fuel caches and other sites across the Arctic which contain various amounts of debris, including full and empty drums.

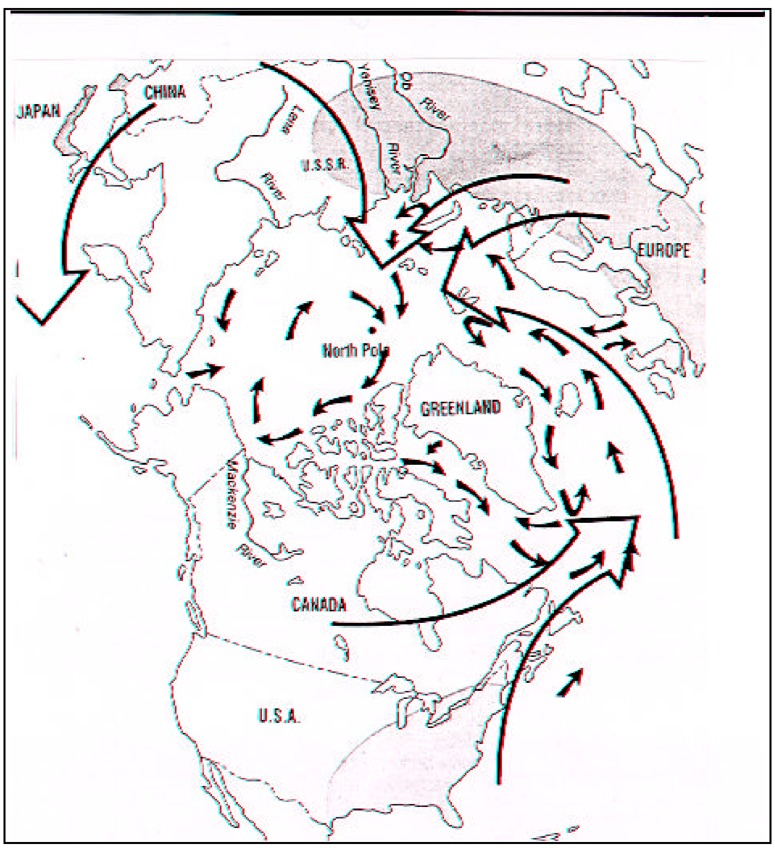
Elevated concentrations of persistent organic pollutants including PCBs, heavy metals and petroleum have been found adjacent to some abandoned sites. The extent and nature of these pollution sources and their effects remain to some degree unknown, and will remain so unless there is a continued effort to conduct systematic assessments. While some of these sites have been cleaned up in recent years, many federal government funding sources are being affected by recent budgetary cutbacks and their continuation is currently uncertain.

F. Ocean Disposal

The disposal of wastes into Canada's oceans is controlled by the federal government under the *Canadian Environmental Protection Act*. From 1982 to 1997, forty eight ocean disposal permits for the dumping of dredge spoils and seven permits for the dumping of scrap metal were issued for Canada's Arctic (refer to table). A small number of disposal permits have also been issued authorizing the dumping of petroleum for oil spill experiments and the use of freeze-accelerating additives used in the construction of ice islands. While the issuance of permits to dispose uncontaminated dredge spoils into the ocean continues to be supported by the federal and territorial governments, the disposal of scrap metal into the Arctic Ocean was essentially stopped in 1994 as a result of local community concerns and opposition.

Year	Dredge Spoils	Scrap Metal
1982	4	1
1983	1	0
1984	5	0
1985	12	2
1986	10	1
1987	2	1
1988	2	0
1989	2	0
1990	3	0
1991	4	0
1992	2	1
1993	1	0
1994	0	0
1995	0	1
1996	0	0
1997	0	0

Ocean disposal permits have been issued in the past because it was thought that there were no immediate and practical solutions to the problem of land-based dredge spoils and scrap metal disposal. It was often cheaper to dump materials into the ocean than to remove them to other locations for reuse or disposal. The major disadvantages of ocean disposal remain the potential for discharge of floating debris and the release of toxic substances into the marine environment.

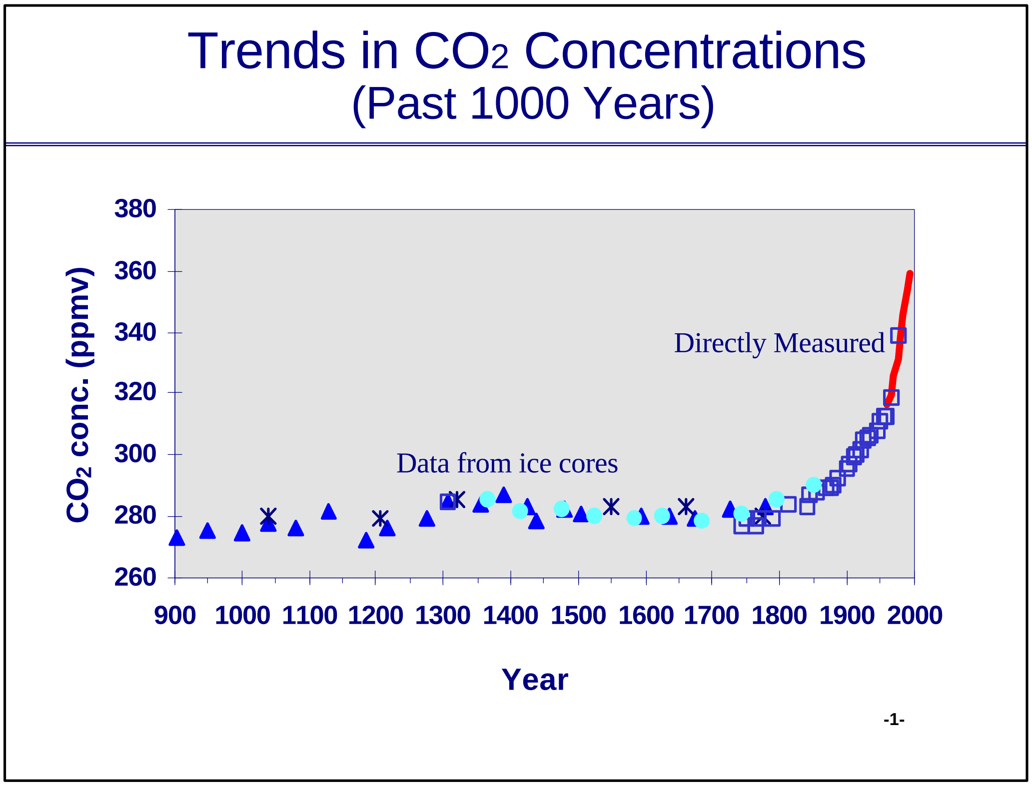


Contaminants from Distant Sources

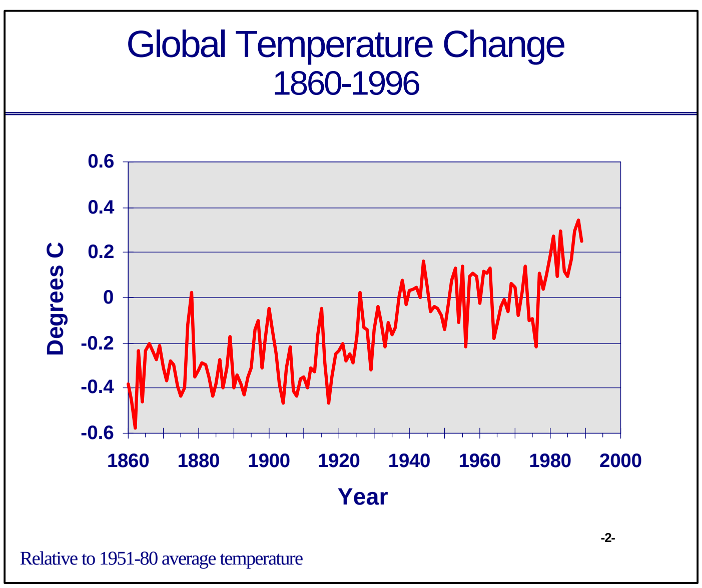
In recent years, scientific evidence has demonstrated the increasing global nature of environmental problems. Although levels of contaminants in the Arctic remain low relative to those in populated urban areas in the south, they are much higher that would be expected from local sources. Greenhouse gases, ozone depleting substances, PCBs, pesticides, heavy metals and other contaminants released from industrialized regions of Europe, Asia and North America are being found thousands of kilometres away in the Arctic. Many scientists view the long range transport of contaminants as the most significant threat to the environmental quality of the Arctic. The distribution of these contaminants indicate that they are being transported to the Arctic primarily by air currents. Ocean currents and northern flowing rivers also connect the arctic ecosystem to the industrialized regions of the world (refer to figure).

A. Global Climate Change (Global Warming)

The Earth's atmosphere is kept warm by a "blanket" of greenhouse gases. A variety of human activities including the burning of fossil fuels and deforestation, have increased the concentration of these gases and the atmosphere's ability to retain heat by enhancing the natural greenhouse effect. Scientists believe that the effects of this global warming will be most strongly experienced in the high-latitude zones, including the Arctic.



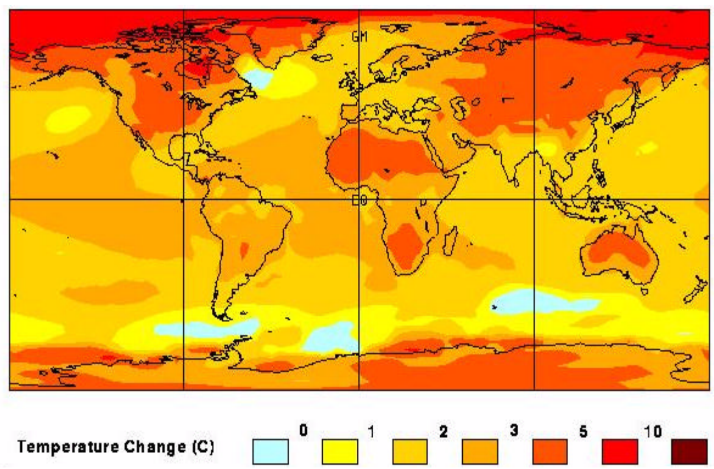
Since the industrial revolution, concentrations of carbon dioxide in the atmosphere have increased by 30% (refer to chart). This level is already higher than any detectable in geological records representing at least the last 10,000 years. Temperature measurements now indicate that average temperatures at the Earth's surface have warmed by 0.3 to 0.6 ^{0}C since 1860 (refer to chart). Scientists predict that if the concentration of these greenhouse gases were allowed to double, Western Arctic summer temperatures would increase slightly, perhaps as little as 0.5^{o}C. During winter however, a dramatic increase in temperature is predicted, perhaps as much as 8 to 10^{o}C. At the same time, scientists predict very little warming, or even cooling, over portions of the northern Atlantic, likely due to changes in ocean circulation (refer to diagram).



The prospect of this long-term warming of the Arctic has led to intense concern and discussion over the possible physical, biological and socioeconomic impacts that might accompany it. The most likely impacts are summarized below.

- Virtually all of the Arctic is underlain by permafrost, some of which would melt, increasing the active layer and disrupting natural drainage patterns. The melting of permafrost could damage roads, buildings and other man-made structures. Exploration and development of minerals, oil and gas could also become more difficult.
- The tree line would gradually move northward reducing the arctic ecozone by 15 to 20%. This could result in tundra vegetative communities becoming restricted in area with, as an example, increased competition among barren-ground caribou for preferred calving territory.
- Average temperatures of marine and freshwater bodies would increase. Thermal expansion of the oceans and melting of glacial ice could elevate sea levels causing beach erosion and flooding by storm surges. Oceans and lakes would experience longer ice-free periods which would benefit tourism, recreation and marine transport but negatively impact transportation by ice roads. Cold water fish and marine mammals could be affected by the water temperature changes and by southern warm water species competing for habitat and food sources.
- Changes in terrestrial habitat and food sources could result in changes to migratory patterns of caribou and migratory birds. These migratory changes could have significant impacts on commercial and subsistence hunting, tourism and other activities that depend upon the annual return of these animal populations.
- Local and regional weather patterns could be altered by changes in precipitation levels, storm events and coastal fog.

Projected Temperature Change between 1910 and 2040 AD



Combined Effect of Projected Greenhouse Gas and Sulphate Aerosol Increases.- Canadian Model

Although the effects of global warming at first appear to be beneficial in terms of a less harsh climate and improved accessibility, the potential negative impacts could alter the very characteristics that make the Arctic unique. The harsh climate has helped to isolate the Arctic, preserving its wildlife and habitat and allowing Aboriginal peoples and their culture to endure. Global warming could jeopardize these important arctic features.

B.   Persistent Organic Pollutants, Heavy Metals and Radionuclides

This class of pollutant is generally characterized by their being very persistent in the environment or having the ability to bioaccumulate in living animals. Persistent organic pollutants include industrial chemicals such as PCBs, agricultural chemicals such as DDT, chlordane and toxaphene, and by-products of human activity such as dioxins and furans. Although data on many persistent organic pollutants is limited, sampling data is showing that PCB, lindane, dioxins, furans, hexachlorobenzene, chlordane and toxaphene are becoming pervasive contaminants in the Arctic. The long-term effect of these pollutants on the northern ecosystem is not currently well understood although some have been linked to reproductive failure and cancer in various animal species. They are also being detected within food chain components, including country foods consumed by northern residents.

High temperature industrial processes in various parts of the industrialized world emit heavy metals into the atmosphere. Recent studies on the origin of Arctic air pollution have concluded that during winter, the majority of the Arctic's heavy metals are transported to the region from sources in the former Soviet Union, Europe and North America. In summer, the contribution of sources in Europe to the contamination of Arctic air can be as high as 75%. Up to 6% of the total emissions of arsenic, cadmium, lead and zinc in all of Eurasia is deposited in the Arctic. Local northern and naturally occurring sources also contribute to heavy metal concentrations in the Arctic.

Like persistent organic pollutants, heavy metals are known to bioaccumulate in animals. Data on heavy metal concentrations is, with the exception of polar bears, much more limited and their interpretation is complicated as it is difficult to differentiate between background and human-caused heavy metal concentrations.

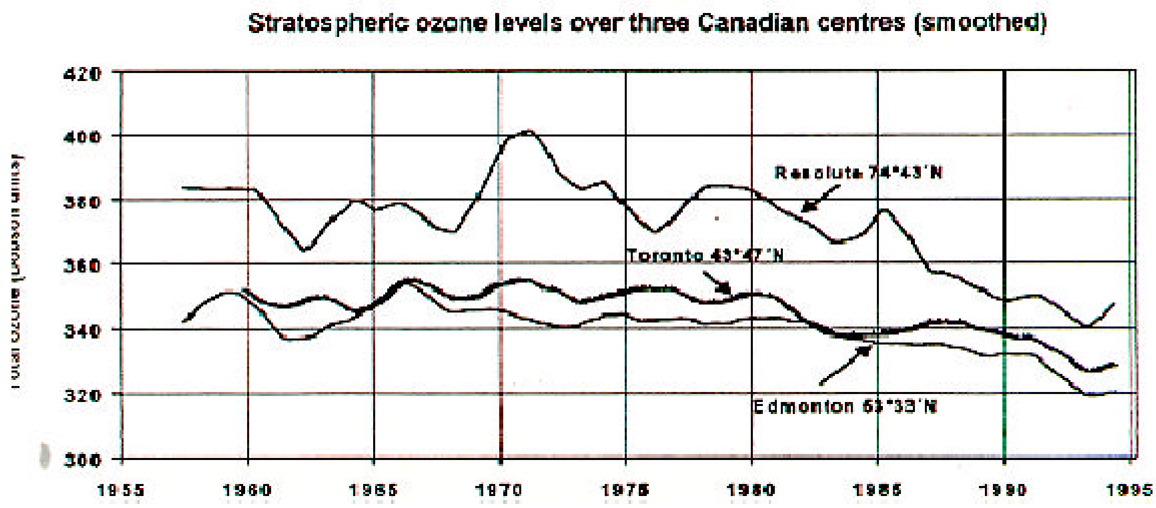
Long term fission products known as radionuclides have entered the Arctic primarily as a result of atmospheric fallout from nuclear weapons testing between 1952 and 1978 and the accident at the Chernobyl nuclear power plant in 1986. Other threats are connected to the activities of nuclear-powered vessels and satellites and the dismantling of Russia's aging military fleet. It has been noted however, that average radioactivity levels in air and annual fallout of radioactivity in the Arctic have both steadily decreased since the 1963 moratorium on weapons testing.

C. Depletion of the Arctic Ozone Layer

Although ozone makes up less than 1% of the atmosphere's total volume, life on Earth would be impossible without it. Ozone in the Earth's stratosphere acts as an effective shield against excessive levels of harmful ultraviolet radiation. Without this protective layer, excessive exposure to ultraviolet radiation could cause health problems in humans including skin cancer and eye cataracts, as well as damage to crops and ecosystems.

Although the chemistry and atmospheric processes associated with depletion of the ozone layer in the Arctic region are not well understood, it is known that ozone destruction is caused by it reacting with chlorofluorocarbons, halons and other manufactured chemicals. These chemicals are collectively known as ozone depleting substances. Natural atmospheric processes also play a role in the complex chain of events that lead to the destruction of the stratospheric ozone layer. Although scientists differ in their assessment of actual ozone loss, recent studies provide evidence for a long-term trend in the decline of winter ozone in the mid-latitudes of the northern hemisphere (refer to figure).

Regardless of the cause or extent of ozone layer damage, governments around the world recognized the need for immediate action in 1989 by ratifying the Montreal Protocol. The protocol requires its signatories to reduce CFC use by 50% before mid 1998 and to freeze halon use at the 1986 level by 1992. The major industrialized countries, including Canada, have since further agreed to ban chlorofluorocarbon use by 1997, ahead of the protocol's requirements.



D. Arctic Haze

The winter air pollution phenomenon known as arctic haze was first observed in the 1950s. This reddish-brown haze is composed of very small solid and liquid particles containing a wide variety of man-made and natural compounds including sulphate compounds, persistent organic pollutants, heavy metals, soot and hydrocarbons. In winter, winds carry these contaminants from the industrialized regions of Eurasia into Canada's arctic. The arctic air mass and winter weather conditions confine the pollutants to the lowermost one or two kilometres of the atmosphere.

Arctic haze can cause reductions in visibility in winter months and trap solar radiation. This, together with the increased blackness of snow covering the ground, can change incoming and out-going radiation levels and potentially modify the climate of Canada's North.