

## Plants in Peril: What Should We Do? Peter H. Raven<sup>1</sup>

*Editor's note: The remarks below were presented at the XVI International Botanical Congress, held from August 1-7, 1999 in St. Louis, Missouri. For additional information about the Congress, see <http://www.abc99.org/>*

Plants provide, directly or indirectly, all of our food; most of our medicine; a large proportion of the chemical substances that we use; or our shelter; and of our clothing. They protect the topsoil, insure the quality of the water that we drink; determine local climates; and ultimately provide food and shelter for all other living beings. They are beautiful and diverse, and nourish our souls as well as our bodies. Yet, we are destroying them at a frightening rate, so that as many as **100,000** of the estimated total **300,000 species** may be gone or on the way to extinction by the middle of the next century. If we do not take action now, by the end of the century we may have destroyed two-thirds of the plant species we currently use and enjoy.

**Why are we doing this?** Are we mad, or do we just not understand the enormity of the crime that we are perpetrating on our children, their children, and **all human beings who will live in the future?** By taking concrete steps in the near future, we could prevent the extinction of the great majority of these plant species. **We must commit to these steps, starting here, starting now.**

First, let's look at the background. The best and most recent estimate we have of the number of species of vascular plants in the world is that of Sir Ghillean Prance, director of the Royal Botanic Gardens, Kew, in England. He estimates, based on rates of discovery and the relative degree to which the plants of different parts of the world are known, that there are approximately 300,000 species, of which botanists have named and catalogued about 250,000. There are therefore some 50,000 species of plants yet to be discovered, or existing in collections but as yet undetected. Here in the United States, Barbara Ertter has estimated that an additional thousand species may be added to the 18,000 currently known. So when we consider plants being endangered and becoming extinct, it is important to recognize that as many as one-sixth of them are currently unknown – we are losing what we have not recognized.

For biodiversity as a whole, the situation is much worse. Sir Robert May estimates conservatively that there are between 7 and 10 million species, not counting bacteria, on the planet, of which only 1.6 million have been recognized scientifically. Just as for plants, the great majority of even the 1.6 million are very poorly known, often from a

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single specimen, a brief description, a locality—nothing more. Human efforts have been notable for their lack of attention to the living world that supports us all. An important conclusion that must be stressed here is that, in the face of the worldwide extinction crisis, we must redouble our efforts to learn about life on Earth while it is still relatively well represented.

The most accurate estimate of worldwide extinction rates is that of Pimm and Brooks (1997), presented at the Second National Forum on Biodiversity in Washington, DC. They concluded that humanity's impact has increased extinction rates throughout the world to levels rivaling the five mass extinctions of geological history. Their analysis of the fossil record suggests that in the periods between mass extinctions, species become extinct at the rate of 0.1 to 1 extinctions per million species-years. For a wide range of well-known groups of organisms, it can be demonstrated that the known current extinction rates are several hundred times higher. The fate of the areas of greatest concentration of endemic species – those restricted in range – may prove the most important in determining the actual extinction rate in the years to come. Over the last few thousand years, humans have eliminated about 10 percent of all bird species, and more than 90 percent locally. On the basis of their analysis of the disappearance of species in forest fragments, Pimm and Brooks estimate a global extinction rate of at least 1,000 extinctions per million species-years. Considering the acceleration of habitat destruction around the world, they expect the actual rate over the 21<sup>st</sup> century to be higher. Species loss can be estimated because of the logarithmic relationship between species number and area, demonstrated for thousands of habitats and hundreds of different groups of organisms throughout the world, and so constant as clearly to hold for other groups, less well known.

Although species may persist in habitats that have been reduced to small patches, the tiny populations their amount to what Dan Janzen has called “the living dead.” The populations are simply not large enough to insure survival, whether on grounds of inbreeding and genetic deterioration, or on simple statistical grounds – rolling the dice each generation is a dangerous process! Analyzed overall, the known facts and calculations led Pimm and Brooks to calculate that fragments lose half the species they are going to lose in about 50 years, three-quarters in a century. If current trends continue, and we retain just 5 percent of tropical forests in protected areas, which will be true within 50 years at present rates of destruction, and sooner if these rates are accelerated, or the remaining areas are less than 5 percent of the original extent of the forests.

About 10 percent of the species in well-known groups of organisms, including plants, are threatened with extinction now. Some estimates are higher, but I consider that they have listed too many species that are simply rare or because not enough is known about them. Extrapolating to the future and, assuming that 5 percent of the existing tropical forests would be left as fragments 50 years from now, can predict extinction rates three or four orders of magnitude higher than those prevailing between mass extinctions. This would lead to the loss of between one-third and two-thirds of all species during the second half of the next century, the majority of them in the tropics. Such a loss would easily equal

those experienced during the preceding five mass extinction events that have occurred during world history.

### **What about plants?**

Given the availability of adequate resources and information, plants are in some senses easier to conserve than the members of some other groups of organisms are. This is because they can be grown in botanical gardens, sometimes, as diverse enough samples to insure their long-term survival, and the seeds of many plants can be stored in seed banks. Thus although we would expect the loss that we experience will be lessened by the practice of *ex situ* conservation. In addition, one must keep in mind the problem of genetic depletion: the genetic diversity of plants species is what allows them to grow in a wide range of habitats, and populations characteristically cannot be substituted from one extreme of the species range to another. In addition, the extreme depletion of genetic variation in individual plant species itself threatens them with extinction. Peter Wyse Jackson, director of Botanic Gardens Conservation International (BGCI), estimates that there are perhaps 80,000 species of plants in cultivation in botanical gardens. In addition, there might be another 5,000 species in cultivation outside of botanical gardens. Together these amount to nearly 30 percent of the world's total number of plant species. Although many of them are represented only as single individuals or very small samples, they are still to a varying degree out of harm's way. With actions recommended here and with the participation of the botanical community, that number could be greatly enlarged.

Plants play a central role in the functioning of the living world, along with other photosynthetic organisms (about 50,000 species of algae, and perhaps a few hundred species of bacteria), play in the functioning of the living world, including providing direct and indirect benefits for human beings. The ability of these organisms to transform a small proportion of the Sun's energy into chemical bonds, in which form it makes possible the life processes of the photosynthetic organisms and all others, and forms the basis for the survival of all life on Earth. The photosynthetic activities of cyanobacteria, carried out over billions of years, gradually changed the Earth's atmosphere from a reducing one to an oxidizing one, a process that took place before terrestrial life existed, and which probably made its existence possible.

Virtually all human food comes directly or indirectly from plants, with just 103 species supplying over 90 percent of the calories we consume, although tens of thousands of other plant species have been used for food by human beings at some time, or are being used somewhere now. In addition, for at least three-quarters of the people in the world, plants are the primary source of medicine, and thousands of plants are registered in the pharmacopoeias of countries such as China and India, where they have been used for millennia. In western medicine, the role of biologically derived compounds, many of them from plants, are also of fundamental importance, dominating a large fraction of the world's trade in prescription and over-the-counter drugs. The many roles of plants include supplying building materials, including wood, bamboo, and other products; clothing (cotton, linen); and biomass to produce energy, and also include many products that plants will provide in the future (vitamins, antibiotics, plastics, chemical feedstocks,

and so forth). Taken together, these valuable properties clearly demonstrate that plants form an indispensable part of the foundation of human society. Their diversity makes possible many diverse uses that we are just beginning to understand.

Then too, plants form the framework, as well as the productive base, of terrestrial and some aquatic natural communities throughout the world. Without plants, there would be no ecosystem services – no watershed protection, no topsoil protection, no habitats for animals, fungi, and microorganisms. Plants sequester large amounts of carbon, a factor of increasingly clear importance in a world that is warming rapidly as carbon dioxide levels in the atmosphere mount. We shall need plants in all of their diversity to make possible the restoration of natural communities, or the construction of new kinds of communities, in the areas that we have ravaged. They are of utterly central importance for proper functioning of the global ecosystem.

And finally, we need plants simply because they are beautiful, and we enjoy seeing them, and they enrich our lives. Human beings have always been closely associated with plants, from our earliest origins to the present. We find their presence so soothing that we keep them around us, in our gardens, in many of our rooms, in photographs and painting on our walls, so that we will encounter them and think about the form, beauty, and variety of the natural origins from which we sprung. Our minds are conditioned to deal with plants, and comfortable in their presence. We value them, and need to express that value by a substantial effort to preserve as large a proportion of them as possible for future generations to enjoy.

### **What are the steps that could be taken to save plants throughout the world?**

Considering their huge importance to us, we must conclude that it is time to address this problem seriously. The recommended steps are as follows:

- (1) Establish a new coordinating body, presumably sponsored by the United Nations directly, possibly managed by one of its constituent organizations, to monitor the status of plants throughout the world, detect those in most danger, and take steps to conserve them in nature, in botanical gardens, or in seed banks – or preferably a combinations of these strategies.**

Such a combination, when research and education are added, is known as integrated plant conservation. The actions of this body would presumably be done by delegation to national or regional bodies, to move the information and the action closer to the actual plants. Such a body would be able to identify the areas of the world in most critical need, and to recommend the formation of reserves, botanical gardens, and seed banks to ensure the survival of the most critically threatened plant species. Their recommendations would be expected to help inform the actions of the Convention on Biological Diversity (CBD) and the Global Environment Facility (GEF), as well as national and regional conservation bodies; and they would be able to focus on the areas in greatest need. Every country should set up an appropriate biodiversity authority, with a subsection dealing

with plants, at the appropriated place in its government, and thereby would be enabled to make an indispensable contribution to the future of its people.

The new global body for plant conservation should be at its heart, in the words of Peter Wyse Jackson, a multidisciplinary and cross-sectoral alliance. A number of organizations are working effectively in plant conservation now, and could benefit greatly from the kind of overall international coordination that the global body could provide, based on an explicit recognition of the fact that the job of plant conservation must be done for our common benefit. Among the organizations that must be involved are Botanic Gardens Conservation International (BGCI), the American Association of Botanical Gardens and Arboreta (AABGA), and the Center for Plant Conservation (CPC), which are cosponsoring a major conference on plant conservation at Asheville, North Carolina, next summer; the International Association of Botanic Gardens (IABG); the International Plant Genetics Resources Institute (IPGRI), which concentrates mainly on crops and economically valuable wild plants; and the Food and Agriculture Organization of the United Nations (FAO).

The Plant Conservation Program (PCS) of World Conservation Union's Species Survival Commission will be announced at this Congress. This new program, which concentrates in a coordinated and cooperative way on hotspots of plant diversity around the world and the survival of species in them, deserves special mention. The "International Agenda for Botanic Gardens in Conservation" being developed by the BGCI in cooperation with several of the institutions just mentioned also promises to be of great importance in formulating the overall aims and objectives of the new global effort in plant conservation, particularly since the worldwide network of botanical gardens is clearly a key element in achieving these objectives. In addition to these coordinating groups or alliances of organizations, there are also some individual organizations that deserve very special mention. For example, Royal Botanic Gardens, Kew, through its overall conservation programs and the development of its Millennium Seed Bank at Wakehurst Place, deserves very special mention, is contributing to an extraordinary degree to the conservation of plants. These organizations, and similar ones that I have not mentioned, should be strengthened and their activities regarded as integral parts of a global plant conservation strategy. In this connection, it is particularly important that their plans and activities be made explicit and mutually available.

**(2) Secure additional funding for the study of plants throughout the world both by strengthening the major museums and other institutions that have holdings of specimens and literature and thus global importance and by building capacity to deal with plants in every country of the world.**

Nations are the only effective means by which problems of the sustainable use of natural resources can be addressed. They will be able and willing to act in their own interests only if they have their own institutions and their own scientists to make recommendations about what's best for them. Organizations like INBIO in Costa Rica and CONABIO in Mexico should be replicated throughout the world, shaped to fit the circumstances of individual countries. The preservation of biodiversity cannot

be accomplished effectively as an enterprise managed from the outside. Individual nations provide the only effective means of dealing with these problems on the ground, or working for their benefit with corporations and non-governmental organizations, with grassroots groups, and with foreign and international organizations for their own benefit.

Probably 80 percent of the world's scientist live in industrialized countries, which have about 20 percent of the world's population and also about 20 percent of the world's biodiversity, but about 85 percent of the world's economy. At least three-quarters of the remaining active scientists live in just a few countries, with China, India, Brazil, and Mexico prominent among them: covering perhaps 40 percent of the world's population. For a majority of the remaining countries of the world, there are very few scientists and scientific institutions, and limited capacity to deal with the conservation of biodiversity and its sustainable use. Building these institutions and training these scientists ought to be a top priority for the Convention on Biological Diversity (CBD), which has been so preoccupied with so-called biosafety issues that it has been unable to turn its attention adequately to the purposes for which it was established so far. The Global Environment Facility (GEF) ought to provide funds for capacity building, and not as stopgaps for existing budgets that cannot otherwise be funded. This will lead to the construction of a sustainable future, and must be emphasized even though the lack of funds and the severe economic problems that beset many developing countries, especially the poorest among them, make it very difficult to take a long-range view of their problems. Much more generosity on the part of individual donors will be necessary if the situation is to address the conservation of plants, or of biodiversity generally, in a serious and effective manner. There is no step more important for the conservation of plants or for the sustainable use of biodiversity around the world than building capacity in developing countries everywhere.

### **(3) Make the information about plants accessible generally on the INTERNET.**

The spread of information throughout the world, and especially to those in developing countries who need it the most, is one of the most important strategies that we can pursue to help humanity move towards a condition of sustainable development in the new millennium. Major efforts should be made to computerize the information available on herbarium specimens and in the literature, to digest it, and to make it widely available. This will expedite the identification of centers of plant diversity, and their protection. There is great need to computerize information about the holdings in botanical gardens and seed banks, information which is of critical importance but not generally or easily available now. Although, as stated earlier, probably some 85,000 of the world's 300,000 species of plants are in cultivation, there is no efficient way to learn where they are, and thus to use them or monitor their survival. As living plants, Kew alone holds some 32,000 taxa, about a tenth of the world's total, in its collections. In addition, there are hundreds of thousands of accessions in seed banks, a BGCI survey of some 152 botanical gardens that maintain seed banks revealing a total of 255,832 accessions. The seed bank

at the Royal Botanic Gardens, Kew, alone holds some 4,900 species represented by 12,400 (mainly) population samples.

Further efforts to collect living plants in botanical gardens and arboreta, or to gather them in seed banks, will continue to be an inefficient process unless we get on with the formation of a generally accessible database. Such a database should make clear which species of plants exist in cultivation or in seed banks anywhere; where it came from; and who is the authority for their identification. The BGCI is making excellent strides toward the development of such a database through electronic comparison of the records of different gardens, and should be encouraged to bring this work to completion as soon as feasible. Although the expenditure will seem high, there is strong possibility that, even given our best efforts, our great-grandchildren may live in a world in which more than half of the plant species that exist now will be known only as specimens, even assuming that they will have been found. This would be a much poorer world, and not one that we should wish to leave as a permanent reminder of our greed.

**(4) Place much more emphasis on the importance of alien introduced plants and animals on the survival of biodiversity throughout the world.**

This is an enormous problem, and one that is properly starting to receive the international attention and funding that it deserves. Plants, animals, and other organisms often will not be able to survive in nature if they are not somehow protected from the hordes of alien species that so severely threaten their survival throughout the world. Studies of alien species, and of ways of controlling them, are therefore of paramount importance, and must be taken strictly into account when evaluating the status of species in nature so that they can be protected for the future. At the same time, the encouragement of the horticultural use of plants, the improvement of horticultural strains, and the incorporation of additional plants into the horticultural trade is greatly to be encouraged, being an important element in the survival of plant species in a way that people can truly appreciate.

**(5) Maintain, at the national level, an active census of the condition of the country's plants, so that it will always be obvious which are well protected in nature, which are so abundant as not to cause concern, and which are rare and endangered.**

Botanical gardens, not essentially display gardens but rather areas where genetically adequate samples of plants can be protected effectively, should be established and supported internationally to ensure the survival of plant species in all regions of the world. Seed banks should be set up nationally or regionally, with adequate provisions for access and protection of the rights of the countries from which the seeds were derived initially, and funded as part of an international system so as to insure their permanence. These gardens and seed banks will constitute a system far too precious for all humanity to entrust their survival to the vagaries of fate, or fluctuating national fortunes. The Millennium Seed Bank at the Royal Botanic Gardens, Kew, aims first to obtain and to store genetically representative samples of the seeds of the entire British flora. By 2010,

Kew will attempt to add to its collections 10 percent of the world's plant species, primarily those of arid areas. This is an ambitious effort that should be generally supported. In addition, they are supporting the creation of seed banks in other countries, and setting standards by which access to the seeds is unimpaired for non-commercial use. This ambitious effort should be generally supported and presumably augmented with similar efforts around the world, coordinated and leading to the preservation of as high a proportion as possible of the world's plant species. Ultimately, the survival and, when necessary, re-establishment of populations of plants in nature is generally the best way to safeguard their genetic diversity and their future. It is imperative that the cooperation that we have witnessed in the last decade between land stewardship organizations and botanical gardens continue to thrive and to grow.

**(6) Devote special attention to the conservation of medicinal plants, which are so important to the livelihood of a great majority of the world's population, and to the development and implementation of means for their sustainable use.**

The increasing demand for products derived from medicinal plants throughout the world, and especially the developing world, is driving many of them near extinction. They are the only sources of medicine for a majority of the world's people, and strategies that insure their survival and important elements in local communities urgently need global attention. The same can be said for the wild relative of cultivated plants.

**(7) Internationally fund an ongoing program of research on plant population biology and reproductive characteristics generally, so that the genetics and ecology of plants can be understood properly and used as part of the overall conservation scheme.**

Recently, we have begun to realize how important the survival of pollinators is to the survival of healthy plant populations; and plants exist in nature, like animals, as part of balanced biological communities. Another problem of special importance is that of recalcitrant seeds—seeds that cannot be dehydrated by the usual methods and stored in seed banks—and adequate funding must be applied to its solution, so that all plants can more easily be saved from extinction. Perhaps as many as one-fifth of the world's plants have recalcitrant seeds. To expedite a major international effort to preserve the world's plant species, this problem must be solved.

All plants are important ecologically, and in relation of human beings, in one way or another. My principal point in raising this proposal is to urge the formulation of a comprehensive scheme by which we will save them all—a priceless gift for future generations. Efforts to educate the general public, and people throughout the world, about plants and their importance to human beings should be strengthened, because they are of fundamental importance in building a secure and sustainable world for the future.

I emphasize once more that the survival of biodiversity throughout the world depends on the degree to which we approach the ideal of sustainable development around the world. A world in which human beings have wasted 25 percent of the topsoil and 20 percent of

their agricultural lands; cut a third of their forests; and changed the characteristics of the atmosphere significantly—one in which we are ending the century as 6 billion people, consuming or wasting an estimated 45 percent of the total net terrestrial photosynthetic productivity and consuming about 55 percent of the available fresh water—that is not a world that allows much space for the survival of plants or other organisms. Indeed, it is one in which species have been, and will be increasingly, hounded to extinction.

Nonetheless, because of the unique properties of plants and their importance to us, they are one group for which we can—indeed must—truly make a difference.

In order to establish the alliance proposed here, a new coordinating body for plant conservation, I call for a major U.N.-sponsored conference soon, designed to work out the details of implementing a plan of the sort I have just outlined and estimating the budget necessary for it. Considering the importance of plants to the survival of humanity in a healthy and prosperous condition into the 21<sup>st</sup> century and beyond, we should be able to find the necessary resources. In fact, anything less would be neither intelligent nor worthy of us. Let us determine here and now to take these steps, and take them together.

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