Biodiversity, Sustainability, and Our Common Future

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The spirit of the Osaka Expo '90 event, which through its beauty and profound animating spirit brought so many people to realize how close and fundamentally important are the linkages between humans and the living world, and how interdependent we are with the other living beings that share this world with us. The world today, however, is so different from the world of fifty or one hundred years ago, and changing so rapidly, that it is has become a matter of common survival to find new ways of thinking and new ways of acting in order to shape the kind of future that we would like to have. In fact, we live in a world that has grown so rapidly in population, levels of consumption, and unsustainable uses of technology that the challenges we face often seem insurmountable. Our failure to face them, however, will necessarily condemn our children and all those who come after us to bed limited to far fewer opportunities than we enjoy today, in a world that is less beautiful, less nurturing, less healthy, and less sustaining than ours.

We appear already to have outstripped the limits of global sustainability, but at the same time have acquired important tools to deal with the problems that we face. None are more powerful that those associated with the advances in science, engineering, and medicine that we have developed at an ever-accelerating rate, and our ability to share these advances and build on them worldwide. That we must do so is clearly indicated by the following trends and relationships.

Just over half a century ago, in 1950, the world population amounted to approximately 2.5 billion people; today it exceeds 6.3 billion. The United Nations estimates that the global population might begin to level off at about 8.5 billion people around the middle of this century, but that estimate is based on numerous assumptions about the success of actions that we must sustain to prevent it from growing much beyond that level. Today, the less developed countries of the world, with about 82% of the world's population – 5.1 billion people – add about 80 million additional people per year; the more developed countries (including Japan and the United States), with about 18% of the world's population – 1.2 billion people -- about 1 million additional people. Half the world's people live on less than $2 per day; one in eight people is starving; and one in two is malnourished in caloric intake or for at least one important nutrient – thus much more susceptible to illness and premature death.

How did we arrive at this situation? Just 400 generations (about 10,000 years) ago, humanity, after perhaps two million years of evolutionary history, consisted of a total of about three to four million people on all continents, an impressive and sometimes dominant locally dominant species, but not so different from the millions of other species that existed on Earth. At about that time, however, our ancestors mastered for the first time the ability to grow plants as crops, and thus were able to produce large quantities of food that they could store over unfavorable seasons. With that advance, their numbers began to increase rapidly, and they began to form villages, towns, cities, and states, each accumulating more wealth in the form of both stored food and the commodities for which it would be exchanged, and engaging in warfare to increase the land they had available to cultivate and to take wealth directly from their rivals.

Over the past 10,000 years, those same villages became the homes for poets, philosophers, lawyers, builders, religious leaders, tool makes, and all the varied professions that make up the modern world. Written language was developed about 5,600 years ago, the Great Pyramids a few hundred years later, and the civilizations of China, Japan, the Greeks, the Romans, and many others that have not survived over the millennia. As time passed, the intricate relationships between people within these societies developed into what we now consider our modern and varied world civilization, a system of values and thoughts that at the same time comprises the routines of our daily lives and forms the context for our fears, our hopes, and our dreams.

Neither the mores nor the accepted winning strategies that would have been effective for our hunter-gatherer ancestors have obvious relevance in this modern world. Nevertheless, we must assume that much of the genetic and social endowment that we had gained over the two million years of our previous humanity and the billions of years that passed while we were following the unique pathway of our evolution from the beginning of life on Earth still affect us in ways of which we are only dimly aware. They certainly may no longer be appropriate survival tools in a world that has changed over the course of these 400 human generations beyond imagination. It is the struggle to find appropriate ways to live in the modern world and in the future that makes it necessary for us to examine carefully where we have been and where we actually are. In doing so, we must find the new ways of thinking that will be indispensable to the perpetuation of the civilization we have chosen and its improvement for the indefinite future that we tacitly assume will be our lot and that of those who come after us.

Even a consideration of the massive changes that have occurred during the past half century alone ought to be sufficient to rally us to massive collective action, but so far this has not been the case. Consider a world in which nearly a fifth of the world's topsoil has been lost during this very short period; one in which a fifth of the agricultural land that was cultivated in 1950 has been lost to salinization, desertification, unplanned urban growth, and similar causes; and one that has only two-thirds of the forests that were present at the start of this period. Then add the fact that we have altered the quality of the atmosphere by adding nearly a sixth to its content of carbon dioxide and depleted its protective ozone shield by about 7%, and ask what our overall plans are to deal with these unsustainable results of our activities.

To achieve our current levels of agricultural productivity, we are treating our agricultural lands with an estimated 3 million metric tons of pesticide annually; fixing nitrogen at a rate that greatly exceeds that of all natural processes combined and approaches toxic levels in many regions, and bringing more and more unsustainable lands under cultivation. We currently devote to crops an area about the size of the continent of South America, while pastoralists graze an estimated 3.3 billion cattle, sheep, and goats on an additional 20% of the world's land surface, most of it declining rapidly in productive capacity. Two-thirds of the world's fisheries are being harvested beyond sustainability.

The lives of rural people generally are becoming poorer, and their prospects more limited than they were even a few decades ago. Major cities are growing, and yet little thought is being given, and less action being taken, about how to form those cities in ways that will be sustainable and afford opportunities to their inhabitants. Within a few years, more than half of the world's people will be living in cities of more than a million people, and hundreds of millions of additional people will join them over the next few decades. Getting the kind of education, and information, to the rural poor everywhere is a necessity for them now, and will be an even greater necessity in the future if, as many of them will, they do move to the cities. In addition, the emergence of hundreds of millions of new consumers in the less developed countries will accentuate current environmental problems unless we deal with the attendant problems effectively.

To summarize what we have been presenting in a different way, human beings are currently estimated to be using directly, destroying, or wasting nearly half of the total productivity of terrestrial photosynthesis. In addition, we are using directly more than half of the renewable supplies of fresh water annually. Over wide areas of the world, the endless search for firewood and water consumes the potentially productive lives of all women and children, who have no chance to gain an education or contribute to the progress of their societies or that of the world as a whole. Over the North China plain, which produces some 40% of China's food (food for some 500 million people), the water table is estimated to be dropping by 1.5 meters per year. It is also dropping over much of India, the effects of increasing incursions of seawater being evident around much of the subcontinent's coastline. It is clear that the availability of water will define many of the battlegrounds of the world of the future, just as oil defines them now. What is most tragic about these trends, however, is that they are taking place in a world in which some 700 million people are

already living in a condition of endemic starvation, twice that many in absolute poverty, and with some 14 million babies under the age of four starving to death or dying of diseases related to starvation each year.

Since the publication of the report of the World Commission on Environment and Development in 1987, we have become accustomed to thinking of the world as one in which the less developed countries will gradually become industrialized and richer, using the traditional industries and techniques that less than a 20% of us in control of some 80% of the world's resources. This is a pleasant dream, since if it were true it would allow those of us who live in the wealthy countries of the world to continue to increase our levels of consumption still more, and simply assume that we have little responsibility for the poorer people of the world. Unfortunately, it is not a dream that can come true if we continue to use current technologies as we are. When India was gaining its independence, Gandhi pointed out that it could not assume a standard of living like that of Great Britain because, lacking an empire, it did not have the resources to do so.

More recently, Wackernagel and Rees have calculated that, using present technologies, human beings are consuming the Earth's natural productivity at about 120% of its sustainable rate, and that the percentage continues to grow. Put another way, it would take two additional planets comparable to Earth to support the world at the standard of living of the more developed countries of today, three if the population doubled, and 12 if those standards of living doubled. Recall that current conservative estimates have 2 billion people being added to the world's current population of 6.3 billion by the middle of the century we have just entered: how will we feed, clothe, and care for them adequately? Considering that about 400 generations – 10,000 years – ago, just at the time when crop agriculture was being developed, the entire human population consisted of only several million people with little collective impact, it is clear that we now live in a time that is uniquely challenging, and that we must determine what kind of a future we want, and then take the steps to achieve it.

In other words, we are currently living unsustainably off the planet's natural productivity, and destroying much of it in the process. As former U.S. Vice-President Al Gore put it, we are treating the world as if it is a business in the course of liquidation, rather than a place where we wish to have our children and grandchildren enjoy the benefits available to us today. Attaining global sustainability, although often ignored, is the most important goal that lies before us.

The Role of Biodiversity

Perhaps the most serious of all the environmental challenges that we face is that of the accelerating loss of biodiversity, the species of plants, animals, fungi, and microorganisms that make up the living world. It should be clear from the remarks I have already offered that biodiversity cannot be saved in isolation, but only in the context of a sustainable world. A world in which the negative environmental trends that we have set in motion simply continue and intensify is not one in which sufficient resources or attention could be marshaled to deal with the living organisms with which we share this beautiful planet, and which make our life here possible. At the same time, if we lose large number of those organisms, we lose with them many of the strategies that we might build on them to create the sustainable world that should be the goal of our efforts.

How many kinds of organisms exist? In the most useful estimate of total numbers of species of eukaryotic organisms, Lord May of Oxford carefully reviewed the calculations for individual groups. He estimated that there might be a total of between 7 and 13 million species, with only about 1.6 million of them having been identified and named scientifically. For practical purposes, we might adopt a median estimate of 10 million species, but do so knowing that only a very small proportion of the species of very large groups like fungi, nematodes, and mites have been named, so that the actual total numbers are

very difficult to estimate. Most scientists consider that the actual number will prove to be larger than 10 million, but it is simply not possible to be certain. For prokaryotes, bacteria, archaebacteria, and similar forms, as well as viruses, there is simply no reliable way to make a reasonable estimate of total numbers, and those estimates that have been attempted to date should be disregarded.

One important conclusion from these numbers is that we know very little about the organisms on Earth now. Even at conservative estimates, only about one in six has actually be catalogued and given a scientific name, and for the vast majority even of those that have been named, we know next to nothing. In tropical most forests, we probably have named only about one in 20 of the total number of eukaryotic organisms; and so when we lose these forests and their biodiversity, we lose for all time the ability to understand most of them, to appreciate them, or to use them to build our sustainability – without having even known that they existed.

How rapidly are species of eukaryotic organisms being lost? This rate can be estimated by first by determining the extinction rates of organisms from the fossil record of the past 65 million years, using species with hard body parts that are well enough represented to provide a sound basis for estimating how much time elapsed between their appearance and disappearance. Many of the species for which such estimates have been made lasted from one to several million years, so if we assume the same rate has continued to the present, and use the shorter time (to derive minimum increases from contemporary observations), we could say that, on average, one species per million per year becomes extinct. For an estimated 10 million species of eukaryotic organisms, then, we would expect to lose about 10 species per year. Turning now to the recorded literature of the past several hundred years, and extrapolating the rate from groups that have been carefully observed during this period, including vertebrates, butterflies, and vascular plants, we can estimate that several hundred species per year is the likely rate from 1600 to the present.

The numbers of species of a given group, or of all species, that exist in a given area, turns out to be a function of the size of that area, and to be related to that size logarithmically, as determined by the principles of the field of Island Biogeography. Worked out first on for islands, the same relationships have proved to hold for mainland areas of relatively uniform habitat. Although not all "excess" species may disappear immediately, they will statistically be on the way to ultimate extinction by virtue of their population sizes and relationships within the community. To take one key terrestrial habitat, the tropical moist forests of the world, already reduced to less than half of their original extent, are estimated to hold about half of the world's species of eukaryotic organisms. It depends very much on what actions we will take, but many calculations suggest that these forests will have been reduced to 5% or less of that original area within 50 years. Such a decrease, if we do allow it to happen, would be expected by itself to lead ultimately to the extinction of more than half of the species in those forests, more than a quarter of all species on Earth, during the course of the 21st century. And the vast majority of these species will never have even been seen by a scientist before they disappear.

The destruction of other habitats is proceeding apace also. Probably only about 15% of all species of eukaryotic organisms occur in marine habitats, but again, our knowledge is so inadequate that we are really unsure what the actual numbers may be. The richest of all marine habitats, coral reefs, are being destroyed rapidly as a result of many malign influences, and again, we do not know, for the most part, what we are losing.

Particularly destructive of biodiversity, and second only to habitat loss in the magnitude of its effects, is the rapid spread of alien invasive species around the world. All of the world's harbors are now largely populated by organisms that came from elsewhere, often in bilge water, the native species rapidly vanishing before this onslaught. Approximately a third of the threatened and endangered species in the United States face extinction primarily because of competition with or destruction by alien invasive

species, and this problem, which we collectively have yet to face squarely, causes huge and rapidly growing economic losses in agricultural lands, grazing lands, and native communities around the world.

Finally, it must be pointed out that the loss of genetic diversity in natural populations is also poses very serious problems not only for the survival of the species involved, but also for human futures in different parts of the world. The particular genetics of individual populations of organisms involve unique adaptations to individual places, and make those populations most suitable for restoring natural productivity or restoring communities in those places. As many scientists have shown explicitly, the populations of particular plants and animals in different parts of Japan are not genetically equivalent to one another, much less to other populations of the same species in Russia, China, Korea, or even Europe; and they have great significance in their own right that we need to understand and respect. Taking habitat destruction, the spread of alien invasive species, and other environmental trends together, it can readily be envisioned that we may be facing the loss of two-thirds of all species of plants, animals, fungi, and microorganisms over the course of the 21st century. This would be an extinction event comparable to that which occurred at the end of the Cretaceous Period, 65 million years ago, when the course of life on Earth was altered permanently – and yet we can still mitigate its effects and save many of the species in danger of extinction if we chose to do so.

Does the extinction of species affect human prospects in a major way? The answer to this question must be a resounding "yes," because it is from these species that we obtain our foods and most of our medicines, the chemical feed stocks for old and new industries; and, in a newfound age of molecular biology, the genes that we need for further improvement of other organisms for our purposes. It is just fifty years since the postulate of the double-helical model of DNA by James Watson and Francis Crick, thirty since a gene was successfully transferred from one unrelated species of organism to another, and little more than a decade since the first field tests of genetically-modified (GM) crops. During the past five years, sequencing the genomes of various kinds of organisms has given us new insight into their functional properties. As individual families of genes come to be understood across diverse groups of organisms, we shall come to understand much better than once would have been thought possible the ways in which their characteristics are formed in either a developmental or an evolutionary context. This will open vast new frontiers for biological understanding and the development of new strains of living organisms of great use to humans attempting to build a sustainable and healthy world. If we lose the organisms before we understand them, however, many of the advances that would otherwise have been possible will be lost permanently: seeking the bases for biological understanding and improvement will be much more difficult in the world of the future, regardless of the array of new techniques that may become available to us over the years.

In addition to their value as individual species, the combination of those species in communities and ecosystems of organisms, from wetlands to forests, grasslands, freshwater, and marine areas, provides immense value in regulating the functioning of natural systems and providing wide-ranging environmental services to human society. Understanding the functioning of individual species reveals the properties that must be used in restoring and re-forming sustainable ecosystems once the original ones have been destroyed. Pollinators and other useful insects; birds that help control harmful insects on crops; medicines and other useful products from natural communities; watersheds that regulate the flow of water to agricultural and urban areas; breeding grounds for economically useful marine species – all of these are examples of the values provided as a basis for our lives by relatively undisturbed ecosystems, and provide ample reasons for protecting them.

Finally, and in the spirit of the International Cosmos Prize and the Osaka Expo '90 Floral Exposition, it must simply be said that we have no right to destroy such a large proportion of what are as far as we know our only living companions in the universe. What is involved, therefore, is not only a practical problem, but also a moral and ethical one. Our languages have undoubtedly formed around our ability to

communicate about organisms; our art has its roots also in an effort to communicate about them; and our comfort in their presence demonstrates the natural feelings that we have for them. Those relationships define our humanity in ways that we grasp only dimly, and yet are of fundamental significance. Plants and animals are important to us in ways that have nothing to do with our using them as food, fuel, or medicine, and we need to respect and preserve them for those reasons also.

Preserving Biodiversity, Building a Sustainable World

The central question facing us, then, is how we can preserve as much as possible of our priceless endowment of biodiversity in the context of building a sustainable world. We should not only want to save that biodiversity for its own sake, but because it is so important to build the sustainable systems that we need to support human life in the future. In a world where 18% of the people control 80% of the resources, however, it is not evident that the motivation to build such a world exists.

Vision has not been lacking in the past. On the eve of World War II, U.S. President Franklin Delano Roosevelt in a significant address to Congress, spoke as follows:

"… we look forward to a world founded upon four essential human freedoms. The first is freedom of speech and expression – everywhere in the world. The second is freedom of every person to worship God in his own way – everywhere in the world. The third is freedom from want, which, translated into world terms, means economic understandings which will secure to every nation a healthy peacetime life for its inhabitants – everywhere in the world. The fourth is freedom from fear, which, translated into world terms, means a world-wide reduction of armaments to such a point and in such a thorough fashion that no nation will be in a position to commit an act of physical aggression against any neighbor – anywhere in the world. That is no vision of a distant millennium, it is a definite basis for a world attainable in our own time and generation…. Freedom means the supremacy of human rights everywhere."

But where are we now? With three times the population of the world in which Roosevelt spoke, the institutions founded in the wake of World War II to guide us to a peaceful and sustainable future – the United Nations, World Bank, and International Monetary Fund – although they have clearly done much good over the years, do not seem capable of leading the world's nations to the kind of secure future that Roosevelt and his colleagues envisioned. The gap between rich and poor has become greater, and is not only a financial one but also increasingly an information gap that we neglect at our peril.

If we are able to attain a sustainable world, it must fundamentally be founded on mutual respect. Most people, and most nations, are highly introspective, and regard their current situation as one that will continue and be enhanced in the future. For example, the United States, with 4.5% of the world's people, controls about 25% of the world's economy and is home to about a third of the world's scientists and engineers; Japan, with about 2% of the world's people, controls about 10% of the world's economy, and has well over a tenth of the world's scientific and technical output. In contrast, all of the less developed countries of the world put together, with about 82% of the world's people, have about 20% of the world's economy, and perhaps 10% of its scientific output. If we are to build a sustainable world, we will need to do it together; we are interdependent to a remarkable degree; and yet the relationships just quoted are not promising in this respect. It is of critical importance for us to get to know one another better so that we can grow beyond the insularity of our individual situations, our individual customs, and our individual nations and come to respect one another so that we can attempt to build a sustainable world that will provide the kind of opportunities that we would want for ourselves and our children.

The American environmentalist Kai Lee, in his book "Compass and Gyroscope," put it this way:

"How much misery will it take to make a global norm of sustainability first visible, then credible, then feasible, then inevitable? We do not know. And we do not know if the lessons of environmental disaster can be learned in time to ward off still more suffering. However bleak that prospect, we in the rich nations must bear the certain knowledge that our societies are both historically responsible for many of the circumstances that imprison the poor and that we will on average fare much better than they. Against this background it is possible to see that sustainable development is not a goal, not a condition likely to be attained on earth, as we know it. Rather, it is more like freedom or justice, a direction in which we must strive, along which we search for a life good enough to warrant our comforts."

If we can satisfy the basic condition of respect for one another, attaining sustainability would be an obvious objective that we would share, and towards which we would work. Since the instability that we are generating now is the product of population levels, affluence (consumption), and the widespread use of inappropriate technologies, it is obvious that we need to find and maintain a stable population level. No amount of adjustment of consumption or development of new technologies could offset the effects of a population that continues to grow indefinitely. If the world's people were well nourished and supported, each able to express himself or herself to the extent of their ability, we would not be so concerned with population growth. Such a condition is so far from reality, however, that we much work together to approach population stability as soon as we possibly can do so. To a large extent, this means empowering women everywhere, a trend that is highly desirable both morally and in terms of the human ability that we forego when we fail to do so.

Beyond that, science and technology have a great deal to contribute for our common welfare. Advances in these fields promise improved health, more efficient ways of manufacturing, a better quality of life for our citizens, and the possibility of sustainable developments in all areas. Further, they power the modern world's economic progress. Thus it is estimated that some 60% of the economic progress in the United States depends on science and technology; worldwide, contributions from these fields make possible at least a third of total economic growth. What is often neglected, however, is that the growth and development of science, engineering, and medicine is necessary for the welfare of people in every country, and not simply for the rich ones. No country can take full advantage of the discoveries and advances made elsewhere if it has not built its own base, and that translates into a lack of ability to become sustainable, reliable trading partners and allies for all other nations. The more developed countries like Japan and the United States depend on all nations for their own prosperity, and benefit directly from contributions to the development of science and technology around the world.

Many of the specific contributions that science and technology can make to sustainable development are summarized in a publication of the U.S. National Research Council entitled "Our Common Journey: A Transition toward Sustainability" (1999). Significant advances in basic knowledge, in the social capacity and technological ability to use it, and in the political will to act on this knowledge will be needed to achieve the transition to sustainability. Energy plays a particularly important role, and the decarbonizing of the world's energy economy will be essential to alleviate problems of global warming and move away from dependency on the world's decreasing supplies of fossil fuel in the future.

Improved education in science and mathematics, both formal and informal, will be necessary everywhere for the world to move toward sustainability in the future. Not only will such educational advances be necessary to provide an adequate workforce in these areas, they will be necessary for the formation of a supportive societal context for using the advances that are achieved. The nations of the world have much

to gain from exchanging education experiences and strategies with one another. Powerfully, science also provides a common language for effective communication between diverse groups of people who might otherwise not be as easily able to understand one another. Science is intrinsically rational, not values driven, and understood as such can become even more important as one of the binding elements in a modern world that sorely needs to be drawn closer together.

Important advances have been made at the international level too, which, given the global nature of many of these challenges, is clearly appropriate. Thus the Interacademy Panel (IAP) brings together academies of science from throughout the world, and has formed an Interacademy Council (IAC) to conduct studies on important topics related to science, engineering, medicine, and development for our common benefit. The Third World Academy of Sciences has long been effective in raising the standards in science and technology in less developed countries, and holds great promise for the future. At the program level, the Millennium Assessment, based on an association of non-governmental institutions and individuals, will continue to contribute information of fundamental importance about the state, productivity, and value of ecosystems and thus facilitate our common progress toward a sustainable world. And there are many other outstanding examples of international cooperation that we should cherish and nurture for the global benefits that they are delivering.

Industry must become a partner of individual governments and multinational institutions in working toward a sustainable world. Political terms are characteristically short, and actions that may seem expedient from a political perspective may frequently turn out to contradict the common interest. It is difficult for governments to deal with long-term trends such as climate change because necessary actions may seem too difficult to undertake in view of their short-term economic impact and consequent political damage. For a corporation, in contrast, the trends are real, and must be addressed in order to return long-term value to shareholders. That certainly should not be take to imply that corporations can afford to be altruistic, but they do need continually to re-invent themselves or risk becoming irrelevant over the course of time.

In the face of all these trends, what can we do to enhance efforts to understand and preserve biodiversity? First, we must organize the available knowledge and gain more knowledge as rapidly and efficiently as possible. We know definitely about a sixth or even fewer of the world's eukaryotic organisms, and most of them only superficially. Since so much of the future of sustainable development depends on the proper understanding and sustainable use of biodiversity, it is important that these steps be taken as efficiently and rapidly as possible, and enhanced throughout the world. For this to happen, wealthy nations such as the United States and Japan will need to contribute much more than is currently the case to assist many less developed countries in the inventory of their own biodiversity.

As it is gained, information about biodiversity should be organized as envisioned by the Global Biodiversity Information Facility (GBIF) in readily accessible databases that serve multiple users well. Information about the uses and conservation status of organisms need to be enhanced and accumulated. The kinds of national biodiversity institutes that have been organized in Mexico (CONABIO) and Costa Rica (INBio) could, adapted to local conditions, serve as models for the rest of the world, and the development of such agencies, extremely valuable at a national level, should be encouraged internationally.

Parks and reserves are of key importance for the preservation of biodiversity, and the discussions at the recently completed World Congress on Protected Areas held in Durban, South Africa, should form part of the basis for their further development. Again, the wealthy nations of the world should in terms of the development of global sustainability support the less developed ones in the establishment and maintenance of systems of reserves adequate to protect the world's biodiversity. The increasing

participation of international NGOs in conservation efforts worldwide is another encouraging development in this area.

As mentioned earlier, the alarmingly rapid spread of alien invasive species, plants and animals, throughout the world poses a great and growing threat to the survival of biodiversity. Increasingly, the problem is being recognized as a factor of great significance in the survival of biodiversity. In the United States, it is estimated that $140 billion annually is spent or lost because of the effects of alien invasive species. There is genuine urgency in organizing information and action plans in this area for dealing effectively with invasive alien species in all regions not only to avoid expensive control measures in agricultural and grazing lands but to protect native biodiversity as well.

Ex situ preservation – maintaining stocks of plants and animals apart from their natural ranges – is another important element in the preservation of biodiversity. Priority should be given to those species that are unlikely to survive in nature without human intervention, with attention to the possibility of re-introducing them into the wild when conditions are appropriate. Priority should also be given to unique taxa that lack close relatives and to species of known or suspected ecological or economic importance, The Convention on Biological Diversity (CBD) is an international instrument for protecting the diversity of life on Earth, and its scope and activities should, with some degree of urgency, be further developed and implemented widely.

Within the CBD respect, the development of the United Nations Environment Program's Global Plant Conservation Strategy (GPCS) is most welcome and should be supported. It provides for global inventories, the implementation of *in situ* and *ex situ* strategies for plant conservation at the national level, and augmented efforts to educate the public about the value of plants to human and other life. These efforts, which are just in their initial stages, should be maintained and enhanced to the degree possible, and provide a valuable model for global conservation in general.

Concluding Remarks

Biodiversity, however, cannot be preserved in isolation from other environmental trends, but only as part of the search for a sustainable world: if everything is consumed in the name of progress, ultimately there will be no more progress. The pressures that we have discussed are certainly making the world ecologically less stable, less diverse, and with less promise for the future, but it is up to us to decide where we will let the process go, and when we decide that we really will commit ourselves to achieve sustainability. The kinds of trends that have occurred since 1950 simply cannot be allowed to persist indefinitely. As George Schaller, a well-known conservationist from New York put it, "We simply cannot afford another century like the last one."

Many important areas, then, need to be addressed in order to achieve global sustainability, which will include a great deal of attention to the sustainable use and preservation of biodiversity. Among these, energy stands out, both because its traditional sources are being consumed rapidly, and because of the pollution associated with them. Pollution, an especially severe problem in developing countries, affects the health of everyone, but especially children, and needs to continue to be addressed substantially. In addition, the production of energy by burning coal, oil, and natural gas worsens the problem of global warming through the emission of carbon dioxide, thus seriously threatening global stability. In view of these problems, the needs for increasing amounts of energy to feed growing economies must be met increasingly in non-polluting ways through the use of cleaner energy alternatives such as hydro power plants, solar panels, and wind energy projects, with the substitution of natural gas for coal whenever possible a positive intermediate step. Moreover, as the number of automobiles continues to increase rapidly throughout the world, their effects must continue to be considered and monitored, and efficient

alternatives for personal transportation developed, these clearly involving the development of cities and the organization of work in the future. Experimental approaches to the development of less-polluting transportation systems should be highly valued and multiplied. Everyone in the world has an interest in these areas, and there is much potential gain for China in pursuing inventive, rather than traditional, approaches to these problems.

Agriculture and grazing have an enormous impact on sustainability worldwide, and the improvement of agricultural practices so that high productivity can be attained on the lands now cultivated will allow a correspondingly high proportion of uncultivated lands to be available for preservation. Most grazing of natural grassland is unsustainable, and alternative systems involving cultivated pastures should be substituted wherever possible. Looming shortages of water, among other problems, make the application of modern genetic technology and cultural practices, such as precision farming, indispensable components of the food-production systems of the future, especially since water supply is likely to be greatly magnified as a source of friction among nations in the near future. Water should be regarded as a basic human right, and sustainable supplies should be conserved carefully. Other severe problems are being caused by the enormous amounts of chemical fertilizers and pesticides that are being applied to agricultural lands worldwide; they are increasingly failing to offset losses of soil fertility and the breakdown of soil structure. Again, genetic modification of crops to avoid such environmental damage and to improve the nutritional value of the crops seems clearly to be an important ingredient in the agriculture of the future. Finally, the erosion that is so widespread, particularly in less developed countries, must be brought under control.

Just as the achievement of sustainability will be necessary to maintain as large as possible a fraction of the world's biodiversity, the intelligent use and maintenance of biodiversity is one of the most important keys to our ability to build sustainability for the future. In a context that nurtures respect between people, wherever they live and whatever they believe, the ingredients for a sustainable world, in which every human being would have the opportunity to develop his or her potential fully. Such a world would be peaceful and healthy, and would offer the opportunity for the development of sustainability and peace for human beings everywhere. It could only be the product of a truly new way of thinking, one that would go far beyond the mores and successful strategies of our hunter-gatherer ancestors, and put our children in a position to cherish and develop the civilization that millennia of human effort have made available to us.

In the spirit of the Osaka Expo '90 and the International Cosmos Prize, let us pledge to do what we can individually to build a sustainable world, based on an appreciation for our fellow human beings, and to put aside personal and national ambitions for the sake of the common good. Only by doing so can we win true security and peace, qualities that should for us represent our very highest and most worthy ambitions. As Gandhi said, "The world has plenty to satisfy everyman's need, but not enough to satisfy our greed." If we accept our role as citizens in an interconnected world, where everyone's fate should be a matter of deep concern for all of us, we will find ways to limit population, adopt sustainable levels of consumption, and develop the new technologies we need to move peacefully into the sustainable world that we need to build together in the future.