CLIMATE OF CHANGE

A Glimpse of Canada's Future

David Suzuki Foundation

Finding solutions

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A Glimpse of Canada's Future

Many Canadians have a gut feeling that the weather has changed during their lifetimes. They remember the snowbanks being higher in Ottawa when they were growing up. The summers feel hotter in Toronto. In the last year alone, record-setting events from the worst eastern hurricane in over 20 years, to a crippling snowstorm in Victoria, to the Red River flood have people talking even more than usual about the weather.

Are these events just part of normal variability in weather? Or are they the concrete signs of a more ominous climate change that most scientists and some politicians are warning about?

In 1992, the federal government made a commitment to stabilize Canada's emissions of greenhouse gases which scientists believe are altering the global climate system. It is now certain that we will fall short of that commitment.

So far the debate on climate change and how to deal with it has been confined primarily to scientists, bureaucrats, politicians, big business and environmental groups. The vast majority of Canadians are left wondering what it could possibly mean for them. Even the concept is confusing. "Global *warming*" sounds like good news for a country with a winter climate. Besides, surely it won't affect us, or our children, in our lifetimes.

This report asks the question: *Is climate change a real threat to Canadians and, if it is, what should we do about it?*

First let's look at what the scientists are saying.

1

Is climate changing?

Climates have always changed. This can be a good thing. If the last ice age had not given way to a lengthy warm period, Canadians wouldn't be here to enjoy it. But we are about to consider another change, which has already begun and will have results that are not so beneficial.

In the last 20 years, scientists have become more and more concerned that human activities such as fossil fuel burning and destruction of the rainforest have increased enough to affect the very atmosphere of the planet. Researchers have been analysing vast amounts of data to determine whether a new climate change is under way, if human activity is contributing to it, and what the results might be.

During the past few years, a scientific consensus has emerged – climate change *is* now occurring, *human activity* is largely responsible, and the consequences will impose *severe challenges* for human communities and natural ecosystems in the decades to come.

Global warming can mean regional cooling

Global heating doesn't mean it will get warmer everywhere. Climate changes cause heat to be distributed, which can result in cooling here and there. The east coast of Labrador, for example, has cooled by more than 0.4°C over the past 30 years – a trend that happens to be consistent with current models of global warming. [2] Moreover, rising and falling temperatures are only one aspect of changing climate. For reasons such as these, scientists prefer the term "climate change" to "global warming."

WEATHER AND CLIMATE

By now most people have heard of global warming. What they may not realize is that global average temperature is only a technical indicator of the real problem. The real worry is what's happening to the weather. And why.

Weather is tangible and local. We are immersed in it constantly – temperature, pressure, humidity, clouds, wind, rain and snowfall. We see, feel and experience the weather and its effects. By contrast, climate is something of an abstraction: the average weather over a stated area. (The "global" climate is something nobody could possibly experience!) The climate in a certain region is the average over many years of daily, seasonal and yearly fluctuations in weather indicators – temperature, precipitation and so on – measured and recorded across that region. [1]

Climate provides a way of talking about the weather. But the weather referred to is always much more varied than any climatic average. When scientists

note a small change in climate, they are averaging the measured results of what may be quite large changes in local weather events and effects. A small increase in average temperature may mask what really was a sharp rise in heat waves. A modest increase in wind and precipitation levels on average can in reality represent a lot more severe rainstorms.

Volcanoes and ocean currents

Volcanic eruptions and ocean circulation interact with climate. When volcanoes erupt, they send out clouds of tiny persistent particles, known as "aerosols," which block or reflect sunlight and tend to offset global warming. Thus, the 1991 eruption of Mt. Pinatubo in the Philippines caused a temporary two-year global cooling of about 0.4°C.

The El Niño Southern Oscillation event in the tropical Pacific warms currents off the west coast of South America, producing widespread impacts from heavy rainfall in the southern U.S. to drought in Australia. El Niño's latest warming cycle lasted five years, compared to its usual two. Not only has some recent climate change been linked to this extended effect, but the longer El Niño itself has been attributed to global warming. [4]

WHY CLIMATES CHANGE

Climate reflects an elaborate mix of natural forces occurring over different time periods and geographic scales. Fluctuating ocean currents and volcanic eruptions are smaller forces that influence climate over years to decades. Alterations in Earth's orbit, which take many millennia, may affect the intensity of incoming sunlight, with climatic consequences. [3] However, the current focus of attention is on the link between climate change and atmospheric concentrations of "greenhouse gases."

The atmosphere encasing the planet includes certain gases that, among many other services to life, create the now-familiar greenhouse effect. They let in sunlight but prevent the escape of infrared heat, much like the glass of a greenhouse. Without this natural blanket, Earth would have been too cold for life as we know it to have evolved, let alone survive. These greenhouse gases consist mainly of water vapour, carbon dioxide and methane. Higher concentrations of them trap more heat in the atmosphere and warm up the global climate.

Scientists believe that the atmospheric levels of greenhouse gases have fluctuated over time, reflecting natural cycles among the air, oceans, rocks and soils, vegetation and animals. For example, forests and wetlands are cited as natural reservoirs for storing the earth's supply of carbon. At times, these reservoirs act as "sinks," absorbing more carbon than they release; at other times,they become "sources," releasing more carbon than they absorb. On average, natural cycling processes are believed to have removed as much carbon as they have added, thus keeping greenhouse heating in check.

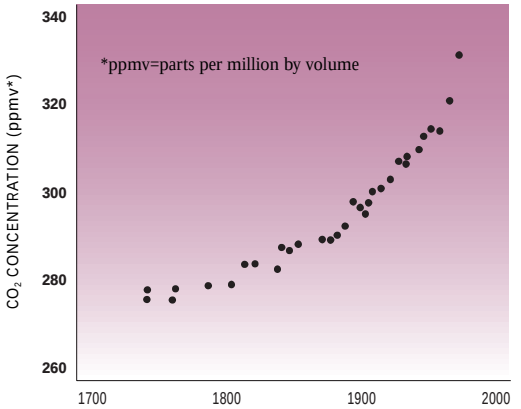

FIGURE 1. ATMOSPHERIC CONCENTRATIONS OF CO_2, 1744-1983

SOURCE: Carbon Dioxide Information Analysis Center [5]

THE HUMAN INFLUENCE ON CLIMATE

The concern among scientists is that, since the Industrial Revolution, human activities have raised the concentrations of greenhouse gases in the atmosphere, thereby trapping additional heat. On one hand, these gases are the main emissions from human technologies, especially carbon dioxide (CO_2) from combustion. (Water vapour, by far the largest product of combustion, immediately joins the enormous and fast-moving natural water cycle of evaporation and precipitation, whereas CO_2 can remain aloft for centuries.) On the other hand, deforestation has a double effect: shifting carbon contained in trees to the atmosphere, while also reducing the number of trees that remove carbon dioxide from the air.

CO_2 represents about half of the atmosphere's greenhouse gas heat-trapping capability. Meanwhile, concentrations of other gases which have a human origin, such as methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs), are also rising, while new research is under way to determine the importance of human-caused aerosols – sulphates and smoke particles produced from smelting and the burning of fossil fuels and biomass.

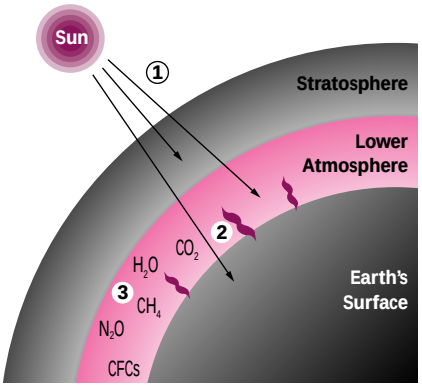

FIGURE 2.
THE GREENHOUSE EFFECT

1. Sunlight warms the earth's surface, where it is absorbed.
2. Heat energy is re-radiated back to space.
3. Greenhouse gases trap some of the outgoing heat in the lower atmosphere.

SOURCE: Province of British Columbia [8]

AN OVERWHELMING SCIENTIFIC CONSENSUS

A large number of the world's leading climate scientists recently agreed that there is now evidence of "a discernible human influence on global climate."[6] They agree on two things. First, there has been a statistically significant increase in global temperature during the last hundred years. Second, after accounting for the natural causes of variations in temperature patterns, this increase is attributable in large part to human activities.

What's more, the rate of temperature change is alarming. Over the past century, observed global warming has occurred at a pace faster than in any other period during the last 10,000 years. And it seems to be accelerating. Between the most recent ice age and the current ice-free period, average global temperature has risen by an estimated 0.5°C per millenium. [7] Today scientists speak of a 1 to 3.5°C increase in a century. Hence, we now seem to be participating in an unwitting and dangerous climatic experiment on human communities and natural ecosystems alike.

TABLE 1. HUMAN-CAUSED GREENHOUSE GASES

GAS	CONCENTRATION INCREASE[1]	ATMOSPHERIC LIFETIME (YEARS)	MAJOR SOURCES
Carbon dioxide	28%	50-200	Fossil fuel burning, cement manufacture, deforestation, other land uses
Methane	146%	12	Livestock, rice paddies, solid waste, coal mining, oil and gas production
Nitrous Oxide	13%	120	Fossil fuel and biomass combustion, fertilizers, landfills, coal seams
CFCs	—[2]	50-264	Refrigeration, aerosols, industrial solvents, insulating materials

[1] 1775-1994.

[2] Only manufactured in this century.

SOURCE: Intergovernmental Panel on Climate Change [6]

Intergovernmental Panel on Climate Change (IPCC)

Since 1988, an international panel of scientists has been reviewing the scientific and technical information on climate change. The IPCC has produced a series of assessments which document the growing scientific consensus on human-caused climate change. More than 2,500 scientists from over 80 countries took part in the landmark 1995 assessment. Canadians have made important contributions to all three of the panel's working groups covering the science, impacts, and policy responses to global climate change.

Cycles and debts

Similar to a balanced national budget, the global carbon supply has been stable on average for thousands of years. Now human intervention, especially fossil fuel burning and deforestation, is tipping the balance by returning stored carbon to the atmosphere faster than natural processes can absorb it. Like governments, the carbon cycle is spending more than it takes in, accumulating a CO_2 debt that leads directly to global climate change.

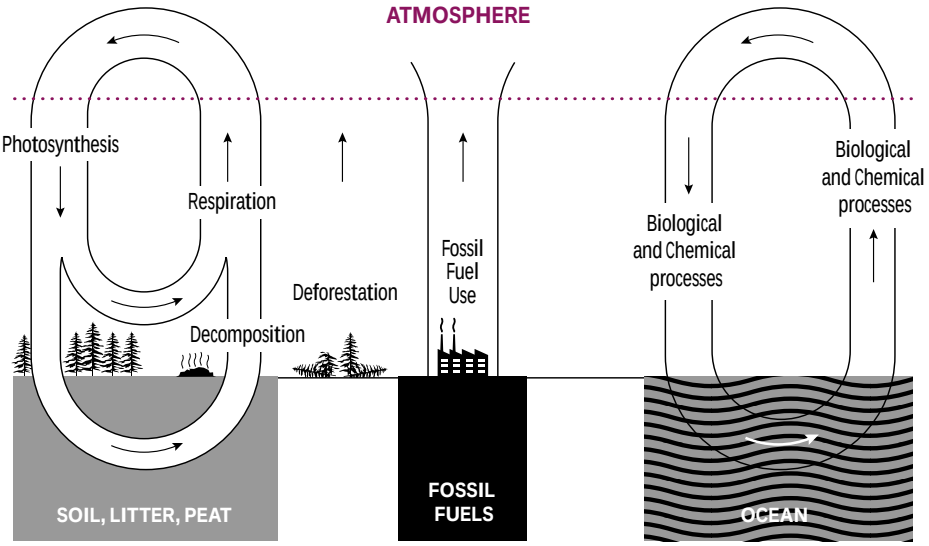

FIGURE 3. THE CARBON CYCLE

SOURCE: California Energy Commission [9]

Deciphering climate change

To analyse climate change, climatologists use meteorological records, which go back about a century, an interval that happens to correspond to the period of perceived global warming. In estimating a global average, they have to compensate for such trends as the effect of expanding "urban heat islands" on temperature records. They use sophisticated computer models to distinguish the effects of natural processes (interactions of oceans, clouds, vegetation, etc.) on temperature. By comparing natural effects with those from human emissions, scientists estimate the human contribution to temperature change.

CHANGE IS ALREADY HAPPENING

The scientific consensus is bolstered by some very compelling facts:

- Global average temperature has increased 0.3 to 0.6°C over the past century, with most of this rise in the last 40 years. [6] Canada has warmed about twice as much. Within the country, some regions (the Northwest) have become a lot warmer (2°C), while others have cooled (the Atlantic). [10]
- The ten warmest years, globally, of the past 130 have all occurred since 1980.
- Sea levels have risen 10 to 25 centimetres, as warmer temperatures have caused thermal expansion of oceans and melting of glaciers and ice sheets. [6]
- The number of days of heavy rainfall over the continental U.S. has jumped 20% since 1900. [11] In Canada, some studies have found more frequent tornadoes in recent years, and an increase in heatwaves in southern areas. [9, 12]

The evidence of global climate change is all around us.

PREDICTIONS FOR FUTURE CHANGE

Canadian and international scientists are virtually unanimous in their view that the observed global temperature increase will continue, bringing with it changes in other climate patterns. The best computer models are now projecting climate change under various conditions for growth in world populations, economies and emissions of greenhouse gases and aerosols. The results include:

- Global temperatures are expected to be 1 to 3.5°C higher by the year 2100, with the greatest increase in northern countries. Canadian models predict an unprecedented global warming rate of 0.2°C per decade. [13] North-central Canada may warm by 5°C, and up to 8°C in winter, by the middle of the next century. [14]

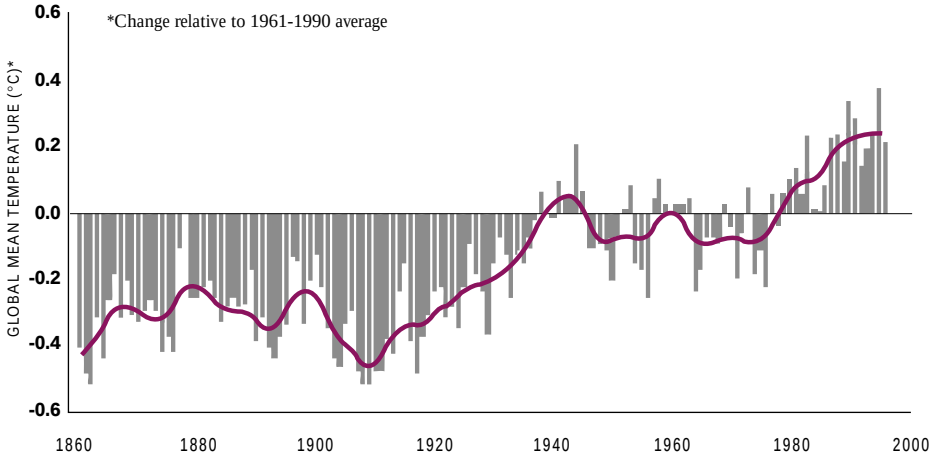

FIGURE 4. GLOBAL AVERAGE TEMPERATURE CHANGES, 1860-1996

SOURCE: Hadley Centre for Climate Prediction and Research [18]

- Sea levels will continue rising by 15 to 95 centimetres over the next hundred years.
- Winter precipitation will likely increase at high latitudes, while more droughts will occur at low latitudes, as moisture evaporates towards the poles. [15] Higher precipitation is expected for Atlantic, Central and Northern Canada. The Prairies will likely be both hotter and drier. [9]
- Extreme events, by their nature, are difficult to predict. Rising global temperatures will probably mean more mild winters and hot summers, and fewer cold spells. More and heavier storms, as well as an increase in flooding events, could well accompany greater temperature, humidity and precipitation. [11, 16]

On a global scale, changes such as these could wreak widespread economic, social and environmental dislocation over the coming century.

WHAT COULD CLIMATE CHANGE DO?

If carbon dioxide concentrations in the atmosphere grow to twice their present levels, there could be severe local and regional effects:

- Storm surges and flooding would threaten entire cultures, since in the order of 100 million people will be living within one metre above sea level.
- More droughts would lead to increased famine in already vulnerable desert and semi-desert regions.
- Wetlands, coral reefs and other sensitive ecosystems would be jeopardized, and many species would become extinct.
- One-third of the world's forests would undergo major changes in vegetation type.
- Malaria and other tropical diseases would spread, and thousands more people would die annually from heat. [17]

The damage weather can cause

Southern Manitoba's 1997 Red River flood forced 25,000 people from their homes and cost hundreds of millions of dollars in government disaster relief, victims' out-of-pocket expenses, donations from private citizens, etc. In August 1992, Hurricane Andrew killed 54 people, left 250,000 homeless, and created $30 billion worth of damage in the Caribbean and southeastern U.S. [15] More than 500 deaths were caused by an intense heat wave that struck the U.S. Midwest during the summer of 1995. Weather-related disasters of this kind help spur (and explain) the concern about climate change.

However, what if increases in atmospheric CO_2 levels more than double? On the world's current path, exceeding a doubling of concentrations is not only possible, but increasingly likely. In fact, analyses suggest that if fossil fuel use continues to grow at current rates CO_2 levels could double by the middle of the next century or even earlier (as soon as 2020), and perhaps triple by the year 2100. [6, 19] Scientists concur that a tripling or greater increase in carbon dioxide concentrations would have pervasive and catastrophic impacts. Our social and ecological systems would virtually collapse.

Danger to low-lying countries

The IPCC studied the vulnerability of 23 countries to a one metre rise in sea level. [16] Since infrastructure and economic activity are often concentrated in coastal zones, in nearly half the countries the capital value lost would be more than half of current gross domestic product. With a one metre sea level rise, the IPCC report concludes:

- 60% of the population of Bangladesh could lose their homes and farms.
- 48 cities in China could be flooded, affecting 72 million people.
- Small island states could lose most of their land, threatening their entire populations.
- Famine could spread, as rice production falls 10% in southern and eastern Asia.

THE NEED FOR GLOBAL ACTION

Hardest hit by climate change will be countries with coastal areas or fragile ecosystems. Many of these vulnerable regions are already poor and plagued by natural disasters.

It is sometimes claimed that certain countries will "benefit" from climate change, while others will "lose," or that, even within countries, certain regions and economic sectors will gain. However, the idea of climate change as an opportunity, where some can take advantage to get ahead of others, overlooks the complex interrelationships and mutual benefits that would be disrupted in our societies, economies and natural ecosystems. Ultimately, the stress of famine, disease, dislocation and species extinction will be felt everywhere. In this respect, climate change is everyone's problem.

And, in view of the widespread devastation it could cause, this shared problem calls for concerted global action.

WE KNOW ENOUGH TO BE ABLE TO ACT

There remains a lot we do not know about global climate change and its impacts. Our understanding of the complex interactions of oceans, clouds and other natural processes in the climate system is still evolving. Scientists cannot say precisely how fast climate change will occur, how precipitation and extreme weather patterns will be be altered, or how the effects will be distributed geographically. We also cannot predict with certainty the future levels of human-caused greenhouse gas emissions and aerosols, the vulnerabilities of different regions of the world, and their capacities to adapt to climate change. [16]

However, let's review what we *do* know:

- Rising concentrations of greenhouse gases have provoked an unprecedented increase in global average temperature over the last hundred years.
- A strong scientific consensus has emerged that human activity is responsible for the climate change now under way.
- The global, regional and local effects of this climate change are likely to be devastating.

In any case, a lack of certainty on the details is no excuse for inaction. Individuals and governments make decisions every day without knowing all the facts ahead of time. They invest enormous sums to protect against future dangers or catastrophes. People buy insurance, even though they don't know if their families will ever suffer the anguish and loss of a house fire. Governments spend vast amounts of public funds on national defense and health care, although they don't know if a war or epidemic will ever cross their borders. The serious threat posed by global climate change is no different.

We will never be absolutely certain about the full nature of climate change in our lifetimes. Scientists are continually improving our understanding through cautious research and aggressive debate. Indeed, the hard-wrung scientific consensus on changing climate supplies a firmer basis for policy action than the forecasts that underlie many of our fiscal policies. Clearly, we know enough about the potentially staggering effects of climate change to take decisive global, national and local action.

Given this world view, some idea of what climate change could mean to our own communities and natural ecosystems would be helpful.

The insurance business wakes up to climate change

Climate change is bad news for the insurance industry, which is highly sensitive to weather extremes. Worldwide, storm-related losses averaged $11 billion per year between 1990 and 1995, compared to $1.7 billion annually during the 1980s. [20] Here in Canada, 1996 was a record year for disaster losses. Hail and flooding, for the most part, cost insurers over $600 million. Of course losses are up for other reasons, too (more insurance bought, more private properties, etc). But the trend is clear. Since 1990, a number of major companies have closed down in the wake of natural disasters, and at least two others have stopped insuring against them.

At the July 1996 international climate change negotiations in Geneva, 57 European insurance firms issued a call for action on reducing greenhouse gas emissions.

2

What will climate change mean for Canadians?

Should Canadians care about global climate trends? Let's put the question a different way: do we care about the weather?

Writers and cultural historians say that coping with weather is part of the Canadian identity. Farmers, foresters, fishers, and others who work in the large resource sector of our economy are directly affected by weather conditions. Tourism and much recreational activity, from skiing to time spent at summer cottages, are weather-dependent. The TV weatherperson is a Canadian invention. Shovelling winter snow and dealing with rain runoff are integral to the national experience. Partly because our weather is already so variable, we tend to take pride in our ability to handle whatever comes – not forgetting, of course, to complain at the same time!

Climate change means that Canadian weather-awareness is not about to diminish, and our ability to handle weather surprises is really going to be tested.

One of these tests will involve yet another Canadian tradition: concern for regional economic disparities. In agriculture, for example, weather changes will alter local opportunities. In certain areas, greater precipitation and the "fertilization effect" of higher carbon dioxide levels in the air could improve some crop yields. In other areas, heat waves and drought could have the opposite effect. A trend towards increased precipitation concentrated in short periods could bring more floods. And so on. New disparities between sectors and regions within the country could easily appear.

Let's consider some scenarios. Imagine what Canada could look like in the 21st century if we do not take global action on climate change. Of course this is a difficult hypothetical case because so many other things will change over the coming decades. So, to simplify matters, suppose that everything else in the country remains the same while climate change goes ahead unimpeded. What could it mean to Canadian communities and ecosystems?

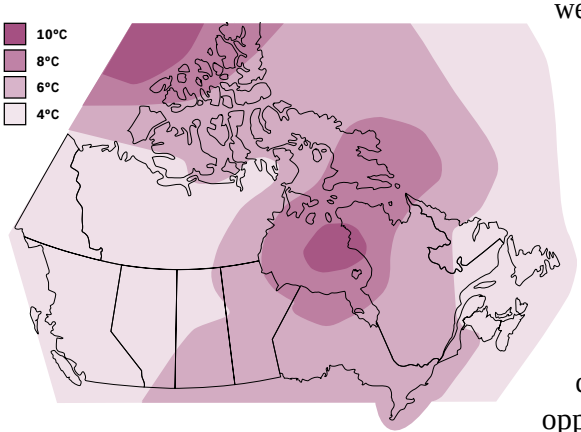

FIGURE 5. PROJECTED TEMPERATURE INCREASES IN CANADA

Projected temperature increases during December, January and February, assuming twice current levels of CO_2.

SOURCE: The Pembina Institute for Appropriate Development [21]

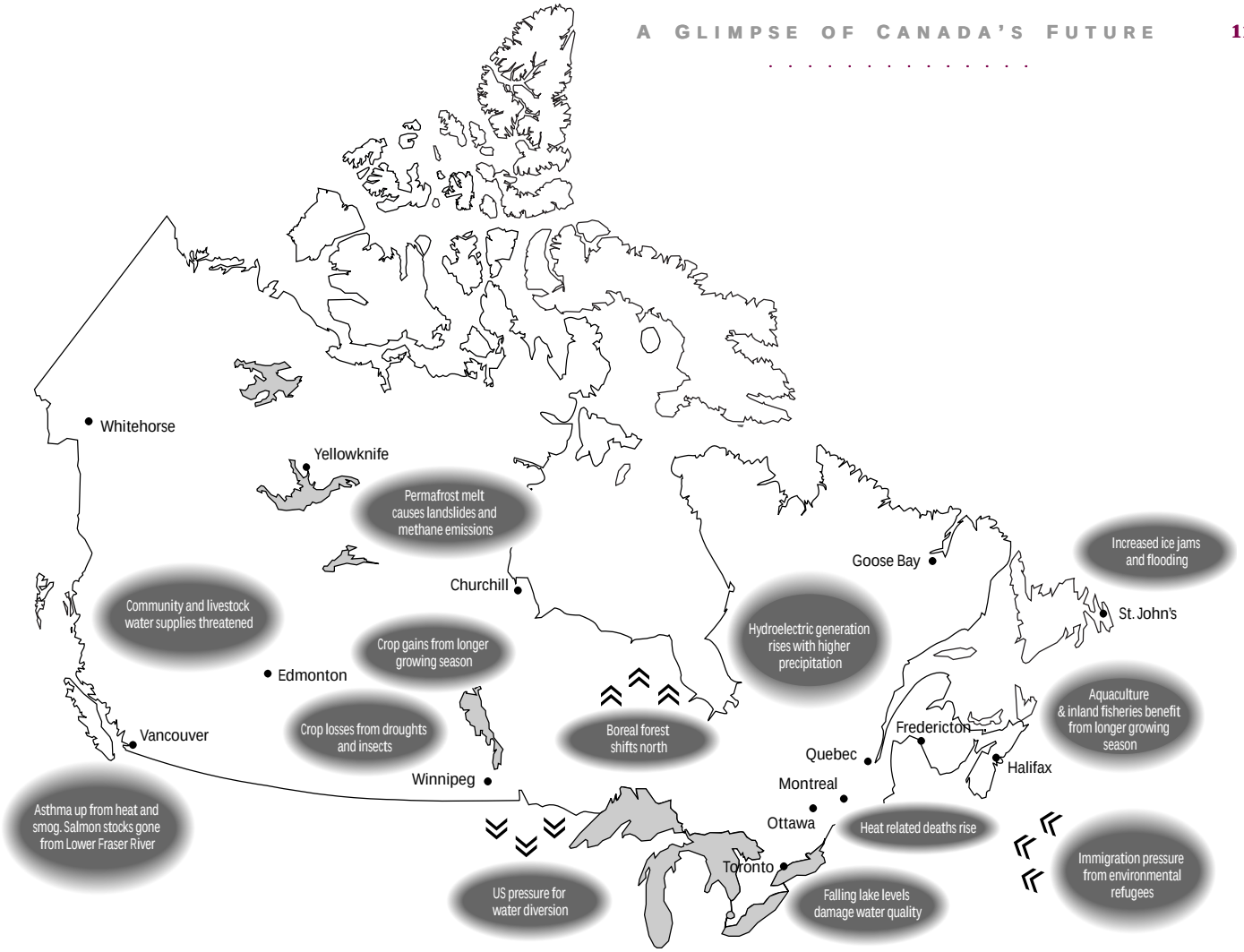

FIGURE 6. CANADA IN THE 21ST CENTURY: OUR CHILDREN'S FUTURE?

What Canada could look like in the next century — and this is just the beginning.

If you think this map looks like science fiction, consider what is already happening:

- Spring comes a week earlier than it did a decade ago in the Northern Hemisphere. [4]
- Glaciers have retreated in the Rockies and the permafrost line is moving northward. [10]
- Atlantic cooling has lowered cod growth rates, adding to the East Coast fishery's decline. [10, 22]
- Vegetation has increased 10% above the 45th parallel since 1980. [4]

SOURCES: Environment Canada [23, 24], Environment Canada et al. [25], and Canadian Climate Program Board [10]

The following examples suggest the kinds of situations that could develop if we do nothing to address the threat of changing climate. Generally, these examples are based on a doubling of CO_2 concentrations in the atmosphere. As mentioned earlier, doubling is conservatively estimated for the end of the next century, with tripling a distinct possibility over the same timeframe. Some scientists maintain that carbon dioxide levels could double as soon as 2020. Whatever the exact timing of the increase, many of the climate change impacts are already upon us.

Our work and livelihood: some scenarios

A COMMERCIAL FISHER

In the 21st century, on the Pacific Coast, warmer ocean temperatures and reduced river flows shift salmon populations northward. Certain southern species, such as Fraser River sockeye, are drastically reduced and some local stocks eliminated. [26] Other fish species which favour warmer temperatures, including tuna and hake, move in. [24]

A crisis faces the fishers and, through them, coastal communities stretching from Prince Rupert to the Lower Mainland. The long chain of fish processing and service industries that depend on the salmon fishery for their business has been rocked by the combined effect of overfishing and changing ocean conditions. At stake is not just an income but a way of life.

A WHEAT FARMER

In the 21st century, hotter and drier summers on parts of the prairies bring more frequent and prolonged droughts. As water tables drop by 4 metres, lakes and sloughs dry up, dust storms appear, and soils erode with alarming speed. [27] Heat waves bring more insects and disease. More frequent hailstorms and early snowfalls cause huge crop losses.

Yet effects vary. A hailstorm hits some fields, but not others. Some farm communities disappear, but not others. Some farmers can afford the rising costs of irrigation, pest control and crop switching (e.g., from spring to winter wheat), but others cannot. [28]

The scene is reminiscent of the "Dirty Thirties," with rising bank foreclosures and government pay-outs for income relief. But there are also similarities to certain prehistoric times, when the prairie climate was 2°C warmer than today. Then, droughts lasted several decades longer. Water tables fell by 5 metres and salt was introduced into much of the remaining surface water. [10]

A COASTAL RESORT OWNER

For those who can keep them, ocean beaches on the Atlantic coast are at a premium in the 21st century. Rising sea levels and more storms erode beaches ferociously, particularly those with gradual slopes which are more exposed to waves and currents. Each 10-centimetre rise in sea level causes the average beach to retreat 10 metres. Hundreds of millions of dollars are being spent worldwide to rebuild sandy beaches. (It is estimated to cost over $1 billion US to protect 100 kilometres of beaches in the Netherlands against a one-metre sea level rise.) [29]

At the same time, hotter summers increase the demand for coastal recreation. But only the wealthy are able to afford a beach holiday. Few species of shorebirds and tidal zone sea creatures survive.

Fish and climate change

Fish are highly sensitive to temperature and ocean current changes. Salmon, for example, are cold water fish – they delay breeding and their eggs will not hatch if temperatures are not cold enough. If they have the genetic flexibility, salmon will be pushed to migrate northward in order to avoid higher water temperatures. It is quite possible that certain races will not be able to move, leading to extinction. Juvenile salmon feed in river estuaries and deltas, which are threatened by rising sea levels. A 30-centimetre rise in sea level would wipe out an estimated 40% of the biologically rich Puget Sound tidal flats in Washington State.

Our health and lifestyles: some scenarios

A HOMEOWNER IN A RIVER DELTA

In the 21st century, a 40-centimetre sea level rise, combined with storm surges (from the reduced air pressure and winds of storms), causes frequent severe flooding from the ocean. Salt water enters ground and community water supplies. The river itself also floods frequently. Local gardening and agriculture have been decimated. Construction of new and upgraded dikes is very costly and encroaches further on shoreline marshes. Birds and fish disappear as feeding and breeding grounds are lost.

With people's homes at risk, the effects ripple through communities. Stress, trauma, property damage, disruption and falling property values cause a decline in local trade and commerce. There are constant calls for government relief and private donations. Homeowners don't have flood insurance because insurance companies no longer offer it.

AN ABORIGINAL HUNTER

In the 21st century, dwindling caribou herds are plagued by clouds of mosquitoes and flies. They nose with difficulty for vegetation under deeper snow. Wooded areas have been ravaged by forest fires. Warmer summers and deeper snow have reduced cow pregnancy rates, causing a steady decline in caribou populations. [30]

Permafrost melts, and lakes and wetlands dry up. Sensitive to the land's productivity, aboriginal hunters, trappers, fishers and gatherers find their traditional lifestyle in tatters. New ways of life, such as agriculture, are challenging the old. Villages have been evacuated, traplines destroyed. Melting of littoral strips has eliminated land-fast ice, and where permafrost has thawed the ground is a messy quagmire. [31] Hunting on land and ice is therefore much more difficult and treacherous.

AN URBAN CONDO DWELLER

Along with rising CO_2 levels, the number of very hot summer days in Toronto and Montreal has doubled in the 21st century, causing several hundred more heat-related deaths each year. [32] The heat and increased smog aggravate asthma, cardiovascular disease and other ailments, especially in children, the elderly, the poor and the homeless. Each year, tens of thousands of Canadians die from such illnesses. [33] Malaria has appeared in southern Canadian cities. [23] In Toronto, street asphalt buckles in the sun, hydro bills for air conditioning have soared, and taxes have risen to pay for more ambulances and fire departments. Crime and anti-social behaviour grow in the sweltering heat.

Spreading disease

Rising temperatures and precipitation help the spread of insect-borne and other diseases, such as malaria, equine encephalitis (sleeping sickness), Lyme disease, cholera and dengue fever. A University of Ottawa researcher estimates that an average global temperature increase of just 0.5°C could cause 80 to 120 million more cases of malaria, as mosquito carriers spread throughout Africa and Central and South America. [34] (In 1993, there were 300 to 500 million cases reported worldwide and 2 million deaths.) Mosquito-borne sleeping sickness primarily attacks farm animals. However, it did cause human deaths in a 1983 Manitoba outbreak and could devastate agricultural communities. [10]

The natural environment: some scenarios

WETLANDS

In the 20th century, Canada's bogs and marshes still provided critical water storage and fish and wildlife habitat. Prairie wetlands, for example, had once been the staging grounds and habitat for more than half of North American waterfowl. But two-thirds of Canadian wetlands were lost, primarily to expanding agriculture, between European settlement and the mid-1980s. By then, the number of ducks breeding in the Prairies had reached dangerously low levels. Despite rehabilitation efforts, wetlands continue to be at risk in the 21st century. With climate-related increases in flooding and shifts in regional water tables, many prairie wetlands have disappeared.

NORTHERN PERMAFROST

Permafrost is the permanently frozen ground that even at the end of the 20th century underlay much of the tundra, though it was already ebbing away, with ground temperatures rising even faster than air temperatures. Now the accelerating thaw of permafrost causes erosion and landslides, clogs up rivers and streams, drains small lakes, and destroys wetlands and deltas. Even at the northern edge, along the Beaufort Sea, where the coast is now moving inland by as much as a metre each year, storm surges expose permafrost to summer thaw. The tundra, turning into swamps, releases large amounts of methane into the atmosphere, which exacerbates global warming. [31]

BOREAL FORESTS

In the 21st century, Canadian northern forests suffer the greatest damage from climate change. An average global temperature increase of 0.2°C per decade has pushed forests northward an average 30 kilometres every ten years. But this change was faster than many tree species were used to moving (up to 20 kilometres a decade). [2] Unable to keep up with the temperature increase, the boreal forest has fallen into a severe decline, devastated by the fires and pests that accompany higher temperatures. The heaviest impact is at the southern boundary, as hardwoods and grasslands move in. [2] The deciduous forests have reached James Bay.

ARCTIC ICE

On the Arctic Ocean, the summer sea ice cover has all but vanished in the 21st century. The polar bears can no longer use it to hunt seals. Not that there are many seals around for them to hunt, because the fish species that seals feed on are also declining. They relied on the microorganisms that grew on the underside of the ice. The Arctic food chain is collapsing. [31]

The Boreal forest

Boreal forests, accounting for much of the forested area in Northern Canada, Europe and Russia, are particularly vulnerable to climate change. The IPCC estimates that two-thirds of these important forests could disappear under a doubling of carbon dioxide concentrations. Canada's boreal forest has already lost a fifth of its biomass to fire and insect damage over the last twenty years. As a result, it has switched from being a carbon sink to a source, releasing more carbon than all Canadian cars and power plants combined. [35]

Conclusion

These scenarios are bleak. We described them to show the direction that some people's lives, their communities and the natural environment could take in a world of unchecked climate change.

Of course, we could have included examples that show benefits to communities and ecosystems. However, the idea that agricultural gains in northern Saskatchewan would offset agricultural losses in southern Alberta hides the fact that *individual* farmers and communities would likely be devastated. Similarly, while some plant species would flourish in a CO_2-laden atmosphere, this hardly compensates for the decline and extinction of other species unable to adapt fast enough.

Overall, the impacts may even out for certain regions or economic sectors. But the unavoidable conclusion is that, unless we act decisively on climate change, Canadian communities and ecosystems will suffer real and lasting hardship.

IMPROVING OUR UNDERSTANDING

The scenarios were culled from numerous impact studies based on specific regions and sectors of the country. We still need a comprehensive understanding of how climate change will affect Canadians. In particular, we need to know more about how regional climates are changing, how they influence natural ecosystems, what the economic and social consequences could be, and how communities could adapt to change. Some sense of the economic damage across Canada is important in order to decide what actions to take and how much to act.

In universities and governments throughout the country, scientists are working to improve measurements and predictions of regional climate change. Government agencies (for example, Environment Canada and Natural Resources Canada) and other organizations (for example, the Canadian Climate Program Board and the Royal Society of Canada's Canadian Global Change Program) are sponsoring research, promoting awareness, and supplying policy advice. A Climate Research Network now links Canadian scientists and provides funding for regional and global climate studies.

The Canada Country Study, which is currently under way, will provide the first-ever national assessment of the social, economic and ecological impacts of climate change. Two other detailed regional studies have already been completed for the Mackenzie and Great Lakes-St. Lawrence basins. The Mackenzie Basin study demonstrated how we need to involve more than just scientists, bureaucrats and lobby groups in the discussions on impacts. Clearly, communities, businesses, unions, First Nations and ordinary citizens must all be engaged, as well.

These efforts will improve our understanding of the effects on Canadian communities and ecosystems. In the meantime, action is needed, and in acting we will learn where more research is required.

An early warning: the Mackenzie Basin

The alarming ecological damage in the vast Mackenzie Basin is an early indicator of what climate change can do to vulnerable ecosystems. A recently completed six-year study predicted some effects of continued regional warming over the next 50 years:

- Great Slave and Great Bear lakes are expected to fall to below current minimum water levels.
- Ice on the Peace River could stop 200 km from its normal upstream advance.
- Permafrost thaw will increase, producing landslides and erosion.
- Peatlands could disappear from areas south of the 60th parallel.
- Forest fires will likely become more frequent and severe, affecting wildlife and forestry. [35]

3

What should we do about climate change?

Canadians may wonder why we are being asked to take action. After all, Canada accounts for just 2% of today's global emissions of greenhouse gases. By far the largest contribution to future emissions growth will come from developing countries, as they industrialize. Shouldn't these countries then be the ones to reduce their emissions?

While Canada's emissions are small in the global context, we remain one of the heaviest *per capita* emitters of greenhouse gases. That's because we use a lot of energy, given our colder climate, longer transportation distances, and "energy-intensive" lifestyle choices (bigger homes, more cars, etc.). Compared to people in other countries, therefore, Canadians continue to produce a large amount of greenhouse gases on a per person basis.

What's more, the climate change we are now seeing is largely the result of industrialization by developed countries, including Canada, over the past hundred years. It may well make sense for Canadians to invest our dollars in reducing emissions in other countries – known as "joint implementation." These cooperative actions could bring the biggest bang for the buck. In any case, developing nations are looking to us to lead by example in achieving sizeable emissions reductions.

The questions confronting Canadians now are: what actions can we take, when should we take them, how much should we do, who should act, and exactly how do we go about it?

THE KINDS OF ACTION

There are three basic options for dealing with climate change:

- *Inaction*. We do nothing and suffer its effects.
- *Adaptation*. We respond to climate change as it occurs. This includes anticipating the effects of climate change before they reach us and acting on them after they've happened.

The problem of momentum

Carbon dioxide can stay in the atmosphere for anywhere from decades to centuries. As a result, even if we cut CO_2 emissions today, atmospheric concentrations will continue to rise because of the buildup from past emissions. To use our earlier analogy, the carbon dioxide debt will continue to accumulate, although by smaller and smaller amounts, as the effect of past emissions diminishes. So climate change will proceed even after emissions have been reduced. This problem of momentum is one reason why we need to act as soon as possible.

- *Mitigation*. We prevent future climate change. That means cutting our greenhouse gas emissions to control the atmospheric buildup that leads to climate change.

Take the example of flooding from a rise in sea level. Theoretically, coastal dwellers could just let it happen. Of course, practically speaking, they would do something – sandbag, shore up existing dikes, etc. (part of adaptation). They could build new elaborate dike systems in anticipation of the flooding (also adaptation). Alternatively, Canadians could reduce their use of fossil fuels to do their part in preventing future flooding (mitigation).

Both adaptation and mitigation do not guarantee that all the flood damage will be averted. It may be impossible or too expensive to build dike systems big or soon enough to stop all the damage. Cutting emissions now won't prevent flooding caused by greenhouse gas emissions 50 years ago. Policy makers call these "residual damages."

INACTION IS COSTLY

Doing nothing about climate change could have dire economic consequences. The IPCC estimates that the annual damages to developed countries would be 1-2% of GDP – or between $8 billion and $16 billion a year for Canada. In developing countries, the costs could be much higher – as much as 9% of GDP annually. [36]

Also important is the fact that much of this damage, including the effects of sea level changes, will be irreversible. The kind of catastrophic flooding that would occur in low-lying countries is likely to be well beyond human capability to adapt. A great deal of ecological damage, where species populations are dangerously reduced or even eliminated, would be impossible to reverse, as well. What's more, such ecological impacts are not easily measured in dollar terms.

In any event, the costs of inaction – economic, social and ecological – are obviously high.

ACTION HAS ITS COSTS, TOO

The costs of adapting to climate change and reducing emissions can also be substantial. "Costs" in this case are not just what we pay for the actions, but also how their implementation will affect our economy and competitiveness. Policy makers call these "economic costs." For example, a tax to discourage the use of fossil fuels (a so-called "carbon tax") would increase the cost of our export products. If the tax is big enough, and other countries do not impose a similar tax, it could hurt our international competitiveness.

However, there are many options for cutting emissions that will not only cost little or nothing, but will actually save money and deliver other environmental benefits to boot. Policy makers call these "no regrets" actions. Moreover,

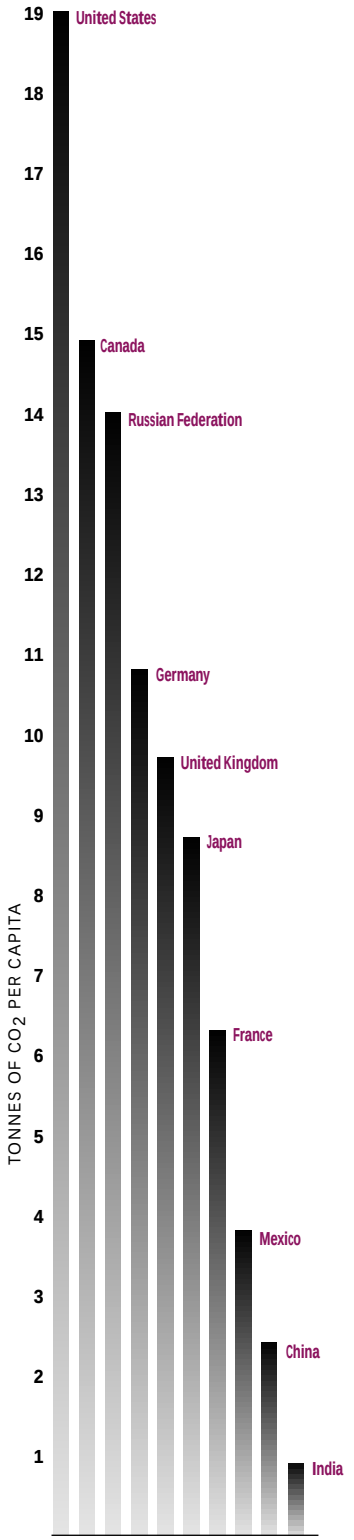

FIGURE 7. PER CAPITA CO_2 EMISSIONS BY INDUSTRIAL ACTIVITY FOR SELECTED COUNTRIES, 1992

SOURCE: World Resources Institute [37]

unlike the damages from climate change, mitigation costs can usually be reversed over time as we get new information. That is, if we discover that a certain impact is not happening, or that a certain action does not work, dollars can be directed elsewhere.

So the costs of action can be much smaller, and in some cases negligible, compared to the effects of doing nothing.

A MIX OF ACTIONS IS NEEDED

We need to both cut emissions and respond to climate change as it happens. Why?

The rapidity with which change will probably occur, and the extent of expected damage, mean that communities and ecosystems could never completely adapt. This necessitates some amount of mitigation. In addition, for the next several decades at least, climate change will continue even if we cut emission levels, because of the buildup from past emissions. That means some amount of adaptation is required.

Adaptation and mitigation are therefore not alternatives for action; they go hand in hand.

It is necessary to get a better sense of the costs of action and inaction, so information and research are also important. The IPCC agrees that countries must choose the appropriate mix of adaptation, mitigation and research to suit their particular national circumstances. [38]

WE MUST ACT NOW

If early action is not taken, global warming rates are shortly expected to exceed 0.2°C per decade – what most scientists consider to be a dangerous pace for climate change. At this accelerated rate, it is critical to move quickly on cutting emissions, to prevent the further accumulation of greenhouse gases in the atmosphere.

Answering criticism: the measurement controversy

Critics dispute the evidence of climate change, and hence the need to act on it. For example, they cite the temperature records from satellites, which between 1979 and 1995 showed an average global cooling in the lower troposphere of 0.05°C per decade. But reliable meteorological records date back further (to 1860) and indicate an average surface warming of 0.13°C per decade. Researchers have found that if the satellite data are corrected for El Niño and major volcanic eruptions during the period, a small warming trend results. [39] The overwhelming body of evidence, including analysis of glacier ice cores and other paleoclimatological studies, suggests that Earth is warmer than it has been for thousands of years.

TABLE 2. ADAPTATION AND MITIGATION: SOME EXAMPLES

ADAPTATION	MITIGATION
Building dikes, sea walls and causeways in low-lying areas	Switching from fossil fuels to renewable energy sources
Improving ship and dock structures for higher ice flows	Increasing mass transit to reduce single occupant vehicle use
Planting more trees to help species migrate	Planting trees in previously unforested areas
Planting different crop varieties and fishing different species	Investing in energy-efficient appliances and equipment to cut energy use
Expanding agricultural irrigation systems	Changing livestock feed to curb methane emissions

SOURCE: Intergovernmental Panel on Climate Change [17]

We cannot afford to wait around for more information in the hope of being certain about climate change and its impacts. Such certainty is not required for any other public policy area where prevention is the goal. International currency markets are highly uncertain; yet the Canadian government buys foreign currency at huge cost to protect against the risk of a devaluation in our dollar. There is more than enough compelling scientific evidence on the likelihood of climate change, and the global devastation it would cause, to take action now.

Furthermore, if we do delay, dealing with climate change could become much more costly or even impossible. Some damage will be irreversible. Other impacts will be more expensive to mitigate. Opportunities for lower-cost mitigation generally only appear once in a while. For example, a factory owner who is replacing old machinery, and chooses to invest in a new energy-efficient technology, provides an emissions reduction for years to come. Once equipment is installed, the expense and inconvenience of a retrofit may well prevent the adoption of new technology. We need to act now to make sure that cost-effective opportunities for prevention (e.g., equipment replacement and energy-efficient building design) are not missed.

WE CAN DO SOME CHEAP THINGS FIRST

And the good news is that there are many no regrets actions which can be taken right away at little, if any, cost. The IPCC estimates that 10-30% of energy use could be cut over the next few decades at no net cost. ("No net cost" means that the actions provide benefits, such as savings in energy bills, greater than their costs.) [38] The same conclusion was reached by a panel of experts brought together by the Royal Society of Canada several years ago. According to the Canadian Options for Greenhouse Gas Emission Reduction (COGGER) report, Canada could stabilize its greenhouse gas emissions and then reduce them by 20% by 2010 without hurting the economy. [40]

Moreover, actions that cut energy use or encourage renewable energy offer additional benefits, such as creating local jobs and reducing air pollution. In other countries, these side benefits have been shown to offset the costs of reducing emissions anywhere from 30 to 100%. [41]

So we can take some initial actions that are inexpensive, save resources and provide environmental "double dividends."

CANADA NEEDS TO DO MORE

Even the federal government has admitted that Canada will not meet its current international commitment to stabilize greenhouse gas emissions at 1990 levels by the year 2000. In fact, our emissions are expected to be between 8 and 13% higher by the end of the century. We are not alone, however. No country outside Europe will fully meet its stabilization target.

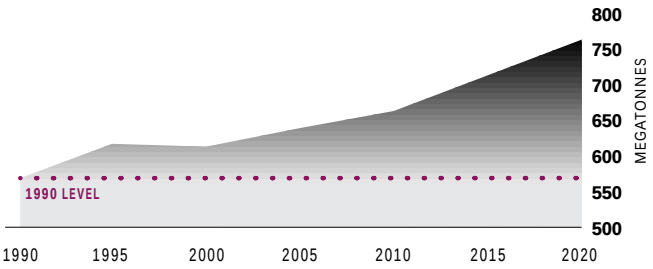

FIGURE 8. CANADA'S GREENHOUSE GAS EMISSIONS

SOURCE: Natural Resources Canada [44]

In any case, stabilizing emissions will not be enough to reach the ultimate international goal: to stabilize global atmospheric concentrations of greenhouse gases. In its most recent assessment, the IPCC states that in order to stabilize CO_2 concentrations, global emissions would have to be reduced by one- to two-thirds. [6] That implies much stronger action by individual countries, such as Canada.

How much more we need to act, and at what cost, are the real questions. Canadians must decide where dollars are best spent to achieve the greatest emissions reduction – in which sectors, at home versus abroad, etc. We need to figure out the right mix of policies to implement the actions, including government regulations and "economic instruments" – policies that work with market forces, such as taxes and the removal of subsidies for greenhouse-gas-emitting industries.

It makes little sense not to implement low-cost no regrets actions immediately. But, to achieve much deeper emissions reductions, we could have to turn to policies with higher costs and significant economic consequences for the country. Some sectors and regions could benefit (e.g., the renewable energy industry), while others could bear costs (e.g., the petroleum industry). These are the tougher issues for public debate.

What you can do

You can help prevent climate change by taking action in your home, car and community. For example, you can:

- let politicians know your views on public transit, deforestation, etc.;
- insulate your house properly and keep thermostats turned down;
- buy energy-efficient lights and appliances;
- practice the "4Rs" ("Reduce, Recycle, Reuse and Replace");
- ride a bike or bus, or walk to work;
- set up car pools with co-workers; and
- plant trees in your yard and community.

For more details on what you can do, please read the Pembina Institute's report in this series, *Taking Charge: Personal Initiatives*.

EVERYONE MUST ACT

All Canadians have a part to play in preventing climate change. The federal government's national action program has as its cornerstone a voluntary effort that asks Canadian businesses to reduce their greenhouse gas emissions. So far, however, the Voluntary Challenge and Registry (VCR) Program has had a negligible impact on Canada's emissions. It is fundamentally flawed by a lack of clear emissions reduction targets, reporting requirements and other features of voluntary agreements used successfully in other countries. The program also overlooks individual Canadians, who account for a quarter of national emissions. There are large opportunities to make our homes and transportation networks more energy-efficient.

As a result, calls have come from within and outside government for substantial improvements to the VCR. [42, 43]

If voluntary initiatives are to work, government must create the right incentives to guide individual and corporate action. While most businesses strive to act responsibly, their focus is clearly on the bottom line. Governments need to put in place the right "market-pull" policies (economic instruments) that will encourage cost-effective emissions reductions.

It is clear that the current lack of action on climate change is caused by several factors:

- inadequate understanding of the basis for climate change and how it relates to our way of life;
- media portrayal of the issue as a controversy, in which representations of "pro-" and "anti-climate change" factions are given equal weight;
- tremendous inertia at the individual, corporate and government levels against changing perspectives and thinking creatively; and
- the inability of politicians to act decisively on a slow-moving catastrophe, where major costs must be incurred now to reap benefits 15 or 20 years down the line (when different players will take the credit!).

Governments, businesses and private citizens must all do more to help fight the threat of climate change.

WHERE DO WE GO FROM HERE?

The threat to Canadians is clear. Our climate is changing, and the effects could be disastrous. There is a new scientific consensus on global climate change and the human role in it. We know the risks well enough to take immediate action globally and at home. Just as we commit money to health care, defense and other preventative programs in the public interest, we need to reduce our vulnerability to the very real dangers of climate change.

In December 1997, Canada will join other developed countries at the second international climate change conference in Kyoto, Japan. The goal will be to sign a protocol committing to emissions reduction targets after the year 2000. The David Suzuki Foundation urges Canadians to contact politicians with your views on climate change and what should be done about it. We also ask you to read the remaining reports in this series, which will look more closely at the specific policies and measures to address this serious threat to our future.

Within the lifetimes of our children, the planetary biosphere could undergo immense and disruptive alterations in response to changing climate. Canada's Parliamentary All-Party Standing Committee on the Environment rated the potential consequences of climate change as "second only to all-out nuclear war."[45] How much is it worth to ensure a livable future for our children and grandchildren?

The road to Kyoto

Have we come very far on the path to global emissions reductions? The answer, unfortunately, is no. In 1992, Canada signed the UN Framework Convention on Climate Change, which committed developed countries to the goal of emissions stabilization by the end of the century. Only a handful of countries might still achieve this goal. In the meantime, a series of negotiations has been under way to implement quantified emissions reduction targets after the year 2000. The push for the upcoming conference in Kyoto, Japan is for legally binding, medium-term targets that would take effect somewhere between 2010 and 2020.

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CLIMATE OF CHANGE:
THE DAVID SUZUKI FOUNDATION'S NEW REPORT SERIES

A Glimpse of Canada's Future

Written by Ellen Battle and Bill Stipdonk of Metrix Consulting and by Dr. David Suzuki, this report examines the ways Canada could be affected by climate change. Some of the topics covered include: how the greenhouse effect works, and how a warmer world will affect the social, economic and environmental fabric of Canada.

The Role of Government

A Briefing Paper to the Honourable Paul Martin, September 29, 1997

Canadian energy production and consumption are currently subject to taxation rules and government programs which interfere with the nation's ability to meet its greenhouse gas reduction targets. In this report, Michael Margolick of ARA Consulting Group shows how Canada's economy is currently structured to encourage ever-greater energy consumption, and therefore higher emissions of greenhouse gases. The report also presents a rationale for a plan to reduce greenhouse gas emissions.

Canada's Window of Opportunity

This report examines how a lowering of greenhouse gases would affect Canada's social, economic, and environmental goals. Specifically, the authors outline the benefits of switching to cleaner, less harmful energy sources. Suggestions for strategies which would help Canada make the transition to a sustainable future are also included. Authored by Ralph Torrie and Dr. Amory Lovins, this report provides readers with a snapshot of how Canada might prosper in a low-carbon future.

Taking Charge: Personal Initiatives

Written by Pembina Institute climate change director Robert Hornung, this report shows how the actions of individuals and communities can affect climate change. Examining everything from personal purchasing habits, daily behaviour, and lifestyle choices, to official community plans and growth strategies (development permits, zoning bylaws, etc.), the authors show how local actions can significantly cut Canada's rate of greenhouse gas emission.

Keeping Canada Competitive

Since the 1992 Rio Earth Summit, few countries have lived up to the agreed goal of stabilizing greenhouse gas emissions at 1990 levels. Here in Canada, it is estimated that emissions are already between 8 and 13% above 1990 levels – one of the worst records of any developed nation. Canada's former chief negotiator Doug Russell, (with contributions from Pembina Institute's Robert Hornung) review how Canada's performance has compared with other countries, and examine the implications of Canada's failure to keep pace with international efforts to reduce greenhouse gas emissions.

Canadian Solutions

In the final report of the series, we will analyse the commitments Canada makes in Kyoto at the Conference of Parties and propose an action plan to fulfill those commitments. Written by the David Suzuki Foundation, this report will propose policies for Canada's municipal, provincial, and federal levels of government. The report will also suggest ways that individuals can get involved in promoting proactive climate change policies.

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Finding solutions in science and society

The goal of the David Suzuki Foundation is to study the underlying structures and systems which cause environmental crises and then work to bring about fundamental change. We do this in four ways:

Research: The David Suzuki Foundation seeks out and commissions the best, most up-to-date research to help reveal ways we can live with nature.

Application: We support the implementation of ecologically sustainable models – from local projects, such as habitat restoration, to international initiatives, such as better frameworks for economic decisions.

Education: We work to ensure the solutions developed through research and application reach the widest possible audience, and help mobilize broadly supported change.

Advocacy: We urge decision makers to adopt policies which encourage and guide individuals and businesses, so their daily decisions reflect the need to act within nature's constraints.