The Winners of the Blue Planet Prize 1993

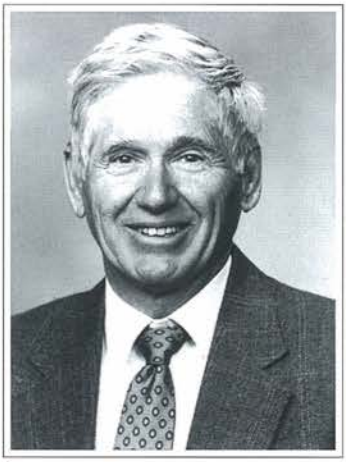
1993

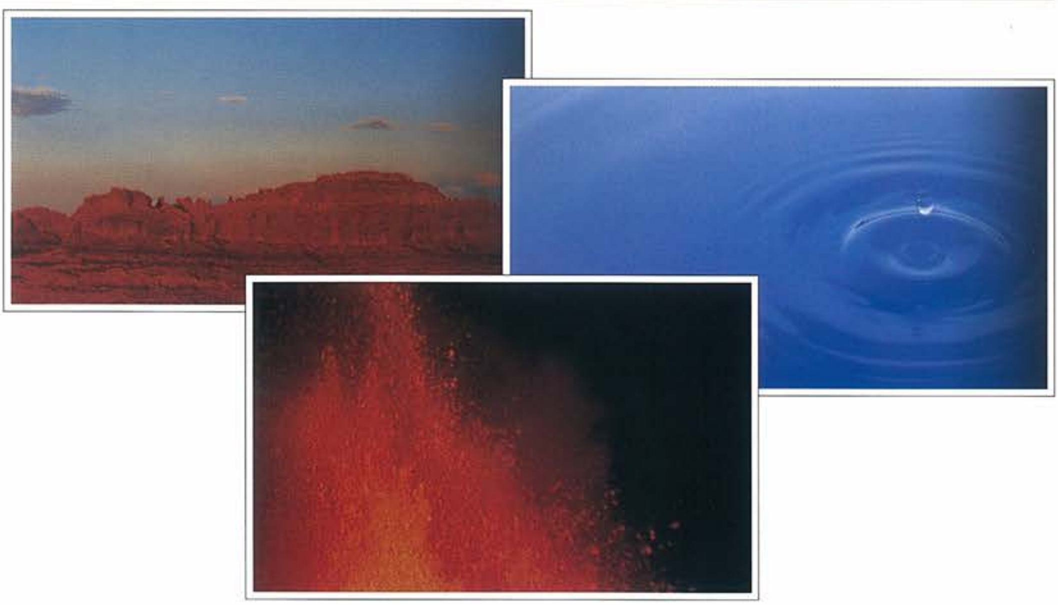
Blue Planet Prize

Dr. Charles D. Keeling (U.S.A.)

Professor, Scripps Institution of Oceanography at the University of California, San Diego

IUCN–The World Conservation Union (Headquartered in Switzerland)





The 1993 awards ceremony opened with a slide presentation showing the essential beauty of nature and how human beings are a part of life on Earth.

His Highness Prince Akishino and Her Highness Princess Kiko attend the awards ceremony for the 1993 Blue Planet Prize.

Prince Akishino and Princess Kiko toast the laureates.

Dr. Keeling accepts the 1993 Blue Planet Prize.

Dr. Holdgate, representing the IUCN, accepts the 1993 Blue Planet Prize.

Professor Takashi Mukaibou, chairman of the Presentation Committee, describes the Blue Planet Prize selection process.

Jeno C. A. Staehelin (left), Switzerland's ambassador to Japan, and Michael A. G. Michaud, minister counselor for environment, science and technology at the U.S. embassy in Japan, listen as His Highness Prince Akishino addresses the audience.

Seated in the audience during the symposium, which focused on population-related problems, the winners add their views on the population debate.

Profile

Dr. Charles David Keeling

Professor, Scripps Institution of Oceanography at the University of California, San Diego

Education and Academic and Professional Activities

1948 B.A., University of Illinois

1953–56 Research Fellow, California Institute of Technology

1954 Ph. D., Northwestern University

1956–64 Assistant Research Chemist, Scripps Institution of Oceanography, University of California, San Diego

1961–62 Guggenheim Fellow, Meteorological Institute, University of Stockholm

1964–68 Associate Professor of Oceanography, Scripps Institution of Oceanography, University of California

1968 Professor of Oceanography, Scripps Institution of Oceanography, University of California

1969 Guest Professor, Zweiten Physikalisches Institut of the University of Heidelberg

1981 Half-Century Award of the American Meteorological Society

1986 Fellow, American Academy of Arts and Sciences

1990 Fellow, American Association for the Advancement of Science

1991 Maurice Ewing Medal, American Geophysical Union

Dr. Keeling has also been Scientific Director of the Central Carbon Dioxide Laboratory of the World Meteorological Organization since 1976.

Dr. Charles D. Keeling is an earth scientist who has conducted pioneering research into carbon dioxide levels of the atmosphere and ocean, as well as the global carbon dioxide gas cycle. The first to recognize the importance of scientifically measuring atmospheric carbon dioxide levels, Dr. Keeling in 1958 began precise measurements using nondispersive infrared analysis at the Mauna Loa Observatory in Hawaii and started atmospheric observation at the South Pole. Continuing his research for more than 30 years, Dr. Keeling has amassed a great deal of useful data. This long record of atmospheric carbon dioxide levels has provided the international scientific community with an invaluable body of data that today forms the basis for an ongoing discussion of global warming.

Born in 1928 in Scranton, Pennsylvania, Dr. Keeling received his undergraduate degree from the University of Illinois. In 1954, he earned his doctorate from Northwestern University. Dr. Keeling joined the Scripps Institution of Oceanography at the University of California, San Diego, in 1956 and became the Professor of Oceanography in 1968, a title which he holds to this day.

Lecture

A Brief History of Atmospheric Carbon Dioxide Measurements and Their Impact on Thoughts about Environmental Change

Dr. Charles D. Keeling

Introduction

More than a few people have wondered why I have spent 40 years focused mainly on a single chemical molecule; carbon dioxide. I would like to explain to you how it was possible to maintain an interest in this simple molecule for so long. I will start by taking you back to the beginnings of science when neither this molecule, nor any other molecule, was known to anyone. Then, after sharing with you some of the early developments of science which led to the discoveries of carbon dioxide and its importance to life and to the Earth's environment, I will explain how I more or less accidentally became interested in studying this substance, and inadvertently joined a long succession of scientists who have investigated its role in nature.

Early History of Carbon Dioxide

Let us contemplate the world as seen by people living before the birth of modern science. We can imagine that the most curious among them attempted to understand the nature of air, water, and the matter which makes up living plants and animals. For example, people could perceive that strong winds involved some kind of invisible substance. Perhaps it was the same substance that caused bubbles under water. But lacking means to probe further into causes, and lacking any understanding of how matter was made up of tiny molecules, they were unable to make any great progress in understanding nature better. Thus, they had no real idea of why plants have leaves, or how climate might be influenced by a changing composition of an atmosphere made up of individual gases mixed together. Indeed, the notion that climates could change was not thought about.

Because people then had no idea that plants exchange substances with the air and that air contains substances that influence climate, the topic which became my life work could not have been conceived before modern science laid the groundwork for understanding the chemistry of gases. Of course, people were free to speculate, and, as an example, Stephen Hales, born in the late 1600s, asked in an essay on vegetables in 1727 whether the leaves of plants might not be there because the plants drew some part of their nourishment from the air.

The discoveries which led to an understanding of the nature of air began in 1754 with the observations in Scotland by Joseph Black, who found that something in air could be precipitated in water containing lime to make a milky solid material. This substance he called "fixed air." It was actually carbon dioxide gas, but he had no idea that it was composed of car-

Table 1 Early Measurement of CO_2 in Air

	Approximate Time	Mean Concentrations Found
Alexander von Humboldt	1797	circa 1% (10,000 ppmv)
Theodore de Saussure	1815	596 ppmv
	1827	506 ppmv
	1828	447 ppmv
	1829	403 ppmv
	1830	373 ppmv
Jules Reiset	1870	290 ppmv

bon and oxygen as the modern name implies, because these chemical elements had not yet been identified.

During the next 30 years, a time shorter than I have been measuring carbon dioxide, the chemistry of the atmosphere was worked out by the great "pneumochemists," as they were called at the time. The discovery was made that liquid water could be separated into two gases, one of which was a new gas that was called "inflammable air," but is now called hydrogen. The other was later called "oxygen." Soon afterwards that gas was discovered to be part of air, where it is mixed with a nonreactive gas that later came to be called nitrogen. Fixed air, the gas discovered by Joseph Black, was shown to consist of oxygen and another element that came to be called carbon. Lavoisier, who discovered this a short time later, proposed the theory of oxidation by which elements, in general, combine to form molecular compounds.

With this tantalizing insight into a basic premise of modern chemistry, the discovery of many more elements and of many chemical reactions soon took place. Meanwhile, other naturalists, led mainly by sheer curiosity as had been the first pneumochemists, began to probe the process by which plants grow.

Even before Lavoisier had positively identified oxygen as a gas and given it its present name, an Englishman named Priestly had found that vegetables grown in a confined space caused the air to change in some way that supported combustion. He thus came close to realizing that plants give off oxygen when they grow, although he mistakenly thought the plants were removing something from the air called "phlogiston." Soon after Priestly's discovery, a Dutchman named Jan Ingen-Housz found that plants do what Priestly discovered only in the presence of sunlight. In the dark they appeared to "poison" the air, as he said. A Frenchman, Senebier, further noticed that plants grew better if they were supplied with "poisoned air," which he recognized to be not a poison at all but fixed air, that is, carbon dioxide. In 1796 Ingen-Housz then carried Senebier's idea even further by proposing that the organic matter of plants comes from the carbon that Lavoisier had found to be part of fixed air; that is, plants don't just transform carbon dioxide into some other gas, they utilize part of it, as well. Ingen-Housz also suggested that this carbon is absorbed by plants through the leaves, not from the ground as most people had previously supposed. Ingen-Housz cited the evidence of Alexander von Humboldt that air typically contains 1% carbon dioxide.

Von Humboldt's first measurements of carbon dioxide in air were much too high. This didn't matter to Ingen-Housz's theory, but it established a bad precedent. It took many years before the amount present in the air was correctly measured, as indicated in the summary shown in Table 1.

In 1804, Theodore de Saussure showed that water was also an essential chemical in photosynthesis, combining with carbon to make actual living matter. He also demonstrated more clearly than Ingen-Housz that the carbon involved in plant growth came from the air. Curious about the carbon dioxide in the air, he made the first detailed measurements of its concentration there, measuring it near Geneva, Switzerland, under different wind conditions, different hours of the day and different months of the year. The mean value that he found was roughly 0.04% by volume, which I will put in modern units as 400 parts per million by volume (ppmv). This value was much less than von Humboldt had found, but still in considerable error.

De Saussure's *Memoires*, published in 1830, nevertheless ushered in a period of increasingly precise measurements of atmospheric carbon dioxide, culminating in some nearly correct measurements in the 1880s by a Belgian named Jules Reiset. Reiset's data were the first to show correctly the seasonal cycle in atmospheric carbon dioxide. These data indicated that summer values on the Atlantic Coast of Belgium were lower than winter values by about 10 ppmv. This seasonal difference we now know to be due mainly to the uptake of carbon dioxide by plants, which gradually reduces the amount of carbon dioxide in the air over the whole Northern Hemisphere from May to September, and over the Southern Hemisphere from November to March. Unfortunately, none of the other investigators of carbon dioxide reproduced the seasonal cycle even approximately correctly, casting doubt on all of their data.

After the 1880s, interest in carbon dioxide diminished for reasons which I have not been able to establish. Indeed, a quick and easy but not very precise 19th century technique of measurement, called Pettenkofer's Method, became the most common method for measuring carbon dioxide, so that measurements actually became less precise than the best of those of the 19th century. The 20th century data were generally higher than the correct concentrations, although of course this wasn't known at the time.

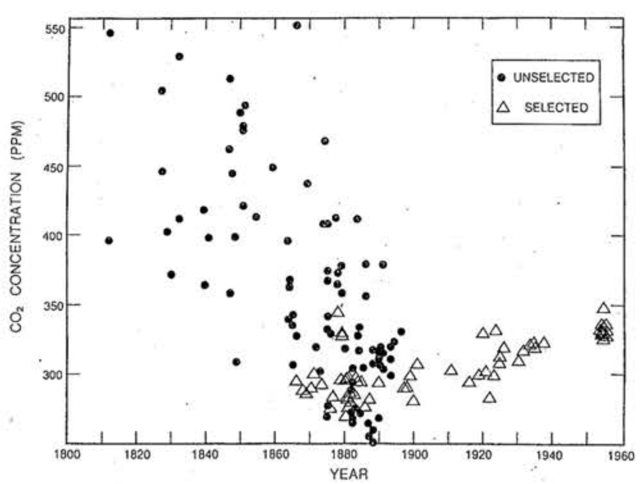


Figure 1 Measurement of the concentration of atmospheric CO_2 in the Earth's atmosphere. Measurement selected by G. S. Callendar as the most reliable are shown as open triangle. Concentration is expressed in parts per million (ppm) by volume.

In the 1930s, in the midst of this period of low interest in atmospheric carbon dioxide, a steam technologist named G. S. Callendar made a personal hobby of carbon dioxide. In a series of papers, he summarized what was known about atmospheric carbon dioxide and its likely effect on climate. He attempted to select the most reliable measurements from the past for study. I have plotted these observations in Fig. 1, distinguishing the ones that he considered most reliable. From these he came to the conclusion that the combustion of coal, along with the other major fossil fuels, methane and petroleum, was probably responsible for causing atmospheric carbon dioxide to increase, as the observations indicated. He correctly perceived that ocean water contains a vast reservoir of bicarbonates and carbonate salts which react chemically with carbon dioxide. He thus supposed that the world oceans had absorbed some of the carbon dioxide produced by combustion. However, on the basis of the direct carbon dioxide observations, he was misled into concluding that the rise in carbon dioxide actually exceeded the amount that had been added to the air by fuel combustion. His most detailed article on the subject was published in 1938 but he continued to publish articles on the subject until 1958, thus overlapping with my first studies. Indeed, we exchanged letters just before his last article was written.

This brings my talk to where I will discuss my own work. From this point on I will call carbon dioxide by its chemical name, CO_2.

A Career Measuring Carbon Dioxide

My interest in atmospheric CO_2 came about quite accidentally. As a student I had studied the irradiation of polymeric films by high-energy neutrons from a nuclear reactor, a subject having little to do with environmental science. After receiving my doctoral degree I decided to change fields and study geological processes, from the viewpoint of a chemist. At the California Institute of Technology, in Pasadena, California, my supervisor, Dr. Harrison Brown, allowed me to choose a topic to study, and I decided to determine how the acidity of natural waters is influenced by contact with CO_2 gas in the atmosphere. The rivers and lakes that I visited all happened to be near forests. As part of my experiments, which began in 1954, I measured the pressure exerted by CO_2 dissolved in the water, and the amount of CO_2 in the air. Since I didn't know how constant the CO_2 concentrations in air might be, I made measurements every few hours for a day at a time, thus obtaining measurements during both dark and light periods. Inadvertently I was measuring the diurnal cycle of CO_2 in forest air.

To carry out my measurements of CO_2, I built a manometer, which is a device that measures the pressure of CO_2 gas in a confined volume. By measuring the temperature of the gas as well as the pressure, and by calibrating the confining volume, the manometric determination of CO_2 gave a higher precision than had been attained previously by chemical methods. I also similarly measured the quantity of air by the same technique beforehand, and I separated the CO_2 from the air using a new method that I had read about, freezing it out in a trap cooled with liquid air.

My first measurements were made with only a brief prior investigation of the scientific literature. But soon I began to search this literature to learn about atmospheric CO_2. I found out, of course, that it was reported to be quite variable in concentration. For example, only a

Table 2 CO_2 Concentration in Different Types of Air (Buch, 1948)

High Arctic:	150 – 230 ppmv
Modified Arctic:	283 – 316 ppmv
Maritime Polar:	309 – 345 ppmv
Tropical:	319 – 349 ppmv

ppmv: parts of CO_2 per million parts of dry air by volume

short time previously, in 1953, a comprehensive book on the geochemistry of all of the Earth's elements was published. The chapter on carbon quoted extensive CO_2 data by a scientist from Finland named Kurt Buch. As shown in Table 2, Buch had decided that air from different regions of the Earth showed characteristic concentrations that varied from below 200 ppmv in the Arctic, to nearly 350 ppmv in tropical regions. At first I could see no reason to question these data.

Neither did Karl Gustav Rossby, a world famous meteorologist who had pioneered weather forecasting in America and had recently returned to his native Sweden to establish an institution of meteorology there. He decided to include chemical measurements in the study of meteorological processes at his new institute. To do so, he helped to establish a network of some 50 locations in Scandinavia. Measurements of CO_2 at these locations began the same year that I made my first measurements. The Scandinavian data appeared in each issue of a new Swedish journal of geophysics called *Tellus*. The measurements evidently confirmed that large variations of atmospheric CO_2 occurred even in the open air away from plants and major cities, just as Buch's data had indicated.

Since I had been measuring CO_2 in forested areas which might be expected to promote large variations, I was surprised to find that measurements which I made in the afternoon had nearly the same CO_2 concentration everywhere that I went, contrary to the Scandinavian data. Afternoon is when the heating of the ground by the sun causes the air near the ground to mix with air above the trees, so that the effect of photosynthesis on the concentration of CO_2 should not be very strong. I decided that I was probably measuring the same CO_2 concentration as was occurring above the trees. To confirm this, I made additional measurements away from trees, on beaches of the Pacific Ocean during sea breezes, on high mountains at elevations too high for trees to grow, on deserts near my home where there were hardly any plants at all and, with the help of a professor at the Scripps Institution of Oceanography, in air collected on a ship in the eastern Pacific Ocean near the equator. In all cases I found the concentration of CO_2 in the afternoon to be close to 315 ppmv. I came to the conclusion that the published 20th century data generally were in error and that the CO_2 concentration, when not locally influenced, was nearly the same at least from the equator to the northern limits of the United States, and perhaps everywhere.

It took me two years to reach this conclusion. The year was 1956. I learned that plans were being made for a large international study of the environment called the International Geophysical Year, and that this study was to include measurements of atmospheric CO_2. These were to be patterned after the Scandinavian program already operating. I expressed my concerns to several planners of the International Geophysical Year that the data might not be very useful if the Scandinavian method were to be used. One of these planners was Dr. Harry Wexler, director of research for the U.S. National Weather Service. I showed him my best open-air measurements of CO_2 which suggested that the concentration of CO_2 varied only slightly with the previous location of the air, contrary to the Scandinavian data. His response was to tell me about a new remote station where such measurements could be made over long time periods. The location was called the Mauna Loa Observatory on the island of Hawaii. The observatory had been constructed the year before, high on the mountain of Mauna Loa. He was eager to see the observatory used during the International Geophysical Year, and he encouraged me to try to make measurements there.

I also talked with Roger Revelle, director of the Scripps Institution of Oceanography. From his own examination of the existing measurements of CO_2 over the past century, he still accepted the idea that CO_2 varied from place to place. He argued that the best way to decide whether CO_2 was increasing in the air was to obtain a limited number of measurements in many places so as to establish an average "benchmark" value of the global average concentration. Then in 10 or 20 years one could remeasure CO_2 to see if it had increased in the air. He proposed that I make extensive CO_2 measurements from ships and airplanes.

In the summer of 1956 I moved to the Scripps Institution of Oceanography and with the urging of both Revelle and Wexler I followed both of their approaches. The scope of the study is shown in Fig. 2.

The method of measuring CO_2 that I had used at the California Institute of Technology had allowed me to analyze about 500 samples in two years. To accomplish a much more exten-

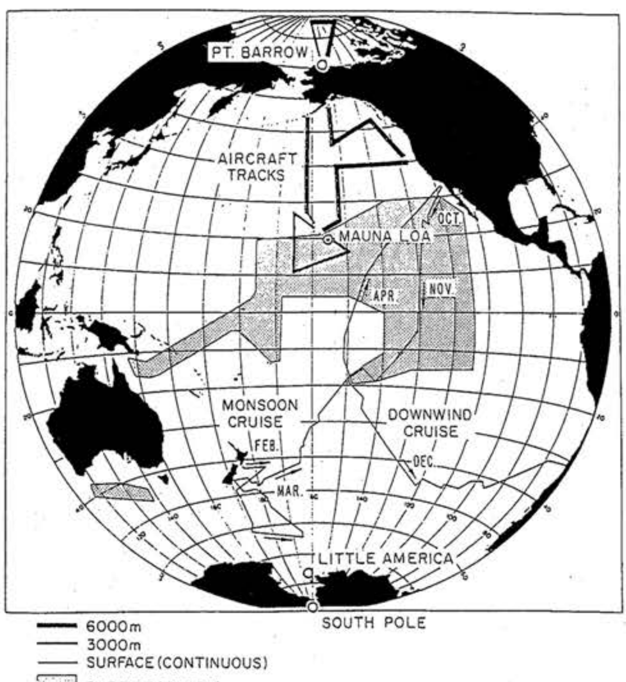


Figure 2 Locations of stations and ship tracks for sampling atmospheric CO_2. Stippled (gray) areas indicate regions where sampling took place along multiple ship tracks, not shown individually.

Table 3 CO_2 Concentration in Different Regions in 1962

Arctic:	313 – 325 ppmv
Pacific Ocean at 20 °N:	315 – 321 ppmv
Equatorial Pacific:	317 – 321 ppmv
South Pole:	317 – 319 ppmv

Measurements by the Scripps Institutions of Oceanography

sive program for the International Geophysical Year, I took advantage of semiautomatic infrared gas analyzers which had become commercially available. None of them had been used to measure atmospheric CO_2 precisely, but at least one model seemed likely to be capable of doing so. After testing this one, I was able to purchase several, including one unit for the Mauna Loa Observatory, one for Antarctica, one to be put on a ship, and one for my laboratory in La Jolla. They had to be calibrated, and for this purpose I built a new and more precise manometer. This manometer was completed in 1959; it is still the basis of calibrating the gas analyzers in my program and since 1975 has been the primary basis for calibrating atmospheric CO_2 analyzers internationally.

At the close of the International Geophysical Year in 1959, it became clear that the gathering of data to fulfill Dr. Revelle's benchmark study should not be shut down and started up again only after 10 to 20 years, as he had first suggested. Especially the data from the Mauna Loa Observatory and the South Pole showed interesting features never seen before in any CO_2 data. These became more and more interesting as the records became longer. A clearly marked seasonal oscillation had shown up in the data from the Mauna Loa Observatory in the first year of uninterrupted measurements, beginning in the final months of 1958 and extending through 1959, as shown in Fig. 3. We know now that a similar cycle appears everywhere in the Northern Hemisphere. Thus, it seems astounding that this cycle was never clearly seen in earlier measurements, since the methods available in the 19th century were already adequate to show it. The times of fall and rise in CO_2 corresponded to the expectations of when plants absorb CO_2 during the active growing season, and release it through decay processes, as de Saussure had anticipated a century and a half earlier. As indicated in Table 3, the spatial variations in CO_2, even when the seasonal cycle was taken into account, were much smaller than earlier 20th century data had indicated.

An increase in atmospheric CO_2 concentration from year to year, already hinted at by data obtained during the International Geophysical Year, became ever more clearly seen as the records at the Mauna Loa Observatory and elsewhere became longer. By 1963 the average rate of increase was well enough established by these data to be compared with the rate of CO_2 injection into the air by fossil fuel combustion. The data showed that the fraction of fossil-fuel-derived CO_2 which apparently remains in the air was about 50%. This fraction has remained nearly the same up to the present time, suggesting a steady mechanism for its removal from the air. This mechanism is absorption by the oceans, the same mechanism that Callendar had described in the 1930s, but had then questioned because the existing CO_2 data appeared to disprove it.

I should not, however, imply that the removal rate has remained perfectly steady. Let us now turn to a consideration of the entire record of atmospheric CO_2 for the Mauna Loa Observatory, from the first measurements in 1958 until early this year (1993). Interannual variations in the rate of rise of CO_2 are quite clearly evident in the record, and seem to be caused by natural oscillations that do not affect the average fraction of CO_2 remaining in the air from fossil-fuel combustion on longer time scales. The accompanying series of diagrams serves to illustrate this.

The first of these is a plot of monthly data, shown by dots in Fig. 4. The seasonal cycle, as shown previously just for 1958 and 1959, is clearly seen every year, superimposed on the long-term rise. The average cycle, combined with the rise, is shown by a smooth curve through the data. The seasonal cycle is obviously quite regular, since the dots and the curve agree closely. If the average seasonal cycle is removed from both the data and from the curve, thus "seasonally adjusting" the data, the long-term trend in CO_2 is seen more clearly, as in Fig. 5.

To compare this rising trend with the amount of CO_2 injected into the air by fuel combustion, I have calculated the amount of CO_2 injected each year and summed it with all amounts injected earlier. In this way I obtain the cumulative increase shown in Fig. 6. The units are gigatons of carbon contained in CO_2, where one gigaton is equal to a thousand million metric tons. As indicated, about 80 gigatons were released up to 1959, rising to 230 gigatons in 1993. By adjusting the plotting scale, this curve can be compared to the previous plot of the seasonally adjusted atmospheric CO_2 data. When this is done (see Fig. 7), the patterns of the rise in CO_2 and of fossil-fuel CO_2 emissions are seen to be remarkably similar. This comparison is one of the most convincing indicators that the rise in atmospheric CO_2 is closely related to the injection of CO_2 from fossil fuels.

Another interesting feature of the Mauna Loa record is seen in the previous plot of the actual monthly data (see again Fig. 4). The seasonal cycle is seen to be larger in the latter part of the record than in the earlier part by about 15%. This increase is probably not entirely a result of any single cause, but the main reason is likely to be that the growth rate of plants has

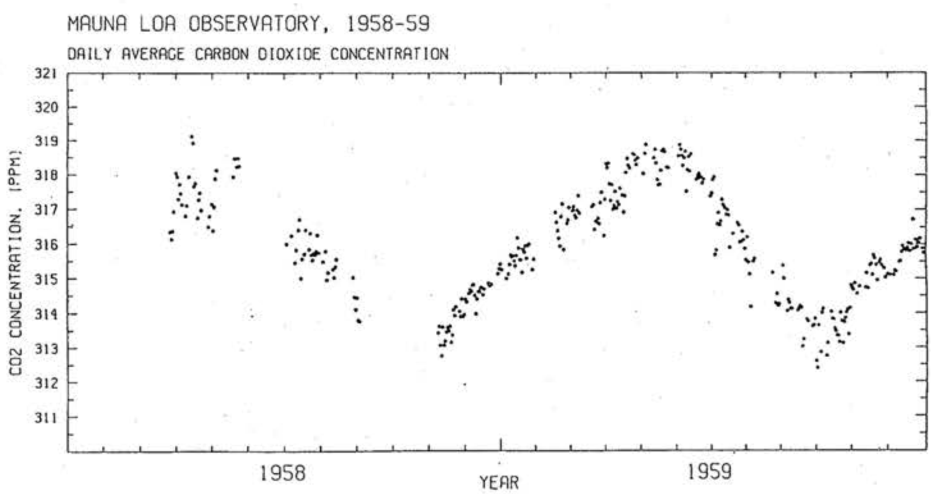


Figure 3 Daily average measured concentration of CO_2 in air at the Mauna Loa Observatory, Hawaii, measured during the first two years of sampling at this station. Concentration is expressed in ppm by volume.

increased since 1958. Perhaps this has occurred because the growing season of plants on land has become longer or because of improvements in agriculture, but part of the reason may be that the plants are responding to the increase in atmospheric CO_2, which has risen 13% since 1959. If so, this is a fulfillment of the original suggestion of Senebier that plants grow better when they are supplied with more fixed air, as CO_2 was known in the 18th century.

A close look at the comparison of seasonally adjusted CO_2 data to the curve for fossil fuel emissions (Fig. 7) shows that the actual CO_2 data tend to migrate from above to below the fossil-fuel curve and back every few years. To see this pattern better, I show in Fig. 8 a plot of the difference between the two curves, in effect what the seasonally adjusted CO_2 record would have looked like if burning of fossil fuels had not caused the CO_2 to increase year after year. I call this a CO_2 "anomaly." The vertical scale is expanded in the plot to see the fluctuating pattern of the anomaly more distinctly. The times when the CO_2 anomaly was rising correspond generally to times when large changes in weather have occurred in connection with a tropical phenomenon called El Niño. The times of the latter are shown by vertical arrows. The same patterns are seen globally in CO_2 records from near the North Pole to the South Pole. Processes involving both oceans and vegetation contribute to the oscillations but appear to do so in opposite ways, that is, the exchange of CO_2 between the air and the oceans oppose variations in uptake and release of CO_2 by plants on land. Thus, even larger CO_2 oscillations would have occurred during El Niño events if growing plants alone had caused the patterns.

I do not have time to describe many additional details about how atmospheric CO_2 measurements may help us to understand the cycling of carbon in nature. Thus, I now come to the

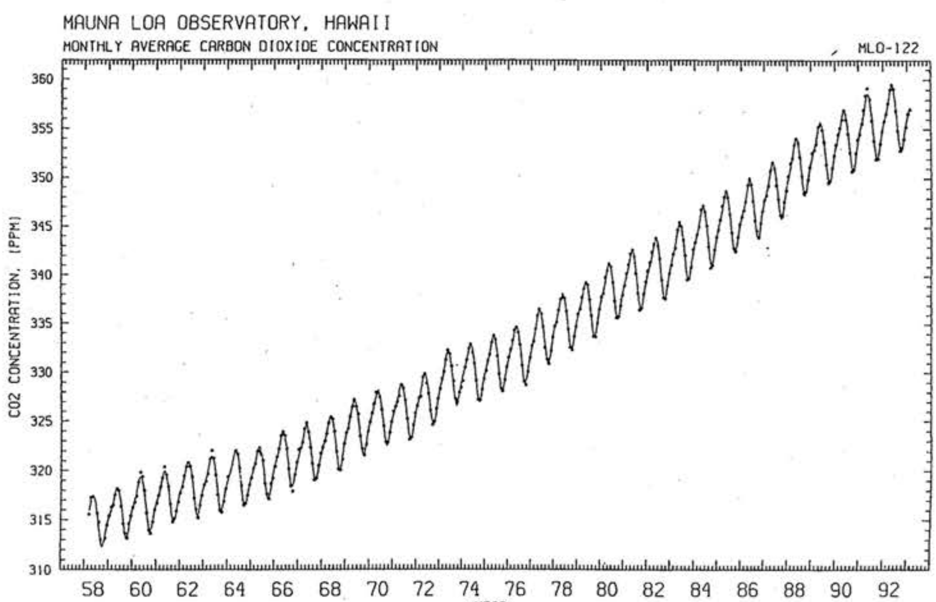


Figure 4 The concentration of CO_2 in air, in ppm, at the Mauna Loa Observatory from 1958 to 1993. Monthly averages are shown as solid dots. A smooth curve indicates the seasonal cycle superimposed on a long-term upward trend.

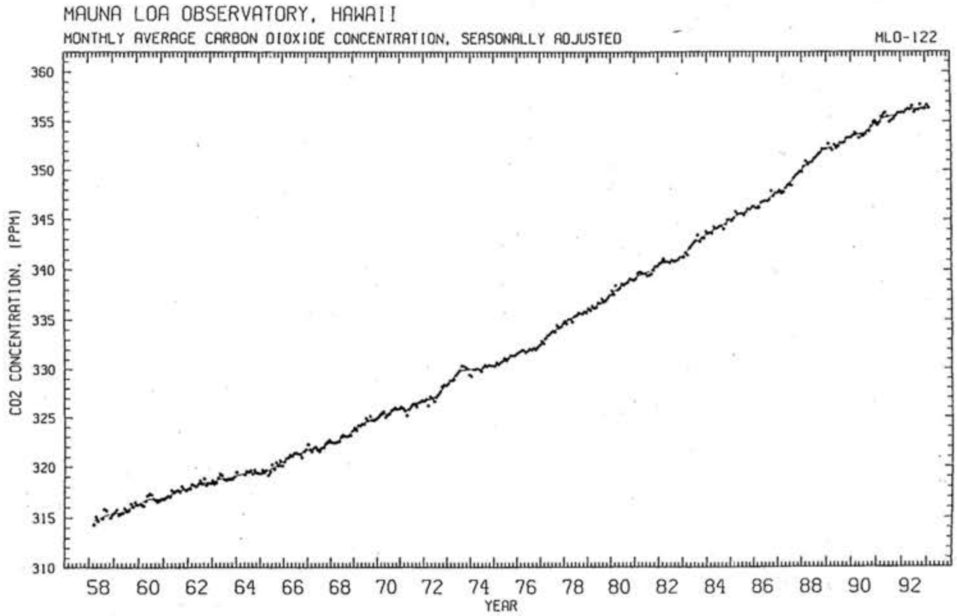


Figure 5 The same plot as Figure 4, except that the seasonal cycle is removed.

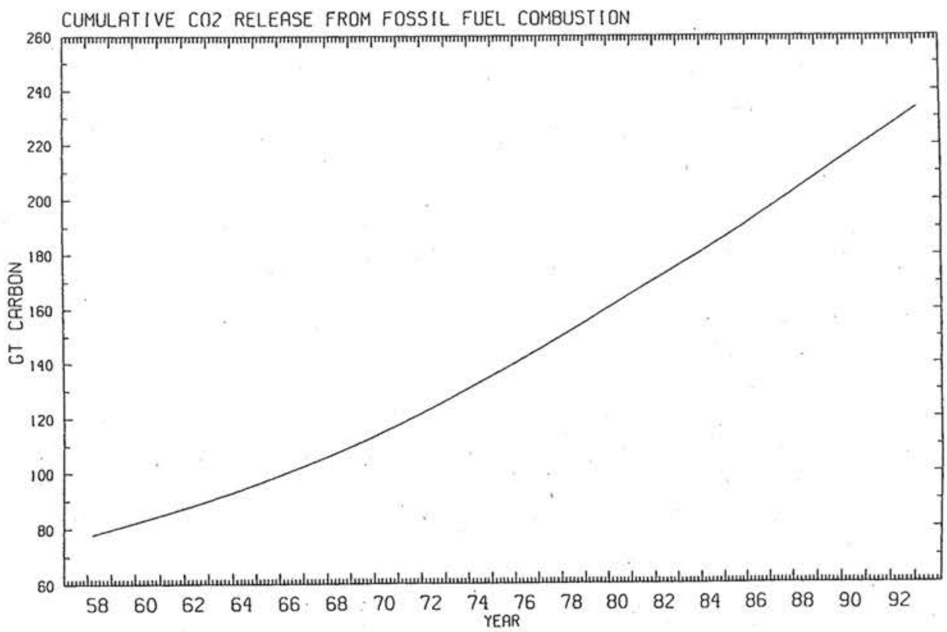


Figure 6 A plot of carbon in the fossil fuel that has been released to the atmosphere, expressed in gigatons (thousands of millions of metric tons). Amounts are cumulative, i.e., the amount for each year includes all of the previously released carbon.

close of my lecture.

Concluding Remarks

I have traced the history of carbon dioxide measurements over a period of nearly two and a half centuries, from the time of its first discovery to the early 1950s. After that I have talked mainly about my own investigations of CO_2 in the atmosphere. I should mention, however, that many other scientists have studied atmospheric CO_2 during the past 30 years. Some of the very best measurements are coming now from studies in Japan.

There is no likelihood that the study of CO_2 will slow down in the next few years as it did after the vigorous studies of the last century. There is much more that will be learned about the Earth's carbon cycle, and much of it will be as interesting as what we have already learned.

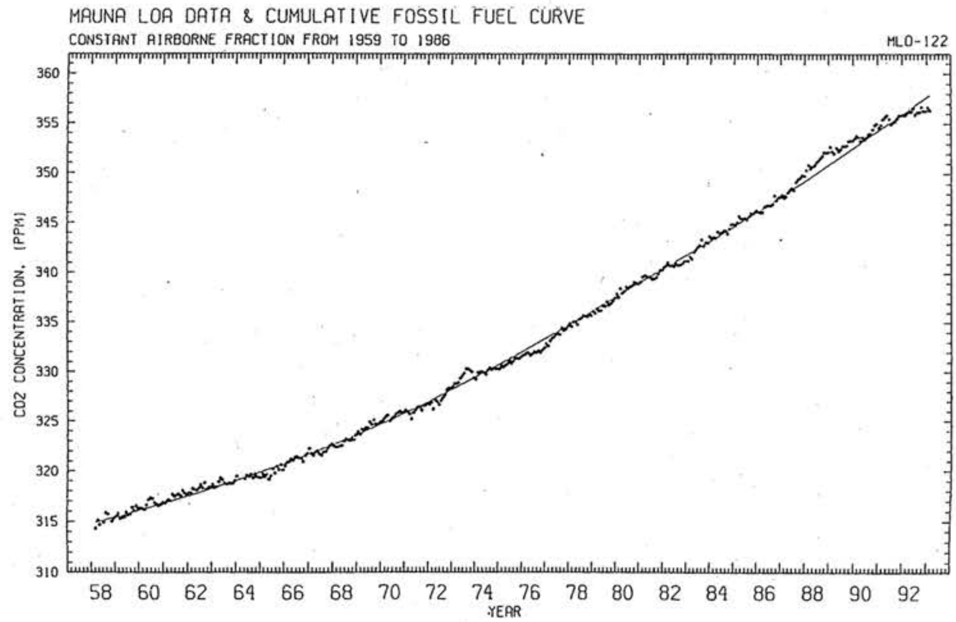


Figure 7 A comparison of the cumulative increase in carbon released by fossil fuel (shown in Figure 6) with the seasonally adjusted rise in atmospheric CO_2 at the Mauna Loa Observatory (shown in Figure 5).

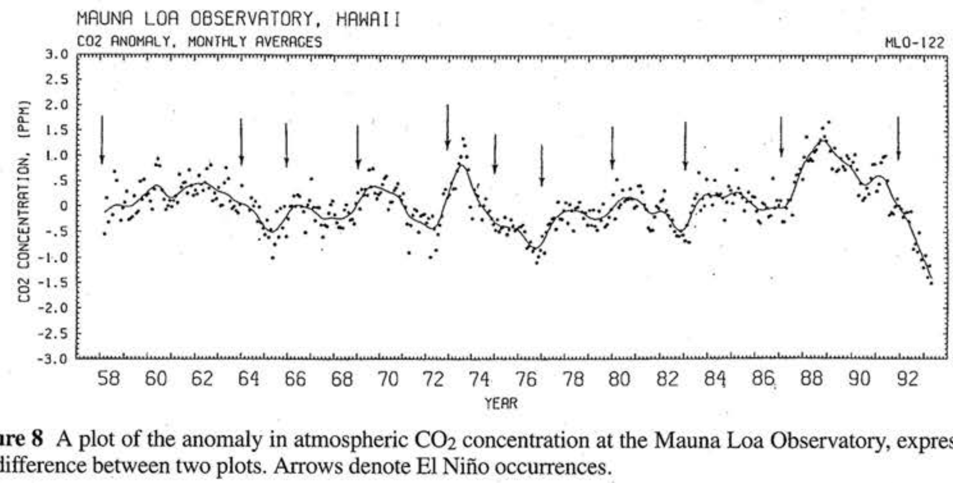


Figure 8 A plot of the anomaly in atmospheric CO_2 concentration at the Mauna Loa Observatory, expressed by the difference between two plots. Arrows denote El Niño occurrences.

Major Publications

Dr. Charles D. Keeling

Articles

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—. "Effect of Local Environment on the Isotopic Enrichment in Plants." *Comitato Nazionale per L'Energia Nucleare*, Laboratorio di Geologia Nucleare Pisa, (1960) 214–215.

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Craig, H. and C.D. Keeling. "The Effects of Atmospheric NO_2 on the Measured Isotopic Composition of CO_2." *Geochimica et Cosmochimica Acta*, 24 (1963), 549–551.

Bolin, B. and C.D. Keeling. "Large-Scale Atmospheric Mixing as Deduced from the Seasonal and Meridional Variations of Carbon Dioxide." *J. Geophys. Res.*, 68 (1963), 3899–3920.

Revelle, R. (Chairman), W. Broecker, H. Craig, C.D. Keeling, and J. Smagorinsky. "Atmospheric Carbon Dioxide." *Report of the Environmental Pollution Panel President's Advisory Committee3*. The White House, November 1965, 111–11.

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Profile

The World Conservation Union* (IUCN)

History

1948 IUCN's predecessor founded by the government of France, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and Ligue Suisse pour la Protection de la Nature.

1961 IUCN's "Morges Manifesto" issued. The World Wildlife Fund (WWF) founded to generate funds for conservation.

1971 The Ramsar Convention (Wetlands of International Importance) established. IUCN hosts secretariat.

1980 "World Conservation Strategy" launched by IUCN, in partnership with WWF and UNEP.

1991 "Caring for the Earth" launched by the same partnership.

1992 IUCN organized the IVth World Congress on National Parks and Protected Areas, in Caracas, Venezuela.

* Formerly known as International Union for Conservation of Nature and Natural Resources

IUCN—The World Conservation Union is an independent, international membership organization committed to conserving the natural environment for future generations. Established in 1948, IUCN has achieved a leadership role in environmental conservation by offering practical solutions and policies based on results of scientific monitoring and analysis and field experience. The organization also actively disseminates important knowledge about the sustainable use of the World's natural resources. Its 773 members include 62 sovereign states, some 100 governmental agencies, and more than 600 nongovernmental organizations and affiliates. IUCN uses this influential network to help conserve biological diversity and promote the appropriate and wise utilization of global resources. These efforts are guided by the central idea that human society should develop in harmony with nature.

IUCN's achievements include developing strategies for conserving the global environment; playing a major role in the development and operation of international treaties and legislation, such as those resulting from the Biodiversity, the Ramsar (wetlands) and the World Heritage (natural sites) conventions; planning and executing projects in cooperation with individual governments; setting up and managing comprehensive environmental databases; and producing an extensive series of authoritative scientific, technical and practical publications such as the *Red Data Books, World Conservation Strategy* and *Caring for the Earth*. Thus, IUCN has attained outstanding results in a wide range of fields.

IUCN is headquartered in Switzerland. Dr. David McDowell is presently the director general, and Sir Shridath Ramphal is the president.

Essay

The Convention on Biological Diversity: An Idea Whose Time Has Come

Dr. Jeffrey A. McNeely
Chief Scientist, IUCN

March 1997

Introduction

The 1992 United Nations Conference on Environment and Development, the "Earth Summit," put biological diversity on the international agenda by signing the Convention on Biological Diversity (CBD). The idea of such a convention began at the Third World Congress on National Parks, held in Bali, Indonesia, in October 1982, and was developed further by IUCN's Environmental Law Centre over the following several years. In August 1988, the UN Environment Programme (UNEP) Executive Director Mustapha Tolba convened a high-level panel of experts to advise him on whether a global biodiversity convention was timely and, if so, what it should include. UNEP then convened a series of intergovernmental meetings to develop the CBD. Following several years of negotiations, the CBD was signed at Rio de Janeiro, entered into force at the end of 1993 and has now been ratified by more than 165 countries.

The objectives of the CBD are: "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of utilization of genetic resources." The convention thus covers ecological, economic, and social aspects of biodiversity.

This article will review progress to date in implementing the CBD. Progress can be assessed in two main ways: by considering the state and changes in biodiversity components (i.e. genes, species, and ecosystems); and by measuring the effectiveness of measures taken to implement the CBD. It can be argued that only by measuring the former can we evaluate the latter, and since the entry into force of the CBD, many more site-specific data are becoming available. But these data are not particularly useful at the national or higher levels. Considering the high cost of collecting comprehensive information for assessing and monitoring changes in biodiversity components, the focus in the near term must be on the second approach: assessing the measures taken to implement the CBD.

Progress in implementing the convention

In order to compile information about how the CBD is being implemented, IUCN sent a questionnaire to all parties to the CBD. With over 80 responses (nearly 50% of the parties), several trends are very clear.

- Ninety-three percent of respondents have increased access to information since the entry into force of the CBD and 67% have used information provided through the CBD to develop their activities.
- Ninety-one percent have prepared or are preparing a national biodiversity strategy or action plan (and 90% have developed other strategies or plans related to biodiversity issues); however, biodiversity has been incorporated only somewhat in most forest, agricultural, marine, and protected area strategies.
- Sixty-four percent have undertaken a systematic review of existing biodiversity-related institutions in response to ratifying the CBD and nearly two-thirds of the countries have reviewed their legislation, though only half of the countries consider their biodiversity-related legal and institutional framework to be sufficient and just 23% have enacted specific legislation on access to genetic resources and benefit-sharing.
- Seventy-nine percent have identified important ecosystems and habitats, at least partly in response to the CBD; 61% have strengthened measures for the conservation and sustainable use of these ecosystems and habitats since ratification of the CBD, mostly in protected areas.
- Sixty percent have developed and applied new approaches to sustainable forest management, most of which are at least partially taken in response to the CBD.
- Regarding wild biodiversity, 68% have carried out systematic inventories at the species level and 63% have instituted specific measures for their conservation and sustainable use, while 55% have carried out systematic identification of domesticated biodiversity, but only 39% have implemented specific measures for their conservation and sustainable use.
- Sixty-seven percent have systematically identified threatened components of biodiversity and 59% have implemented specific measures for their conservation and sustainable use (78% of these measures were taken at least partially in response to the CBD).
- Sixty-three percent have been able at least to begin systematically identifying threats to biodiversity.
- Just 30% have developed incentives for implementing CBD measures, while slightly more have sought to identify and eliminate disincentives. Valuation exercises are also coming along slowly, with just 29% of countries having carried out valuation studies.
- Forty-three percent of the countries have enhanced their capacity for implementing the CBD since it was ratified and 55% have developed CBD-related projects that contribute to the alleviation of poverty.
- Fifty-nine percent of the countries involve local and indigenous communities in activities for the implementation of the CBD, but only 38% are implementing the CBD provisions regarding traditional knowledge.
- Thirty-six percent are taking measures to ensure fair and equitable sharing of benefits arising from the use of genetic resources.
- Sixty-four percent of the countries are promoting education and awareness about biodiversity.
- Nearly half the countries perceive that financial resources for biodiversity conservation

and sustainable use have increased since the CBD was ratified, though most of this new funding is from domestic sources.

Some critical issues

Equitable sharing of benefits arising from the use of biological resources, one of the three objectives of the CBD, is a prerequisite for creating the incentives needed to maintain the earth's biotic wealth. Local benefit-sharing, in particular, has the effect of reducing the opportunity cost of forgoing the option of converting *in situ* conservation areas to commercial or other uses, such as arable agriculture, pasture or industrial complexes. Our survey indicates that more progress is needed in this aspect of the CBD. Benefit-sharing needs to be included in discussions on technology transfer, the clearing-house mechanism, access to genetic resources, agricultural biodiversity, and intellectual property rights. The umbrella under which all this could shelter should be the incorporation of benefit-sharing measures in the national biodiversity strategies and action plans governments are preparing.

Transfer of technologies relevant for the conservation and sustainable use of biological diversity continues to be a major area of unfulfilled expectations of most developing countries who are party to the CBD. Technology is an important tool for *in situ* and *ex situ* management of biodiversity. For example, new agricultural technologies have the potential to increase yields to feed the growing human population while reducing unintended adverse environmental impacts. Modern biotechnology could provide tools for understanding the living world and thus may greatly aid assessing and monitoring biodiversity at the national, regional, and global levels. Transfer of relevant technologies will be facilitated and enhanced through the involvement of the private sector in the area of bioprospecting and biosafety in joint ventures with national institutions or local private sector entities.

The disappointing flow of new and additional financial resources envisaged under Article 20 of the CBD has been an issue of considerable discussion. At the Earth Summit, the developed countries committed themselves to providing "new and additional" resources to help developing countries achieve sustainable development. The CBD makes this a legal obligation for biodiversity and the Global Environmental Facility (GEF)—operated by the World Bank, UNEP, and the UN Development Programme (UNDP)—is intended to be one of the main channels for these new funds. If funds are to be genuinely "new and additional," levels of support for biodiversity and total aid must be higher than before the CBD entered into force.

The Global Biodiversity Strategy estimated that effective conservation in developing countries would cost around US$20 billion per year, while current global spending on conservation (all countries) is estimated at US$4.14 billion per year. The average annual commitment of aid for biodiversity in the period 1987–94 was US$445.75 million. This falls massively short of what is needed for global conservation. According to Birdlife International, Organization for Economic Cooperation and Development, UN, and GEF figures provide no evidence that current levels of aid for biodiversity are "new and additional." The available figures indicate that after a peak in the Earth Summit year of 1992, annual aid levels for biodiversity have been lower than in the pre-GEF period of 1987–90. Non-GEF biodiversity aid appears to have fallen substantially since 1992.

Although donors collectively are not satisfying the "new and additional" obligation, some individual donors do appear to have maintained or increased their bilateral biodiversity aid budget, as well as making "new" contributions to the GEF. These include Finland, Germany, the Netherlands, Norway, and Switzerland. Biodiversity investment varies considerably among donors. The biggest overall aid donors—Japan and the U.S.A.—are among the biggest donors to conservation. However, Switzerland and Finland, each with a small bilateral aid program, are among the top five biodiversity funders.

As an umbrella agreement, the CBD is able to address a wide range of important issues. During its third meeting, the Conference on Parties (COP) reasserted its aspiring role as a focal point vis-à-vis other relevant international instruments and processes, especially on such issues as forests, sea-bed mining, intellectual property rights, agriculture, and indigenous and local community affairs. The degree of these interactions and the leadership level adopted by the COP are variable. Perhaps the issue on which interaction is strongest is agriculture, where the CBD covered land, water, plant, animal and microbial genetic resources, wildlife, air and climate, farm inputs, wild sources of food, traditional knowledge, marketing conditions for agricultural products, land-use pressures, and agroforestry. The COP has staked out a leading position in the field of agricultural biodiversity, taking the opportunity to link concerns regarding biodiversity conservation and sharing of benefits with the mainstream economy, drawing on balanced attention to the three objectives of the CBD. The COP sent a message to the December 1996 session of the Food and Agriculture Organization's Commission on Plant and Genetic Resources for Food and Agriculture (PGRFA) to negotiate the revision of the International Undertaking on Plant Genetic Resources in harmony with the CBD. It specified the COP's willingness to consider a protocol on PGRFA under the CBD.

The COP also produced a communication to the World Intellectual Property Organization (WIPO) noting the possibility that WIPO may recommend international copyright protection for scientific databases. This reflected the concerns of developing countries that such a measure could interfere with scientific and technical cooperation, create difficulties in repatriating data and complicate the exercise of the CBD's third objective of equitable benefit-sharing. Even if the COP has yet to articulate agreed areas of concern under the World Trade Organization (WTO), it could still emerge as a significant influence on the activities of both WIPO and WTO.

The COP has also sought to influence intergovernmental discussions on forests to ensure that forest biodiversity concerns are addressed. The COP's contribution here was much weaker than it could have been. The COP message to the Intergovernmental Panel on Forests (IPF) covered analysis of the underlying causes of biodiversity loss, analysis and mitigation of human impacts on forest biodiversity, economic valuation of biodiversity components, and development and use of criteria and indicators. The work program for forest biodiversity will include development of technologies necessary for the conservation and sustainable use of forest biodiversity, take an ecosystem approach and incorporate traditional systems of conserving biodiversity in forests. The COP also called for scientific analysis of the ways in which human activities, especially forest management practices, influence biodiversity and sought ways to minimize or mitigate negative influences arising from such practices.

The COP could have been far more assertive in providing guidance to the IPF, perhaps even suggesting that a protocol under the CBD could obviate any need for a new forests convention. This clearly is not a step governments are yet willing to take. But in any case, strengthening the CBD's relationship to the IPF could have an impact on any decisions regarding extension of the IPF or the establishment of a similar forum for international debate on forest issues.

Our conclusion is that although the COP has clearly advanced in opening to other processes, it still has a long way to go until it can become as influential as required to change processes that have great impact on the conservation and sustainable use of biodiversity.

The need for a protocol to address possible dangers of genetically modified organisms was identified in negotiations prior to the entering into force of the CBD. The need for such a biosafety protocol was discussed by COP-1 and—after heated debate—the process is moving forward, with a formal report expected at COP-4 in 1998. The negotiation of the biosafety protocol shows how the COP can handle a highly contentious issue, transforming it into a primarily procedural matter (possibly because no substantive points are yet being discussed). It is too early to tell whether the biosafety protocol is really a step forward for biodiversity or simply a diversion from much more substantive and urgent issues. It certainly will be somewhat limited, as the COP has determined that the issue of alien invasive species—a real and immediate threat to biodiversity at gene, species, and ecosystem levels—will not be considered under the biosafety protocol.

One of the top CBD priorities is for each country to decide for itself what its own priorities are. The mechanism for this is Article 6, on national biodiversity strategies and action plans, and the integration of the conservation and sustainable use of biological resources into sectoral and cross-sectoral plans. Some 60 countries are receiving support from the GEF to prepare their strategies after COP-2 issued a specific decision toward this end. However, the preparation of strategies risks becoming a somewhat sterile planning exercise, as have other similar efforts before them, if governments see it simply as an obstacle to be overcome before further GEF funds can be assessed. Current indications are that the strategy-formulation process is moving too rapidly in most countries to involve the critical sectors—agriculture, forestry, and fisheries—in a productive policy dialog.

Considerable progress can be reported on biodiversity in the seas. COP-2 adopted the Jakarta Mandate on Marine and Coastal Biodiversity, which provided a checklist covering five areas in which parties to the CBD should take actions for conservation and sustainable use in these habitats:

- integrated marine and coastal area management;
- marine and coastal protected areas;
- sustainable use of marine and coastal living resources;
- mariculture; and
- alien species.

Major international bodies were invited to improve their existing activities and develop new actions which promote the conservation and sustainable use of marine and coastal biodiversity, taking into account the recommendations contained in the Jakarta Mandate. A three-year process will elaborate upon the recommendations for action in the above five areas and possibly others. To assist in the implementation of the process, the CBD Executive Secretary will establish a roster of experts and draw upon a wide range of inputs from governments, intergovernmental organizations and nongovernmental organizations (NGOs), and others.

Conclusion

Many people believe that conserving biodiversity and using biological resources sustainably will benefit all of society. However, conserving biodiversity, using biological resources sustainably and equitably sharing the benefits of such use all involve social costs and benefits that are borne unevenly across segments of society. Therefore, proper policy action should promote the equitable sharing of these costs and benefits in ways that improve the well-being of the poor and weaker sections of society, including local communities, NGOs, the scientific community, industry, and so forth. The CBD offers a unique opportunity for this diverse mixture of interests to work toward the same broad objectives. The international consensus will often be difficult to attain unless all sectors of society contribute to the common goals of the Convention on Biological Diversity.

Lecture

Towards a Sustainable Future

By Dr. Martin W. Holdgate
Director General, IUCN

1. The Challenge: Dreams and Reality

Never before have so many people, in so many countries, been so aware of the need to conserve nature and natural resources. Never before has there been so much talk about sustainable development, proclaimed the only hope for the hundreds of millions who suffer from appalling poverty, and as the pathway by which everybody can attain a decent quality of life. Never before have so many heads of state and government publicly accepted the inseparable link between conservation and development. Never before has there been such a universal understanding of the fact that the future of human civilizations depends on our care for the Earth and its environmental systems—the only known manifestation of life in the universe.

Yet, at the same time as the tide of awareness rises to a flood, the environment everywhere is deteriorating. Land degradation, soil loss, desertification, water pollution, perturbation of climate, the ever-widening "ozone holes," deforestation, food insecurity, and many other alarming symptoms are visible on every side. How can the world hope to sustain the 10 to 12 billion people that UN statistics say will be inhabitants of Earth by the end of the 21st century?

We are running out of space—and time.

2. The Imperative for Action

There are many reasons why national and international action is imperative and urgent.

First, because human misery is being worsened by the deteriorating environment in many regions. Food production per head of population in sub-Saharan Africa fell during the 1970s and 1980s. In the same region, gross national product (GNP) declined by 1.1% per annum in the 1980s. Erosion, salinization, contamination of water supplies, degradation of pastures, urban encroachment, and pollution reduced land fertility in areas as far apart as China and the Sahel.

The economic costs of such damage are alarming: at the Earth Summit in Rio de Janeiro in June 1992, one Eastern European delegate reported that pollution was costing his country the equivalent of 16% of GNP per annum. The loss of biological diversity, especially as a consequence of deforestation on land and the destruction of coral reefs in the sea, threatens to deprive future generations of medicines and genetic resources before their potential has even been evaluated by science. The destruction of wilderness and wildlife threatens the tourist industry that is the main source of foreign currency in a number of developing countries, including some of the poorest African states.

The noneconomic costs are also disturbing. Human cultures throughout the world have been inspired by the beauties of nature. Artists, poets and writers have enshrined them in great literature and paintings. Television has brought magnificent spectacles of scenery and wildlife into the homes of millions of people. Their destruction is bringing spiritual as well as economic impoverishment.

While governments universally condemned these trends at the Earth Summit in Rio de Janeiro, they seem incapable of responding at a rate that matches the rates of change. While there are many real success stories, by which we are rightly heartened, in aggregate they do not counterbalance the losses. And governments seem unaware of the momentum of current processes; of the fact that the world is now committed to major changes, even if the policies and actions that cause them are reversed tonight. Those changes include:

- continued human population growth, largely in the poorer developing countries, where up to half the population is under 16 years of age, and where a population doubling is inevitable even if these young people simply reproduce themselves;
- increasing demands for energy and essential raw materials, because 75% of the world is underindustrialized and must industrialize if it is to give its increasing populations a decent quality of life, and create the economic growth and infrastructure essential for population stabilization;
- deforestation and land degradation (desertification) in the tropics, because growing populations need land to cultivate, depend largely on wood for fuel, and are being forced to use marginal land unsustainably because there is not enough good land for them;
- ozone layer depletion, because even if chlorofluorocarbons ceased to be made and used today, their residual time in the atmosphere is so long that it will be decades before their impact wanes; and
- climate change, because greenhouse gas concentrations are already close to twice preindustrial concentrations, and there seems no way the developing world can industrialize without some increased use of fossil fuels even if there is an immense improvement in energy efficiency. This in turn brings a threat of major changes in world ecology and world agriculture.

These and other trends—like those in air and water pollution which are becoming more serious in many regions—are expressed in the environment, but are not primarily environmental in origin. They are symptoms of fundamental defects in national and international social, economic, and political systems and will only be reversed or stabilized if national and global economies and politics change. And this will only occur if people on the ground demand that change, and if governments then follow.

The symptoms of the human disease are not confined to the environment. We are becoming aware of an even more sinister linkage—between environmental stress and security. There are already alarming signs that a combination of environmental degradation, poverty, population pressure, and defective governmental and institutional systems can easily flash over into conflict, generating worse environmental degradation and the spectacle of tens of thousands of suffering refugees. Governments, even in poor countries, spend billions of dollars annually on military preparations, to buy what they perceive as security. They spend far less on the cancer of environmental degradation that is quite literally eating away at their vitals and that may cause the wars for which they are so busily preparing.

Any impartial observer must conclude that a new approach is urgent. Rhetoric must be converted to action, and the rate of successful action must at least double. How is this to be done?

3. The World Context

The first need is to address the causes of the disease, not the symptoms. That means addressing the socio-econo-political system rather than the environmental damage resulting from its deficiencies.

That is the weakness of Agenda 21, adopted by the Earth Summit in Rio de Janeiro. It is excellent in its specification of the actions needed to manage sectors of the environment: to address pollution and desertification, to enlist the contributions of all sectors of the community, and to move forward in a cross-sectoral, integrated way towards sound and sustainable development. But it does not address the world economic and trading systems, the widening gap between rich and poor nations, the crippling burden of international debt, the corruption and incompetence of government in many countries, and the hemorrhage of the arms race. It also deals in an evasive and unsatisfactory way with the need to bring human populations into balance with the natural systems that sustain them.

These problems can only be dealt with by new and more effective political and economic development. And that development has to take account of two apparently divergent trends in today's world.

On the one hand, supranational problems and actions are reducing the autonomy of the nation state. It is clear, for example, that the world's economy depends on the world's ecology, and that the planet is one linked, environmental system. The threatened disturbance of global climate through greenhouse gas emissions, largely from the industrialized countries, and the increased penetration of the stratosphere by damaging ultraviolet radiation as a result of ozone layer depletion, again caused largely by the developed world, bring this interdependence home and have provoked international action in response.

A global society is emerging. Many decisions are now taken at the supranational level, for example, by the Group of Seven, the Council of the European Community or the Group of 77. World trade policy is governed by the General Agreement on Tariffs and Trade (GATT) and commodity prices by the various exchanges. New international institutions—like the Earth Council and the Commission on Sustainable Development—are being established and existing ones, especially in the UN system, are being strengthened. Law is becoming increasingly international, in the environmental as in other fields. A recent review listed 121 global treaties and other legal instruments dealing with environmental issues, together with a further 265 agreements at the regional level. Overriding obligations, such as that to safeguard the environment in time of war, are being codified. And while it cannot yet, sadly, claim universal success, the establishment of the peacekeeping role of the United Nations is an indication of the world community's reluctance to stand back and allow societies to destroy themselves by military conflict.

The world is also united by modern information technology. People throughout the world hear of events as they happen. An earthquake, a flood, a governmental crisis or even a presidential haircut can be on almost everyone's television screen while the event is still in progress. While the media select and distort, they make it difficult for governments to evade, and they have unquestionably built worldwide bonds of human sympathy, which may in turn exert pressure on governments. This has been a principal factor in the rise of the environmental movement.

At the same time, some trends have been towards decentralization. It is increasingly recognized that the care and sustainable use of the environment depend especially on local communities and individuals—farmers, fishermen, foresters, factory workers, consumers—and the way they exercise individual choices. As a consequence, the development process is being stood on its head. In place of solutions propounded and imposed by external "experts," with external and unfamiliar technology, new approaches involve learning from the poor, decentralization, local community empowerment, local initiatives, and diversity. Development is being seen not as a blueprint but a flexible, adaptive learning process. And local groups can often solve an environmental problem, or sow the seeds of environmental crisis, without central government's knowledge or involvement.

Everybody has heard of the importance of biological diversity. In the development process, cultural diversity has emerged as a crucial element. What people do depends on their beliefs, and these reflect culture, religion and tradition. Working with the grain of culture, and cherishing its adaptive values, is another key to success. And the literal "bottom line" is the individual. Inspiring, motivating, educating, guiding and empowering people is the ultimate way to secure sustainable living. We know that this will involve changes in the pattern of resource use and consumption in developed countries like this one as well as in the developing world. Adopting and pursuing an environmental ethic, nationally, communally and individually, is likely to be the essential foundation for the new approach we must have if we are to cure the global disease. Our patients are people, and they must believe in our treatment.

The response we need must therefore be people-centered and environment-based. It must be truly integrated, involving all sectors of society and matching action to need: the needs of people and the tolerances of nature. For nature is not all-embracing and endlessly forgiving. Political choices about development strategies will succeed or fail not only on their popularity with the electorate, but also on their environmental realism. The world is littered with abandoned installations, eroding farms, saline soils, silted reservoirs and useless factories that testify to the folly of forgetting the limits of nature. And the debt burden that cripples many countries today results, at least in part, from the disastrous promotion of inappropriate technology by lending agencies who bear no liability for their actions.

Our response to the disease must be a search for a universal cure. It must be globally linked, but locally applied. The rich, developed countries could just possibly turn their backs on the rest of the world and use their strengths to maintain their own lifestyles while the poorer countries disintegrated into famine, desertification and chaos. Such action would be wrong, by any moral code. But the lesson is not one we in the rich North find easy to accept, for it places a disproportionate burden on us to carry the economic and intellectual burdens of supporting the world's development. Aristotle summed up the precept 2,000 years ago when he said, "Between unequals, equity demands not reciprocity, but proportionality."

4. The Foundations for Successful Action

In 1972, Barbara Ward and Rene Dubos emphasized global interdependence by giving their "background" book for the United Nations Conference on the Human Environment, in Stockholm, the title *Only One Earth*. In 1987, the World Commission on Environment and Development added the penetrating comment, "The Earth is one, but the World is not." They sought a solution in sustainable development, defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Few concepts in recent years have been so widely quoted, and played in aid of so many preconceived ideas, as that of sustainable development. Some have proposed that it means achieving the highest feasible rate of economic growth without fueling inflation. Some have argued that it means characterizing the "carrying capacity" of natural resources and constraining human demands within that capacity (stretched as far as practicable by technology, but ultimately limited by the productivity of a finite ecosystem on a finite Earth, where the Second Law of Thermodynamics rules.)

Much of this debate is, in my view, sterile and pointless. The Roman Emperor Nero achieved lasting notoriety by fiddling while his city burned about him, and those who divert themselves with the minutiae of conceptual analysis at this juncture deserve a similar judgment from history. The essential concept is clear enough, and we have to get down to action on the ground—action for sustainable living.

5. Caring for the Earth: A Strategy for Sustainable Living

In 1980, IUCN joined with the United Nations Environment Programme and the World Wide Fund for Nature to prepare the World Conservation Strategy. In 1991, the same three organizations published a second volume, Caring for the Earth: A Strategy for Sustainable Living. This sets out nine basic principles, and 132 specific actions, as medicine for the human disease.

The nine principles are:

1. Respect and care for the community of life. This is the ethical foundation of the whole strategy. There is a duty of care for other people and other forms of life, now and in the future. Development should not be at the expense of other groups or later generations.
2. Improve the quality of human life. This is the real aim of development—to enable human beings to realize their potential, build self-confidence and lead lives of dignity and fulfillment. Economic growth is an important component of development, but it should not be a goal in itself.
3. Conserve the Earth's vitality and diversity. Natural systems keep the planet fit for life, shape climate, cleanse air and water, regulate water flow, recycle essential elements, create and regenerate soil, and enable ecosystems to renew themselves. The genetic diversity of

nature is the basis for continuing evolution and the source of resources vital to humanity.

4. Minimize the depletion of nonrenewable resources. Our industrialized civilizations depend on nonrenewable resources like minerals, oil, gas and coal. Demand is bound to rise as less-developed countries industrialize. The effective "life" of these resources should be extended by recycling, by using less of a resource to make a particular product, or by switching to renewable substitutes where possible.
5. Keep within the Earth's carrying capacity. Although precise definition is difficult, there are finite limits to the capacity of the planet's natural systems to support human life, and withstand impacts without dangerous deterioration. Greenhouse gases and acid oxides, produced by burning fossil fuel, and halocarbons that deplete stratospheric ozone, are threatening to cause such deterioration. Policies that bring human numbers and lifestyles into balance with nature's capacity must be developed.
6. Change personal attitudes and practices. If they are to implement the ethic for living sustainably, people must reexamine their values and alter their behavior. Society must promote values that support the new ethic and discourage those that are incompatible with a sustainable way of life. And the need for changes in lifestyle must be explained through education and public information.
7. Enable communities to care for their own environments. Most of the creative and productive activities of individuals and groups take place in local communities, including businesses and citizen's groups. Communities need to be informed and enabled to act to create sustainable societies that are in tune with local environments, resources, cultures and aspirations.
8. Provide a national framework for integrating development and conservation. Governments must develop national programmes for achieving sustainability that involve all interests and promote an integrated approach to environmental management. Consistent laws, institutions, and economic and social policies are essential. The programme must be adaptive, continually redirecting its course in response to experience and new needs.
9. Create a global alliance. No nation today is self-sufficient. If we are to achieve global sustainability, a firm alliance must be established between all countries. Lower-income countries must be helped to develop sustainably, and to protect their environments in the process. Global resources of atmosphere and ocean must be safeguarded by collective endeavor. The ethic of care applies at the international as well as the national and individual levels. All nations stand to gain from worldwide sustainability—and are threatened if we fail to attain it.

These general principles provide the basic logic for the actions needed to solve human problems and to use environmental resources sustainably. They provide the foundation for the 132 specific actions. But they will get nowhere unless they are applied in the real world. How? I suggest that the movement from strategy to action demands changes in approach at local, national and global levels, matching the dual processes of internationalization and decentralization I have already mentioned.

At the local level, the need is for both environmental and cultural sensitivity. Any global strategy is inevitably generalized. It has to be adapted to the needs and cultures of particular communities and the capacities of the environment in specific localities—a variant of the familiar statement, "Think globally, act locally." Thus while a development plan demands sound technical survey and analysis, in which modern scientific methods can contribute much, the subsequent development of an action plan demands great cultural sensitivity and understanding.

This in turn demands a listening ear and the development of solutions through the participation, indeed the leadership, of the people who live on the land. Communities of the rural poor are often far more sophisticated than their rulers in capital cities give them credit for. They often have detailed knowledge of their environments, even if their records are scientifically unorthodox. They are able to adjust to change swiftly and on the basis of understanding of the behavior of the local environment gained over many centuries. They often know the solutions if they are empowered to carry them out.

Development must respect diversity and cherish it. Over millions of years, the Earth's ecological systems have developed as a response by living organisms to geological, topographical and climatological conditions. Throughout human history, people have adjusted their cultures and lifestyles in the same way. The resulting diversity contains rich and valuable information, which should be the starting point of the development process. The values, approaches, crops and technologies of other regions and cultures should be transferred only with the greatest care and as grafts on the local stock of knowledge.

At the national level, the first need is to accept that the role of central governmental institutions and the international agencies that may work with them is an enabling one. Governments must accept the value of diversity and the need for local leadership in the development of detailed action plans. They must support and empower communities in those processes. They do, however, have the responsibility for creating the overall framework for development.

This needs to be attentive to scale. While some problems must be addressed locally, others demand a national strategy and national infrastructure, including both physical planning of settlements, industry, communications and transport, and social instruments such as appropriate land tenure, sound and properly enforced laws, appropriate economic measures, education, information, health care and security. Good development is difficult without good government.

Some problems—like the management of river basins shared between nations, or of coastal seas, or pollution that moves across frontiers—can only be addressed internationally. Many ecological systems and biological dispersal routes pay no heed to frontiers. Hence, international cooperation is essential.

Many overarching socioeconomic problems obviously need attention on a global scale. For example, we need new systems for economic valuation. Present systems tend to undervalue natural resources, especially those used at the local level and outside the formal national economy. As a result, the decisions made by central and local governments as to which kinds of land use to favor, and which kinds of environment to change, are often defective. The decisions of consumers are also influenced by economic valuations, and if the prices charged for products do not correctly reflect the costs imposed on the environment in their manufacture or use, sustainability is undermined. Yet because of the global nature of trading and economic systems, any changes to economic theory and methodology need international consensus.

World trading and economic mechanisms also need critical review. It is common knowledge that the burden of debt incurred in the past for often inappropriate development schemes is now crippling the ability of many of the world's lowest-income countries to adopt new and more sustainable development paths. Low commodity prices, controlled by markets in the developed world, further depress the economies of such countries, while high tariffs on their manufactured goods tend to lock them into remaining exporters of raw materials. The global alliance must be an economic alliance dedicated to creating the conditions for sustainable development in harmony with the environment, and if the world trading systems and agreements do not favor that process, they will need changing.

New technologies are needed. Those on which development in the North has been based are wasteful in their use of raw materials and energy, and we need new approaches that are more conserving of nonrenewable resources. Recycling and waste avoidance are imperative. Only thus can we have the benefits of modern technology without its impacts. And a consequence, which is almost countercultural in today's industrialized world, is that the consumer society may need to become a conserver society. Goods may need to be more durable, and advertising emphasize the facilities for upgrade and refurbishment rather than replacement.

Finally, the global alliance must go far beyond government-to-government help through official development assistance. In terms of financial flow, this assistance is trivial compared with that in the private sector. Official development assistance is invaluable in providing scientific and technical expertise and helping governments formulate strategies and develop infrastructures, but the test is whether those infrastructures create conditions that favor private-sector investment, both of indigenous wealth within the country and through international investment.

6. Caring for the Earth in Practice: The Role of IUCN

The award of the Blue Planet Prize recognizes that IUCN—The International Union for Conservation of Nature and Natural Resources, or more briefly, The World Conservation Union—has had some success in addressing the above problems. I do not want to claim too much: the fact is that no institution can claim total success in this difficult field, and we need a new approach if we are to have any prospect of success. But IUCN certainly has the potential to contribute, and I want to say a few words about why before concluding this lecture.

First, IUCN is preadapted by its structure. Almost uniquely among environmental bodies it is a union of governmental and nongovernmental sectors—of states, state agencies and both international and national NGOs. It also combines a professional Secretariat (now numbering almost 500 staff worldwide) with voluntary networks. There are now almost 6,000 volunteer experts in the Union's six Commissions. They are drawn from a wide range of professions, countries, institutions and organizations, not all of them IUCN members. They are linked by a common commitment to conservation.

This is a model for the cross-sectoral approach the world community demanded at the Earth Summit in Rio de Janeiro. We need alliances of governments, government agencies and the nongovernmental sector, because only by pooling the skills and enthusiasm of all can we hope to accelerate and reorientate action. We need the expertise of permanent institutions like the IUCN Secretariat, and the enthusiasm and knowledge of worldwide networks of committed volunteers. We need dynamic and at times challenging debate, because we do not know all the answers and must share our visions and thoughts about solutions. We must not be afraid of change, or of challenge to our established values, even though both are uncomfortable things to deal with. We need action on the ground, linked to worldwide machinery that will draw out and promulgate the lessons learned. We need flexibility to adjust action to regional priorities. We need ability to adjust programme and priorities with the times.

These are all characteristics of IUCN today. That does not mean that we are a perfect and complete body. We have weaknesses. Our dialogue with the corporate sector, for example, has evolved slowly and haltingly, partly because many of our member organizations have yet to be convinced that the corporate sector is willing to look beyond short-term profits, aggressive and competitive marketing, and minimal investment in environmental protection. The work of the Business Council on Sustainable Development has done much to build confidence, but we need to go further. For the private sector of industry is the dominant engine of change in the world. It manages finance flows far greater than government-to-government aid. It will be the leader in developing new technology—and needs dialogue with government, the regulator and the environmental movement which understands the limits and sensitivities of the Earth if that technology is to be sustainable. We need to give priority to new dialogue. We have already begun, with the business sector here in Japan.

7. The Future

What does the future hold? Quite frankly, there can be no grounds for confidence.

The optimistic scenario assumes that we shall indeed create the new dialogue between government, the corporate sector and the nongovernmental environmental movement. That we shall create partnerships that link communities and enlist every citizen in the action required. That we shall succeed in convincing people of the need to adjust their personal goals and adapt their lifestyles, so that their descendants may inherit a world that is beautiful, diverse and able to offer everyone a life of decency, quality and fulfillment.

To do this we have to work with the grain of human culture and tradition, and to touch people's beliefs and sense of ethics and human decency. We have to empower local communities to steer their own development—and this means a fundamental change in how some governments work. Not easy. Indeed, Caring for the Earth has already been attacked as hopelessly utopian.

But what is the alternative? The pessimistic scenario is one in which the gaps in the fabric of civilization yawn ever wider until part at least of that fabric collapses. It might be indeed possible for the developed countries to stand back, protect their own lifestyles and allow mortality to rise in other regions, balancing populations by nature's harshest means. But this would erode the total ability of the Earth to support life, and there would be no guarantee that the interactions in the world environmental system, as well as in the world political system, would tolerate such a selfish separation.

The fact is that the unifying processes in the world are too strong to stop. Travel, universal information, ever-tightening economic links and many other factors make it simply incredible that a quarter of humanity could contemplate shaping a future that left the other three-quarters to drift and disintegrate. We have to tackle the poverty gap, widening as it is between nations and within nations, and which is creating a new environmental degradation gap. We have to do this by rallying behind the visions that have for long been best in human society: equity, alliance and care for one another and the Earth, on which we all depend.

We in IUCN believe that we have to be optimistic. And I hope that you in Japan share that view and will yourselves be making the contribution the world needs from you. Your country has one of the strongest economies in the world. Your industry is unrivaled in its technical skills. You are well able to create the new, sustainable industrial processes that use a minimum of energy and raw materials, produce no or negligible pollution or waste, and provide environmentally friendly products that can be recycled at the end of their useful lives. You can forge alliances with environmental organizations like ours, and develop an increasingly creative and useful national nongovernmental sector. Nationally, you can set an example of environmentally sound development, but I have to say that this will mean changes, not least in the field of land-use planning. You can play a large part in supporting the sustainable development of the neighboring countries of Southeast Asia. I hope you will pick up these challenges and so contribute leadership to a world that needs it greatly.

IUCN sincerely thanks the Asahi Glass Foundation for the award of this prize, which will encourage us to new endeavors. We look forward to working more closely with you, in Japan, with your immense ability to contribute to the human future. We hope that we may welcome you shortly as state members of the Union. We look forward to working with industry and nongovernmental organizations in this dynamic and creative country.

Thank you again.

Major Publications

IUCN

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