

The Montreal Protocol on Substances  
that Deplete the Ozone Layer

Achievements in



# Stratospheric Ozone Protection

P R O G R E S S   R E P O R T  
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# About This Report

On September 16, 1987, a group of twenty four countries assembled under the auspices of the United Nations Environment Programme to sign the initial Montreal Protocol on Substances that Deplete the Ozone Layer. Today, twenty years later, the Montreal Protocol has been ratified by over 190 countries, each of which has committed to meeting strict time-bound reduction obligations for each of the nearly 100 substances controlled by the Protocol. In those twenty years, great progress has been made. Whereas in 1987 production of controlled ozone-depleting substances exceeded 1.8 million tonnes annually, by the end of 2005 it had been reduced to some 83,000 tonnes. The vital measures undertaken by the Protocol Parties to achieve these reductions are helping to protect human health and the environment.

The 95 per cent reduction that has been achieved to date would not have been possible without the strong support of the governments that are parties to the Montreal Protocol and their many international and local partners. The partnerships among these actors have fundamentally changed the way the world community does business, spurring the development of new alternatives and technologies that have served to protect the ozone layer. In addition, because most ozone-depleting substances are also potent global warming gases, the reductions achieved by the Protocol have served to support efforts to address global climate change.

While the world community has accomplished much, the work of the Montreal Protocol is not yet finished. Scientific assessments now predict a healing of the ozone layer later this century. Those predictions, however, rely on the assumption that the Montreal Protocol will be implemented in full. And so it must. Among other things, this means completing the phase-out of the first generation of ozone-depleting substances in developing countries and completing the phase-out of hydrochlorofluorocarbons (HCFCs), a class of second generation chemicals that has a phase-out schedule that currently extends out to 2040.

This report covers the important and substantial achievements of the people, programmes and organizations that have, together, achieved so much, and are continuing the vital work of protecting the earth's ozone layer for this and future generations.



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Those of us who have been fighting for the ozone layer since the early 1980s look back in amazement at what has been accomplished. Most of us consider our work on ozone as the most important part of our lives.

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—Dr. Iwona Rummel-Bulska,  
United Nations Environment Programme

# A C H I E V E M

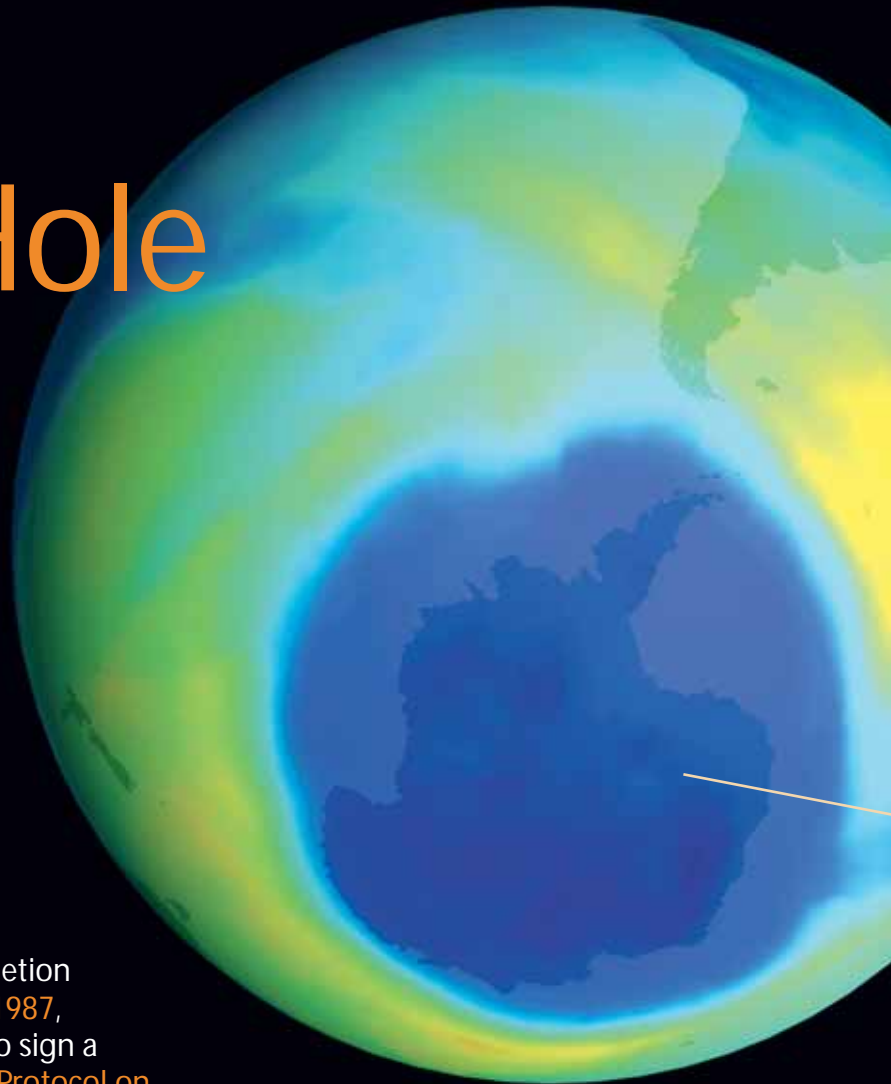
OVER THE PAST TWO DECADES - THE 191 PARTIES TO THE MONTREAL PROTOCOL AND THEIR PARTNERS HAVE MADE SIGNIFICANT STRIDES TO PROTECT THE EARTH'S STRATOSPHERIC OZONE LAYER, THE ENVIRONMENT, AND PEOPLE'S HEALTH.

## Healing the Ozone Hole

The ozone layer acts like a shield in the upper atmosphere (the stratosphere), to protect life on Earth from harmful ultra-violet (UV) radiation. In 1974, scientists discovered that emissions of chlorofluorocarbons, or CFCs, were depleting ozone in the stratosphere. CFCs were a common aerosol propellant in spray cans and were also used as refrigerants, solvents, and foam-blowing agents.

In the 1980s, scientists observed a thinning of the ozone layer over Antarctica, and people began thinking of it as an "ozone hole." Additional research has shown that ozone depletion occurs over every continent.

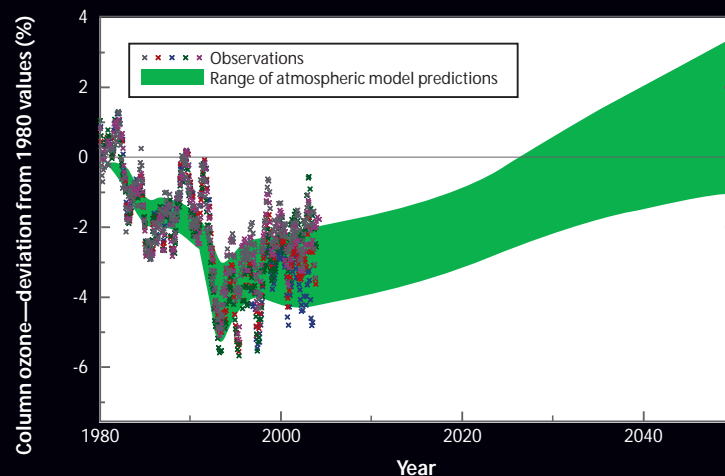
As our scientific knowledge about ozone depletion grew, so too did the response to the issue. In 1987, leaders from many countries came together to sign a landmark environmental treaty, the [Montreal Protocol on Substances That Deplete the Ozone Layer](#). Today, more than 190 Parties have ratified the treaty. These countries are committed to taking action to reduce the production and use of CFCs and other ozone-depleting substances to protect the ozone layer.



# EMENTS

Sustained recovery of the ozone layer will require worldwide phase-out of ozone-depleting substances.

## Global Ozone Depletion and Recovery



Source: Intergovernmental Panel on Climate Change/Technology and Economic Assessment Panel. Special Report on Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons. (Cambridge: Cambridge University Press, 2005.) Figure SPM-3.

The ozone layer has not grown thinner since 1998 over most of the world, and it appears to be recovering because of reduced emissions of ozone-depleting substances. The ozone layer is projected to return to pre-1980 levels by 2050 to 2075.

## OZONE: GOOD UP HIGH, BAD NEARBY


Ozone is a gas that occurs both in the Earth's upper atmosphere (the stratosphere) and at ground level. Ozone can be "good" or "bad" for people's health and the environment, depending on its location in the atmosphere.

"Good" ozone is produced naturally in the stratosphere and is "good" because it blocks harmful UV radiation from reaching the Earth's surface where it can harm people and ecosystems.

"Bad" ozone is an air pollutant found at ground level and is "bad" because it is harmful to breathe and can damage crops, trees, and other vegetation. Ground-level ozone is a main component of urban smog.

# Saving Lives

We care about ozone depletion because a thinner ozone layer allows more UV radiation to reach the Earth's surface. Overexposure to UV radiation can cause a range of health effects, including skin damage (skin cancers and premature aging), eye damage (including cataracts), and suppression of the immune system. Researchers believe that overexposure to UV radiation is contributing to an increase in melanoma, the most fatal of all skin cancers.

An aerial photograph of a crowded beach. The foreground is filled with rows of people sitting on towels or blankets, many with colorful beach umbrellas. The water is a vibrant blue, and several people are swimming or playing in the surf. In the distance, a few small boats are visible on the water. The sky is clear and blue.

The United States has estimated that by the year 2165, actions to protect and restore the ozone layer will have prevented 6.3 million skin cancer deaths and produced US\$ 4.2 trillion in societal health benefits in that country alone<sup>1</sup>.

<sup>1</sup> U.S. Environmental Protection Agency, Office of Air and Radiation. November 1999. The Benefits and Costs of the Clean Air Act, 1990-2010. EPA 4W-R-99-001. [www.epa.gov/air/sect812/prospective1.html](http://www.epa.gov/air/sect812/prospective1.html).

**Then:** Ozone-Depleting Substances Were All Around Us...

**Now:** More Ozone-Friendly Products, Better Processes, and New Equipment Are In Use

All parts of our daily lives have been touched by ozone-depleting substances. Prior to the 1980s, CFCs and other ozone-depleting substances were pervasive in modern life. But thanks to the work of individuals, businesses, organizations, and governments around the world, substitutes that are safer for the ozone layer continue to be developed for many ozone-depleting substances. The phase-out of ozone-depleting substances has also made a substantial contribution toward the reduction in greenhouse gas emissions since their global warming potential is very high.

### Computers

**Then:** Solvents containing CFCs and methyl chloroform were used to clean circuit boards during their production.

**Now:** Some companies have eliminated the need to clean circuit boards during their production. Others use water or have temporarily switched to HCFCs.

### Polystyrene Cups and Packing Peanuts

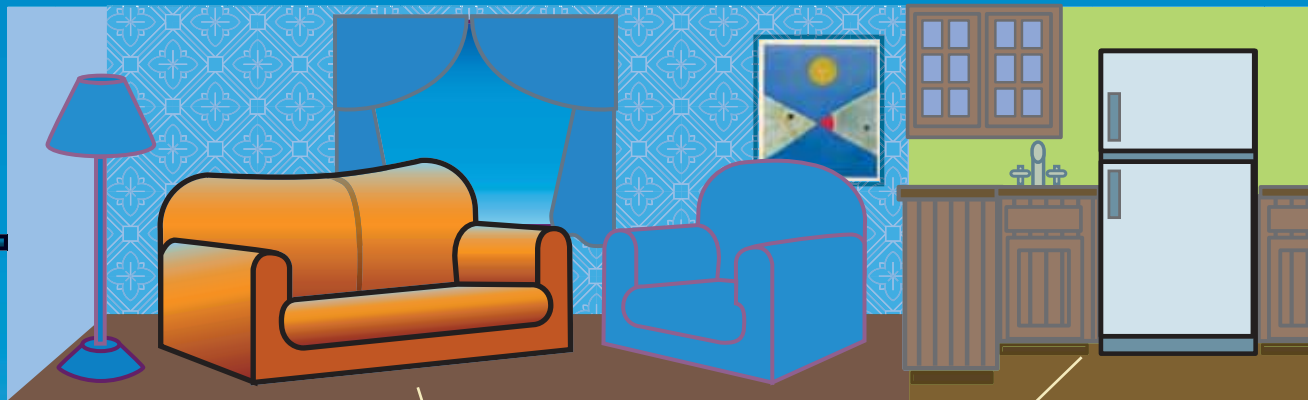
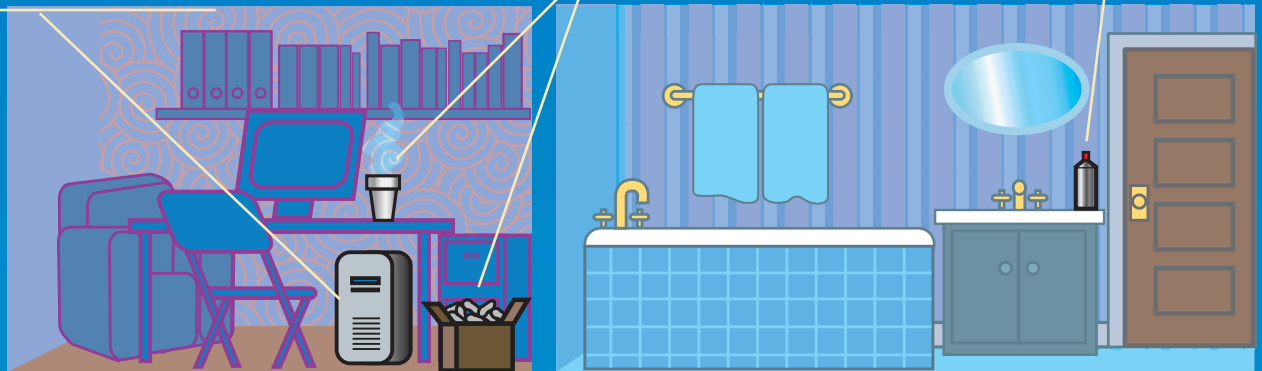
**Then:** Some polystyrene cups and foam packing "peanuts" were made using CFCs.

**Now:** These products are made with materials that do not deplete the ozone layer.

### Aerosol Cans

**Then:** CFCs were the propellant used in various spray cans.

**Now:** Pumps and alternative propellants using hydrocarbons are being used.



### Air Conditioners

**Then:** CFCs were used as the coolant in household air conditioners.

**Now:** HCFCs and HFCs are among the alternatives replacing CFCs.

### Furniture

**Then:** Foam-blowing agents containing CFCs were used in furniture making.

**Now:** Water-blown foam is now often used.

### Refrigerators

**Then:** CFCs were used in refrigerator coolants and foam insulation.

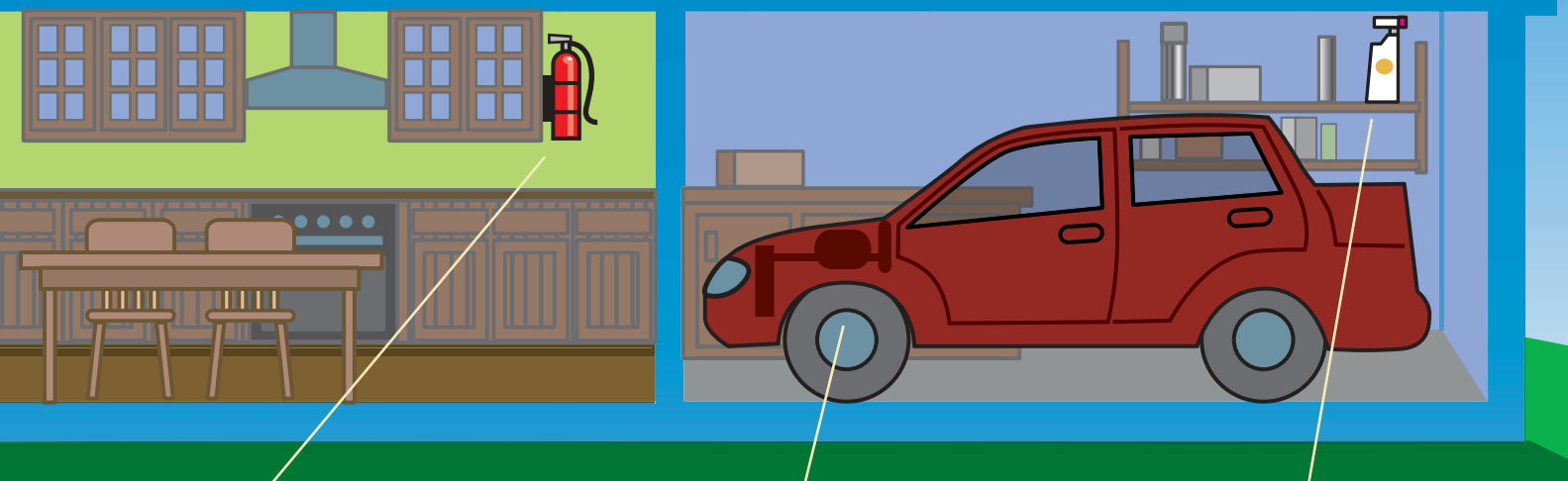
**Now:** HCFCs and HCs have replaced CFCs, and still other substitutes are on the horizon that will not deplete the ozone layer.

## Common Ozone-Depleting Substances and Some Alternatives

Substance	Uses	Ozone-Depleting Potential*	Global Warming Potential**
Chlorofluorocarbons (CFCs)	Refrigerants, cleaning solvents, aerosol propellants, and blowing agents for plastic foam manufacture.	0.6 – 1.0	4,680 – 10,720
Halons	Fire extinguishers/fire suppression systems, explosion protection.	3 – 10	1,620 – 7,030
Carbon tetrachloride (CCl <sub>4</sub> )	Production of CFCs (feedstock), solvent/diluents, fire extinguishers.	1.1	1,380
Methyl chloroform (CHCl <sub>3</sub> )	Industrial solvent for cleaning, inks, correction fluid.	0.1	144
Methyl bromide (CH <sub>3</sub> Br)	Fumigant used to control soil-borne pests and diseases in crops prior to planting and in commodities such as stored grains. Fumigants are substances that give off fumes; they are often used as disinfectants or to kill pests.	0.6	5
Hydrochlorofluorocarbons (HCFCs)	Transitional CFC replacements used as refrigerants, solvents, blowing agents for plastic foam manufacture, and fire extinguishers. HCFCs deplete stratospheric ozone, but to a much lesser extent than CFCs; however, they are greenhouse gases.	0.01 – 0.5	76 – 2,270
Hydrofluorocarbons (HFCs)	CFC replacements used as refrigerants, aerosol propellants, solvents, and fire extinguishers. HFCs do not deplete stratospheric ozone, but they are greenhouse gases.	0	122 – 14,130

\* Ozone-depleting potential (ODP) is the ratio of the impact on ozone caused by a chemical compared to the impact of a similar mass of CFC-11. The ODP of CFC-11 is 1.0.

\*\* Global warming potential (GWP) is the ratio of the warming caused by a substance compared to the warming caused by a similar mass of carbon dioxide. The GWP of carbon dioxide is 1.0.



### Fire Extinguishers

**Then:** Halons were commonly used in hand-held fire extinguishers.

**Now:** Conventional dry chemicals, which don't deplete the ozone layer, and water have largely replaced halons.

### Car Air Conditioners

**Then:** CFCs were used as the coolant in automobile air conditioners.

**Now:** HFCs have replaced CFCs and new, more climate friendly alternatives are on the horizon

### Degreasers

**Then:** CFCs or methyl chloroform were used in many solvents for degreasing.

**Now:** Water-soluble compounds and hydrocarbon degreasers that do not deplete the ozone layer are available for many applications.



# Protecting the Planet

UV radiation can damage sensitive crops, such as soybeans, and reduce crop yields. Some scientists believe that marine phytoplankton, which serve as the base of the ocean food chain, are already under stress from UV radiation. This stress could have profound effects on the food chain and on food productivity.

Additionally, since most ozone-depleting substances are also potent greenhouse gases, replacing these substances with alternatives that are safer for the ozone layer can also reduce greenhouse gas emissions and slow climate change.

# Everyone Benefits

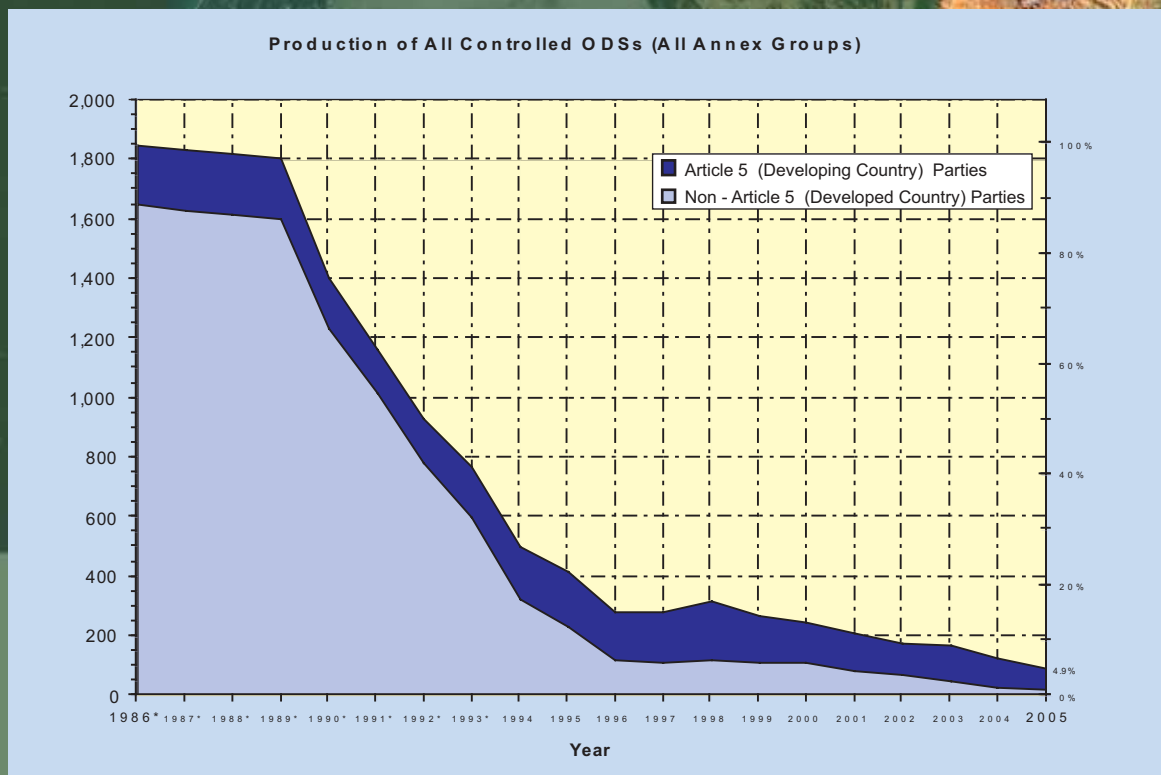
Because stratospheric ozone depletion is a global issue, people around the globe benefit from all investments made in technology and sound science to protect the ozone layer.

The Montreal Protocol experience has also created valuable enhancements in national capacity to deal with environmental issues, and an invaluable understanding that working together, the global environment can be protected.



# The Phase-out of Ozone-depleting Substances

By the end of 2006, the 191 Parties to the Montreal Protocol had together phased out over 95 per cent of ozone depleting substances, reducing production levels from a 1987 level of over 1.8 million weighted tonnes annually to some 83,000 tonnes in 2005.



## Ozone-depleting Substances Phase-out Status for Developed Countries

Chemical Group	Most Recent Phaseout requirement	Current Aggregate Status
Halons	1/1/94 – only essential uses allowed	Phase-out complete
CFCs	1/1/96 – only essential uses allowed	1,243 exempted for 07
Carbon tetrachloride	1/1/96 – only essential uses allowed	Phase-out complete
HBFCs	1/1/96 – only essential uses allowed	Phase-out complete
Methyl chloroform	1/1/96 – only essential uses allowed	Phase-out complete
Bromchloromethane	1/1/02 - only essential uses allowed	Phase-out complete
Methyl bromide	1/1/05 – only critical uses allowed	5,496 exempted for 07
HCFCs	1/1/04 – 35% reduction required	72% reduction achieved

## Ozone-depleting Substances Phase-out Status for Developing Countries

Chemical Group	Recent Phaseout requirement	2005 Aggregate Status
Halons	1/1/05 – 50% reduction required	85% reduction achieved
CFCs	1/1/05 – 50% reduction required	75% reduction achieved
Carbon tetrachloride	1/1/05 – 85% reduction required	95% reduction achieved
HBFCs	1/1/96 – only essential uses allowed	Phase-out complete
Methyl chloroform	1/1/05 – 30% reduction required	67% reduction achieved
Bromchloromethane	1/1/02 - only essential uses allowed	Phase-out complete
Methyl bromide	1/1/05 – 20% reduction required	41% reduction achieved
HCFCs	1/1/16 - Freeze at 2015 levels	19,817 tonnes consumed

Based on data available 2/2007, tonnes expressed in ODP values

# Partners in Ozone Protection

Many organizations have played a pivotal role in protecting the stratospheric ozone layer—both in the past efforts they made to eliminate use of first-generation ozone-depleting substances and in their current undertakings to reduce their use of second-generation ozone-depleting substances. Leadership, investment, and innovation are the keys to these important achievements.



## PARTNERSHIP WITH INDUSTRY

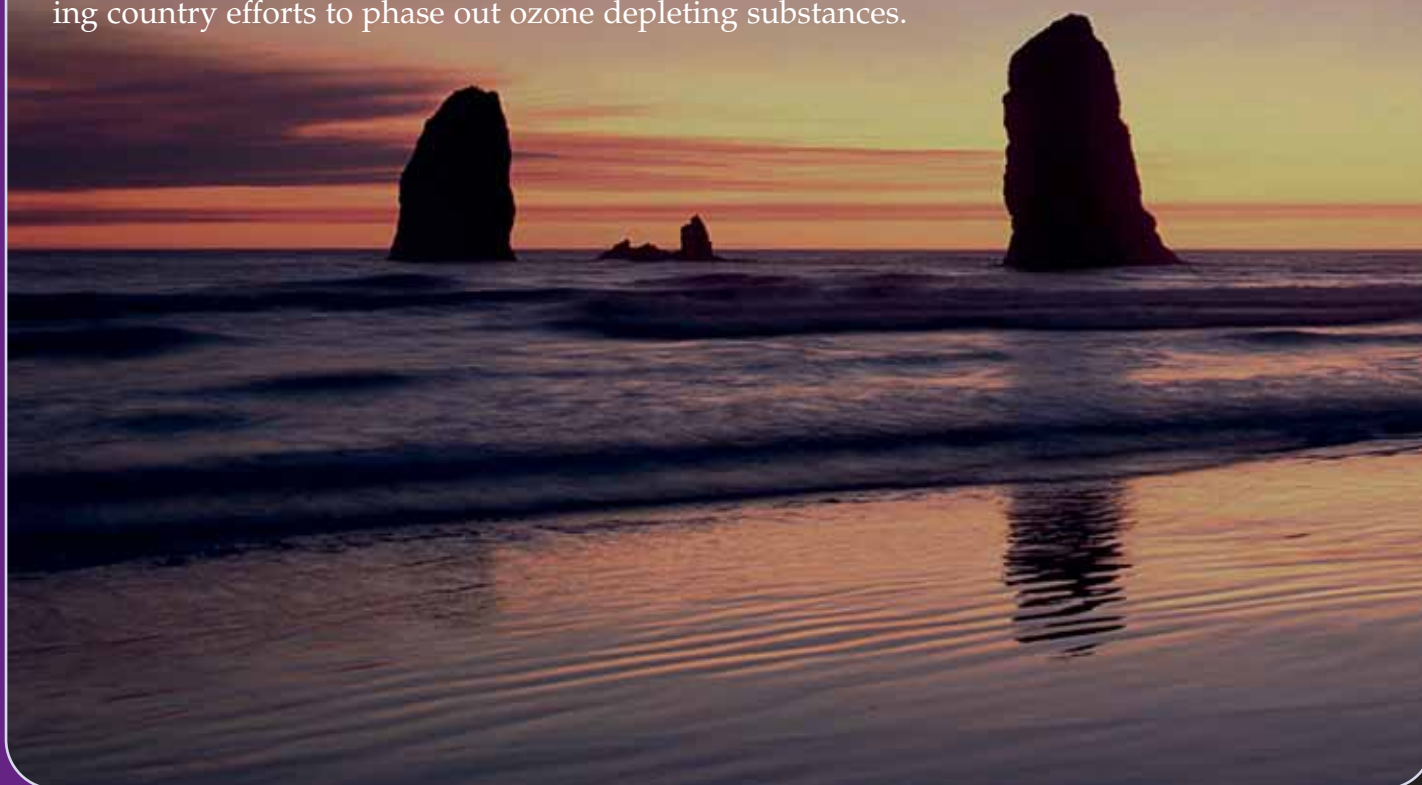
Among the key partnerships that have enabled the Protocol Parties to reduce reliance on ozone-depleting substances by 95 per cent is the invaluable partnership with industry. Time and again, industry has come forward with new, more ozone friendly alternatives and products to meet the increasingly stringent requirements posed by the ozone protection effort. Industry participation in the process of dissemination of information on new methods and technologies has also been critical to the Protocol's success to date.

## The Role of the Protocol's Assessment Panels

The Protocol's assessment panels on science, environmental effects, and technology and economic issues have been three key pillars in the ozone protection regime. Through the provision of independent, technical and scientific assessments as well as information responding to specific inquiries by the Protocol Parties, the Panels have enabled the Parties to take informed decisions on critical issues affecting the protection of the ozone layer.

## The Multilateral Fund for the Implementation of the Montreal Protocol

The Protocol Multilateral Fund and its four implementing agencies (The United Nations Environment Programme, The United Nations Development Programme, The United Nations Industrial Development Organization and the World Bank) have since 1990 provided exemplary support to developing countries, enabling them to meet their reduction obligations under the Protocol. By the end of 2005, the Fund had approved 5,202 projects and activities in over 140 countries which, when fully implemented, are expected to eliminate annual consumption of nearly 224,000 tonnes and annual production of nearly 138,000 tonnes of ozone depleting substances. The Fund's innovative equality based management structure and funding principles and its unique support for the operation of national ozone units in 140 developing countries have contributed significantly to the continuing success of developing country efforts to phase out ozone depleting substances.

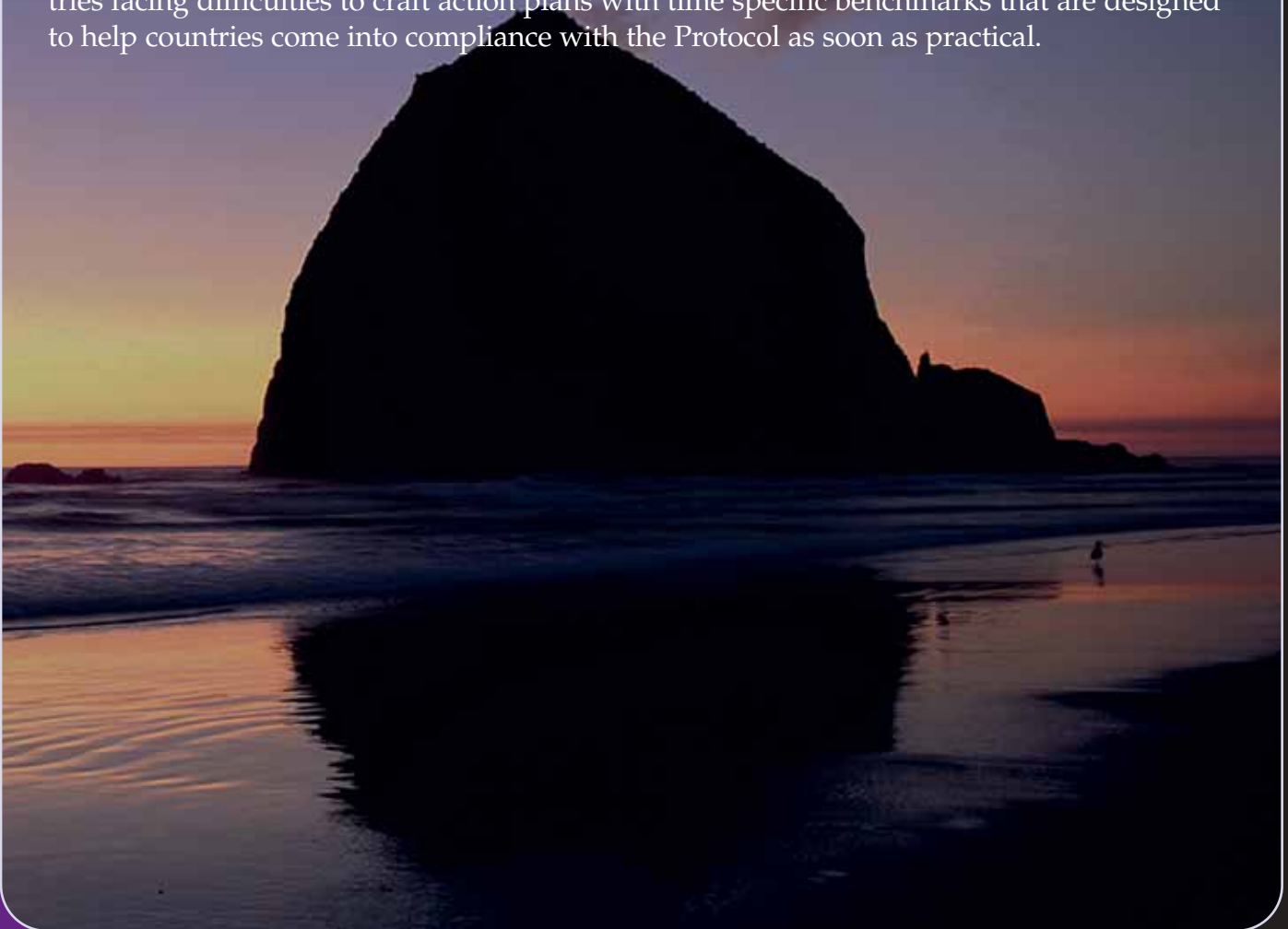


# The Role of Non-governmental Organizations

Non-governmental organizations in such diverse fields as industry and environment have played a unique and important role in the continued development and implementation of the Montreal Protocol. They have often served to bring critical issues to the attention of the Parties and the media and to urge the Parties to support informed decisions on both the national and international levels.

## The Montreal Protocol's Non-compliance Regime

It is not often that a compliance regime is thought of as a partner, but the unique regime established by the Montreal Protocol has truly worked in partnership with countries facing difficulties. The non-compliance regime includes an Implementation Committee made up of Parties elected from geographically diverse regions. This body works together with countries facing difficulties to craft action plans with time specific benchmarks that are designed to help countries come into compliance with the Protocol as soon as practical.



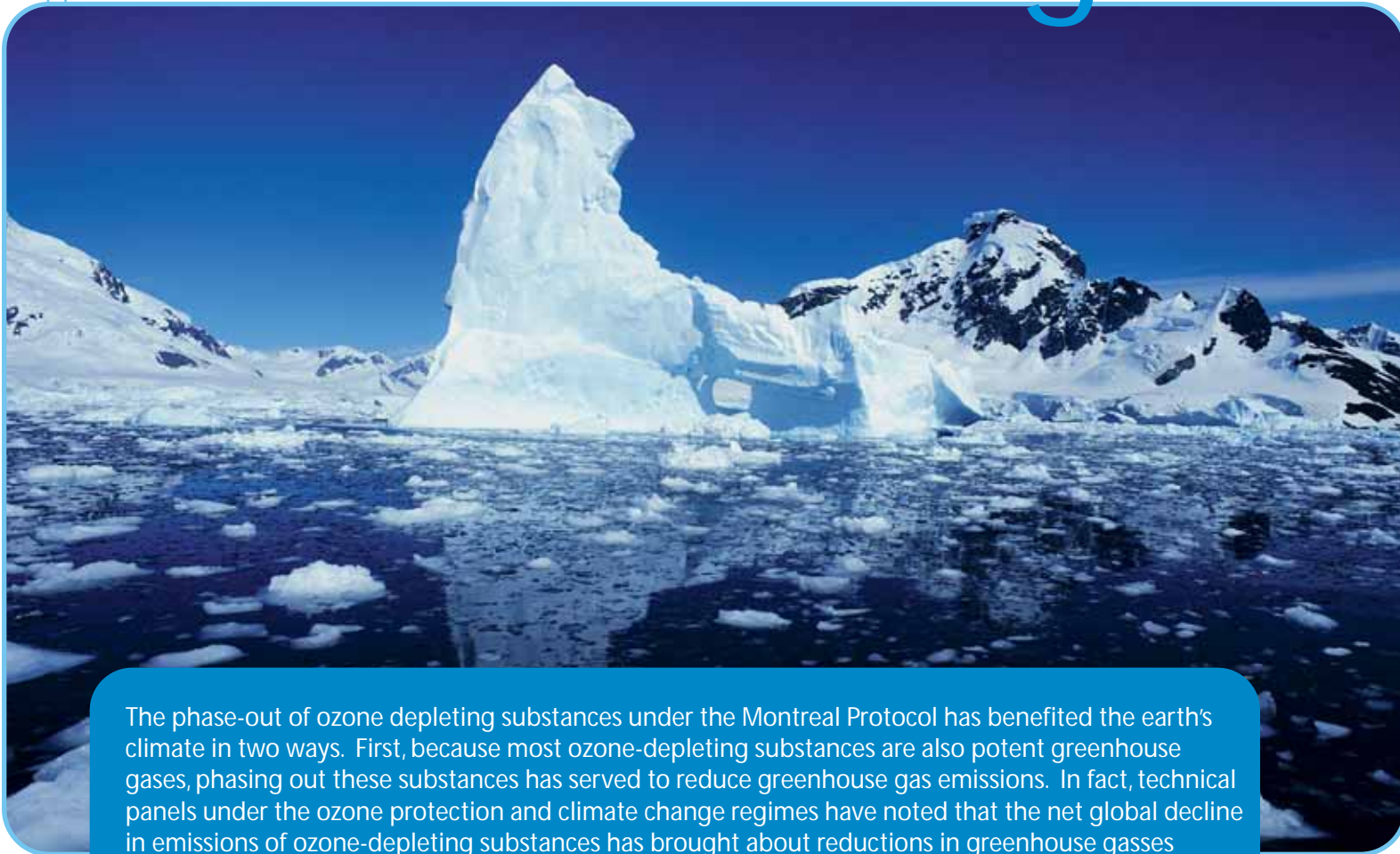
# Promoting Sun Safety

Because it will not be possible to see the full effect of efforts to restore the Earth's protective ozone layer for at least another 50 years, many countries have undertaken efforts to protect public health from UV radiation by promoting sun safety in schools and communities around the globe. Sun safety can include a variety of measures such as wearing sunglasses, hats, and other protective clothing; applying sunscreen; and planning outdoor activities around efforts to avoid overexposure to the sun as UV levels get higher.

These efforts, which have included outreach on the Montreal Protocol, have contributed to both public health and a greater understanding of the ozone depletion issue.



# The Benefits of the Montreal Protocol to Climate Change



The phase-out of ozone depleting substances under the Montreal Protocol has benefited the earth's climate in two ways. First, because most ozone-depleting substances are also potent greenhouse gases, phasing out these substances has served to reduce greenhouse gas emissions. In fact, technical panels under the ozone protection and climate change regimes have noted that the net global decline in emissions of ozone-depleting substances has brought about reductions in greenhouse gasses equivalent to several billions of tonnes of carbon dioxide equivalents. These enormous reductions make the Montreal Protocol a key contributor to the global fight against climate change. In addition, the phaseout of the CFCs, Halons and HCFCs that remain will deliver still more climate benefits. But the Montreal Protocol phase-out has also supported the earth's climate in a second way. In the process of converting from ozone-depleting substances, related equipment has often been upgraded in a manner that makes it less leaky and more energy efficient. Less leakage reduces direct emissions of substitute materials to the environment and greater energy efficiency requires less power production, which in turn reduces greenhouse gasses emitted during fossil fuel combustion.



# A Walk Through History

## Science

**1928**  
Scientists synthesize CFCs.

**1974**  
Nobel prize winners Molina and Rowland discover that CFCs can break down stratospheric ozone.

**1973**  
Scientists detect CFCs in atmosphere.

**1975**  
Scientists discover that bromine, used in fire-retarding halons and agricultural fumigants, is a potent ozone-depleting substance.

**1985**  
British Antarctic Survey team discovers Antarctic ozone hole (7.3 million square miles), marking the first evidence of stratospheric ozone depletion.  
Scientific research reveals stratospheric ozone layer depletion has adverse environmental and human health effects.

**1991**  
International scientists agree that CFCs are depleting the stratospheric ozone layer in the northern and southern hemispheres.

## Action

**1975**  
SC Johnson announces corporate phaseout of CFCs as aerosol product propellants.

**1976**  
United Nations Environment Programme (UNEP) calls for an international conference to discuss an international response to the ozone issue.

**1978**  
U.S. bans non-essential uses of CFCs as a propellant in some aerosols (e.g., hair sprays, deodorants, antiperspirants). Canada, Norway, and Sweden follow with a similar ban.

**1981**  
UNEP acts on a proposal to develop a global convention to protect the ozone layer.

**1987**  
Twenty-four countries sign the Montreal Protocol on Substances That Deplete the Ozone Layer.

**1989**  
All developed countries that are parties to the Montreal Protocol freeze production and consumption of CFCs at 1986 levels.

**1996**  
Developed country parties eliminate production and import of CFCs, carbon tetrachloride, methyl chloroform, and hydrobromofluorocarbons.

**1994**  
Developed country parties eliminate production and import of halons.

**1993**  
DuPont™ announces that it will halt its production of CFCs by the end of 1994.

**1992**  
Copenhagen amendment adds HBFCs, methyl bromide and HCFC controls to the Montreal Protocol

**1990**  
London Amendment to the Montreal Protocol adds controls on carbon tetrachloride and methyl chloroform and creates the Multilateral Fund

## COLLABORATORS IN ATMOSPHERIC CHEMISTRY



In the 1970s, chemists Sherwood Rowland and Mario Molina discovered that CFCs contribute to ozone depletion. The two collaborators theorized that CFC gases react with solar radiation and decompose in the stratosphere, releasing chlorine atoms that are able to destroy large numbers of ozone molecules.

Their research was first published in *Nature* magazine in 1974. The National Academy of Sciences concurred with their findings in 1976, and in 1978 CFC-based aerosols were banned in the United States. Further validation of their work came in 1985 with the discovery of the ozone hole over Antarctica. In 1995, the two chemists shared the Nobel Prize for Chemistry with Paul Crutzen, a Dutch chemist who demonstrated that chemical compounds of nitrogen oxides accelerate the destruction of stratospheric ozone.

2000

Japan Meteorological Agency reports the hole in the stratospheric ozone layer over the Antarctic is at its largest ever—more than twice the size of Antarctica.

2050-2075

Earliest timeframe projected for the ozone layer to recover.<sup>2</sup>

2004

Developed country parties to the Montreal Protocol reduce use of HCFCs by 35 percent.

2010

All developing countries that are parties to the Montreal Protocol scheduled to phase-out CFCs, halons and carbon tetrachloride.

2015/2016

All developing countries that are parties to the Montreal Protocol scheduled to phase-out methyl bromide and methyl chloroform in 2015/ freeze HCFC production and import at 2015 levels in 2016.

2030/2040

All developed countries that are parties to the Montreal Protocol scheduled to phase-out HCFCs/ developing country parties scheduled for HCFC phaseout in 2040.

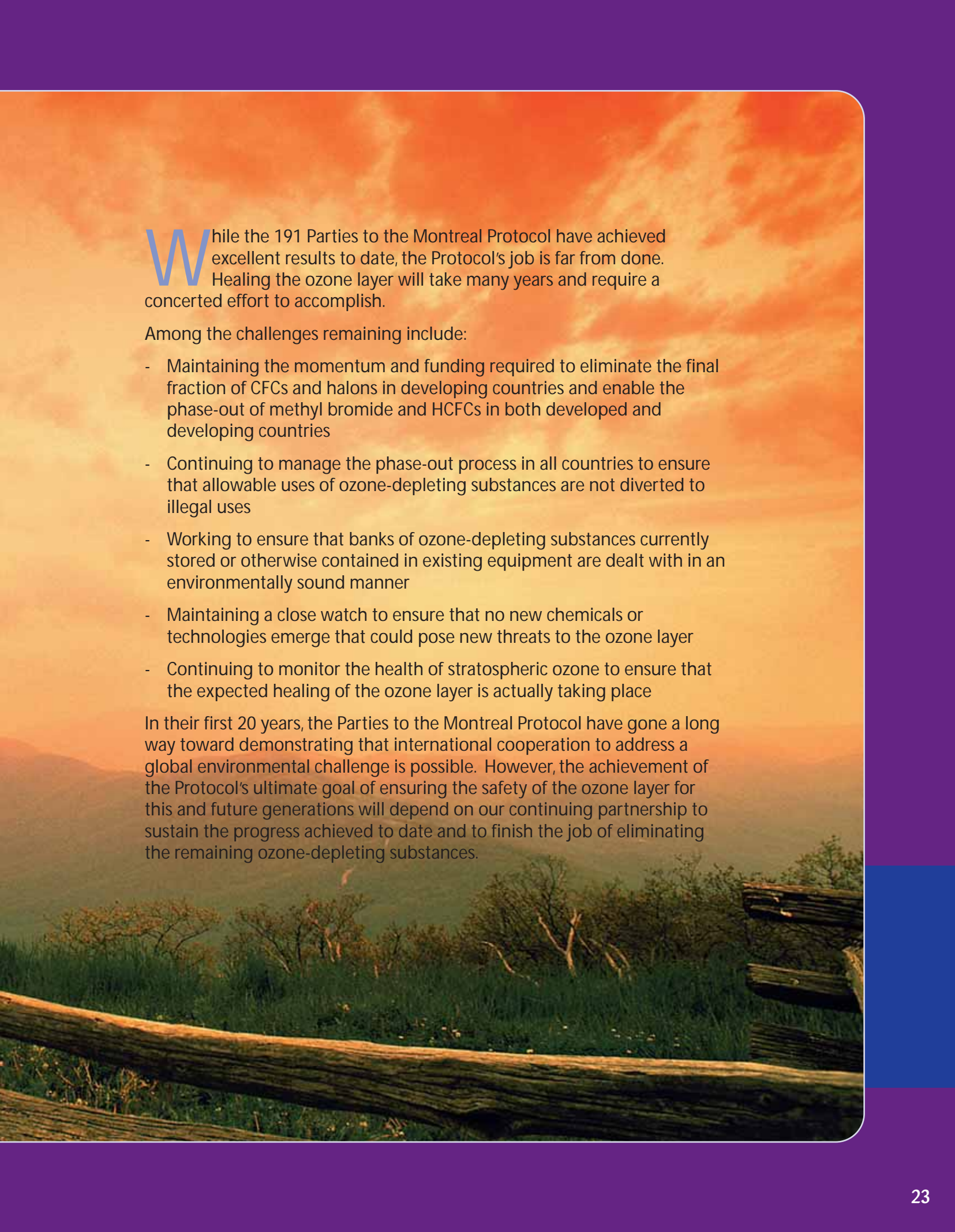
2002

All developing countries that are parties to the Montreal Protocol freeze methyl bromide production at 1995–1998 average level.

2 Executive Summary, WMO/UNEP Scientific Assessment of Ozone Depletion: 2006, Scientific Assessment Panel of the Montreal Protocol on Substances that Deplete the Ozone Layer, August 18, 2006. p. 7.

# Looking Ahead





While the 191 Parties to the Montreal Protocol have achieved excellent results to date, the Protocol's job is far from done. Healing the ozone layer will take many years and require a concerted effort to accomplish.

Among the challenges remaining include:

- Maintaining the momentum and funding required to eliminate the final fraction of CFCs and halons in developing countries and enable the phase-out of methyl bromide and HCFCs in both developed and developing countries
- Continuing to manage the phase-out process in all countries to ensure that allowable uses of ozone-depleting substances are not diverted to illegal uses
- Working to ensure that banks of ozone-depleting substances currently stored or otherwise contained in existing equipment are dealt with in an environmentally sound manner
- Maintaining a close watch to ensure that no new chemicals or technologies emerge that could pose new threats to the ozone layer
- Continuing to monitor the health of stratospheric ozone to ensure that the expected healing of the ozone layer is actually taking place

In their first 20 years, the Parties to the Montreal Protocol have gone a long way toward demonstrating that international cooperation to address a global environmental challenge is possible. However, the achievement of the Protocol's ultimate goal of ensuring the safety of the ozone layer for this and future generations will depend on our continuing partnership to sustain the progress achieved to date and to finish the job of eliminating the remaining ozone-depleting substances.

For more information on the Montreal Protocol or ozone depletion, please contact

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