Loss of plant diversity: a call for action

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The world's biological diversity is a vast and often undervalued resource. Encompassing every form of life, from the tiniest microbe to the mightiest beast, biodiversity is the variety and variability of all plants, animals and microorganisms and the ecological complexes of which they are part. The earth's biodiversity – its ecosystems, species and genes – are the product of over 3000 million years of evolution. Throughout this time, small changes have accumulated in populations, resulting in a multitude of living forms closely adapted to the physical conditions they face and to each other. They supply all our food, much of our raw materials and energy and many of our medicines. Intact ecosystems also play a central role in the functioning of the biosphere. Plants are fundamental in stabilizing climate, protecting watersheds and soil and maintaining the chemical balance of the earth. When key species are lost, vital ecological services are disrupted.

Cultures from ancient times to the present day have exploited biodiversity. Ten thousand years ago neolithic farmers in the Middle East and elsewhere developed some of our most important crops and livestock from their wild relatives. They soon recognized that certain species were more suitable than others for their needs and that within populations some plants and animals had characteristics more suited to their specific requirements. They selected, bred and used these individuals in preference to others, practices that continue to this day. Through selection and breeding, human societies have developed thousands of local races of crops and livestock, each fitting a particular need in a specific physical environment and evolving in harmony with the diverse systems of land and natural resources management of which they are integral parts.

These local races are not only numerous, fulfilling a variety of needs and adapted to different conditions, but also genetically variable, which means that even in bad years at least some individuals can survive and pass on adaptability to adverse climatic conditions, water scarcity, low fertility, problem soil and aquatic systems, pests and diseases. The maintenance of this diversity has until recently been ensured by traditional systems of agriculture and land use. In some instances, it depends on introgression with wild and weedy relatives growing near by, in both natural vegetation and disturbed field margins. However, with the advent of scientific breeding some four human generations ago, new plant varieties, animal breeds and strains of microorganisms began to be developed in response to the needs of quite different, intensive production systems. Breeders assembled desired genetic traits from different varieties, and in some cases different species, gradually enabling the development of the high yielding genotypes that sustain modern societies. High performance under intensive agriculture requires genetic uniformity. This is achieved by screening existing diversity for the few characteristics that are needed at any one time, largely disregarding the remainder – until, that is, a new need arises.

The development of modern varieties, breeds, strains and production systems, while increasing productivity and thus helping to satisfy the needs of a rapidly growing world population, has also created a number of problems. Modern varieties are ill-suited to the needs of small producers, who farm with low management inputs on often marginal lands. The so-called high yielding or high performance varieties are more accurately high-response varieties, since their performance hinges on substantial external inputs (e.g. fertilizers, pesticides), which are sometimes deleterious to the environment. Without such inputs, their high potential is not realized. The new systems are also more vulnerable to the challenges of pests and diseases. Large, genetically uniform fields and herds encourage the rapid spread of pests and pathogens. Plant breeders are therefore dependent upon the availability of the pool of diverse genetic material represented by local races and wild relatives in their effort to keep one step ahead of tomorrow's unexpected calamities, since in themselves modern varieties provide too restricted a gene pool for further breeding. Without a diverse genetic reservoir to draw from, further improvement may not be possible.

Can we put a monetary value on this genetic pool? One of the major reasons why nothing is done about biodiversity loss is that national economic systems and policies fail to value the environment and its resources adequately. This is perhaps understandable. Because biodiversity is complex and information on its component parts and their interactions is incomplete, it is extremely difficult to determine accurately the economic and ecological value of the full range of goods and services that it provides. However, preliminary indications suggest that the value of biodiversity outweighs conservation costs by a significant margin. Information is gradually accumulating on the economic benefits of using genetic diversity in conventional crop breeding. Wild relatives of commercial crops have provided genetic material worth billions of dollars in higher crop yields. A few examples will illustrate the point. In Asia, by the mid-1970s genetic improvement had increased wheat production by US$2 billion (thousand million) and rice production by $1.5 billion a year by incorporating dwarfism into both crops. A 'useless' wild wheat plant from Turkey was used to give disease resistance to commercial wheat varieties worth $50 million annually to the USA alone. One gene from a single Ethiopian plant now protects some varieties of barley from yellow dwarf virus. An ancient wild relative of maize from Mexico – a perennial with resistance to seven major diseases and which can grow at high altitudes on marginal soils – can be crossed with modern varieties with potential savings to farmers estimated at $4.4 billion annually worldwide.

The contribution of genes from wild relatives has often been limited by the difficulty of making viable crosses between wild and domesticated species. The biotechnology revolution, including recent developments in recombinant DNA technology ('genetic engineering'), raises the prospect that useful traits may soon be transferred between species that could not previously be crossed by conventional means. Moreover, biotechnology permits a better understanding of how gene expression works. This knowledge can be used to facilitate the use of germplasm in the development of modern crop varieties. Advances in plant biotechnology have also led to novel and precise screening tools, for example stimulating interest in plants as sources of raw materials for new medicinal products. Biotechnology also has much to offer to the conservation of genetic resources. It is already leading to improved methods of storing germplasm of plants, animals and microbes, for example *in vitro*. However, this does not diminish the need to maintain the richest possible pool of genes. Rather, it reinforces it. The relationship between biotechnology and genetic resources is in fact one of mutual dependence. The future of biotechnology depends on conservation of a wide array of genetic diversity, its raw material. As the field of biotechnology develops, the range of future germplasm is certain to increase. The stake which the biotechnology industry holds in the conservation of biodiversity should thus not be underestimated. While breakthroughs are occurring with increasing speed, options for the future are being foreclosed by genetic erosion. The projected loss of species diversity could cripple the genetic base required for the continued improvement and maintenance of currently used species and deprive us of the potential to develop new ones.

The genetic base of the staple crops is generally very narrow. Half the Canadian prairies are planted with just one variety of wheat; the USA's entire soyabean industry stems from six plants from one place in Asia. The number of different species on which we rely for food, fibre, timber, medicines and other natural products is likewise extremely limited. Only a tiny proportion of plant and animal species have yet been tested for their usefulness. The range of species used as food, for example, is extremely limited. Of an estimated 265,000 species of plants, only about 7000 have ever been cultivated or collected for food. Of these, 20 species currently supply 90% of the world's food, and just three – wheat, maize and rice – supply more than half. Many food crops of regional or local importance have been relatively neglected by science. There is much potential to look beyond today's major crops at other species that may have value either in themselves or as sources of genes. After all, peanuts, potatoes and other crops once considered of little use are now valuable sources of food.

The case for conserving biodiversity is therefore well established on economic as well as scientific grounds. Biodiversity is essential for sustainable development, adaptation to a changing environment and the continued functioning of the biosphere – indeed, for human survival itself. However, the evidence suggests that many human activities are leading to depletion of the planet's biodiversity. The world's biological wealth is being depleted at an ever-increasing rate and this will adversely affect the well-being of people in both industrialized and developing nations.

The opportunity to exploit wild relatives as potential breeding material is increasingly limited by the degradation of ecosystems, especially in the tropics. Habitats are disappearing beneath agriculture, cities, industrial developments and dams and are being irreversibly damaged by pollution, overuse and erosion. Many species are also threatened by overexploitation, illegal trade and competition with introduced alien species. Species extinctions have increased steadily since 1600 and are now at an unprecedented high. Most of these species vanish unknown. The loss of genetic diversity within species is occurring even faster than species extinction. Breeders throughout the world are engaged in developing better and higher-yielding cultivars of crop plants to be used on an increasingly larger scale. Traditional food plants and local races of staple crops are being abandoned and lost for ever in favour of newly developed ones. Worldwide, food crop yields are increasing, but the yield is coming from ever fewer varieties. Uniformity is replacing diversity, just when the need for diversity is increasing.

Insufficient effort has been made to ensure the conservation of biodiversity in the face of the extensive destruction of plant-rich habitats, species extinction and genetic erosion. Most countries do not have a complete inventory of their plants, and most of the knowledge on their use is held by traditional societies, whose very existence is now under threat. The intense pressure on biodiversity will continue to increase unless appropriate measures for conservation and sustainable use are taken. There has been international consensus on this point for more than two decades, starting with the United Nations Conference on the Human Environment in 1972. Since then there has been the establishment of the International Board for Plant Genetic Resources (IBPGR) in 1974 (which became the International Plant Genetic Resources Institute (IPGRI) in 1994), the adoption by the Food and

Agriculture Organization (FAO) Conference in 1983 of the International Undertaking on Plant Genetic Resources and the establishment of the Inter-Governmental Commission on Plant Genetic Resources. Such documents as *Environmental Perspective to the Year 2000 and Beyond*, the *Report of the World Commission on Environment and Development*, *Caring for the Earth: a Strategy for Sustainable Living*, the *Global Biodiversity Strategy* and *Agenda 21* of the United Nations Conference on Environment and Development also emphasize the importance of protecting biological diversity and provide general principles for action.

But concrete action and policy reforms by governments and development agencies are still needed. The lack of sound national biodiversity strategies and action plans, adequate trained manpower and sufficient funding are the major impediments to biodiversity conservation. Two-thirds of all species occur in developing countries, particularly in the tropics, which are not able to finance investments in their conservation and sustainable use. By and large, it is the developed countries that have the technology to exploit and benefit from them. Activities will probably be proposed within the framework of the *Convention on Biological Diversity*, which will no doubt add further to the financial burden of those countries that are rich in biodiversity or that host rare or endangered species. Ways of sharing the costs and benefits of conserving genetic resources must be devised. Social, political and economic decisions by all players will be needed: those who have or need resources, and those who have or need technologies. The potential of plant genetic resources can best be exploited if they remain accessible to all users and if the information and technology on how to use them is widely disseminated. Neither having a particular, valuable genetic resource nor having the technical capability to develop new products from it should give exclusive rights of ownership or profit. No country is self-sufficient in genetic resources. While possession and custody of a potential genetic resource might be limited to one nation, the benefits from this resource can accrue to all nations. There needs to be a fair balance of benefit between custodian and consumer.

The *Convention on Biological Diversity* has begun to address these important topics, but the road ahead is difficult. Worldwide investment in the conservation of plant genetic resources has been very modest and is by no means secure. The integration of conservation and development plans is almost non-existent. National cross-sectoral cooperation is limited. The resources, power and capacity to promote conservation are unequally distributed. Local people are rarely brought into the process of planning the conservation and management of the genetic resources they shape and maintain. However, there is general agreement both in the scientific community and among the public in both industrialized and developing countries that there is a need for a global effort to conserve as much of the gene pool of crop plants as possible and to tap this reservoir for the benefit of all.

The important point is that, if conservation is to be given the priority it needs, all the institutions concerned must coordinate their efforts. Genetic resources underpin, and are threatened by, virtually every area of human activity. Only the broadest possible cooperation at both the national and the international levels can save them.