Long ago, the animals and the birds and fishes along the shores of Great Slave Lake lived in peace and friendship. All spoke the same language at that time, when the world was new and people had not come out yet. No animal ate another animal. All lived on plants and leaves and berries.

One night in this long ago time, the darkness was very thick and snow began to fall. All night it fell. The night continued, so that it seemed never to have an end. The snow became deeper and deeper. Plants and bushes were covered and the animals had difficulty in finding food. Many of them died. At last their chief called a council of all the living.

“Let us send messengers to the Sky World,” the council decided. “They will find out from the Sky People what is causing this long night and the deep snow.”

So they sent a messenger—one member of every kind of animal, bird, and fish that lived on the shores of Great Slave Lake. Those who would not fly were carried on the backs of those who could fly. So all reached the Sky World and passed through the trap door.

Beside the trap door stood a great lodge made of deerskins. In the lodge were three little bears. This was the home of Black Bear, an animal not on the earth at the time. Their mother, the cubs said, was in her canoe on the lake nearby; she had gone out to spear caribou. The animal people did not like the idea of Black Bear’s spearin caribou, one of their own group. But they said nothing about it. Instead, they looked around the lodge. Hanging from the crossbows overhead were some curious bags. “What are in those bags?” they asked the cubs.

At first the cubs would not answer. When asked again, they said slowly, “We can’t tell you. Wait until our mother comes back. She asked us to stay here and watch them.”

I wonder if those bags have something to do with us,” the earth people wondered to themselves. So they asked the cubs again about the bags.

Pressed by their questions, the cubs finally told them. “This bag contain the winds. That one contains the rain. This one, the cold. That one, the fog. This one—” But they would not say what was in the last bag.

“We dare not tell you about this one,” said the youngest cub. “Our mother told us that it is a big secret. If we tell you what is in it, she will be angry when she returns and will spank us.”

The visitors felt sure that the last bag contained the sunshine, and sunshine was what they wanted. So they left the lodge and held a council. They saw Black Bear landing her canoe on the far shore of the lake. Quickly they made a plan.

“Mouse, you go to Bear’s Canoe and gnaw a deep cut in the handle of her paddle close to the blade. When you have finished your work, you signal to Caribou.

“Caribou, as soon as you get the signal, you jump into the lake and begin swimming. Before Black Bear gets close, swim ashore and run into the woods. The rest of us will hide until it is safe to take the bag of sunshine.”

Before Fox hid himself, he put his head inside the lodge and said to the cubs, “Keep a lookout for the caribou. It may come near you here.”

Mouse ran to the far shore of the lake and gnawed the paddle. As soon as she signaled, Caribou jumped into the water.

The cubs saw him and yelled to their mother. “Mother! Mother! Look at the caribou!”

(continued)
The earth people, watching from their hiding places, saw Black Bear jump into her canoe, seize the paddle, and begin to stroke as hard as she could. Caribou also watched as he swam. Soon the paddle broke, the canoe turned over, the Black Bear disappeared beneath the waters of the lake.

Caribou swam ashore, Mouse returned to her friends, and all the earth people ran into the lodge. They pulled down the bag they wanted, and in it they found the sun, moon, and stars. These they threw down through the trap door. When they opened the door, they saw that snow covered the tops of even the highest pine trees. While they watched, the snow began to melt from the heat of the sun.

Thinking the earth world soon would be safe, the animals started down. But some of them had accidents. Beaver split his tail, and the blood was spilled over lynx. Moose flattened his nose and Buffalo bruised his back. Ever since then, Beaver’s tail has been flat, Lynx has been spotted, Moose has had a flat nose, and Buffalo has had a bump in his back. Since that time also, there have been bears in the earth world, for the three cubs came with the earth people.

But it was still hard to get food. The snow melted so quickly that the earth was covered with water. The fish, who had been living on the land, found that they could swim and so they carried their friends on their backs. The ducks set to work to pull the land up from beneath the water.

At last the people were so hungry that they sent Raven out to look for dry land. At that time Raven was the most beautiful of all birds. While looking for land, he found the body of a dead animal. Although he had never before eaten anything except berries and willow leaves, he began to feast on the body of his animal brother. As punishment, he was changed into the bird he is today. All the animals and birds hate him; and even man, who eats everything else, will not taste his flesh.

Then the people sent Ptarmigan out to look for dry land. When Ptarmigan came back, he carried on his back a branch of willow. It was a message of hope. As a reward, ptarmigans turn white when the snow begins to fall in the Barren Land. Thus they warn the animals and the people that winter is near.

But the peaceful and friendly life on Great Slave Lake was no more. When the floodwaters had gone, the fish found that they could no longer live on the land; if they did, they would be eaten by the birds and the animals. The birds found that they were safer high in the trees and up in the mountains than anywhere else. Every animal chose the place that suited it best. Soon the birds and fish and beasts could not understand the same language.

Not long afterward, the first human beings came to Great Slave Lake. Since then, there has been no peace.
### The Big Snow

**Worldview Comparison Chart**

**Instructions:** Compare the beliefs and values communicated in the Dene story “The Big Snow in the North Land” with those you think modern North America holds. What is the possible effect on culture or on the physical world of these beliefs? The first heading is started for you, but you can add other ideas.

<table>
<thead>
<tr>
<th>Belief or Value</th>
<th>Dene (First Nation)</th>
<th>Possible Effect</th>
<th>Modern North America</th>
<th>Possible Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relationship of animals to each other</strong></td>
<td>Animals once lived in friendship.</td>
<td>People don’t want to hurt the animals.</td>
<td>Everything is part of a food chain—predator eats prey.</td>
<td>People take advantage of the animals—don’t think about how they help each other.</td>
</tr>
<tr>
<td><strong>Origin of natural forces, weather</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relationship of the individual and the group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relationship of people and nature</strong></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>
The Indian Ten Commandments

- Treat the Earth and all that dwell thereon with respect.
- Remain close to the Great Spirit.
- Show great respect for all your fellow beings.
- Work together for the benefit of all Mankind.
- Give assistance and kindness wherever needed.
- Do what you know to be right.
- Look after the well-being of mind and body.
- Dedicate a share of your efforts to the greater good.
- Be truthful and honest at all times.
- Take full responsibility for your actions.

Author Unknown
Marshall McLuhan’s global village has arrived. Our world has shrunk, thanks to satellite, fibreoptics, and other electronic media. You can no longer ignore what is happening on the other side of the world, for it happens in your living room every evening. You need to get to know your neighbour: in Australia, in Africa, in Europe, in South America, in Asia. You are interdependent.

The David Suzuki Foundation’s
DECLARATION OF INTERDEPENDENCE

THIS WE KNOW: We are the earth, through the plants and animals that nourish us. We are the rains and the oceans that flow through our veins. We are the breath of the forests of the land, and the plants of the sea. We are human animals, related to all other life as descendants of the firstborn cell. We share with these kin a common history, written in our genes. We share a common present, filled with uncertainty. And we share a common future, as yet untold.

We humans are but one of thirty million species weaving the thin layer of life enveloping the world. The stability of communities of living things depends upon this diversity. Linked in this web, we are interconnected—using, cleansing, sharing and replenishing the fundamental elements of life. Our home, planet Earth, is finite; all life shares its resources and the energy from the sun, and therefore has limits to growth. For the first time, we have touched those limits. When we compromise the air, the water, the soil, and the variety of life, we steal from the endless future to serve the fleeting present.

We may deny these things, but we cannot change them.

THIS WE BELIEVE: Humans have become so numerous and our tools so powerful that we have driven fellow creatures to extinction, dammed the great rivers, torn down ancient forests, poisoned the earth, rain and wind, and ripped holes in the sky. Our science has brought pain as well as joy; our comfort is paid for by the suffering of millions. We are learning from our mistakes, we are mourning our vanished kin, and we now build a new politic of hope. We respect and uphold the absolute need for clean air, water and soil. We see that economic activities that benefit the few while shrinking the inheritance of many are wrong. And, since environmental degradation erodes biological capital forever, full ecological and social cost must enter all equations of development. We are one brief generation in the long march of time; the future is not ours to erase. So where knowledge is limited, we will remember all those who will walk after us, and err on the side of caution.

THIS WE RESOLVE: All this that we know and believe must now become the foundation of the way we live. At this turning point in our relationship with Earth, we work for an evolution; from dominance to partnership; from fragmentation to connection; from insecurity to interdependence.
NIYI OSUNDARE

(To a solemn, almost elegiac tune)

Lynched
    the lakes
Slaughtered
    the seas
Mauled
    the mountains

But our earth will not die

Here
    there
    everywhere
    a lake is killed by the arsenic urine
    from the bladder of profit factories
    a poisoned stream staggers down the hills coughing
    chaos in the sickly sea
    the wailing whale, belly up like a frying fish, crests
    the chilling swansong of parting waters.

But our earth will not die

Who lynched the lakes. Who?
Who slaughtered the seas. Who?
Whoever mauled the mountains. Whoever?

Our earth will not die

And the rain
    the rain falls, acid, on balding forests
    their branches amputated by the septic daggers
    of tainted clouds

    Weeping willows drip mercury tears
    in the eye of sobbing terrains
    a nuclear sun rises like a funeral ball
    reducing man and meadow to dust and dirt.

(continued)
But our earth will not die.

Fishes have died in the waters.
Birds have died in the trees.
Rabbits have died in their burrows.

Fishes.
Birds.
Rabbits.

But our earth will not die

(Music turns festive, louder)

Our earth will see again
eyes washed by a new rain
the westering sun will rise again
resplendent like a new coin.
The wind, unwound, will play its tune
trees twitting, grasses dancing;
hillsides will rock with blooming harvests
the plains batting their eyes of grass and grace.
The sea will drink its heart’s content
when a jubilant thunder flings open the skygate
and a new rain tumbles down
in drums of joy.
Our earth will see again

this earth, OUR EARTH.
THREATS TO THE OZONE LAYER

During the 1970s, scientists discovered that the amount of ozone in the upper atmosphere was declining. Beginning in the 1980s, large portions of the ozone layer over both the North Pole and the South Pole thinned out by about 50 per cent. The “holes” remained for two or three months of each year, but later filled in again (Figure 20.16). Scientists believe that the reason for this thinning involves the reaction of ozone with human-made pollutants that have been accumulating in the upper atmosphere.

Probe 10, Nelson. 1996.
Ozone Depletion Worsens

EEK—Hole in the Ozone Layer Opens Again!

Aerosol Cans: Deadly and Dangerous

Can We Keep Sunshine Safe?

Fate of the Arctic Remains Up in the Air

Loss of the Ozone Layer Protection: Malformed Amphibians

Rapid Collapse of the Antarctic Ice Shelf Stuns Scientists

What About Ozone Pollution?

NEW THREATS TO SKY

Radiation Hazard to Eyes

Deadly Chlorofluorocarbons: We’ve Got to Make Changes
In Canada and around the world, more and more industry leaders and communities are learning that there are opportunities that make both economic and environmental sense. They’re finding out energy conservation and energy efficiency save money and create new industries and jobs.

**Canadian Communities**

Municipalities across Canada are reducing greenhouse gas emissions through a wide range of projects. Local governments say they can achieve one quarter of Canada’s Kyoto target while creating jobs and strengthening the health of our communities.

**Halifax**: A city-wide composting program now prevents organic matter from reaching landfills. This has cut methane production by the equivalent of over half a million tons of carbon dioxide per year, compared to 1995.

**Calgary**: Calgary is achieving its target of six percent below 1990 levels ahead of schedule and at 50 percent projected costs, with substantial energy bill savings and employment created. Through the “Ride the Wind” initiative, the light rail system is powered by wind-generated electricity.

**Edmonton**: Target—to reduce emissions by six percent below 1990 levels by 2010, and 20 percent by 2020. Has already reduced emissions through one landfill waste-to-energy project by 174,949 tonnes.

**Regina**: Reduced emissions from internal operations nine per cent, or 10,000 tonnes annually, from 1988 levels. Energy retrofits will reduce emissions another four percent and save $400,000 annually.

**Sudbury**: Will reduce emissions by 21,000–51,000 tonnes per year with a co-generation and district energy system. Retrofit programs aim to reduce energy consumption 30 percent and save more than $800,000 annually.

**St. John’s**: Retrofits to municipal buildings are expected to deliver annual energy savings of $600,000, improve workplace lighting and comfort levels, and reduce maintenance costs.

**Toronto**: Reduced emissions by 67 percent below 1990 levels, exceeding the city’s goal threefold, generating thousands of jobs and reducing costs for many operations. Success was achieved through landfill waste-to-energy programs, energy efficiency building retrofits, streetlight changes, and more efficient vehicle fleets.

**Companies**

Many companies are dramatically reducing greenhouse gas emissions, often exceeding the Kyoto target. So far, this is generally achieved at minimal cost or with considerable savings.

**Abitibi-Consolidated (Forest Products)**: Reduced emissions on average 10 percent below 1990 levels, and 27 percent below 1988.

**Alcoa (Aluminum Manufacturing)**: Committed to reducing emissions by 25 percent from 1990 levels by 2010, and by 50 percent from 1990 levels over the same period if their inert anode technology succeeds.

**Alcan (Aluminum Manufacturing)**: Reduced emissions by over two million tonnes worldwide over the last decade; plans to cut another 500,000 tonnes in the next four years.

**BP (Petroleum & Renewables)**: Achieved its target, eight years early, of reducing emissions 10 percent worldwide below 1990 levels at no net cost. Energy investments in renewables to grow 40 percent in 2002.

**Canadian Chemical Producers’ Association**: Members reduced emissions 39 percent below 1992 levels, primarily due to declines in emissions of nitrous oxide.

**Canterra Towers (Buildings)**: Oxford Properties reduced energy consumption by 30 percent and emissions 28 percent below 1992 levels, saving tenants $1.5 million dollars in operating costs.

**Dofasco (Steel Production)**: Reduced emissions 22 percent below 1990 levels by 1999, and 20 percent per unit of production. Target: to further improve specific energy intensity by 10 percent by 2010.
The Green Leaders (continued)

DuPont (Chemical Manufacturing): Reduced emissions worldwide by 45 percent and improved energy efficiency by 15 percent over 1990 levels. Uses renewables for 10 percent of global energy use. Target: to reduce emissions by 65 per cent.

Dow (Chemical Manufacturing): Reduced emissions by 14 percent below 1990 levels, and reduced the level of CO2 per kg of product by 50 per cent. Target: to reduce emissions per unit of production another 10 per cent.

General Motors: Reduced emissions by 37 percent below 1990 levels, with a 30 percent reduction in emissions per vehicle produced. Target: to reduce emissions by 56 percent by 2005.

IBM (Information Technology): Reduced energy consumption worldwide by 25 percent through conservation, pocketing $527 million. Canada’s operations reduced emissions by 33 percent since 1990.

Inco (Mining & Manufacturing): Reduced emissions by seven percent below 1990 levels by 1999. Target: to reduce emissions by a further one percent annually to 2005.

Mining Association of Canada: Metal mining in Canada reduced total emissions by 25 percent below 1990 levels and improved per-unit emissions of metal concentrate by 13.8 per cent. Nonferrous metal smelting and refining decreased emissions by 1.8 percent and improved intensity by 15.9 over the same period.

Nike (Garment Manufacturing, U.S.): Action Plan—To reduce CO2 emissions worldwide from business travel and from facilities and services to 13 percent below 1998 levels by 2006.

Toronto-Dominion Centre (Buildings): Cadillac Fairview reduced electricity consumption in Canada’s largest office complex by about 21 million kWh annually—enough energy to power 6,000 homes—saving $2.5 million per year in energy costs.


The information on this page is subject to change. For the most recent figures, please contact the municipality or business directly.
Major Elements of the Climate System
Projected Temperature Change Between 1975-1995 and 2040-2060

Temperature Projections for Canada for Winter and Summer Seasons Under Doubled Concentrations of CO₂

Climate changes will not be distributed uniformly. For a doubling of carbon dioxide concentrations, Canadian climate models project an increase of 3.5°C in the earth’s average annual temperature but show more substantial warming over much of Canada, particularly in winter.

Different models have different projections for how much temperatures will change. For instance, the Geophysical Fluid Dynamics Laboratory GCM (GFDL 91) model projects increases of 2 to 6°C in the winter and 2 to 3°C in the summer, while the Goddard Institute for Space Studies GCM (GISS 85) model projects increases of 2 to 14°C in the winter and 1 to 2°C in summer.
Blowing Up Your World:
Individual Responsibility in Environmental Issues

1. One student is given a balloon and asked to blow it up so it is full-blown. The balloon should not be tied but should be held closed.

2. Tell students that the balloon represents the world they have inherited from past generations. It is obviously tight with the environmental stress put on it.

3. Have the students determine how they are adding to or detracting from this stress by having them respond to a number of questions. In response to each question, students will raise their hands to indicate a positive response.

4. The student with the balloon will blow one big breath of air for every 3 to 5 students whose behaviour damages the environment.

5. For each question, students record their scores on a piece of paper.

Questions:

1. How many of you leave your bedroom light on when you are not in the room? (Hands down get 2 points.)

2. How many of you walked, biked, inline skated, or took the bus to school today instead of coming by car? (Hands up get 3 points.)

3. How many of you drink a soft drink, then throw the container in the garbage? (Hands down get 3 points.)

4. How many of you use aerosol hairspray or hair products? (Hands down get 3 points.)

5. How many of you use a hair dryer, curling iron, electric razor, or other energy-consuming convenience appliance, especially in the morning? (Hands down get 3 points.)

6. How many of you, when you go to the store, get a bag for your purchases, even if you have only one or two small items to carry? (Hands down get 2 points.)

7. How many of you carry lunch to school in a reusable container? (Hands up get 2 points.)

8. How many of you eat take-out or cafeteria food that is served in Styrofoam or plastic containers? (Hands down get 7 points.)

9. How many of you use handkerchiefs instead of disposable tissues or cloth towels instead of paper towels? (Hands up get 2 points.)

10. How many of you plan to buy a sports car when you can afford it? (Hands down get 4 points.)

11. How many of you throw your old cell phone away when you get a new one? (Hands down get 3 points.)

12. Is your sewage treated before it flows into a body of water? (Hands up get 6 points: zero points for those who don’t know.)

Add up your score:

31-40 Very good! You’re an environmentalist!
21-30 Good! You’re starting to save the world!
11-20 Lots of room for improvement.
0-10 You’re exiled to the town dump!

Did the balloon blow up? What must we do to save our environment?

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The Deal: The Kyoto Protocol, a plan constructed in Kyoto, Japan, in 1997, is the only international agreement that sets targets to reduce greenhouse gas emissions that cause climate change. It represents a decade of negotiations and includes mechanisms to provide efficient implementation.

The Problem: According to scientists, greenhouse gases form a blanket in the upper atmosphere, trapping heat from the sun and contributing to the phenomenon commonly known as global warming. There are a number of gases targeted as culprits, the most important one being carbon dioxide, or $\text{CO}_2$, which is produced when fossil fuels, such as coal oil and natural gas, are burned. Some of the other contributing gases are methane ($\text{CH}_4$) and nitrous oxide ($\text{N}_2\text{O}$), as well as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluorides ($\text{SF}_6$), which are used as refrigerants, heat conductors and insulators. Chlorofluorocarbons are also powerful greenhouse gases. Canadians currently produce 700 megatonnes of greenhouse gases per year. This translates to 2% of global emissions coming from a country with about $\frac{1}{2}$ of 1% of the world’s population. In other words, the average Canadian produces four times the global average level of emissions.

The Target: In order for the Kyoto Protocol to come into force, 55 countries that produce 55% of the developed world’s 1990 carbon dioxide emissions must ratify it. The European Union ratified in May, 2002, and Japan followed suit a month later. In December, 2002, Canada ratified the agreement under Prime Minister Jean Chretien. More than 100 countries have now ratified the agreement. The reduction targets are different for each country, but Canada must reduce its emissions over the years of 2008 and 2012 to 6% below 1990 levels. A recent study, “Kyoto and Beyond,” shows that we can cut Canada’s total emissions in half by 2030 using existing technology, while maintaining our quality of life and economic growth at “business as usual” levels.

Who’s Not In? Developing countries, including India and China, are exempt from reducing greenhouse gases in the first phase of Kyoto reductions because their per-capita emissions are much lower than those of developed countries. It is important to note that China has already made cuts even without legal requirements to do so. Unfortunately, the United States, the world’s most profligate energy user, has not opted to ratify, along with Australia.

The Business Plan—Cap and Trade: It’s actually a straightforward plan in which Ottawa, after consultations with the industrial sector, would set a mandatory limit, or cap, for greenhouse emissions. Industries especially affected would be the oil and gas industry, the industrial sector, and generating plants. The oil-rich province of Alberta has concerns about the impact of this plan, but the Canadian government predicts that Alberta’s economy will actually grow by an estimated 12% by 2012 assuming a middle-of-the-road plan for implementing Kyoto. An emissions trading system between energy-efficient firms and inefficient ones would develop, allowing businesses to sell unused portions of their caps. New and expanding operations would have to purchase emission permits through this trading system.

The Wrinkles: There are other methods by which large firms having difficulty meeting their targets can gain Kyoto credits. One is to finance abatement programs in developing countries and even in industrialized nations that are in need of creative solutions to the problems of global warming. Such programs could take the form of:

- education programs
- development programs to implement the use of alternative and renewable fuel sources such as natural gas, wind, and solar power
- projects to develop cattle feed that reduces or stops cows from belching methane gas
- afforestation projects
- aggressive biofuels and energy-efficiency programs

(continued)
Bigger Wrinkle: Canada wants a 70-million-tonne credit for clean (natural gas and hydro) exports, especially to the U.S., that displace dirtier fuels, reducing gas emissions. However, the United States has not agreed to ratify Kyoto, so the UN has not agreed to this credit. That leaves a gap of 96 million tonnes a year which new policies will have to fill. The most controversial offset, as the credits are called, is Russia’s so called “hot air” program, which would allow the country to export excess pollution rights to countries that might not otherwise be able to meet their quotas. This is possible for Russia because of the collapse of so many Russian industries after the fall of the Soviet Union, leaving emissions already far below their 1990 levels.

References:

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David Suzuki Foundation: “Climate Change: FAQs” at: <www.davidsuzuki.org/Climate_Change/Kyoto/FAQs.asp>

David Suzuki Foundation: “Climate Change: Kyoto Protocol” at: <www.davidsuzuki.org/climate_change/kyoto/kyoto_protocol.asp>
| The Deal | |
| The Problem | |
| The Target | |
| Who’s Not In | |
| The Business Plan | |
| The Wrinkles | |
| The Bigger Wrinkle | |
Is it possible to protect the environment and see economic growth at the same time? This is a big question. And with us to discuss all this, from the environmental group Greenpeace, Kert Davies, and from the U.S. Chamber of Commerce, Bill Kovacs.

Mr. Kovacs: I would argue that the only way you can ever have environmental protection is by generating the wealth to protect the environment. If you go through the history of civilization, you find that we started off really as a subsistence economy, then we moved to agriculture, then we moved to industrial. And at each stage of the process you accumulate wealth. But the lower the stage of the process, the more you deplete the resources, the more you deplete the wood, the coal—whatever it is that’s in the ground—the more you use the resources. And then, as you move from an industrial society to an information and service society, you then have created the wealth and you begin to reinvest that in environmental protection.

And if you look at what’s happened over the last 30 years, the American business community has put $3 trillion into environmental protection. Every single environmental indicator is going the right way. So I would make the argument that the only way that you can ever have true environmental protection is to really generate the wealth that can pay for it.

Mr. Borgida: Mr. Davies, your rebuttal?

Mr. Davies: The question that is brought up by that is: Why can’t this economy, the most robust economy in the world, take the lead and the rightful leadership role that the U.S. should have on this issue of global warming?

Now the Bush administration says it’s a real problem, humans are causing it, the burning of fossil fuels is at the root. And yet the government’s reaction is to do nothing. I don’t get it.

Mr. Kovacs: Well, let’s put it this way. You can sit there and say the government is doing nothing, but all of the studies are based on very small amounts of data. And they’re asking you to make the assumption that we’re going to put 2.4 million people out of work, that we are going to lose about $300 billion a year in the GDP. So I guess the question that I would ask you is: If you were going to implement the Kyoto Treaty, how could you do it without costing 2.4 million jobs and $300 billion a year to the economy?

Mr. Davies: I don’t believe those numbers. I think we can grow the economy. I think we can build clean energy jobs. I know that wind power, for example, has grown 40 percent in the last year in this country. There is a path forward that includes clean jobs, clean cars. U.S. industry is the boldest in the world, the most innovative. We should be selling this technology to the developing world. We should be moving forward with our innovation and our prowess in these things, and leading the world forward to a clean energy economy that not only protects the environment but makes lives better everywhere.

Mr. Kovacs: I would agree with you that we certainly should be selling our energy efficient technologies to the world. That is the number one thing that we should be doing. Because the truth of the matter is, if the United States went out of business tomorrow, the rest of the world is still going to continue to emit more greenhouse gases. China, Mexico, India, they’re going to continue to emit. So what we have to do is we do have to transfer this technology there.

Mr. Davies: We have an obligation. We are 25 percent of the pollution in the world, with 5 percent of the population. We have an obligation to act now, and act quickly.
Mr. Kovacs: Well, we are acting. If you look at the energy efficiency of the United States, for example, it took 20,000 BTUs in 1970 to create a dollar of GDP. Today it takes 8,000. We’re about 60 percent more efficient than we were then. We’re efficient on the amount of oil that we’re using. We’re efficient on every single aspect of—

Mr. Davies: And yet the Bush administration says we need more oil and doesn’t say we need more renewable energy, more clean energy. It doesn’t make sense.

Mr. Kovacs: No. If you look at the Bush energy plan, it talks about renewables. It talks about tax credits to spur investment. In the House bill, you have $22 billion worth of new investment into renewables. But the bottom line is, no matter how much you talk about it, renewables as you talk about them—wind and sun and solar and geothermal—is about 1 percent of all of the energy in the United States.

Mr. Davies: We just did a report with the European photovoltaic industry—or the European Wind Energy Association, and found that wind could provide 12 percent of the world’s electricity in 20 years. That’s a short time frame. It can be done. It’s on that path already.

Mr. Kovacs: I think that’s a great example. You have to ask the viewing public: How many people want a windmill in their yard? These things are about 120 feet high, 60-foot blades.

Mr. Davies: Who wants a coal-fired power plant in their yard?

Mr. Kovacs: They’re not.

Mr. Davies: Who wants a nuclear power plant in their yard? This goes both ways.

Mr. Kovacs: They serve large communities. The wind and a wind farm is—

Mr. Davies: Wind is making money for farmers in Iowa and all around the world.

Mr. Borgida: Mr. Davies, let me interrupt for a minute. This is an engaging conversation; I want to ask you one quick question, though. You mentioned a windmill in your yard and those kinds of things. Not everybody in the world has a yard in which to place a windmill, and are concerned about this issue. There are Third World people out there who are concerned about surviving each day. How do you make your case, particularly on the environmental side, to a part of the world where making it through the next day is important?

Mr. Davies: There is nothing better for the developing world than renewable energy. It is low input. There are no wires required. You set up a distribution system that’s just for a village, build solar power for that village. At the meeting in Bali right now, Greenpeace is demanding that governments of the world put a whole lot more money than they are right now into renewable energy for the poorest people in the world. It just makes perfect sense. It fits perfectly with those economies.

Mr. Borgida: Mr. Kovacs, a thought on that?

Mr. Kovacs: I think the economists are very clear that people don’t worry about the environment until they have a set standard of living. For example, if you want to address deforestation, that occurs when there is about a $7,000 per household income. And you have to begin generating wealth in these nations. And generating wealth means moving them from subsistence living to industrial and then into the information age. And the best way to do that is technology transfer. I think that the United States is very well-equipped to do that, and we should do it. And that’s probably the one point we agree on.

Mr. Davies: And we would agree on that.

Mr. Kovacs: The bottom line is we have to—

Mr. Davies: The point is we have to leapfrog the dirty technology and go to the clean—not let these countries and these people make the same mistakes that we made in going through these dirty pathways. It’s simple.
Tanka
The Natives tell us,
“We hear the Spirit who speaks
In rushing waters
Powerful and mystical
We call it Manitoba.”

Haiku
Water, plentiful
Flowing oh so gracefully
Ours forever? No.

Statement:
“Of all the social and natural crises we humans face, the water crisis is the one that lies at the heart of our survival and that of our planet earth.”

UNESCO Director: General Koichiro Matsuura
Although the absolute quantities of freshwater on Earth have remained approximately the same, the uneven distribution of water and human settlement continues to create growing problems of freshwater availability and accessibility.
According to Population Action International, based upon the UN Medium Population Projections of 1998, more than 2.8 billion people in 48 countries will face water stress or scarcity conditions by 2025. Of these countries, 40 are in West Asia, North Africa or Sub-Saharan Africa. Over the next two decades, population increases and growing demands are projected to push all the West Asian countries into water scarcity conditions. By 2050, the number of countries facing water stress or scarcity could rise to 54, with their combined population being 4 billion people—about 40% of the projected global population of 9.4 billion (Gardner-Outlaw and Engleman, 1997; UNFPA, 1997).

- Many African countries, with a population of nearly 200 million people, are facing serious water shortages. By the year 2025, it is estimated that nearly 230 million Africans will be facing water scarcity, and 460 million will live in water-stressed countries (Falkenmark, 1989).

- Today 31 countries, accounting for less than 8% of the world’s population, face chronic freshwater shortages. Among the countries likely to run short of water in the next 25 years are Ethiopia, India, Kenya, Nigeria and Peru. Parts of other large countries (e.g., China) already face chronic water problems (Hinrichsen et al., 1998; Tibbetts, 2000).

- Bahrain, Kuwait, Saudi Arabia and the United Arab Emirates have resorted to the desalinization of seawater from the Gulf. Bahrain has virtually no freshwater (Riviere, 1989). Three-quarters of Saudi Arabia’s freshwater comes from fossil groundwater, which is reportedly being depleted at an average of 5.2 km³ per year (Postel, 1997).

(continued)
Some 460 million people—more than 8% of the world’s population—live in countries using so much of their freshwater resources that they can be considered highly water stressed (UNCSD, 1999; WMO 1997). A further 25% of the population lives in countries approaching a position of serious water stress (WMO, 1997). Water scarcity occurs when the amount of water withdrawn from lakes, rivers or groundwater is so great that water supplies are no longer adequate to satisfy all human or ecosystem requirements, resulting in increased competition between water users and demands.

**Definitions of Water Stress and Scarcity**

An area is experiencing water stress when annual water supplies drop below 1,700 m$^3$ per person. When annual water supplies drop below 1,000 m$^3$ per person, the population faces water scarcity.

Sources: UNPD, UNEP, World Bank, and WRI. 2000.
A water-covered planet facing a water crisis seems paradoxical. And yet that is exactly the reality on planet Earth, where 97 percent of the water is too salty to quench human thirst or to irrigate crops. Tackling water shortage issues with desalination—drawing fresh, drinkable water out of salty seawater—is common in the desert nations of the Middle East, the Caribbean and the Mediterranean. But as the cost of desalination drops and the price and demand for water climb, countries in temperate regions are turning more and more to the sea.

Large-scale desalination facilities are even turning up in the U.S., one of the world’s most water-rich countries. As part of an ambitious plan to reduce pumping from depleted underground aquifers, water officials in the Tampa Bay, Fla., area are contracting the construction of a desalination plant capable of producing 25 million gallons of desalted water a day. They are relying on desalination to supplement the region’s future water demands. Houston is also looking at desalinating water from the Gulf of Mexico to keep from going dry.

People have been pulling freshwater out of the oceans for centuries using technologies that involve evaporation, which leaves the salts and other unwanted constituents behind. Salty source water is heated to speed evaporation, and the evaporated water is then trapped and distilled.

This process works well but requires large quantities of heat energy, and costs have been prohibitive for nearly all but the wealthiest nations, such as Kuwait and Saudi Arabia. (One exception is the island of Curaçao in the Netherlands Antilles, which has provided continuous municipal supplies using desalination since 1928.) To make the process more affordable, modern distillation plans recycle heat from the evaporation step.

A potentially cheaper technology called membrane desalination may expand the role of desalination worldwide, which today accounts for less than 0.2 percent of the water withdrawn from natural sources. Membrane desalination relies on reverse osmosis—a process in which a thin, semipermeable membrane is placed between a volume of saltwater and a volume of freshwater. The water on the salty side is highly pressurized to drive water molecules, but not salt and other impurities, to the pure side. In essence, this process pushes freshwater out of saltwater.

Most desalination research over the past few years has focused on reverse osmosis, because the filters and other components are much smaller than the evaporation chambers used in distillation plants. Reverse osmosis plants are also more compact and energy-efficient.

Although reverse osmosis plants can offer energy savings, the earliest membranes, made from either polyimide fibers or cellulose acetate sheets, were fragile and had short life spans, often no longer than three years. These materials are highly susceptible to contaminants in the source water—particularly chlorine, which hardens the membranes, and microbes, which clog them. Pretreatment regimes, such as filtering out sediments and bacteria, must be extremely rigorous. A new generation of so-called thin composite membranes, made from polyimide films, promises to eliminate these problems. Though still susceptible to contamination, these new membranes are sturdier, provide better filtration and may last up to 70 years.

Technical performance is important, but it alone does not drive the adoption of desalination as a source of clean water. With or without technical improvements, the market for desalination equipment will very likely show healthy growth in the next 10 years as cities and other consumers realize the potential and favourable economics of existing equipment, according to James D. Birkett, who runs West Neck Strategies, a private desalination consulting company based in Nobleboro, Me.

Hundreds of suppliers are already selling many thousands of pieces of equipment annually. These desalination units range in capacity from a few gallons a day (small emergency units for life rafts) to several million gallons a day (municipal systems). “So confident are the suppliers that they enter into long-term contracts with their customers,” Birkett says, “thus...”
assuming themselves the risks of performance and economics.” The desalination plant on Tampa Bay, scheduled to be operational by the end of 2002, will be funded and operated in such a manner.

Today the best estimate is that about 1 percent of the world’s drinking water is supplied by 12,500 desalination plants. No doubt, this is only the beginning. In the future, the water in your glass may have originated in the seas.
Approach #2: Redistribute Supplies
Bagged and Dragged

Pipelines make it possible to move freshwater cheaply over vast distances of land. If only the same were possible over the oceans. Dragging waterproof plastic or fabric containers behind tugboats may be the answer.

Beginning in 1997, the English company Aquarius Water Trading and Transportation Ltd. has towed water from mainland Greece to nearby resort islands in enormous polyurethane bags, helping the tourist destinations deal with increased demand for drinking water during the peak season. Another company, Nordic Water Supply in Oslo, Norway, has made similar deliveries from Turkey to northern Cyprus using their own fabric containers.

The seemingly far-fetched concept of water bags was born in the early 1980s out of the desire to move large amounts of water more cheaply than modified oil tankers can do. For many years, tankers and barges have been making deliveries to regions willing to pay premium prices for small amounts of freshwater, such as the Bahamas, Cyprus and other islands with inadequate sources. Tankers have also supplied water during short-term droughts and disasters such as the 1995 Kobe earthquake in Japan.

Aquarius has manufactured eight 790-ton bags and two 2,200-ton versions; the latter hold about half a million gallons of water each. Aquarius has also developed models that are 10 times larger than the ones in use today, and last year Nordic began manufacturing bags that can hold nearly eight million gallons.

Water bags could offer a less expensive alternative to tankers—bags in the Aquarius fleet cost anywhere from $125,000 to $275,000—but some technical problems remain. In particular, making such large bags that are capable of withstanding the strains of an ocean voyage is difficult. For freshwater deliveries to the Greek isles and to Cyprus, bags need be dragged no farther than 60 miles. The piping systems needed to connect the bags to water supplies on land can be built from existing technology, but bags have ripped during transport on several occasions.

A third water-bag inventor, Terry G. Spragg of Manhattan Beach, Calif., is solving the problems of both volume and towing in a different way. With the support of privately hired scientists and consultants, Spragg has patented specialized zippers, with teeth more than an inch long, that can link water bags like boxcars. He has demonstrated the technology but has yet to sell it for commercial use.

Thus far this technology has been used only for freshwater deliveries to emergency situations and to extremely water-scarce coastal regions with a reliable demand for expensive water. But for some communities with no other option, water bags may offer a new and clever solution.

New York City is a metropolis of flamboyant excess, except when it comes to water. No one would suspect it, but the Big Apple has clamped down on water wasters, and after 10 years of patching leaky pipes and replacing millions of water-guzzling toilets, the city is now saving billions of gallons of water every year.

Back in the early 1990s New York City faced an imminent water shortage, and it was getting worse with every flush, shower and tooth brushing. With an influx of new residents and an increase in the number of drought years, the city needed to find an extra 90 million gallons of water a day—about 7 percent of the city’s total water use. Instead of spending nearly $1 billion for a new pumping station along the Hudson River, city officials opted for a cheaper alternative: reduce the demand on the current water supply, which was piped in from the Catskill Mountains.

Officials knew that persuading New Yorkers to go green and conserve water would require some enticement—free toilets. The city’s Department of Environmental Protection (DEP) stepped in with a three-year toilet rebate program which began in 1994. With a budget of $295 million for up to 1.5 million rebates, the ambitious scheme set out to replace one third of the city’s inefficient toilets—those using more than five gallons of water per flush—with water-saving models that do the same job with only 1.6 gallons per flush. With the rebate program, the DEP hoped to meet the largest part of its water-savings goal.

New Yorkers embraced the plan. Some 20,000 applications arrived within three days of its start. By the time the program ended in 1997, low-flow toilets had replaced 1.33 million inefficient ones in 11,000 buildings. The result: a 29 percent reduction in water use per building per year. The DEP estimates that low-flow toilets save 70 million to 90 million gallons a day citywide—enough to fill about 6,700 Olympic-size swimming pools.

But more efficient flushes weren’t enough. The toilet rebate program happened concurrently with the city’s water audit program, which continues today. For much of the city’s history, the amount building owners paid for water was based on the size of their property. Following a law passed in 1985, however, the city began keeping tabs on water use and charging accordingly. The law dictated that water meters be installed during building renovations, and the same requirement was applied to construction of new homes and apartments beginning in 1988. As of 1998, all properties in the city must be metered.

Homeowners who want to keep their water bills down under the new laws can request a free water-efficiency survey from Volt VIEWtech, the company that oversees the city’s audit program. Inspectors check for leaky plumbing, offer advice on retrofitting with water-efficient fixtures and distribute free faucet aerators and low-flow showerheads.

Low-flow showerheads use about half as much water as the old ones, and faucet aerators, which replace the screen in the faucet head and add air to the spray, can lower the flow of water from four gallons a minute to less than one gallon a minute. Volt VIEWtech has made several hundred thousand of these inspections, saving an estimated 11 million gallons of water a day in eliminated leaks and increased efficiency.

In efforts to save even more water, New York City has gone outside the home and into the streets. Water officials have installed magnetic locking caps on fire hydrants to keep people from turning them on in the summer. The city is also keeping an eye underground by using computerized sonar equipment to scan for leaks along all 32.6 million feet (6,174 miles) of its water mains.

Although the city’s population continues to grow, per person water use in New York dropped from 195 to 169 gallons a day between 1991 and 1999. From all indications, this trend is following its upward path. Water conservation works. And New Yorkers are proving that every flush makes a difference.

Namibia is the driest African country south of the Sahara Desert. Blistering heat evaporates water faster than rains can rejuvenate the parched landscape, and there are no year-round rivers. Residents of the capital city, Windhoek, must do more than just conserve water to secure a permanent supply. They must reuse the precious little they have.

By the end of the 1960s, most underground aquifers and reservoirs on seasonal rivers near Windhoek had been tapped dry by the capital’s burgeoning population, which has grown from 61,000 to more than 230,000 in the past 30 years. Transporting water from the closest permanent river, the Okavango—some 400 miles away—was too expensive. This crisis inspired city officials to implement a strict water conservation scheme that includes reclaiming domestic sewage and raising it once again to drinkable standards.

The city’s first reclamation plant, initially capable of producing only 460 million gallons of clean water per year when it went on line in 1968, is now pumping out double that amount enough to provide about 23 percent of the city’s yearly water demands. Officials hope to boost that supply number to 51 percent with an upcoming facility now under construction.

To make wastewater drinkable, it must undergo a rigorous cleaning regimen. First, large solids are allowed to settle out while biofilters remove smaller organic particles. Advanced treatments remove ammonia, and carbon and sand filters ensure that the last traces of dissolved organic material are eliminated. The final step is to purify the water by adding chlorine and lime. To guarantee a safe drinking supply, the reclaimed water is tested once a week for the presence of harmful bacteria, viruses and heavy metals. (Industrial effluent laden with toxic chemicals is diverted to separate treatment plants.) Compared with local freshwater sources, the reclaimed water is equal or better in quality.

Despite 32 years of access to high-quality recycled water, the residents of Windhoek still doggedly oppose its use for personal consumption. For this reason, most of this purified wastewater irrigates parks and gardens. But sometimes people don’t have a choice about their water source. In times of peak summer demand or during emergencies such as drought, local freshwater reservoirs are strained, and Windhoek relies heavily on treated effluent to boost supply. During the drought of 1995, for instance, reclaimed water accounted for more than 30 percent of the clean water piped into homes.

Officials hope to bolster support for the recycling program through enhanced public education—like letting the word slip that besides irrigating the city’s greenery, treated wastewater is the secret ingredient in the prized local brew.
Examples of Focus Questions:
Water: Some Solutions

1. Explain why there was an imminent water shortage in New York in the early 1990s.

2. How were New Yorkers convinced to “go green?” Discuss the plan in a few sentences.

3. What else did the city do concurrently to help conserve water? Explain the program.

4. What is Volt VIEWtech?

5. What statistical evidence is there that New York’s water conservation plans were successful?

6. Although 97 percent of the earth is water, much of it cannot be used. Why not?

7. Define the term desalination. Describe the process.

8. What is reverse osmosis? What are the pros and cons of this process?

9. Eventually, what percentage of the world’s drinking water will be supplied by desalination?

10. After skimming and scanning the article, what do you think “Sweating the Small Stuff” means?

11. What does the expression “bagged and dragged” refer to? Where has this process begun to occur? Why?

12. Explain the initial reason for the development of water bags.

13. Evaluate these water bags as a useful invention.

14. What do you think the expression “waste not, want not” means?

15. Describe the water problems facing Namibia, Africa.

16. Explain their solution to their problem.

17. What is the quality level of the reclaimed water? What has been the response of the people? Hypothesize why this is so.
### Major Air Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Physical Characteristics</th>
<th>Effect on humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur dioxide (SO₂)</td>
<td>colourless gas with a pungent odour</td>
<td>Irritation of the respiratory tract; may aggravate asthma</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>colourless, odourless, tasteless gas</td>
<td>When inhaled, reduces the body’s ability to use oxygen; in high quantities, may cause drowsiness or asphyxiation</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂)</td>
<td>reddish-brown gas</td>
<td>Irritating; can impair lung function; at high concentrations, makes breathing difficult for people with respiratory problems</td>
</tr>
<tr>
<td>Ozone (O₃)</td>
<td>pungent smelling, colourless gas, formed when sunlight heats other air pollutants</td>
<td>Significantly reduces lung function, even in healthy people</td>
</tr>
<tr>
<td>Particulates</td>
<td>microscopic solids or liquids; vary widely in size and chemical composition</td>
<td>Can irritate the eyes and respiratory system; cause coughing and breathing difficulties; associated with cardiac problems; finer particles can cause deep lung damage</td>
</tr>
</tbody>
</table>

#### Air Pollutants in Canada

- **Particulates**
  - 53%
  - 22%
  - 16%
  - 6%
  - 1%

- **Sulphur dioxide**
  - 70%
  - 28%
  - 3%

- **Carbon monoxide**
  - 66%
  - 11%
  - 4%
  - 12%
  - 7%

- **Nitrogen oxides**
  - 64%
  - 30%
  - 5%

- **Hydrocarbons**
  - 42%
  - 22%
  - 25%
  - 10%
  - 2%
Urban air pollution, also known as smog, has five main components, each of which is harmful to the human respiratory system. Sulphur dioxide ($\text{SO}_2$) is a colourless gas with a pungent odour. It causes irritation of the upper respiratory tract and eyes and may lead to an increase in respiratory diseases. Carbon monoxide (CO) is also a colourless gas, but odourless and tasteless. Low concentrations of CO slow reflexes, while higher concentrations may cause drowsiness and asphyxiation. Nitrous dioxide ($\text{NO}_2$), a reddish-brown gas, also causes an increased risk of respiratory infection and produces constricted air passages in people suffering from asthma. Ozone ($\text{O}_3$), a pungent-smelling, colourless gas, causes coughing and irritation to the lungs and eyes. In addition to the gases, microscopic particles of solids and liquids suspended in the air contain a variety of irritating chemical compounds. These particulates reduce visibility and can damage the lungs and heart.
### Nitrogen Oxide Emissions

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<tr>
<td><strong>Transportation</strong></td>
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<td>59</td>
<td>1181</td>
<td>58</td>
<td>1117</td>
<td>54</td>
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<td><strong>Industrial Sources</strong></td>
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<td>23</td>
<td>481</td>
<td>24</td>
<td>564</td>
<td>27</td>
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<tr>
<td><strong>Power Generation</strong></td>
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<td>12</td>
<td>234</td>
<td>12</td>
<td>266</td>
<td>13</td>
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<tr>
<td><strong>Fuel Combustion</strong></td>
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<td>66</td>
<td>3</td>
<td>69</td>
<td>3</td>
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<tr>
<td><strong>Incineration/Misc/Ot</strong></td>
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<td>2</td>
<td>57</td>
<td>3</td>
<td>64</td>
<td>3</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>2106</td>
<td>100%</td>
<td>1999</td>
<td>100%</td>
<td>2060</td>
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### Volatile Organic Compound Emissions

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<td><strong>Incineration/Misc/Ot</strong></td>
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<td>33</td>
<td>933</td>
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<td>857</td>
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<td>28</td>
<td>647</td>
<td>24</td>
<td>592</td>
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<tr>
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<td>9</td>
<td>239</td>
<td>9</td>
<td>238</td>
<td>9</td>
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<tr>
<td><strong>Power Generation</strong></td>
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<td>0</td>
<td>3</td>
<td>0</td>
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<tr>
<td><strong>TOTAL</strong></td>
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<td>100%</td>
<td>2679</td>
<td>100%</td>
<td>2682</td>
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### Sulphur Dioxide Emissions

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<td>4</td>
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<td>2</td>
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<td>0</td>
<td>0</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>3305</td>
<td>100%</td>
<td>2805</td>
<td>100%</td>
<td>2802</td>
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The automobile has probably done more to shape the character of 20th-century Canada than any other piece of technology. It has given us mobility and independence. It has given us the convenience of going where we want to, when we want to, and of doing so in comfort. It has liberated the average person from the limitations of time and place, opening up new opportunities and offering new experiences. More significantly, it is one of the pivotal elements of our economy. No wonder, then, that Canadians have made the car such a central fixture of their lives.

But the automobile also affects the environment in many ways. Cars and their associated infrastructure use resources, consume energy, and emit pollutants on a substantial scale. They are a source of noise and congestion and a leading cause of accidental deaths. They have also radically reshaped the landscape—directly through the building of expressways, roads, and other infrastructure, and indirectly through effects on settlement patterns.

The automobile’s impact has been all the greater because of its success. More than 12 million cars now traverse Canada’s roads—one for nearly every two Canadians, one of the highest ratios of car ownership in the world. Each of these cars travels, on average, more than 16,000 km per year, a total of some 200 billion kilometres, or more than 1,000 times the distance between the Earth and the sun.

Because it is so tightly woven into the fabric of Canadian life, the car presents a special kind of environmental dilemma. On the one hand, there is the need to eliminate or reduce the environmental stresses associated with it. On the other, there is the desire to preserve the advantages it has given us. Reconciling these objectives presents a considerable challenge.

As Figure 1 shows, the automobile is part of a complex web of interactions. To determine its place in a sustainable environment, we must examine its impacts and devise solutions that effectively respond to this entire range of interactions.

Figure 1: The automobile and sustainability

(continued)
Environmental Implications of the Automobile (continued)

The Car and the Economy

In Canada, the demand for automobiles and associated products and services has stimulated activity in virtually every sector of the economy, contributing to a standard of living that is one of the highest in the world.

With the economic boom that followed the Second World War, car ownership rose dramatically. More people could afford to live and work in widely separated areas, and low-density suburbs began to spring up at the edges of large cities and nearby towns. For the suburbanites, car ownership was not only a convenience but often a necessity.

More cars and expansive development increased the demand for motor vehicle infrastructure, such as roads, bridges, and parking lots. More service outlets, dealerships, gas stations, auto parts stores, and other car-related services became necessary. Motels, restaurants, and retail businesses along well-travelled routes also began to benefit. Both directly and indirectly, the automobile had become an important influence on Canada’s economic activity, employment opportunities, and development patterns.

In general, the fortunes of the motor vehicle industry have been a good indicator of those of the economy as a whole. In good economic times, car production increases; in bad times, it declines (Fig. 2). And as the automobile industry goes, so go the many other industries, such as mining, manufacturing, and retail sales, that depend on it. In 1988, for example, the motor vehicle manufacturing industry used more than $30 billion worth of materials, indirectly stimulating demand in sectors such as energy and mineral resources (Statistics Canada, 1988a).

Between 1986 and 1990, about 1.9 million motor vehicles and $35 billion worth of motor vehicles and parts were produced each year (ISTC, 1991). The value of these goods was equal to over 6% of Canada’s Gross Domestic Product and accounted for more than a quarter of the nation’s exports (Statistics Canada, 1990b, 1990f). In 1990, 572,000 people—roughly one out of every 20 working Canadians—were employed in jobs directly linked to motor vehicles. They earned approximately $16 billion in gross wages (Statistics Canada, 1990c).

Retail sales of motor vehicles, parts, and associated services make up the largest proportion of Canadian retail activity—35% in 1988 (Statistics Canada, 1988b). Hotel, restaurant, and other retail businesses associated with domestic automobile travel amounted to $9.1 billion, or 64% of domestic travel spending, in 1990 (Statistics Canada, 1990c).

Figure 2: The relationship between number of automobiles and Gross Domestic Product
The Car and the Environment

Most Canadians are aware of the high-profile environmental concerns associated with automobiles, such as the consumption of fossil fuels and the subsequent air pollution that accompanies their use. While these are legitimate concerns, a number of less obvious but equally significant environmental stresses occur during the car’s life cycle. These impacts are related not only to its use but also to its manufacture, demand for infrastructure, and disposal. Understanding the full spectrum of these impacts is an important first step towards minimizing the negative environmental effects of the car.

Motor Vehicle Manufacture

The transformation of raw resources and energy into motor vehicles gives rise to a variety of environmental consequences. The most important of these are the depletion of nonrenewable resources (including metals and energy) and the environmental stresses associated with the production and use of these resources.

Use of nonrenewable materials. In 1989, the average motor vehicle weighed 1,428 kg, 77% of which was metal (Table 1). It can therefore be estimated that more than 2 billion kilograms of metal could be used in the manufacture of the 1.9 million motor vehicles produced each year in Canada. While much of this metal is recovered or recycled when the vehicle is taken out of service, it is neither cost-effective nor technologically possible to recover all of the metal used in motor vehicle manufacture. Furthermore, because the number of vehicles being produced is growing, more metal is needed for the manufacture of new vehicles than can be obtained from old ones. Consequently, some depletion of nonrenewable resources is inevitable.

In addition, the extraction, smelting, and refining of these metals can give rise to a number of other concerns, such as land disturbances, leaching of metals from mine tailings, acid mine and saline drainage, runoff of milling effluent containing toxic reagents used to extract minerals from the ore, and release of nitrogen oxides (NOx), volatile organic compounds (VOCs), sulphur dioxide (SO2), carbon dioxide (CO2), carbon monoxide (CO), particulates, and other pollutants (Government of Canada, 1991).

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain carbon steel</td>
<td>643.6</td>
</tr>
<tr>
<td>High-strength steel</td>
<td>106.4</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>14.1</td>
</tr>
<tr>
<td>Other steel</td>
<td>21.4</td>
</tr>
<tr>
<td>Iron</td>
<td>208.6</td>
</tr>
<tr>
<td>Plastics/composites</td>
<td>102.0</td>
</tr>
<tr>
<td>Fluids/lubricants</td>
<td>81.6</td>
</tr>
<tr>
<td>Rubber</td>
<td>61.1</td>
</tr>
<tr>
<td>Aluminium</td>
<td>70.7</td>
</tr>
<tr>
<td>Glass</td>
<td>33.6</td>
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<tr>
<td>Copper</td>
<td>22.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>9.1</td>
</tr>
<tr>
<td>Other materials</td>
<td>47.5</td>
</tr>
<tr>
<td>Total</td>
<td>1427.7</td>
</tr>
</tbody>
</table>

Table 1: Weights and types of materials utilized in the construction of an average motor vehicle, 1989

Consumption of energy. As much as 20% of all the energy consumed throughout the life of a vehicle goes into its manufacture (Matsumoto, 1984). It has been estimated that between 66 and 105 gigajoules of energy are needed to produce a motor vehicle, depending on the proportion of recycled materials used. This is equivalent to the energy contained in between 2000 and 3100 L of gasoline, or the amount of fuel consumed by 16,000 to 26,000 km of driving. Production of the 1.9 million motor vehicles made in Canada in 1989 would thus have consumed between 1.8% and 2.9% of Canada’s end-use energy demand, or the energy used by the final consumer (Tien et al., 1975; Government of Canada, 1991).

The environmental stresses that may result from using this energy depend on its source. Fossil fuels, for example, emit SO2, CO2, NOx, CO, and particulates, while nuclear power plants generate toxic radioactive wastes, which are often difficult to dispose of. Hydroelectric energy may cause ecological disruption through flooding. Regardless of origin, electric power requires the construction and maintenance of transmission lines and associated rights-of-way.

Infrastructure and Land Use

The infrastructure required by the increasing numbers of vehicles on Canada’s roads today can be linked to a variety of environmental effects, including the occupation of productive land and the alteration of ecosystems.
Overall, there are about 879,000 km of highways in Canada (Statistics Canada, 1991). In urban areas, up to 42% of the land in downtown cores and 18% of the land in greater metropolitan areas may be occupied by motor vehicle infrastructure, including roads, rights-of-way, bridges, garages, retail outlets, and parking lots (Simpson-Lewis et al., 1979). In Toronto, 2% of the city’s area is devoted specifically to parking (Macpherson, 1988).

Much of this land was once prime agricultural land. Urban development patterns, while beginning to change, are still often characterized by the demand for low population density suburbs and are based on the assumption that cars will be the primary mode of transportation. As most of Canada’s largest urban centres—the Windsor–Quebec City corridor, for example, or British Columbia’s Lower Fraser Valley—have typically developed in productive agricultural areas, motor vehicle infrastructure usually consumes some of the country’s best farmland. The most recent data available show that, between 1981 and 1986, 55,200 ha of rural land near 70 Canadian cities was urbanized. Of this, 59% was prime agricultural land (Government of Canada, 1991).

Roads and supporting services for vehicles affect the environment in numerous other ways as well. Road salt, leaked motor oil, and particulate emissions, for example, wash off road surfaces and concentrate in ditches and storm sewers. The extent of the contamination of water and land by these routes has not yet been determined. In addition, highway construction may alter traditional drainage patterns, and soil erosion and landslides may occur more frequently around roads and bridges. Roads may also divide otherwise undisturbed lands, interfering with the movements of wildlife and altering habitats.

The Demand for Fossil Fuels

In 1990, transportation accounted for 29% of Canada’s end-use energy demand. Retail sales of gasoline for motor vehicles accounted for 54% of this, or 16% of end-use energy demand (Statistics Canada, 1990d). Although fuel consumption per vehicle has declined in recent years, a number of concerns remain. These include dependence on a nonrenewable energy source, the environmental damage that accompanies the exploration, extraction, refining, storage, delivery, and disposal of fossil fuels, and the pollution produced by combustion.

Consumption of energy resources. In 1988, the average personal-use passenger car was driven 6% farther but consumed 22% less fuel than its 1980 counterpart. The average fuel consumption of all in-use automobiles decreased from 16.5 to 12.0 L/100 km between 1980 and 1988 (Statistics Canada, 1991). For new cars, the average consumption decreased from 10.2 to 8.1 L/100 km over the same period (Transport Canada, 1991). Reduced engine size and vehicle weight have both contributed to improved fuel efficiency.

Energy production and delivery. About 35% of the crude oil that enters Canadian refineries is turned into motor gasoline. The processing and handling of these substances can result in such environmentally damaging events as oil and gas spills. Between 1985 and 1990, an average of 7.9 million litres of motor gasoline and 16.2 million litres of crude oil per year were reported to have been spilled in Canada during extraction, transportation, refining, storage, and delivery (NATES, 1992). It is suspected that unreported events, such as the dumping of contaminated ballast from tankers and runoff from roads and sewers, may release even greater amounts (OECD, 1991).

Furthermore, leaking gasoline from underground storage tanks has recently begun to emerge as a significant contributor to the contamination of soil and water. A single litre of gasoline can make up to 1 million litres of water unfit for human consumption (Kruss et al., 1991).

In 1987, crude oil refineries collectively discharged, on a daily basis, 1,080 kg of oil and grease, 4,039 kg of suspended solids, 77 kg of phenols, 21 kg of sulphide, and 726 kg of ammonia nitrogen. However, a general downward trend in refinery discharges has been apparent. Between 1972 and 1987, discharges of oil and grease were reduced by 87%, suspended solids by 81%, phenols by 96%, sulphides by 99.5%, and ammonia nitrogen by 93%. In 1987, refineries were, on average, in compliance with monthly emission standards 94% of the time and with daily standards more than 99% of the time (Losier, 1990).

VOCs, which contribute to the formation of ground-level ozone, are commonly released into the air when gasoline is transferred between facilities and vehicles are refuelled. In 1985, these processes contributed an estimated 6% of the human-released VOCs in Canada (Government of Canada, 1991).
Fossil fuel combustion. Emissions from fossil fuel combustion can lead to a number of environmental and human health problems (Table 2). In the past 20 years, factors such as improved fuel efficiency, the increased use of emission control devices, and stricter new car emission control standards have contributed to a decline in per-vehicle emissions of some common pollutants. A new car today emits only 24% of the NOx, 4% of the VOCs, and 4% of the CO of a new car in the early 1970s (Motor Vehicle Manufacturers’ Association 1991). Between 1985 and 1990, total emissions of NOx from automobiles decreased from 352,000 to 248,283 t, VOC emissions decreased from 412,700 to 340,838 t, and CO emissions decreased from 4.0 to 2.7 million tonnes (Kosteltz and Deslauriers, 1990; Environment Canada, Pollution Data Analysis Division, unpublished data).

Reduced automobile emissions may be contributing to improved urban air quality in some Canadian cities. For example, in Vancouver, Calgary, Toronto, Ottawa, Montreal, and Quebec City, where cars are a major influence on air quality, indicators such as ambient NO2 and CO decreased by an average of 8.6% and 33%, respectively, between 1980 and 1990 (T. Furmanczyk, personal communication).

<table>
<thead>
<tr>
<th>Emission</th>
<th>Health impacts</th>
<th>Environmental impacts</th>
</tr>
</thead>
</table>
| Nitrogen oxides (NOx)    | • NO2 is a lung irritant at high concentrations.  
• NO2 may lead to depression of the immune system, with children and the elderly being at risk.                                           | • NO2 reacts with water to form nitrate (NO3-) a source of acid rain.                                   |
| Carbon monoxide (CO)     | • CO reduces the ability of the blood to carry oxygen, with smokers, persons with heart disease, and those with anemia being especially sensitive.                                                   | • CO may contribute to the formation of ground-level ozone by depleting the atmosphere’s supply of hydroxyl radical (OH). |
| Carbon dioxide (CO2)      |                                                                                                                                                | • CO2 is an important greenhouse gas, contributing to global warming.                                   |
| Volatile organic compounds (VOCs) | • Many individual VOCs (e.g., benzene) are known to have or are suspected of having human health effects ranging from carcinogenicity to neurotoxicity.                                                                 | • VOCs contribute to the formation of ground-level ozone.                                               |
| Ozone (O3)                | • Exposure to O3 is associated with changes in lung function, decreased immune function, and possibly the development of chronic lung disease.                                                               | • O3 reduces agricultural productivity and the growth rate of trees.                                     |

Source: Modified from Healthy City Office (1991)
In spite of these improvements, the automobile remains a major source of some pollutants. A 1985 survey of national air emissions showed that gasoline-powered cars contributed 18.7% of total NOx emissions, 22.9% of total VOC emissions, and 37.1% of total CO emissions (Kosteltz and Deslauriers, 1990). Although emissions of these pollutants from the average personal-use passenger car decreased between 1980 and 1988, the total number of kilometres driven increased. As a result, the reduction in overall emissions was less dramatic than might have been expected (Fig. 3).

The occurrence of ground-level ozone, a product of the interaction of NOx, VOCs, and sunlight, should also be decreasing. However, because of the increased number of vehicles on the road, emissions of NOx and VOCs still lead to concerns about ground-level ozone, especially in urban centres where automobile use is concentrated. The Lower Fraser Valley, the Windsor–Quebec City corridor, and the Southern Atlantic Region have been identified as problem areas, as they exceed Canada’s maximum acceptable ground-level ozone objectives most frequently (Hilborn and Still, 1990).

Canadian emissions of CO2, which contribute to increasing CO2 levels internationally and concerns of global warming, have decreased on a per-vehicle basis in recent years as average fuel efficiencies have improved. Nevertheless, between 1987 and 1990, total CO2 emissions from automobiles rose slightly, from 48.4 to 49.0 million tonnes, as a result of the increase in vehicle numbers and use. In 1990, automobiles continued to be among the most important sources of CO2 in Canada, accounting for almost 11% of our total emissions (Jaques, 1992).

**Disposal.** Large amounts of waste motor oil, containing a diversity of contaminants ranging from PCBs to metals, enter the environment because of improper disposal. Of the estimated 230 million litres of waste motor oil generated by motor vehicles in 1990, approximately 50% was rerefined and 34% was used as fuel to power incinerators and furnaces. The remaining 16%—over 36 million litres—is believed to have been disposed of in ways that allow environmental contamination, including dumping in landfills and sewers and use as a dust suppressant (Environment Canada, Office of Waste Management, unpublished data).

(continued)
Driving and Maintenance Habits

Technical improvements in fuel efficiency and emission controls can be offset by the driving and maintenance habits of automobile owners. A Vancouver study, for example, showed that passenger cars made up 98.4% of downtown rush-hour traffic but carried only 62.6% of the commuters (B.C. Transit, 1990)—an inefficient use of transportation energy when compared with the use of public transit vehicles (Table 3). In addition, traffic congestion reduces fuel efficiency and increases pollution, as engines not running at maximum efficiency tend to consume more fuel and release proportionately more emissions. It has been estimated that a 16-km trip taken in light traffic and requiring 11 minutes would produce 2 g of VOCs; the same trip in heavy traffic and requiring 30 minutes would generate 7 g—a 250% increase (Go Green, 1990).

Vehicle emissions may often be lowered by simple repairs, such as replacing the air filter or spark plugs, resetting the engine timing, or adjusting the carburetor, measures that may also increase fuel efficiency and improve driving performance.

Automobile Air Conditioners

Approximately 60% of the cars and light-duty trucks sold in Canada are equipped with air conditioners that contain chlorofluorocarbons, or CFCs, which contribute to stratospheric ozone depletion and global warming. Even well-maintained motor vehicle air conditioners leak CFCs during their normal functioning, and additional CFCs are usually released when air conditioners are serviced. Furthermore, old air conditioners release whatever CFCs they still contain when crushed at auto wreckers. In 1991, motor vehicles accounted for 23% of Canada’s CFC consumption (Environment Canada, Commercial Chemicals Branch, unpublished data).

Disposal

Once automobiles, or any of their components, wear out, the issue of their disposal must be contended with. A great deal of material goes into the manufacture of a car, making discarded vehicles and components a significant source of metals, plastics, and rubber. Although some materials in scrapped cars are recycled, the disposal of others presents problems.

The disposal of tires illustrates the challenge. An estimated 19.5 million vehicle tires are discarded every year in Canada, about 13 million of which come from passenger vehicles (CCME, 1990). However, no process exists for converting old tires into materials suitable for manufacturing new tires, in the way that new metal products, for example, can be made from old.

At present, 62% of discarded tires are landfilled, 18% are recycled or retreaded, 6% are burned in an environmentally acceptable manner as a fuel source, and the remaining 14% are stockpiled (CCME, 1990). Although landfilling may not be a desirable method of disposal, stockpiling presents risks such as fires, the emissions from which contaminate adjacent air, land, and water. Such an event occurred in 1990, when 11.5 million discarded tires caught fire at a stockpile site near Hagersville, Ontario.

(continued)
New technologies may lead to uses for discarded tires and change their status from waste to resource. Researchers are now exploring the incorporation of rubber from waste tires into plastics and asphalt. However, considerably more research will be needed before such uses will be accepted as operationally, economically, and environmentally feasible.

Recycling

About 75% of the materials in scrap vehicles can be recycled (Siuru, 1991). In fact, automobile recycling already contributes significantly to national production levels of some materials. The salvage of platinum from old catalytic converters, for instance, accounts for one-third of domestic platinum production. In addition to extending the life span of nonrenewable resources, metal recycling requires 50–74% less energy for production and releases 86% less air pollutants, 76% less water contaminants, and 97% less solid waste than metal production from ores (Government of Canada, 1991).

Most metallic components, such as engine blocks, starting motors, and generators, can be and are reused or recycled, but nonmetallic items, such as plastics, fluids, and rubber, are more difficult to contend with. Car manufacturers are now intensifying their research on recycling, and especially on ways of dealing with nonmetallic components. In North America, one of the most recent initiatives has been the formation of the Vehicle Recycling Partnership to coordinate the research activities of the major automobile manufacturers and to establish recycling guidelines.

An important concept that has been receiving increasing attention is “design for recycling.” The idea is that recyclability should be designed into the car from the beginning by selecting materials that can be recycled and by making the car easier to dismantle. Many manufacturers, for example, now label plastic components with standard codes to make it easier to sort them by chemical composition when they are recycled.

To encourage the recycling of certain other components, some provinces place a fee on their purchase. A few, for example, charge tire fees, with the objective of funding research into environmentally acceptable methods of disposal. In British Columbia, a similar system has been set up to facilitate the collection and recycling of lead-acid batteries, thus preventing them from being landfilled or burned. Such fees can help to reduce the landfilling of waste, particularly toxic items such as batteries.

(continued)
Inspection and Maintenance Programs

Inspection and maintenance programs are aimed at reducing in-use vehicle emissions and are designed to detect vehicles with excessive emission levels. The Greater Vancouver Regional District's program, possibly the most comprehensive in North America, consists of an annual visual inspection of emission control devices and the measurement of tailpipe emissions. Owners are charged a fee for the inspection, and those whose vehicles do not meet the standards are required to restore them to proper operating condition before being issued registration or re-registration documents. Inspection and maintenance programs are in place or being planned for other regions of Canada.

Employer-Sponsored Initiatives

Some employers have taken steps to reduce the dependence of their employees on automobiles. These include flexible schedules that allow employees to commute during off-peak times or to work longer hours per day but fewer days per week; telecommuting, or communicating with work by phone, fax, or computer, which allows some employees to work out of their homes on a full- or a part-time basis; subsidized parking for employees who carpool, to encourage groups of employees to coordinate their commuting; and satellite offices that enable some employees to work closer to home and reduce commuting distances.

Alternative Transportation Modes

<table>
<thead>
<tr>
<th>Transportation mode</th>
<th>NOx</th>
<th>VOCs</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light rail</td>
<td>43.0</td>
<td>0.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Transit bus</td>
<td>95.0</td>
<td>12.0</td>
<td>189.0</td>
</tr>
<tr>
<td>Van pool</td>
<td>24.0</td>
<td>22.0</td>
<td>150.0</td>
</tr>
<tr>
<td>Car pool</td>
<td>43.0</td>
<td>43.0</td>
<td>311.0</td>
</tr>
<tr>
<td>Single-occupant car</td>
<td>128.0</td>
<td>130.0</td>
<td>934.0</td>
</tr>
</tbody>
</table>

Table 4: A comparison of emissions by transportation mode (g/person-100 km)

In areas of high population density, a shift to alternative transit modes can be encouraged by controlling access by cars, improving public transit systems, improving interfaces between cars and public transit (for example, park and ride), and creating and improving facilities for walking and cycling. In low-density suburban developments, where public transit is less practical, car- or van-commuting schemes may be more efficient (Reid, 1986). As well as using less energy, alternative modes of transit produce lower emission levels per passenger (Table 4).

Reduction to Accidentally Released VOCs

The Canadian petroleum industry has installed equipment in the Vancouver and Toronto areas to recover releases of VOCs that occur during the transfer of gasoline between facilities (CPPI, 1991a). In addition, refineries decreased the amount of butane added to summer gasolines in Canada in 1991 to reduce their volatility and thus minimize VOC releases during refuelling and transfer (CPPI, 1991b).

CFC Replacement in Air Conditioners

As part of Canada’s commitment to phase out CFCs, automobile manufacturers will replace CFC-12 in air conditioners with hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) by the year 2000. HCFCs have considerably less stratospheric ozone-depleting potential than CFCs, while HFCs have virtually no capacity to deplete stratospheric ozone. Both groups of compounds appear to have significantly less impact on global warming than CFC-12. Some automobile manufacturers will voluntarily begin to use HFCs and HCFCs as soon as 1993 but will continue to service vehicles containing CFC-12 until the end of the century. Some also plan to install recycling equipment in authorized service centres to reduce CFC-12 losses during servicing.

New Emission Standards

Automobile manufacturers have voluntarily agreed to introduce, in Canada, vehicles that meet the stringent exhaust emission standards being progressively introduced in the United States beginning in 1994. These vehicles will emit 60% less NOx and 29% less VOCs than are currently allowed. The government is developing comprehensive emission control regulations to be effective in the 1996 time frame.

Alternative Fuels

Currently available alternatives to gasoline include propane, natural gas, methanol, ethanol, and oxygenated gasolines (varying mixtures of gasoline and alcohol) such as M85, which is 85% methanol and 15% gasoline. These fuels burn more efficiently than gasoline and thus emit fewer pollutants. Furthermore, ethanol and methanol can be produced from biomass (continued)
Environmental Implications of the Automobile (continued)

and are therefore renewable. Domestic automobile manufacturers have recently begun to introduce flexible-fuel vehicles that can run on conventional fuel as well as M85 or ethanol.

Electric vehicles or those powered by hydrogen cells may provide a renewable and even cleaner generation of alternatives to gasoline. In fact, with the development of more efficient batteries, some car makers are now preparing to introduce electric cars to the market. Hydrogen fuels are still in the experimental stages and will require additional research before becoming available to consumers.

The Car and a Sustainable Environment

How can we ensure that the automobile is compatible with a sustainable environment? Certainly there is no simple answer. Cars are likely to be a permanent fixture of industrialized and semi-industrialized societies for some time to come.

Nor can we rely exclusively on technology to put the issue to rest. Technological improvements over the last 20 years have already done much to reduce the environmental impact of the individual car, and further improvements can be expected in coming years. But much of the ground gained through technological improvements is being lost as more and more cars crowd the roads. To offset the effect of growing numbers, we shall have to look to other solutions—urban planning initiatives, economic strategies, and education—to lessen our dependence on the automobile. Eventually, these solutions could give us a more varied choice of transportation options in which the car plays a more efficient role.

Whatever the solutions we choose, they must work within an international as well as a national context. Nothing is accomplished if some of the problems, such as those associated with manufacture or disposal, are simply transferred from one country to another, thus solving problems at home but passing on challenges to global neighbours.

With continuing population growth and rising standards of living, the demand for car ownership will continue to increase. Because of that, we are unlikely to find an ultimate solution to the environmental problems associated with the automobile. Instead, we shall always have to confront the task of balancing the demand for cars with our need for a sustainable environment. That means that the issue must constantly be readdressed, with new solutions devised and old solutions reworked as conditions change.

Above all, we have to recognize the complexity of the many issues surrounding the car and look for solutions on a multitude of fronts—technological, social, economic, political, and ecological. Such a holistic approach is our best chance for preserving the benefits of the car while keeping its environmental effects within the limits of sustainability.

1. In this fact sheet, the term “automobiles” is used synonymously with “passenger cars,” a group that includes both personal-use passenger cars and fleet vehicles. In contrast, “motor vehicles” is defined to include both passenger cars and light-duty trucks and vans.
Overhead—Environmental Implications of the Automobile

Environmental Implications of the Automobile (SOE Fact Sheet No. 93-1)

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The Car and the Environment
Motor Vehicle Manufacture
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   Consumption of energy
Infrastructure and Land Use
The Demand for Fossil Fuels
   Consumption of energy resources
   Energy production and delivery
   Fossil fuel combustion
   Disposal
Driving and Maintenance Habits
Automobile Air Conditioners
Disposal
Meeting the Challenge
Manufacturing
Recycling
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Employee-Sponsored Initiatives
Alternative Transportation Modes
Reduction of Accidentally Released VOCs
CCF Replacement in Air Conditioners
New Emission Standards
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The Car and a Sustainable Environment

These graphics, figures, and charts accompany the article.

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Graphic: Workers on an assembly line
Figure 2: The relationship between number of automobiles and Gross Domestic Product
Table 1: Weights and types of materials utilized in the construction of an average motor vehicle, 1989
Table 2: Major impacts of common pollutants associated with automobile use on human health and the environment
Figure 3: Total annual and per-vehicle emissions of NOx, VOCs, and CO from personal-use passenger cars, 1980-88
Table 3: A comparison of energy use by transportation mode
Graphic: Burning tires at Hagersville (a town)
Table 4: A comparison of emissions by transportation mode (q/person-100 km)

In Canada, a car or truck’s fuel economy is measured in litres per 100 kilometres (L/100 km). For example, a car’s fuel economy rating may be 8.7 L/100 km. This means that, on average, the car burns 8.7 litres of fuel to travel 100 kilometres. By doing the following problems you will gain a better understanding of fuel economy.

1. Rank the following fuel economy ratings from best (most fuel efficient) to worst (least fuel efficient). Use the numbers from 1 to 5 to rank them—1 is the best, 5 is the worst.

Your ranking (best to worst);
12.6 L/100 km ______
6.2 L/100 km ______
9.5 L/100 km ______
7.3 L/100 km ______
10.7 L/100 km ______

2. A car has a fuel economy rating of 9.3 L/100 km.

(a) How many litres of gasoline will be needed to travel:
   (i) 325 km?
   (ii) 750 km?

(b) How many kilometres can this car travel on:
   (i) 45.7 L of fuel?
   (ii) 65.2 L of fuel?

(c) The capacity of the fuel tank is 58.5 L. What is the cruising range of the car?

3. Find, correct to one decimal place, the fuel economy of:

(a) a car that travels 450 km on 52.5 L of fuel.
(b) a van that travels 415 km on 65.0 L of fuel.
(c) a transport truck that travels 6000 km on 1482 L of fuel.

4. Two families drive to Florida for the March break. One family drives a car whose fuel economy rating is 7.3 L/100 km, and the other drives a car that is rated at 10.5 L/100 km. Each family travelled 5,200 km and the average cost for fuel was 45.7¢ per litre. Calculate the amount of fuel that each family used for the trip and also the cost for fuel for each family.

5. Suppose that you or your family drives a car whose fuel economy is 10.6 L/100 km. By having the engine tuned up you can improve the fuel economy to 8.9 L/100 km but the tune-up will cost $125. You drive an average of 20,000 km per year and fuel costs 58.9¢ per litre. Calculate the savings or the costs that will result over the next year by having the engine tuned up now.

(continued)
6. Repeated tests show that the fuel economy of a car is 7.5 L/100 km for highway driving and 12.7 L/100 km for city driving. This car is to be taken on a vacation trip of 8,000 km that is 70% highway driving and the rest is city driving.

(a) Calculate, correct to one decimal place, the expected overall fuel economy on this trip.

(b) Use your answer to part (a) to compute the expected cost for fuel on this trip if the average cost per litre of fuel is 60.3¢.

7. Let’s suppose that, on average, cars operate with a fuel efficiency of 9.3 L/100 km. Let’s also suppose that we could increase the fuel efficiency of every vehicle to 7.3 L/100 km.

(a) How many litres of fuel would be saved each year by a person who drives 20,000 km per year?

(b) If there were 250,000 vehicles in a city, and each of them could burn that much less fuel, how many litres of fuel would be saved?

(c) If the cost of fuel is 59.5¢ per litre, how much money would be saved?

(d) Think of some worthwhile community projects that could be financed with this saved money.

(e) There are over 12,000,000 vehicles in Canada. Perform calculations for Canada similar to those you did for the city in parts (b) and (c). Then suggest several worthwhile national projects that could be financed with the saved money.

8. Clearly there are financial advantages for the consumer to increasing the fuel efficiency of his or her car. Now try to think more globally (for example, think about society or the physical environment).

(a) What are some other advantages to increasing the fuel economy of vehicles?

(b) Suggest some ways that we could improve the fuel economy of our vehicles.

(c) Do you see any disadvantages to increasing the fuel economy of vehicles? If so, what are they?
Emissions from vehicles and from industrial plants get mixed with the air that we breathe. Two of the more common pollutants in the air are nitrogen dioxide and sulphur dioxide. The rain dissolves these and other substances and they come back to the earth in the form of “acid rain.” This rain falls everywhere and causes environmental damage.

To help prevent this, cars and factories have devices which “scrub” their exhaust. These scrubbers remove some of the pollutants from the exhaust before they can enter the atmosphere and produce acid rain.

The concentration of pollutants in exhaust is measured in parts per million (ppm).

Doing the questions that follow will help you to increase your understanding of the mathematics of cleaner air.

1. A scrubber unit installed in a factory removes half of the pollutants each time the exhaust gas passes through it. Untreated exhaust contains 2,000 ppm of contaminants.
   (a) Complete the table of values below which show values of
   n - number of times the exhaust gas passes through the scrubber
   c - the concentration in ppm of contaminants that remain in the exhaust gas

<table>
<thead>
<tr>
<th>n</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

   (b) Plot the ordered pairs from the table of values in part (a). Number of times breathed on an x axis and concentration in ppm on a y axis.

   (c) Could all of the contaminants in the exhaust gas be removed in this way? Explain.

2. A company installed a scrubber which removes one-third of the pollutants each time exhaust gas passes through it. Untreated exhaust contains 1,500 ppm of sulphur dioxide. In its annual report the company states that by passing exhaust gas through the scrubber three times, all of the sulphur dioxide will be removed. You believe this statement to be false. Write a short letter to the company which explains and corrects its error.

3. A scrubber removes two-thirds of the pollutants each time exhaust gas passes through it. Before treatment, the gas contains 1,200 ppm of contaminants.
   (a) What is the concentration of contaminants in the gas after it has passed through the scrubber 2 times?
   (b) After the gas has passed through the scrubber 2 times, what fraction of the contaminants has been removed and what fraction remains?

4. Before exhaust gas can be released into the air, it must contain less than 200 ppm of sulphur dioxide. If untreated exhaust contains 3,600 ppm of sulphur dioxide and if a scrubber can remove half of the pollutants each time the gas passes through it, how many times should the gas be treated before it is released?

5. A manufacturing plant passes its exhaust gas through three cleaning stations before it is released into the atmosphere. Station A removes three-quarters of the pollutants, station B removes one-third of the pollutants, and station C removes half of the pollutants.
   (a) What fraction of the pollutants will be removed after the gas passes through all three stations?
   (b) Does it matter in which order the gas passes through the three stations? Explain.
   (c) If untreated exhaust contains 4,500 ppm of pollutants, what will be the concentration of pollutants after the gas has been cleaned by all three stations?
   (d) A problem with station B is causing it to work at 50% efficiency. What percent of the pollutants will be emitted into the atmosphere after treatment by all three stations?
Greenhouse gases are any gases that absorb infrared radiation and then emit that stored energy as heat. By trapping infrared radiation they contribute to warming of the atmosphere through a process known as the greenhouse effect.

1. Water Vapour (H₂O)

Water vapour is the largest contributor to the greenhouse effect. The amount of water vapour in the atmosphere is determined primarily by the water cycle rather than by human activity. Water evaporates from the surface. Eventually this water condenses and returns to the surface as precipitation. Once global warming begins to occur the amount of water vapour becomes subject to a positive feedback effect. The warmer the air gets the more water vapour it can hold and the more evaporation will occur.

2. Carbon Dioxide (CO₂)

Carbon dioxide is responsible for a majority (60%) of the anthropogenic greenhouse effect due to human activity. A small amount of carbon dioxide exists naturally in the atmosphere about 0.035% of all gases in the atmosphere. Humans also produce a lot of carbon dioxide. The United States produces the most on a per capita basis (over two tons per person annually). Visit the American Forests website if you want to know how much carbon dioxide you produce. To some extent the amount of carbon dioxide in the atmosphere is determined by the carbon cycle. The oceans and plants absorb some carbon dioxide, but human activity produces it faster than it can be absorbed. Carbon dioxide may last 50 to 200 years in the atmosphere before being “scrubbed out” through rainfall as weak carbonic acid.

Sources

- **Fossil Fuel combustion**: The burning of fossil fuels (coal, oil, and natural gas) is the largest single source of greenhouse gases from human activity. Coal produces the most carbon dioxide of all the fossil fuels.
- **Deforestation**: Deforestation is the second largest source of greenhouse gases due to human activity. Destruction of the forests can release the carbon stored in trees if they are burned up. If trees are not replanted they cannot absorb carbon dioxide in the future.
- **Cement manufacturing**: Carbon dioxide is produced during the manufacture of cement. When lime (CaCO₃), an ingredient in
cement, is heated carbon dioxide is released into the air.

3. Methane (CH$_4$)

Methane, a hydrocarbon also known as natural gas, is used as a fuel in homes and industry.

**Sources**

- **Livestock:** Livestock produce methane through the process of “enteric fermentation” of food in their digestive tract, and through their manure. Cattle are the greatest source of methane through these processes, followed by swine.
- **Agriculture:** The main source of methane in agriculture is flooded rice paddies where microorganisms and bacteria decompose anaerobically in the soil.
- **Waste Dumps:** The anaerobic decomposition of wastes in land fills and dumps results in methane. Sometimes the methane is collected and used as a fuel.
- **Coal Mining and Natural Gas Production:** Methane can leak when coal is mined. Sometimes it leaks or is deliberately vented during natural gas production.
- **Wetlands:** The microorganisms and bacteria in wetlands create methane when they decompose anaerobically in the soil.

4. Other Greenhouse Gases

- **Nitrous Oxide (N$_2$O):** This greenhouse gas enters the atmosphere from fertilizers used in agriculture, and from automobile exhaust.
- **Chlorofluorocarbons (CFCs):** A very potent greenhouse gas. It is used as a propellant in aerosol cans, in creating foam plastics, coolant in refrigerators and air conditioners, as a solvent in cleaners, and as an ingredient in fire extinguisher materials. Because it destroys ozone, which is also a greenhouse gas, some of its contributions to the greenhouse effect are balanced out. Recently the levels of CFCs in the atmosphere have stabilized thanks to the Montreal Protocol of 1987 which restricts their use.
- **Ozone (O$_3$):** This much publicized gas is known more for its ability to block harmful ultra-violet radiation than its ability to absorb infrared rays, but is nonetheless a greenhouse gas. The amount of ozone is declining in the upper atmosphere but is found in increasing amounts near the earth’s
Focus Questions: Greenhouse Gases

Work together to answer the following questions in point form:

1. Define greenhouse gases.

2. Determine which gas is the largest contributor to the greenhouse effect. Explain how it contributes to a natural warming of Earth.

3. Identify the sources of CO₂ that contribute to the anthropogenic component of the greenhouse effect.

4. Suggest how livestock add to the greenhouse effect.

5. Contrast the contribution of CFCs to global warming to that of high atmosphere ozone loss.

6. Contrast the present concentration of greenhouse gases with the pre-industrial concentration. Hypothesize about why these specific changes have occurred.
Background Information: (Summary) Today humans release around 5 billion tonnes of carbon to the atmosphere every year through fossil burning and cement manufacture. Approximately another 1.36 billion tonnes per year are released through land use changes such as deforestation. These releases result in another increase of atmospheric CO₂ about 1% per year. This increase is the most plausible explanation for the warming trend we have seen since the mid-19th century.

Problem: Ask students to hypothesize: Which type of vehicles are the biggest sources of CO₂ emissions? Is the amount of CO₂ they produce linked to certain characteristics of the vehicles, such as engine size, fuel consumption, or type of transmission (manual or automatic)? Record different hypotheses.

Hypothesis: Before doing the experiment, make an educated guess about the outcome.

Briefly explain the reasoning behind your hypothesis.

Investigating the Sources of Greenhouse Gases Observations:

1. **Determine and explain** whether the cars that emit the highest level of CO₂ have anything in common.

2. **Determine and explain** whether the cars that emit the lowest level of CO₂ have anything in common.

3. a. **Name** the type and year of automobile that emitted the highest level of CO₂ (of those you chose to investigate).
b. The lowest?

4. Verify whether the automobile with the largest engine displacement also has the greatest CO$_2$ emissions.

5. Describe your level of confidence in the accuracy of this data.

6. Suggest a better way, if there is one, to do this investigation.

7. List and explain our sources of experimental error (if any).
Conclusions:

Part A:
1. Was your hypothesis supported by this experiment? **Explain** why or why not.

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2. **Suggest** ways that Canada can encourage people to drive less or use more efficient means of transportation as a way to reduce greenhouse gas emissions such as carbon dioxide.

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Part B:
1. **Calculate** how many km your chosen car can go on 1 litre of gasoline based on the data at <www.fueleconomy.org>.

_________________________________________________________________________________

2. **Given that** 10 kg of CO₂ are produced per 4 litres of gasoline consumed, how many kg of CO₂ did your car produce from one tank of gas?

_________________________________________________________________________________

3. **Calculate** how many kg of CO₂ your car would produce in a year if you travel 300 kilometres per week.

_________________________________________________________________________________
Given that global warming is likely to be a reality over the next 200 years, human beings will have to make many changes in order to adapt to a warmer climate. However, this is nothing new. Over the course of history people have had to adapt to many different changes in their living environment. Keeping this in mind, agree or disagree with the following statement in a response of about 250 words: Given the adaptability of human beings, the estimated future troubles caused by the effects of global warming are overestimated.

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Climate Change and Wildlife

Climate change caused by increasing emissions of greenhouse gases will affect the health and diversity of plants and animals in virtually every place on earth—and Canada’s north is expected to be among the hardest hit.

Increases in surface temperatures, precipitation and the frequency of severe weather events, a rise in sea level and a decrease in sea-ice will cause many habitats to change ten times faster than they have since the last ice age.

These changes will force species to adapt or shift their ranges more quickly than they ever have in the past, or die off and be replaced by more adaptable species. Those at greatest risk of extinction are species that require different habitats at different stages of their lives, like amphibians, or that inhabit areas that are physically restricted, such as islands, isolated lakes, and mountain tops.

In keeping with predictions that changes will be greatest at high latitudes and altitudes, Canada’s low Arctic tundra and Muskwa–Slave Lake boreal forests are among the most vulnerable regions in the world. Surface warming in the Arctic is expected to be significantly higher than in the rest of Canada and the world. The geographic ranges of plant and animal species are also expected to shift northward and upward in altitude, increasing competition with species already found in the area.

It is expected that the tundra will shrink by as much as two-thirds as other plant species move in to replace native vegetation. Most climate change scenarios suggest that the zone suitable for boreal forests could be displaced as much as 550 kilometres northward over the next century.

Although milder winters could enhance the reproductive capacities of caribou and other species, heavy winter snows and the melting and freezing of snow cover could force them to expend more energy feeding or prevent them from reaching their food. Ice and snow layers may also trap carbon dioxide in the burrows of small mammals, and either poison them or force them to the surface.

Warmer temperatures could create other problems for animals by causing changes in the timing and extent of sea-ice cover. Polar bears in western Hudson Bay, which rely on sea-ice for hunting seals, will disappear from the region if predictions that the ice will melt completely by 2100 come true. Earlier breakup of freshwater ice on lakes and rivers in spring could affect migration patterns, and increase the likelihood of drowning.

Reductions in sea ice also mean reductions in the ice edge around open water. This important part of the marine ecosystem supports a large population of fish, which provide food for a variety of marine birds and mammals.

(continued)
Warming makes ecosystems more vulnerable to disease, parasites and insects and other pests. The earlier emergence of mosquitoes in northern Hudson Bay has already resulted in the death of some incubating seabirds, and forced others to abandon their nests.

Coastal erosion, Prince Edward Island.

Although Arctic ecosystems are expected to be the hardest hit, more southern regions of Canada will also be affected. Fish on both coasts and in rivers, lakes and streams are expected to head further north. Changes in river and stream runoff, due to less snowpack, an earlier ice break-up, a stronger spring flow, and a reduced summer flow, will also greatly impact aquatic ecosystems.

Both the Atlantic and Pacific coasts will see a rise in sea level if global warming continues, resulting in an increase in coastal erosion and flooding, and a loss of coastal wetlands. Fire patterns are expected to change in most of Boreal Canada, affecting forestry practices and habitat available to wildlife. As temperatures increase, crops such as wheat can be grown farther north, causing further losses of wildlife habitat.

Despite projected increases in precipitation, scientists expect there will be a decrease in water availability in many southern regions of the country—particularly the prairies—due to increased evaporation caused by warming. This will further exacerbate water level problems in aquatic ecosystems such as wetlands and marshes, and may cause some to dry up completely.

Although there is no way to predict exactly how certain species will react to climate change, our global biodiversity will be altered irreversibly unless immediate steps to reduce national and international emissions of greenhouse gases are taken. Since the burning of fossil fuels is a primary source of the greenhouse gas carbon dioxide, individuals can take action to reduce climate change by cutting down on fuel consumption—at home, at work, and on the road.
The single most prevailing ___________ responsible for the endangerment of species today is habitat loss and degradation. In fact, about 60 __________ of species that the Committee on the __________ of Endangered Wildlife in Canada (COSEWIC) __________ as being at risk are __________ by habitat problems. If a species cannot find suitable conditions in which to live, it simply will not __________.

As the human population grows, development increases and spreads over the landscape to satisfy human wants and needs. The __________ of houses, buildings, and roads; logging of vast tracts of forest for paper and building materials; mineral __________ and __________ of wild habitats into agriculturally productive fields all mean that habitat for wild species shrinks. And when habitat shrinks, species are squeezed out.

A habitat does not have to be totally destroyed to make it unsuitable for some species. The mere presence of people and associated disturbance can cause some species to __________ certain habitat or prevent them from breeding successfully.

And human presence __________ species in many other ways as well. __________ on roads are particularly dangerous to some snakes that like to bask on the warm pavement and to some birds that tend to feed near roadways. The lights from __________ and from street lights and buildings have been shown to seriously __________ some moth populations.

Control of water flow in rivers, usually for the __________ of electricity, changes conditions downstream, often rendering these water bodies unsuitable for certain species, or __________ their ability to travel to parts of the system they need for feeding or to reproduce. The building of dams or tilling of soil near rivers and streams causes siltation and increases water turbidity, __________ responsible in the __________ of some fish and mollusc populations.

Word List:

- abandon
- affect
- affected
- affects
- construction
- conversion
- decline
- extraction
- factor
- factors
- file
- generation
- identified
- percent
- restricts
- status
- survive
- vehicle
- vehicles
The single most prevailing factor responsible for the endangerment of species today is habitat loss and degradation. In fact, about 60 percent of species that the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identified as being at risk are affected by habitat problems. If a species cannot find suitable conditions in which to live, it simply will not survive.

As the human population grows, development increases and spreads over the landscape to satisfy human wants and needs. The construction of houses, buildings, and roads; logging of vast tracts of forest for paper and building materials; mineral extraction; and conversion of wild habitats into agriculturally productive fields all mean that habitat for wild species shrinks. And when habitat shrinks, species are squeezed out.

A habitat does not have to be totally destroyed to make it unsuitable for some species. The mere presence of people and associated disturbance can cause some species to abandon certain habitat or prevent them from breeding successfully.

And human presence affects species in many other ways as well. Vehicles on roads are particularly dangerous to some snakes that like to bask on the warm pavement and to some birds that tend to feed near roadways. The lights from vehicles and from street lights and buildings have been shown to seriously affect some moth populations. Control of water flow in rivers, usually for the generation of electricity, changes conditions downstream, often rendering these water bodies unsuitable for certain species, or restricts their ability to travel to parts of the system they need for feeding or to reproduce. The building of dams or tilling of soil near rivers and streams causes siltation and increases water turbidity, factors responsible in the decline of some fish and mollusc populations.

PRIVATE PER-CAPITA CONSUMPTION, 1998
Expressed as US$

Less than 200
Insufficient data

Private consumption, measured by the World Bank, is the value of all goods and services, including durable products, purchased or received by households as income in kind.

CONSUMPTION GROWTH RATES AND GDP, 1990-98
The highest consumption growth rates


Natural resources and wastes

POPULATION, consumption and technology impact on the environment by way of two major types of human activity. First, we use resources. We occupy or pre-empt the use of space, and so modify or remove entirely the habitats of many wild species. We extract resources – growing food, catching fish, mining minerals, pumping groundwater or oil. This affects the stock of resources available for humans and for other species in the future.

Resources fall into two main categories. Renewable resources like water or fish are replenished naturally. Non-renewable resources like oil or iron ore have a limited stock that is not replenished, except on geological timescales of millions of years.

Second, we dump wastes – not just those that consumers throw away, but all the waste solids, liquids and gases that are generated from raw material to final product. These affect the state of land, groundwater, rivers, oceans, atmosphere and climate.

Resources have traditionally been the main focus of concern about the impact of population and consumption on the environment. Frequent warnings were issued that we faced massive famines, or that we would “run out” of essential fuels and minerals. More recently it has become apparent that more serious, more immediate and more intractable problems lie in the global threats that derive from our wastes.

NON-RENEWABLE RESOURCES

Ultimately, all non-renewable resources on Earth are limited; if used constantly they must sooner or later run out. So far, however, the threatened exhaustion of non-renewable resources has not happened, thanks to market mechanisms which have ensured successful adaptation.

When shortages of any mineral resource begin to be felt, prices rise. This stimulates more exploration and research, and makes it economical to develop more expensive technology, and to exploit reserves that are more costly to work. Manufacturers find ways of making do with less, recycling increases, and cheaper substitutes are found.

Due to these mechanisms, the projected lifespan of many minerals has remained more or less level or in some cases grown with time, despite dramatic increases in use. In 1989, for example, recoverable reserves of oil and natural gas liquids were enough to cover 41 years of production at current rates. Nine years later they were enough to cover 43 years. Recoverable reserves of natural gas were enough to cover only 23 years of production in 1989; by 1998 this had grown to 57 years. Recoverable reserves of coal did fall, but were still sufficient for more than two centuries of production.

Prices are a good indication of impending shortage, and the prices of minerals have declined in real terms over the past four decades. In constant prices, between 1980 and 1996 the price of metals and minerals fell by an average 41 percent, while that of oil fell by 65 percent.

Of course, this conjuring trick cannot go on forever. But in modern times the human race has not run into shortages of any key non-renewable resource that has actually constrained the end use to which that resource was put. The mechanism of adaptation, based on free markets, resourceful

(continued)
Natural Resources and Wastes (continued)

companies, continual research and canny consumers, has worked very well in this sphere, and there is no strong reason to believe it will not continue to do so.

This is not to say that our use of non-renewable resources is problem-free, but the major difficulties arise from the wastes created in producing and consuming these resources. Extracting and processing fossil fuels and other mineral resources on an increasing scale produces water and air pollution as well as solid wastes.

RENEWABLE RESOURCES

Renewable resources like freshwater, soil or wild fish stocks are much more problematic than non-renewable resources, because most of them are vulnerable to human overuse or pollution.

By definition, renewable resources are replenishable by nature – yet replenishment is not guaranteed. Renewal occurs only if they are given the chance to renew. If we exploit them faster than they can renew themselves, they deplete or degrade. The majority of renewable resources, including the most basic ones needed for human survival – land, food and water – are now affected by human overexploitation or pollution.

FOOD AND LAND

The oldest question about human population and the environment was posed by Malthus. Can agricultural production keep up with potential human population growth? Malthus’ answer was no: agricultural production can only increase arithmetically (3+3+3=9) whereas population can increase geometrically (3x3x3=27).

It followed, Malthus argued, that the human population would always be kept in check by the food supply. In reality, the reverse has usually been the case: market mechanisms have worked to expand the food supply in line with demand, and this expansion has more than matched the growth of the human population.

LAND AVAILABILITY

Malthus’ basic outlook still dominates the popular view, and some recent trends provide material for renewed concern.

In most parts of the world, cultivated land has not been expanding in line with population growth, so the amount of farmland per person has been declining. The area per person has declined only slowly in developed countries, from 0.65 hectares in 1965 to 0.51 hectares 30 years later. In developing countries, where population growth is faster, the area per person fell from 0.3 to 0.19 hectares over this same period.

The steepest fall was in Africa, where the extension of the farmed area has lagged far behind population growth. In 1965, Africa had half a hectare of cultivated land per person, but this dropped dramatically to a mere 0.28 hectares in 1995. If expansion continues at the same rate as it did between 1965 and 1995, and the UN’s medium population projection is realized, then by the year 2040 Africa will have only 0.15 hectares of farmland per person. This is less than Asia had in 1995, and Asia has fewer problem soils and climates, and far more potential for irrigation. Many parts of Central, Southern-Central and West Africa still have abundant land, but much of this is subject to severe soil, climate or disease constraints. It seems likely that many African countries will run into serious land shortages.

FOOD AVAILABILITY

Overall, cereal production has not been keeping pace with population growth for the past decade and a half. The amount of grain available per person rose fairly steadily from 135 kilos in 1961 to 160 kilos in 1992, but since then has averaged about 157 kilos.

We must be cautious before concluding that we are seeing the harbingers of a coming global food crisis. If these developments were really reducing the ability of farmers to meet market demand then we would expect to see rising food prices and declining food intakes.

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Yet neither of these things is happening. On the contrary, allowing for inflation, the prices of most cereals have been on a falling, not a rising, trend. In constant 1990 US dollars, the prices of wheat and maize in 1996 were 40 percent lower than in 1980 and 50 percent lower than in 1960.

Nor was there any overall decline in average food intakes per person. Average daily calorie intake in 1998 was 2,790 calories, the highest on record, following fairly steady growth from 2,295 in 1963. Average daily protein intake was 74.9 grams, again the highest on record, up from 63 grams in 1961.

Improvements were notched up in all developing areas, most rapidly in Asia, but also in Africa, even though average calorie and protein intakes remained low.

How can we explain the simultaneous drop in cereal production per person and the rise in dietary intakes? The simple answer is that people do not live by bread alone: calorie intakes from cereals have been more or less static since 1984. The increase has come rather from meat and fish, oils and other vegetable products. Global meat intake per person grew steadily from 24 kilos per person in 1963 to 37 kilos in 1998.

Within the cereal sector it is likely that cereals are being used more efficiently at every stage, with lower losses in storage and processing between harvest and table. Cereals used for livestock feed are increasingly being replaced by soybeans, and soybean production has been growing rapidly.

The continued improvement is a sign that markets are by and large matching production with effective demand. People are also adapting their diets as a result of health and environmental concerns. For example, all the 1963-98 increase in meat consumption per person came from pork (up 71 percent) and poultry (up 237 percent). It takes considerably less cereal and land to produce a kilo of chicken or pork than a kilo of beef.

Moreover, people's need for dietary energy is, on average, declining. Farming has the highest calorie requirements, followed in turn by heavy industry, light industry, services, and then non-employment. The general trend in all societies is to have higher and higher percentages of people represented in sectors with lower food energy needs.

Barring severe climatic change, it is very unlikely that we face catastrophic food shortages at global level. Research has shown that with relatively modest improvement in regionally specific agricultural practices, the world could feed 10 billion people with current land and technology levels.

Persistent problems
The agricultural sector has been very successful in raising food production since 1945 to meet growing populations and consumption levels, but this has often been at the cost of exporting problems to other ecosystems. High levels of fertilizer application have caused water pollution and eutrophication. The expansion of farmland has been to the detriment of wildlife habitat and biodiversity, which has been further harmed by pesticide use.

Population growth is directly implicated in all of these trends. For example, the area of land needed for any given crop is the product of population, multiplied by consumption per person, multiplied by the area needed to produce each unit of consumption. This latter element is the result of farming technology. Where this has been able to increase yield faster than the growth in population multiplied by consumption, the area needed for farming has fallen over time. But where yields have not kept pace, the area of farms and pastures has increased at the expense of forests and other wild habitats.

Unsustainable soil and water management practices have caused land degradation. A major assessment found that by 1990 soils had degraded on 38 percent of the world’s cropland, 21 percent of pasture and 18 percent of forests. Productivity has declined significantly on 16 percent of agricultural land in developing countries. One recent estimate suggested that cropland productivity is 12.7 percent lower than it would have been without human-induced soil degradation.

Serious problems of food production will also continue in localized areas and in individual countries. These include many countries in sub-Saharan Africa and some individual countries outside Africa such as Bolivia, Haiti and Afghanistan. Many countries that cannot produce enough food
Natural Resources and Wastes (continued)

**Overview**

Natural resources and wastes

For their own needs can pay for food imports by exporting manufactured goods or services. But many marginal areas, and many poor food-deficit or landlocked countries, especially in Africa, are badly placed to develop competitive industries or services.

There are millions of people who do not get enough food for a healthy, active and productive life. The estimated incidence of malnutrition in developing countries has halved from 35 percent of the population in 1969-71 to 17 percent in 1995-97, but because of the growth in population the absolute drop in numbers from 917 million to 790 million, has been much more modest.

The numbers of malnourished will probably continue to decline slowly, while still remaining unacceptably high. However, malnutrition is not a sign that not enough food is available at global or even national level. It is a symptom of poverty and inequality – the poor lack enough money to buy, or enough good land to grow, sufficient food for the needs of their families.

Reducing the number of malnourished means taking measures to create jobs, redistribute land more equitably, and increase the productivity of small and marginal farms through targeted agricultural training, crop breeding, and soil and water conservation programs. Once the poor’s own resources have been boosted, they themselves will grow, or the world market will produce, enough food to meet their effective demand.

**Freshwater**

We live on a planet whose surface is mainly ocean, but freshwater is a much more limited resource. Some 97 percent of all water is salty, currently useless for drinking or agriculture.

Most freshwater is locked up in ice and snow and in aquifers too deep to tap, and the rest is very unevenly distributed. Equatorial regions and some northern latitudes have a surplus. Dry areas in between, including much of Africa, have supplies that are too scarce or too uncertain.

Freshwater is crucial for survival, for health, for agriculture, for industry, and for comfort and leisure. But the freshwater resources of any country are limited. There is only so much to go round: the larger the population, the less there is for each person.

In some countries, shortages are already biting. According to Swedish hydrologist Malin Fahlenmark, a minimum of 1,700 cubic metres of renewable freshwater is needed per person per year to avoid serious problems. Below this level, a country is in a situation of water stress, when water supply problems may become chronic and widespread. There may be a need for long-distance water transfers, reuse of treated waste water, or supply interruptions in dry periods.

Where supplies fall below 1,000 cubic meters per person per year, a situation of water scarcity applies, and a society will face difficult choices between agriculture, industry, personal health and convenience which will hamper development.

In 1995 some 436 million people were already suffering water scarcity or stress. Even these levels of water shortage are causing severe development problems in some areas. There are conflicts among farmers and between farming and urban needs, and heightening tensions between countries dependent on the same resources, such as Israel and Jordan; Turkey, Syria and Iraq; India and Bangladesh; Sudan and Egypt. Saudi Arabia, Israel and the whole of North Africa from Egypt to Mauritania are already withdrawing groundwater faster than it can replenish itself. Yet these countries face population increases of between 52 and 152 percent over the next 50 years.

Different population futures make a considerable difference to water futures. An analysis of the UN’s 1996 population projections has estimated numbers likely to be suffering water shortage in the future. By 2050, on the medium projection, the number of people in countries suffering water stress or scarcity will have risen to 4 billion. If the UN’s law population projection could be achieved, then the total population in countries facing water scarcity or stress would amount to only 2 billion. By contrast, if the world were to hit the high projection, this total would be 6.8 billion.

**Pollution and Wastes**

Perhaps the most intractable threats to the globe today relate as much to what we waste as to what we consume. Pollution places a mounting burden on local and planetary ecosystems. Ultimately it is (continued)
exported to the global commons: the oceans and atmosphere, where our understanding of interactions is still inadequate. Sustainable management strategies are complex to devise and politically difficult to introduce.

In the process of making the end products we actually use, our machines dig up, churn over, swallow up and spew out gigatons of material. One study found that some 93 percent of materials used in production do not end up in saleable products but in waste, while 80 percent of products are discarded after a single use\(^7\).

The result is a veritable avalanche of materials. In 1995, for example, the world produced 1.42 billion tons of cement – about a quarter of a ton for every man, woman and child on Earth. Some 2.57 billion tons of sand and gravel were produced in the 52 countries for which data are available\(^8\).

Figures on carbon dioxide (CO\(_2\)) illustrate how the waste deluge has grown. Back in 1750, the human race produced only 11 million tons of CO\(_2\) from fossil-fuel burning and cement production. A century later this had grown 18-fold to 198 million tons, and in another century a further 30-fold to around 6 billion tons. By 1995 our annual CO\(_2\) output had multiplied by another four times to reach almost 24 billion tons\(^9\).

These material flows have left deepening scars on the planet. The solid wastes that are not incinerated deface or pollute localized areas and water courses. Liquid and gaseous pollutants are more insidious and spread invisibly across the whole globe.

Humans raised the level of CO\(_2\) in the air from 280 parts per million in pre-industrial times to 363 parts per million in 1996. Over this same period we raised methane concentrations by 145 percent. There were no gaseous chlorine in the atmosphere before industrial times. By 1996 there were 2,731 parts per trillion, most of these produced in the 20th century\(^9\).

Significant traces of organic and metallic pollutants are now found in the deepest marine sediments, in the remotest glaciers and icecaps, and in the fat of arctic mammals. Studies of human breast milk have found traces of more than 350 contaminants, including 87 dioxin and dioxin-like compounds and 190 volatile compounds\(^7\).

The rise of pollution and waste is not inexorable. Water and air pollution usually increase in the early stages of economic development, but once a certain income threshold has passed, people tend to value environmental quality more highly and have the resources to pay for protection measures. In most developed countries there have been significant reductions in emissions of lead, sulfur dioxide (SO\(_2\)) and particulates (soot), and widespread improvements in water quality in rivers and around beaches. These are cases of immediate hazard, or easily noticeable local problems, or substances that have been the subject of intense media publicity, where political pressure for change is strong\(^9\).

But even in rich countries waste emissions with less immediate, less visible or less dramatic effects have not been the subject of effective controls. The same is true where the costs are exported over a vast area or over the whole globe, or where remedial action would be costly and might affect powerful business interests or important groups of voters. These include, for example, emissions of the greenhouse gases CO\(_2\) and methane.

Population is always a factor in waste and pollution, along with consumption and technology. The level of production of wastes or pollutants is the product of the number of people, the amount each person consumes, and the amount of waste created for each unit of consumption in the whole process from production and packaging to the consumer and his or her dustbin or sewage outlet.

Several efforts have been made to identify the relative shares of responsibility for rising pollution. Environmentalist Barry Commoner studied examples from the United States between 1946 and 1968. Population growth accounted for only 14 to 18 percent of the increase in synthetic organic pesticides, in nitrogen oxides and in tetraethyl lead from vehicles. It was responsible for only 7 percent of the increase in non-returnable beer bottles and a mere 3 percent of the increase in phosphorus from detergents. In almost every case, technology was the dominant factor. A later study by Commoner of nitrates, cars and electricity in 65 developing countries came to similar conclusions\(^8\).

(continued)
Clearly, technology is always implicated, and in many cases it may be the prime culprit. However, Commoner chose only cases where technological change was rapid. There are other cases where population or consumption are dominant, such as increased methane emissions from livestock or paddy fields. In more and more cases, technological change is a downward pressure, working to reduce our output of wastes, while growth in population and consumption continues to gear it upwards.

Studies of changes in air pollutants (SO\textsubscript{2}, nitrogen oxides, smoke and CO\textsubscript{2}) in countries of the Organisation for Economic Co-operation and Development (OECD) between 1970 and 1988 showed technology as a downward pressure in all four cases – mainly through increased energy efficiency in the case of CO\textsubscript{2} and nitrogen oxides, and through cleaner technology in the case of SO\textsubscript{2} and smoke. Population growth was responsible for a quarter of the upward pressure on emissions, while consumption was responsible for three quarters\textsuperscript{a}. 

\textsuperscript{a}
Our Footprints—They’re All Over the Place

By David Schaller

The word “footprint” offers us many richly symbolic images: Neil Armstrong’s “one small step”; Crusoe’s Friday; the fog that comes “on little cat feet”; the Olduvai tracks of “Lucy;” and yes, even the caution expressed by my elementary school teacher to stay away from “Big Feet”—the junior high kids on the playground who loved to torment first and second graders.

Let’s now look at another dimension of footprint, one equally symbolic and full of meaning to those concerned about environmental protection. If asked who had the bigger “footprint”—an adult female living somewhere in the developing world or your average eight-year-old American child—most of us would select the adult female. Now, insert the word “ecological” in front of “footprint” and repeat the question. The answer—in a moment.

The concept of an “ecological footprint” is an almost intuitive measure of the impact of individuals or societies on nature. It provides a simple yet elegant accounting tool that can help us see the impact of human consumption patterns on the earth. What we do about this information, of course, is the essence of a much larger policy debate.

As we live out our lives, we consume resources and we discard wastes. Each bit of consumption and generation of waste demands a certain amount of productive land and water. The amount of productive land and water needed to support the production of resources we consume and absorb the wastes we create can be considered as our Ecological Footprint. Individuals, households, cities, regions, nations—all can be measured as to their Ecological Footprint.

In their compelling book, *Our Ecological Footprint*, William Rees and Mathis Wackernagel lay out the approach and apply the methodology that is changing the way we look at broad issues of sustainability, ecological carrying capacity, environmental protection, and even social justice. Here, in a nutshell, is the essence of Ecological Footprint analysis applied to the world in which we currently live.

The ecologically productive land of the world currently totals some 3.6 acres for each of the 5.95 billion people now living. The average North American lifestyle currently requires almost 10 acres of ecologically productive lands to supply its resources and absorb its wastes. This tells us immediately that the ecological demands of average citizens in rich countries exceed per capita supply by a factor of three. Someone, lots of someones, somewhere are going without.

Said another way, if everyone currently alive were to consume resources and generate wastes at the pace of the average citizen in the United States (or Canada, or Western Europe, or Japan) we would need three planets in order to live “sustainably.” For the projected global population of nearly 10 billion people in the year 2040 to enjoy the North American lifestyle of today, *a total of six planet Earths* would be needed.

(continued)
Neither scenario seems likely. These projections assume that there will be no improvements in either resource use efficiency or waste elimination techniques. However, we know that improvements in both are happening. The big question is whether they are happening fast enough!

It is, of course, in the inefficiency of resource production that wastes are created and our “environmental” problems manifested. But if we are not looking hard at how and where our “footprint” is being placed, we are missing the chance to do something about those inefficiencies. In looking at the resource consumption and waste generation practices of the average North American, it becomes clear that via trade and technology we have appropriated the ecological capacity of large areas outside our own national boundaries. We have, in fact, exported much of our “footprint.” In their book, Rees and Wackernagel take us through the number crunching and data sources used to calculate footprints for our cities, our nations, and us. If anything, they significantly understate the resource demands needed to support consumption patterns and waste disposal practices.

The challenge posed to all of us is to find the means, and quickly, to reverse the “overshoot” condition we are already in with respect to human impact on the planet. Some would prefer to start with that hypothetical adult female in the developing world whose fertility promises/threatens to add billions more footprints to the earth’s surface in the coming decades. The accounting tool of Ecological Footprints suggests, however, that the place to begin is with the resource consuming, waste generating “average” inhabitant of North America, western Europe, and Japan. The answer to the question posed earlier? It is the eight-year-old child (not to mention his parents, neighbours...) who now has the “Big Feet.”
Today, humanity’s Ecological Footprint is already over 30 percent larger than what the world can offer. This means we are overusing the planet and liquidating its ecological assets. Examples of our overuse include deforestation, collapsing fisheries, and the buildup of heat-trapping carbon in the atmosphere. At the same time, a significant percentage of the world’s people do not have enough resources to meet basic survival needs.

To overcome this sustainability challenge, we need to do a better job of budgeting our planet’s limited resources. Nature provides an average of 2.1 hectares (5.3 acres) of biologically productive space for every person in the world. By 2050 that available space will be reduced to 1.4 hectares (3.5 acres) per person if predictions of global population are accurate. Also, some of this area must be set aside for the estimated 10 million other species on the planet.

On average, people use 2.8 hectares (6.9 acres), but there is a wide range. In some countries, the average is as low as 0.5 hectares (1.2 acres), while others use as much as 13 hectares (32 acres) per person. Even within any given country, individuals’ footprints vary widely.

By more carefully tracking human impacts on the Earth’s resources, we can learn what needs to be done in order to protect our natural assets. We can all be part of the solution. Together, we can reshape the global economy in a way that will allow all people to meet their essential needs without destroying the limited capacity of our planet.
Population and natural resources

While many of the environmental impacts of humankind closely map demographic indicators, this leaves out one vital component: consumption. The per-capita consumption of key natural resources varies hugely around the world. Typically, but not universally, the citizens of rich industrialized nations use more of the world’s resources and produce more waste. Sometimes they thereby deplete their own environments; sometimes other people’s.

For many resources, the United States of America is the world’s largest consumer in absolute terms. For a list of 20 major traded commodities, it takes the greatest share of 11 of them: corn, coffee, copper, lead, zinc, tin, aluminum, rubber, oil seeds, oil and natural gas. For many more it is the largest per-capita consumer.

A typical example is meat. China, with the world’s largest population, is the highest overall producer and consumer of meat, but the highest per-capita consumption in the world is that of the United States. The average United States citizen consumes more than three times the global average of 37 kilos per person per year. Africans consume less than half the global average, and South Asians consume the least, at under 6 kilos per person per year.

Other resources are used much more variably, depending on local circumstances. Fish, for instance, has been a cheap source of protein for hundreds of millions of poor people wherever it has been available. The highest consumption levels are in some of the world’s poorest states, such as the Maldives or Kiribati, where fish is plentiful. Per-capita consumption is also very high in rich nations with well-established fishing traditions – 91 and 66 kilos per capita in Iceland and Japan respectively; way above the global average of 16 kilos per capita per year.

Some consumption patterns reflect the rate of industrial, urban and infrastructure development rather than simply current wealth. Cement, for instance, has in recent years been used in greatest quantities in the rapidly growing Asian economies. The top three places for per-capita use in 1996 were occupied by the Republic of Korea, Taiwan and Malaysia. Each used more than twice as much cement per capita as the United States and four times as much as a typical established industrial nation with well-developed infrastructure, such as the United Kingdom.

Water is also heavily used in a number of developing countries. It is a key strategic resource whose location is largely fixed, like land, but for which many countries rely on their neighbors. Egypt, for instance, relies for 97 percent of its water on flows that originate outside the country, mostly upstream on the Nile. Sudan, also on the Nile, is in a similarly vulnerable position, as are the Netherlands at the mouth of the Rhine, Cambodia on the Mekong, and Syria and Iraq on the Euphrates. All rely on foreign sources for the bulk of their water.

Water use is often as high or higher in poor, arid countries as in rich nations. When precipitation is lowest, demand for crop irrigation is typically highest, and where water-hungry cash crops are grown as well as food, the demands are higher still. When the country is in a poor state of (continued)
development, with dilapidated infrastructure, then water use can be immensely inefficient, producing the highest water use of all, as illustrated by the rates in the arid, cotton-growing central Asian states of the former Soviet Union. During the 1990s Turkmenistan withdrew more than 5,000 cubic meters per person per year, with Uzbekistan, Kyrgyzstan, Kazakhstan, Tajikistan and Azerbaijan all withdrawing 2,000 cubic meters or more per person per year. By comparison, per-capita withdrawals in the United States were around 1,800 cubic meters, in France 650 and in the United Kingdom 200.

But for some resources, consumption depends upon the end use to which that resource is put, as typified by wood. While rich nations use more of it in the form of paper and packaging, poor predominantly rural nations rely on wood to a greater extent for construction and particularly for fuel. Finland, which produces large quantities of paper, is the greatest per-capita user of raw timber, but African and Asian countries are the largest users of fuelwood. Japan, though widely criticized for its harvesting of tropical timbers from Southeast Asian rainforests, lies well down the global list of timber consumers.

Two trends are causing nations, corporations and individuals to reassess their use of natural resources. Since the 1970s, there has been an increasing realization that many resources, notably metals and fossil fuels, will one day run out. And since the 1980s in particular, there has been growing concern about the environmental downside of their profligate exploitation, largely with respect to pollution and the degradation and conversion of land.

Some stories of inefficiency and extravagance have become notorious. It takes the mining of 6 tons of rock to produce a pair of typical gold rings. Only 2 to 3 percent of the energy produced by burning coal in a power station is eventually used to light a bulb or boil a kettle, because of inefficiencies at every stage of its conversion to electricity, its transmission and ultimate use. The average European uses 130 kilos of paper a year – the equivalent of two trees. The average American uses more than twice as much – a staggering 330 kilos a year. The paper and board industry is the United States’ third largest source of pollution, while its products make up 38 percent of municipal waste.

Both governments and companies are now increasingly adopting strategies to reduce their environmental “footprint” on the world. They are doing this by reducing the amount of materials and energy used in providing their services (whether a car or a kilowatt of energy, a meal or a megabyte of information), and by reusing and recycling materials where possible. Much has been done. The gasoline consumption of the average automobile in the United States has halved since the 1970s. During the same period most European homes have been insulated to reduce heat loss by 50 percent or more. Some commercial farmers, particularly in the United States, have doubled the crops they grow with a given amount of irrigation water by using sub-surface drip irrigation.

Much more could be done at no extra cost. Modern technologies – plastic and carbon fibre, optical fibres, e-mail, drip irrigation, electronic systems controls – can all aid the process by making manufacture and communications more efficient and by substituting abundant materials for scarce ones.

Organized recycling, while not invariably energy-efficient, can also be beneficial. Growing concern at the damage to natural forests from paper production has led to a surge in paper recycling. Globally, 43 percent of paper fibre is recycled, a figure that rises to 46 percent in the United States and to 72 percent in Germany. In Britain the film processing industry reuses 5 million film cassettes a year, retailers reuse 40 million clothes hangers, and the aluminum industry recycles some 2 billion cans a year. The latter saves sufficient electricity, which would otherwise go to smelting new aluminum, to power all the nation’s television sets for a one-hour show every night of the year.
The Scale of Our Presence

Humans are perhaps the most successful species in the history of life on Earth. From a few thousand individuals some 200,000 years ago, we passed 1 billion around 1800 and 6 billion in 1999. Our levels of consumption and the scope of our technologies have grown in parallel with, and in some ways outpaced, our numbers. But our success is showing signs of overreaching itself, of threatening the key resources on which we depend. Today our impact on the planet has reached a truly massive scale. In many fields our ecological "footprint" outweighs the impact of all other living species combined.

We have transformed approximately half the land on Earth for our own uses – around 11 percent each for farming and forestry, and 26 percent for pasture, with at least another 2 to 3 percent for housing, industry, services and transport. The area used for growing crops has increased by almost six times since 1700, mainly at the expense of forest and woodland.

Of the easily accessible freshwater we already use more than half. We have regulated the flow of around two thirds of all rivers on Earth, creating artificial lakes and altering the ecology of existing lakes and estuaries.

The oceans make up seven tenths of the planet’s surface, and we use only an estimated eight percent of their total primary productivity. Yet we have fished up to the limits or beyond of two thirds of marine fisheries and altered the ecology of a vast range of marine species. During this century we have destroyed perhaps half of all coastal mangrove forests and irrevocably degraded 10 percent of coral reefs.

Through fossil-fuel burning and fertilizer application we have altered the natural cycles of carbon and nitrogen. The amount of nitrogen entering the cycle has more than doubled over the last century, and we now contribute 50 percent more to the nitrogen cycle than all natural sources combined. The excess is leading to the impoverishment of forest soils and forest death, and at sea to the development of toxic algal blooms and expanding "dead" zones devoid of oxygen.

By burning fossil fuels in which carbon was locked up hundreds of millions of years ago, we have increased the carbon dioxide content of the atmosphere by 30 percent over pre-industrial levels. We have boosted methane content by 145 percent over natural levels.

Through mining and processing we are releasing toxic metals into the biosphere that would otherwise have remained safely locked in stone. We are producing new synthetic chemicals, many of which may have as yet undetermined effects on other organisms.

We have thinned the ozone layer that protects life on Earth from harmful ultra-violet radiation. Most scientists agree that human activities are contributing to global warming, raising global temperatures and sea levels.

These processes affect the habitats and environmental pressures under which all species exist. As a result, we have had an incalculable effect on the Earth’s biodiversity. The 484 animal and 654 plant species recorded as extinct since 1600 are only the tip of a massive iceberg.

We have become a major force of evolution, not just for the "new" species we breed and genetically engineer, but for the thousands of species whose habitats we modify, consigning many to (continued)
The Scale of Our Presence (continued)

**The scale of human activities**
The scale of human activities can be represented partly by observing population density, both over the globe and over time.

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<th>POPULATION DENSITY, 1998</th>
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**Note:** At the end of the 20th century the world average population density was 45 people per square kilometre.

(continued)
The Scale of Our Presence (continued)

OVERVIEW The scale of our presence

Population density per square kilometre:
- Less than 1
- 1-45
- 45-100
- 100-300
- 300-500
- More than 500

Source: RVM.
extinction; compelling others to evolve and adapt to our pressures. We have become a force of nature comparable to volcanoes or to cyclical variations in the Earth’s orbit.

The scale of our activities depends on our population numbers, our consumption and the resource or pollution impact of our technologies – and all three of these factors are still on the increase. The maps on the previous pages illustrate the increasing spread and density of the human population over the last three centuries.

As we enter the third millennium, the destiny of the planet is in our hands as never before, yet they are inexperienced hands. We are modifying ecosystems and global systems faster than we can understand the changes and prepare responses to them. All the factors in this vast equation affect each other constantly. In a globalized world the elements of human activity interact with each other and with local and planetary environments.

In this unprecedented situation, the need to be fully aware of what we are doing has never been greater. We need to understand the way in which population, consumption and technology create their impact, to review that impact across the most critical fields, and to find ways of using our understanding of the links to inform policy.
Consumption Cartoon

We help the environment by consuming less.

We help the environment by consuming lots of environmentally safe products!

Instructions:
1. Read and pronounce the following words with your teacher.
2. As you view the video, listen for each word. Number it in the order you hear it.
3. After viewing, guess the meanings of the words, or look them up in the dictionary. Watch the video a second time, but this time write down as much as possible of the phrase or sentence in which the word occurred.
4. After the second viewing, use each word in a sentence that communicates the meaning of the word. Share your sentences with a partner.

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<th>Word + Surrounding Words</th>
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Recycling Facts

3 Rs Tips

What else can I do?

So now you know it’s important to recycle, but there is actually an overall strategy for reducing waste. This is called the 3 Rs, which are Reduce, Reuse, and Recycle.

Reduce:
- Purchasing items with the least amount of packaging
- Buying in bulk when appropriate
- Not purchasing items that you don’t need

Reuse:
- Using a reusable mug for your coffee
- Sharing newspapers and magazines with friends
- Avoiding disposable items

Recycle:
- Using your community recycling program
- Purchasing products made from recycled materials

Call your municipal office to find out about 3 Rs programs in your community.

Round them all up!
Recycling Facts

Handout 2-46

We create a lot of waste. In one year each of us produces over 240 kilograms of waste in our home.

You have probably heard of Recycling. You probably even recycle a whole bunch of stuff from your home. Chances are that you live in, or do business in, a community that has a recycling program. That's because there are over 160 recycling programs in Manitoba, servicing almost 1 million Manitobans!

But, what exactly is recycling? Recycling is a term that describes the process of converting our “waste” into resources that can be made into new products. It sounds simple, but there are several critical steps involved:

1. First, it is up to us to separate recyclable materials from our regular garbage.
2. Then, your municipality (or their recycling agency) will collect the materials, sort them, and send them to companies all over the world — and some right here in Manitoba!
3. Then, companies use the recycled materials to produce new products, conserving natural resources.
4. The process isn’t one way. You all need to buy items made from recycled materials to ensure that companies continue to use recycled material in their products. Buy Recycled!

But what happens to all the stuff I recycle? Keep reading for tonnes of Manitoba recycling facts!

Recycling (continued)

Recycling Facts

Handout 2-46

Paper

Every year, Manitobans throw out about 32,000 metric tonnes of newspapers, magazines and flyers. Only about 20,000 metric tonnes of this material is recycled. That means that 30% of this material is still being landfilled, burned or littered. What a waste!

Did You Know...

- The amount of landfill space that is taken up by one tonne of newspaper is 3 cubic meters.
- One metric tonne of recycled newspaper saves about 17 trees.
- Using recycled newspapers and magazines reduces the need for mining clay soils, which is used to make newspaper pulp.
- The newspaper collected in your community recycling program is made into new newspaper (so the Sunday comics you’re reading now may be the Sports pages you read two months ago!)

PET (#1) Plastics

Each year, Manitobans throw out about 2,000 tonnes of PET (#1) plastic. About 500 tonnes of PET is recycled... that's only about 40% The rest ... trashed. What a waste!

Did You Know...

- Plastics can take up to 400 years to break down in a landfill.
- PET plastic bottles collected for recycling in Manitoba are usually made into carpeting and fiberfill for pillows, sleeping bags and ski jackets, but can also be made into t-shirts and sweaters, automotive parts, and floor tiles!

Glass

Each year, Manitobans throw out about 14,000 tonnes of glass jars and bottles. Only about 4,500 tonnes are recycled. What a waste!

Did You Know...

- It takes one million years for a glass bottle to break down in a landfill.
- In Manitoba, most recycled container glass is used as aggregate material in roads and sidewalks.
- This saves your community recycling program energy and money because the glass doesn’t have to be shipped to distant markets. Just think... you could be walking on old jam jars!

Aluminum

Each year, Manitobans throw out about 1,400 tonnes of aluminum cans. Only about 30% is recycled in community programs. What a waste!

Did You Know...

- Recycling one aluminum can saves enough energy to run your television for 3 hours.
- Aluminum takes 500 years to break down.
- Once aluminum cans have been remelted, they can be used in any product made from aluminum.
- Aluminum is the most valuable ($$) recyclable material. Help your community keep recycling costs down. Don’t trash cans!

Steel (Tin) Cans

Each year, Manitobans throw out about 5,000 tonnes of steel cans. Only about 1,500 tonnes of this steel is recycled. The rest? You guessed it — landfilled or littered. What a waste!

Did You Know...

- When scrap iron is used instead of iron ore to make steel, water consumption is reduced by about 50%.
- Most of the steel cans collected in Manitoba are recycled at local steel mills.
3 Rs Tips

What else can I do?

So now you know that REDUCE is the first R, but then how do REUSE and RECYCLE fit in?

**REusing** items is easy... many of the items that you recycle, such as glass jars and plastic containers, can be reused over again as storage containers.

**Recycling** is easier than ever thanks to the over 160 community recycling programs in Manitoba. Recycling valuable resources results in many environmental and economic benefits. For instance, since April 1997 in our province:

- Recycled materials were sold at an average of $75 per metric tonne.
- 101,671 metric tonnes of household waste was recycled.
- This means that over $7.6 million dollars stayed in Manitoba’s economy rather than simply being thrown out with the trash!

*So Use Less to Live More!*

**REDUCE** — Reduce the amount of waste you create by using some of the ideas in this brochure.

**REUSE** — Reuse items whenever possible.

**RECYCLE** — Take part in your community recycling program, and purchase products made from recycled materials.

_Check with your municipal office to find out about 3 R’s programs in your community!_

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The Manitoba Product Stewardship Corporation (MPSC) was introduced on January 1, 1996 to encourage the expansion of convenient and efficient recycling services across Manitoba. MPSC is an independent, non-profit organization representing the interest of all sectors of Manitoba, including consumers, industry, municipalities and governments.

Under the Waste Reduction and Prevention Act (WRAP), the MPSC is mandated to establish and administer a waste reduction and prevention program for designated materials in Manitoba. Some of our current programs and initiatives are:

- **Manitoba Product Stewardship Program (MSP)** — Provides financial assistance and technical support for community recycling programs throughout Manitoba. To date there are currently 160 municipal recycling programs active in the province, for which the MPSC pays 80% of the net costs of recycling.

- **Student Action for Recycling (STAR)** — An education resource which provides K-12 school programs in Manitoba with an annual $600 hierarchy to encourage in-school recycling and waste reduction programs. MPSC also has an environmental education website at www.virtualrecycling.com.

- **STAR Plus** — A funding and support program for post-secondary educational institutions in Manitoba to recycle MSP-eligible materials.

- **Litter Abatement Program** — An annual spring media campaign targeted to reduce litter in Manitoba. Campaigns include “Stop Throwing Your Trash in the Street” and “Keep Manitoba Beautiful.”

All activities of the MPSC are currently funded by the 7 cent levy on beverage containers.

**For more information contact:****

Manitoba Product Stewardship Corporation

280 - 534 Kenaston Blvd.
Winnipeg, Manitoba R3N 1Z4

Phone: 412-989-6222
Fax: 204-989-6220
Email: info@mpsc.mb.ca
or visit us at: www.mpsc.com

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Reduce Your Waste

Use Less Live More

[Billboard Image]
Reduce Your Waste

Fact: When our trash disappears off the earth, it is buried in the ground, where it remains unhelpful for centuries.

Fact: More than 20% of the garbage thrown out by the average household is packaging.

Fact: Canadians take home over 25 million plastic shopping bags each week.

You and I create a lot of waste. In one year, each of us produces over 250 kilograms of waste in our homes. That’s a lot of garbage! But did you know...we don’t need to create so much waste in the first place? There are lots of ways you can REDUCE the amount of waste you create, simply by Using Less and Living More!

There are many ways to get the things you need without contributing to our ‘throwaway’ society. By following the suggestions in this brochure, you can reduce the amount of garbage you throw out and reduce the amount of pollution in our environment. You’ll also reduce the energy required to produce and transport goods while conserving valuable natural resources. That’s what Using Less and Living More is all about.

Reducing consumption is the first step. It all starts with making smart choices while shopping and asking yourself whether the items you are purchasing are really necessary.

Read on for ideas to Use Less and Live More!

Steps to Using Less

Buy Only What You Really Need
Before purchasing something, ask yourself if you really need the item. How much junk do you have collecting dust in your basement or garage that you couldn’t live without just a short time ago?

Avoid Disposable Products
Keep in mind that nothing is really "disposable"—in most cases it doesn’t just go away; it just takes up space in a landfill site.

Buy Quality
Buy the highest quality item you can afford and have it repaired when necessary. Clothing is one area where this principle can be easily applied.

Buy in Bulk
When buying food or other products to be consumed in quantity, buy the largest amount you can easily store and use.

Avoid Over-packaged Goods
Always try to choose items with the least amount of packaging. Remember, it’s what’s inside the package that you want!

Buy Recycled Products
When possible, buy products made from recycled material. This helps to ensure stable markets for materials collected through recycling programs.

Carry Your Own Bags
Take your own bag when you shop, or reuse a plastic bag that you were given on a previous trip.

Buy Used Items
This applies to CD’s, sports equipment, cars, building material, clothing, furniture—almost anything!

Rent or Share Instead of Buying
Many things that you need only occasionally, such as tools or party supplies, can be rented or borrowed.

And guess what? Many of these ideas are not only environmentally friendly, but will save you money too!

...and Living More!

Smart shoppers make a big difference in how much waste we create, but there are lots of other things that we can do to be kind to our environment and create less pollution. Here are a few suggestions:

1) Composting
Composting can help to reduce your household waste by about 1/3 and help your yard and garden as well. For information on composting, call Resources Conservation Manitoba at 204-925-3177.

2) Reduce Toxic Wastes at Home

Yard and garden — Avoid the use of pesticides and use only natural lawn care products.

Household Cleaning — Try homemade, alternative cleaning products around the house, such as:
- Glass Cleaner — 1 part vinegar to 10 parts water
- Furniture Polish — 1 part lemon juice to 2 parts vegetable oil
- Disinfectant — 1/2 cup borax to 1 cup water
- Chrome/Stainless Steel Cleaner — baking soda and a damp cloth

Painting Supplies — When painting, buy only what you need. Swap leftover paint with friends.

Used Oil — Do you change your own oil? Call your municipality to find out where you can recycle it.

Household Hazardous Waste — Check with your municipality to see where you should dispose of anything identified on the container as flammable, caustic or toxic.

3) Don’t forget to recycle!

Note: Many of the ideas in this brochure came from some of the great books available about reducing waste. Check your local library!
Recycling Facts (continued)

Litter—What Can You Do?

Final Word on Litter

The MPSC encourages litter abatement and recycling activities to complement waste reduction and recycling activities in each community. Consistent with our anti-litter strategy, the MPSC finances billboards with anti-litter messages across Manitoba. Those communities without billboards can take advantage of these same messages.

MPSC’s anti-litter billboard campaign has included “Slam Dunk Your Junk—Don’t Litter” and “Save Your Trash—Don’t Litter.” During the summer of 2013, “Keep Manitoba Beautiful—Don’t Litter” was introduced and displayed throughout Manitoba.

‘Keep Manitoba Beautiful—Don’t Litter” is a gentle reminder that litter detracts from the natural beauty of our province. Litter devalues our natural environment and affects the image that tourists have of our towns, cities, and parks.

The negative image litter poisons reduces the respect and pride that Manitobans take in their community.

For more information contact:

Manitoba Product Stewardship Corporation
200-539 Kenaston Blvd., Winnipeg, Manitoba, R2N 1Y4

Phone: 204-989-3224
Fax: 204-989-3229
Email: info@mpsc.mb.ca
www.mpsc.com

(continued)
Who Litters?

The Seven Sources of Litter

Although we often assume that litter can be blamed solely on pedestrians and motorists, there are actually seven primary sources of litter. It is important to recognize that these sources of litter can be either deliberate or accidental in nature:

1. Improperly handled household garbage and recyclables
2. Improperly handled commercial refuse
3. Construction and Demolition sites
4. Loading and delivery areas
5. Uncovered trucks
6. Pedestrians
7. Motorists

Litter costs your community, both financially and environmentally. Tax dollars are spent cleaning litter from parks, roads, and public places. Litter pollutes our waterways, damages our landscapes and injures animals and people.

Littering is contrary to the principles of environmental stewardship. Litter can negatively impact community recycling programs, too:

1. Litter from recycling pickup or depots may result in negative perceptions regarding their effectiveness in cleaning up the environment
2. Litter may include products and materials which are recyclable and should be recovered

What Can You Do?

Set an example for others by not littering
Make sure trash cans have lids that can be securely fastened
If you own a business, check dumpsters daily to ensure that top and side doors are closed. Don't overfill dumpsters
Use a litter bag inside your car, truck, boat and on your bicycle
When outdoors, hold onto trash until you reach a trash receptacle
Cover open loads on all trucks
Organize or take part in a community clean-up

Community Clean-up Events

If you decide to organize a clean-up, there are a number of tips to make your project work:

1. Get permission from the property owner of the area you want to clean
2. Visit the site before the day of the clean-up to decide the type of litter that will need to be removed (large debris may require large equipment)
3. Take “before” and “after” photos
4. Tell your local paper, radio station, or TV channel about your project
5. Ask local businesses to sponsor bags, gloves, donuts, coffee
6. Recruit community groups and any other community members who may want to participate
7. Keep a diary of the event and a log of names and phone numbers if you decide to plan another clean-up next year
8. Thank everyone who was involved

STASH YOUR TRASH
don't litter.
I. Pre-Listening Exercises
   1. Name the three most important environmental issues today and propose solutions for each.

II. Listening Exercises
   1. Listen to the interview by pressing the “Play” button of the audio type you want to hear, and answer the questions. Press the “Final Score” button to check your quiz.

   1. What is the name of the girl being interviewed?
      A. Alice
      B. Ellen
      C. Alex
   2. She says we should save water when:
      A. washing cars
      B. cleaning clothes
      C. taking a bath
   3. The girl’s second suggestion is about:
      A. separating different types of garbage
      B. disposing of trash properly
      C. having a family clean-up party
   4. By recycling paper, we can:
      A. protect the forests
      B. cut down on waste
      C. save money
   5. What does the girl do once a month?
      A. She visits a recycling center.
      B. She cleans a neighbourhood park.
      C. She collects newspapers.

   2. Listen to the conversation again as you read the Quiz Script.
   3. Review the Text Completion Quiz.

III. Post-Listening Exercises
   1. Write a short article about the biggest environmental problem facing your country of origin and a solution to resolving this issue.
I. Pre-Listening Exercises

1. Name three environmental problems that face our world today.
2. How would you solve these problems?
3. What image comes to your mind when you think of “recycling?”

II. Listening Exercises

1. Listen to the conversation by pressing the “Play” button of the audio type you want to hear, and answer the questions. Press the “Final Score” button to check your quiz.

   1. What would be the best title for this lecture?
      A. Important Keys to Recycling Paper
      B. Technological Advances Improve Recycling
      C. Steps to Improving Recycling

   2. According to the article, paper materials that are difficult to recycle include:
      A. copy paper
      B. shredded documents
      C. food wrappers

   3. In some cases, recycling could be hazardous to the environment if special precautions are not taken because:
      A. industrial emissions are sometimes created in the process.
      B. chemical waste is sometimes produced as a result.
      C. a great deal of energy is expended to create new products.

   4. According to the lecture, the demand for recyclable materials in the manufacturing of new products is sometimes sluggish because
      A. some governments are unwilling to support expensive recycling methods.
      B. there is a lack of advanced technology to process the materials.
      C. businesses do not invest enough money into research.

   5. Which is NOT one of the main keys to recycling as mentioned in the lecture?
      A. government regulation of waste
      B. better technology
      C. more demand for recycled materials

III. Post-Listening Exercises

1. Write one specific way individuals can have an impact on saving the environment.
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