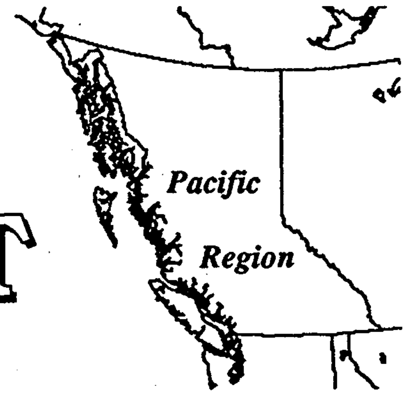
SCIENTIFIC SERVICES DIVISION

REPORT



ATMOSPHERIC CHANGE ISSUES: BRITISH COLUMBIA PERSPECTIVE

Scientific Services Division
Atmospheric Environment Service
Pacific Region

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ATMOSPHERIC CHANGE ISSUES: B.C. PERSPECTIVE

SCIENTIFIC SERVICES DIVISION
ATMOSPHERIC ENVIRONMENT SERVICE
PACIFIC REGION

We are significantly changing the earth's atmosphere. Carbon dioxide concentrations have increased 25% over pre-industrial levels; methane concentrations have doubled in the last 200 years; and chlorofluorocarbons (CFCs) releases are increasing by 5-7% each year. Scientists are observing seasonal "holes" in the ozone layer over both polar regions. The future implications of global atmospheric change for agriculture, forestry, wildlife, and human settlements are disturbing. At the local level, urban air pollution is a threat to human health. Atmospheric change is a serious problem requiring serious responses. Significant changes are needed in development policies and planning. Although such changes may initially be difficult or expensive to accomplish, in the long run the benefits of these changes are likely to exceed the costs.

GLOBAL ATMOSPHERIC CHANGE

Increases in the amounts of trace gases such as carbon dioxide, methane, CFCs and sulphur dioxide produce adverse effects such as an intensification of the greenhouse effect, depletion of the stratospheric ozone layer and acid rain. Through atmospheric pollution, we can now irreversibly alter global processes upon which all life depends. Many scientists fear that this pollution will adversely affect climate, increase the incidence of skin cancers and cataracts, inhibit photosynthesis and cause acidification of lakes and terrestrial ecosystems.

THE GREENHOUSE EFFECT

Carbon dioxide, methane, nitrous oxide, and other trace gases in the atmosphere partially block outgoing radiated heat. This causes the earth's lower atmosphere to warm up, much like the inside of a greenhouse. Without these greenhouse gases, the temperature at the earth's surface would be -18°C instead of the present average of 15°C. This 33°C difference represents the natural greenhouse effect and allows life on earth to exist as we know it.

The denser the layer of greenhouse gases, the more heat is retained and, eventually, the higher the temperature of the earth's surface. Over the past 200 years, levels of carbon dioxide, methane, CFCs and other greenhouse gases have increased markedly as a result of human activity. As greenhouse gases accumulate, scientists believe that the mean surface temperature of the earth will rise and climatic patterns will change.

There is an international scientific consensus that global warming is underway and poses real dangers. A quote from the Ministers and other representatives from 137 countries and from the European Communities meeting in November 1990 at the Second World Climate Conference in Geneva appears in Box 1 and underscores this consensus.

Some gases are more effective than others at changing climate. Carbon dioxide has been responsible for over half the enhanced greenhouse effect in the past, and is likely to remain so in the future.

"We **note** that while climate has varied in the past and there is still a large degree of scientific uncertainty, the rate of climate change predicted by the Intergovernmental Panel on Climate Change (IPCC) to occur over the next century is unprecedented. This is due mainly to the continuing accumulation of greenhouse gases, resulting from a host of human activities since the industrial revolution, hitherto particularly in developed countries. The potential impact of such climate change could pose an environmental threat of an up to now unknown magnitude; and could jeopardise the social and economic development of some areas. It could even threaten survival in some small island States and in low-lying coastal, arid and semi-arid areas."

Box 1. *Ministerial declaration at the November 1990 Second World Climate Conference.*

Atmospheric concentrations of the long-lived gases (carbon dioxide, nitrous oxide and the CFCs) adjust only slowly to changes in emissions. Continued emissions of these gases at present rates would commit us to increased concentrations for centuries ahead. The longer émissions continue to increase at present-day rates, the greater reductions will have to be for concentrations to stabilize at a given level.

The Intergovernmental Panel on Climate Change (IPCC) has calculated that the long-lived gases would require immediate reductions in emissions from human activities of over 60% to stabilize their concentrations at today's levels; methane would require a 15-20% reduction. If no efforts are undertaken to limit greenhouse gas emissions, the IPCC has predicted an increase in the global mean temperature of 3°C above the present value by the end of the next century.

While deforestation and land use changes have contributed significantly to the increase of carbon dioxide earlier in the century, *about 70% of today's carbon dioxide emissions due to human activities are from the burning of fossil fuels* - coals, oil, and natural gas - and these will continue to be the most significant source. Transportation alone contributes one quarter of the total carbon dioxide emissions. Despite our relatively small population (one-half of one percent of the world's population), Canada is responsible for fully 2% of global greenhouse gas emissions. On a per-person basis Canadians are among the largest producers of carbon dioxide. Other industrialized countries such as Japan, Sweden, and West Germany, with comparable standards of living, produce only half as much carbon dioxide per person as does Canada. If Canada is to be a world leader in reversing climate change, then we must reduce our carbon dioxide emissions and contribute to the development of cleaner and more energy-efficient technologies.

British Columbians produce about 84,000 kilotonnes of carbon dioxide annually. The forestry sector, which includes the pulp and paper industry, slash burning and wood waste incineration accounted for the majority of these emissions (54,100 kilotonnes). In terms of energy consumption in the province, the major contributors were gasoline and diesel fuel 35%, wood waste and fuel wood 23%, pulping liquors used in the pulp industry 22% and 19% from natural gas. Overall, 13% of all Canadian carbon dioxide is produced in British Columbia.

Predicting the Future

It is difficult to estimate the hazards from atmospheric change. We are quite certain that emissions from human sources are "enhancing" the greenhouse effect. We are less certain about the magnitude of future temperature change. Estimates from computer models of increases in temperature by the middle of the next century could change depending on what new information can be discovered about the role of oceans, clouds, and other global mechanisms. However, this information will not be available from scientific surveys for another 10 to 15 years. Instead of justifying inaction, such uncertainties should motivate action - the same uncertainties which make it possible to overestimate future warming are just as likely to cause *underestimates* of atmospheric change.

The transition from the last ice age to our present interglacial epoch, a difference of about 6°C, occurred over 5,000 to 10,000 years. Computer predictions are suggesting changes of 3°C *over the next 100 years.* Such rapid changes may be beyond the capacity of many ecosystems to adapt. There may be disruptions in the growth of forests, the production of agricultural crops, and the availability of fresh water until the climate stabilizes again. The world is already vulnerable to severe disruptions in food production if the climate varies over only a three to five year period (witness the recent drought problems in the Canadian prairies and in Africa). Our current systems of food production may experience difficulty surviving such changes. An additional factor here is that the predicted changes in climate will be occurring at a time when the world's population will be nearing 9 billion (in the year 2030) - *3.5 billion more than now.*

The costs of responding to widespread disruptions in food production and water availability will be very large in terms of economic and social costs, as will the costs of protecting coastal areas from rising sea levels.

International Initiatives on Global Warming

The Honourable Robert de Cotret, Minister of Environment announced at the Second World Climate Conference in November 1990 that:

1. Canada has pledged to fully eliminate controlled CFCs by 1997.
2. Canada has committed as a minimum to stabilize at 1990 levels all other greenhouse gases, most notably carbon dioxide, by the year 2000.

Canada maintains, however, that acting alone will do little to reduce world greenhouse gas emissions. Concerted international action is the most effective way of combating global warming. Canada has now taken the position that further reductions in greenhouse gas emissions must be based on a program of targets and schedules agreed upon internationally. A Convention on Climate Change is now being drafted and may be signed at the 1992 United Nations Conference on Environment and Development.

Depletion of the Ozone Layer

Stratospheric ozone is found between 15km and 35km above the earth's surface. This *ozone layer* absorbs most of the ultraviolet radiation from the sun, protecting people, plants and animals from the radiation's adverse effects. Depletion of the ozone layer results in higher levels of ultraviolet radiation at the earth's surface.

By far the greatest contributors to ozone depletion are CFCs and related compounds such as halons and methyl chloroform. They are synthesized chemicals with no counterpart in nature. CFCs, widely used as refrigerants, propellants, and blowing agents, are stable, non-toxic chemicals at ground level.

CFCs are released during the manufacturing process, when equipment is serviced, when products are broken down and during the use of the remaining CFC propellant aerosols. For example, rigid polystyrene foam retains 90% of the CFCs used in its manufacture, which are then released over a number of years as the product disintegrates. Halons, used in fire extinguishing equipment, are three to ten times more destructive than CFCs and may already account for 10% of the ozone thinning. Methyl chloroform is used as a cleaning agent and solvent. Many alternative products and technologies to these ozone depleting chemicals are currently available. CFCs are not the only culprits as it is thought that pollutants from high altitude aircraft, space vehicles and various surface sources also destroy stratospheric ozone.

After decades of producing these chemicals, only recently have we understood how they react in the stratosphere. Throughout most of the atmosphere, CFCs are inactive. However, they slowly drift upward into the stratosphere where their normally stable chlorine-fluorine bonds are broken by ultraviolet radiation, setting free atoms of chlorine which destroy ozone. One atom of chlorine will eliminate about 100,000 molecules of ozone; and chlorine has a lifespan of 70-100 years in the stratosphere.

Scientists have known since 1985 that this phenomena has produced a "hole" in the ozone layer over the Antarctic the size of the United States. This "hole" lasts for about two months, then fills in when seasonal patterns shift. In 1986, a similar but smaller "hole", really just a thinning, was observed over the Arctic. Experimental evidence strongly indicates that this damage, in both the Arctic and Antarctic, is caused by CFCs and other ozone-depleting chemicals. Atmospheric motion plays a large role in influencing ozone chemistry.

Ozone losses of 3% are now being recorded around the world, leading scientists to believe that a generalized depletion is taking place. Springtime ozone levels have, for example, decreased 6-8% over both Edmonton and Toronto.

Each 1% decline in ozone is expected to result in a 4-6% increase in certain skin cancers. About half of known plant species are sensitive to ultraviolet radiation, and for some, productivity is expected to decline by 1-2% for each 1% decrease in ozone. This increase in ultraviolet radiation will also cause more severe sunburns, cataracts, and suppression of the immune system. Inhibition of photosynthesis and reduced fisheries, forests and food production could also result. The economic impacts of these changes may be serious.

Because it takes so long for ozone depleting chemicals to reach the upper atmosphere, the ozone destruction now being observed does not fully reflect all the ozone-depleting substances released to date. Most CFCs and related chemicals are still in the lower atmosphere. The present evidence of ozone depletion, and the threat posed by substances which have still not reached the ozone layer, have been sufficient to convince many nations of the need for urgent action.

CFCs also act as greenhouse gas, being about 10,000 - 20,000 times more powerful than carbon dioxide in their ability to trap heat.

International Initiatives on Ozone Depletion

When the Montreal Protocol was signed in 1987, stipulating a 50 percent reduction in CFC production by 1999, some 16 million tonnes of these ozone-depleters had already been manufactured. Since that time, new scientific findings prompted a call for the complete phasing out of CFCs, halons, methyl chloroform and carbon tetrachloride. These issues were at the centre of discussions at the second conference of Parties to the Montreal Protocol, held in London in June 1990.

In London it was agreed to strengthen the Montreal Protocol to better protect the ozone layer. It was decided that:

1. CFCs were to be reduced by 20 percent in 1993, by 50 percent in 1995, by 85 percent in 1997 and phased out completely in 2000
2. Halons were to be reduced by 50 percent by 1995 and phased out by 2000 (except for essential uses)
3. Carbon Tetraflouride (CCl_4) was to be reduced by 85 percent by 1995 and phased out by 2000,
4. Methyl chloroform production was to be frozen in 1993, reduced by 30 percent in 1994, by 70 percent in 2000 and phased out in 2005, and
5. To use HCFCs (a CFC substitute) only where alternatives are not available and to phase them out by no later than 2040.
6. To set up a fund, now based in Montreal, to assist developing countries in the transition to non-CFC technology.

Canada has decided to go further and faster than the world pace and phase out CFCs by 1997 and methyl chloroform by the year 2000. Such reductions are possible only because the public demands it, and industry has responded to the demands by developing substitute substances and technologies. Some substitutes (the HFCs) do not contain any chlorine at all. In HCFCs, the addition of hydrogen to the CFC structure allows a large part of the chlorine to be removed in the lower atmosphere. A new facility to manufacture HCFC-123 was opened recently in Maitland, Ontario.

In the next 20 years about 60 per cent of future demand for CFC-type products could be met through better conservation methods and the remaining 40 per cent could be met by HFCs and HCFCs, although the aim should be to phase out the latter by the year 2020. Canada has already reduced its consumption of CFCs by 19% from the 1986 baseline year of the Montreal Protocol reductions, well ahead of the Protocol schedule.

LOCAL ATMOSPHERIC CHANGE

Urban air pollution and acid rain are more local and immediate results of atmospheric pollution. This section deals with these two phenomena.

URBAN AIR POLLUTION

In many cities, including Vancouver, the combustion of fossil fuels, primarily from motor vehicles, produces a yellow-brown layer of pollution commonly known as smog. It is especially evident over cities in summer months. Smog results from the reaction of nitrogen oxides and hydrocarbon gases with sunlight to produce ozone and other trace gases. Other pollutants such as sulphur dioxide, carbon monoxide, suspended particulates (smoke), and lead and other toxic metals are also a concern. Table 1 summarizes the effects of some of these and other pollutants.

Table 2. Effects of Some Atmospheric Pollutants.

ATMOSPHERIC POLLUTANT	PRINCIPAL SOURCES	HEALTH AND OTHER EFFECTS
Nitrogen Oxides	Motor vehicle emissions	Can increase susceptibility to viral infections such as influenza, irritate the lungs, and cause bronchitis and pneumonia.
Ground level ozone	Chemical interactions of motor vehicle emissions	Irritates mucous membranes of eyes and respiratory system; causes coughing, choking, impaired lung function; reduces resistance to colds and pneumonia; can aggravate chronic heart disease, asthma, bronchitis, emphysema. Inhibits photosynthesis in plants.
Sulphur dioxide	Cement plants, oil refineries, and other industries	Can provoke or exacerbate cough, phlegm production, chest tightness and wheezing associated with asthma and chronic bronchitis. Can cause plant, forest, and crop damage; and deterioration of man-made structures and materials.
Carbon Monoxide	Motor vehicles	Low-level exposure may exacerbate heart disease and compromise brain function.
Suspended Particulates	Industry, fuel combustion, residential heating, forestry and agricultural burning, motor-vehicles.	Irritation of respiratory tract, bronchitis and chronic cough; visibility impairment.
Toxic Chemicals such as heavy metals (eg. lead), dioxins, furans, polycyclic aromatic hydrocarbons, PCBs, pesticides	Burning fossil fuels, motor vehicles, industry, waste incineration, landfills, mining, forestry/agricultural sprays.	Long term potential health problems. Suspected carcinogens.
Hydrogen sulphide and methyl mercaptans	Pulp mills, petrochemical plants.	Odorous, possible respiratory irritant.

Stricter controls on vehicle emissions have improved levels of air pollution in North America. However, the increasing number of automobiles threatens to reverse this trend. The world's automobile population has more than doubled since 1970 and, unchecked, will grow to 500 million vehicles by the year 2000. In 1987, 11.8 million vehicles were registered in Canada with 1.6 million of these in British Columbia. The growing number of vehicles is of concern because existing standards for ozone and carbon monoxide provide little margin of safety in protecting public health. The current health costs of failing to meet existing air quality standards in the United States is estimated by the American Lung Association at $50 billion per year.

Another major air pollution problem somewhat unique to British Columbia is wood smoke pollution produced by residential heating, tee-pee burners, waste disposal and slash and agricultural burning. For example, one quarter of all our residential heating demand is met through wood burning. Studies show that the impact of woodsmoke in British Columbia is widespread, and sometimes quite significant.

ACID RAIN

Some constituents of air pollution are acids or become acidic when they reach the Earth's surface and interact with water, soil, or plant life. The falling of these acids to the ground is commonly referred to as acid rain even though the pollutants may fall in wet or dry form. The major emissions affecting the composition of acid rain are oxides of sulphur and nitrogen. Substantial portions of these air pollutants are transported by the winds, resulting in acid rain hundreds or even thousands of kilometres from the source of emission.

Emissions of sulphur dioxide

The south coastal area of British Columbia is affected by a variety of industrial point source emissions of acidic pollutants. Sulphur dioxide is emitted on a daily basis from industrial sources in both British Columbia and Washington State. On the south coast of British Columbia, including Vancouver Island, the major emitters of sulphur dioxide are pulp mills, oil refineries and cement plants. In the northern coastal region, three plants, including an aluminum smelter, emit sulphur dioxide. The major sources of sulphur dioxide emitted in Washington State are thermal power plants, petroleum refineries, aluminum smelters, pulp mills and cement plants. Smaller sources of sulphur dioxide include residential heating and internal combustion engines.

The Effects of Acid Rain on Vegetation

Forest die-back, crop damage and vegetation injury from air pollutants are occurring rapidly and on a large scale in many of the developed areas of the world. In Western North America, however, air pollution damage and forest decline are as yet more subtle and localized. Acid rain effects on vegetation in British Columbia have up til now been confined to local areas around emission sources. The effects of acid rain on vegetation include:

a) Acid rain may impact on tree and crop leaves already injured by ozone pollution, and wash out essential minerals, causing additional stress.

b) The nitrogen component of acid rain has been implicated in delaying frost hardiness, increasing the risk of frost injury.

c) The acidification of the soil may reduce root growth or affect the beneficial cooperation between roots and fungus. This may directly or indirectly reduce the ability of plants to cope with drought, and reduce their ability to take up nutrients from the soil.

The Effects of Acid Rain on Aquatic Environments

Lakes within about 250km from the west coast, including those on Vancouver Island and the Queen Charlotte Islands, are classed as having either a high or moderate sensitivity to acid rain. No direct effects of acid rain on aquatic environments has yet been detected, possibly due to the high rainfall and resulting flushing action in these lakes. However, coastal lakes that are downwind of sulphur dioxide sources are potentially at risk to becoming acidified in the future.

Acid rain initiatives in British Columbia.

The British Columbia Ministry of Environment is reviewing sulphur sources that are permitted under the Waste Management Act in British Columbia to ensure that acidic emissions are within acceptable limits to provide protection to sensitive ecosystems. Where there is a reason to do so, permits may be amended. Although British Columbia produces a substantial amount of acid forming emissions, there is some indication that emissions from Washington are carried into British Columbia. This potential source of acidic deposition needs to be considered and the impacts evaluated. The new federal monitoring station on Saturna Island will provide daily information that will be used to estimate regional background acidic deposition and transboundary movement of pollutants.

LIMITING ATMOSPHERIC CHANGE

There is a growing scientific consensus that we should act now to reduce emissions of atmospheric pollutants. Given the uncertain consequences associated with atmospheric change, should decision-makers act now or wait for more information? If we wait to see the proof of the global changes, the costs of dealing with changes in agriculture, forestry, and weather patterns may be much greater than if we act now to start reducing the likelihood of these events occurring. Some scientists feel that the solution is to rearrange or reorganise our affairs so that we consume less energy and reduce pollution. On a per capita basis, Canadians are among the world's most intensive users of energy. Every day millions of individual decisions are made, many of which increase the impact of atmospheric change. We could also be making decisions which reduce the impact of atmospheric change.

Like most North American jurisdictions, British Columbia was built on the assumption that energy and materials would always be cheap and plentiful. This is reflected in the poor insulating quality of our buildings, our reliance on the automobile, the increasing separation of our workplaces from our homes, and the sprawling form of our large cities.

Putting aside for the moment the risks and uncertainties of climate change, decision-makers have sufficient grounds to reduce emissions of atmospheric pollutants solely on the basis of the immediate and direct impacts of stratospheric ozone depletion and local air pollution. Given that existing forms of regulations and incentives for air pollution are nonetheless *leading* to global atmospheric change, clearly we must develop a framework for action that *reduces* emissions of atmospheric pollutants.

Many people are calling for an unprecedented global collaboration among scientists, citizens, and decision-makers to reduce emissions of atmospheric pollutants. Atmospheric change cannot be dealt with in isolation; what one country or province does affects other areas and eventually the globe. For this reason, every country and every sector in society must contribute to solutions, even if their contribution seems minuscule.

There is no single strategy for dealing with the problem of atmospheric change. There are many sources of atmospheric emissions (the combustion of fossil fuels for transportation, lighting, heating; industrial and agricultural processes; and deforestation) and so there need to be a multitude of solutions. Simply treating atmospheric pollution after the fact, as we have attempted until now, is not sufficient.