CONSERVATION OF PLANT GENETIC DIVERSITY

Nigel Maxted
School of Biological Sciences, The University of Birmingham, Edgbaston, UK

Luigi Guarino
International Plant Genetic Resources Institute, Regional Office for the Americas, Cali, Italy.

Keywords: Biological diversity, plant conservation, ecosystem, Convention on Biological Diversity, complementary conservation, *ex situ* techniques, *in situ* techniques, diversity hot spots, center of diversity, habitat loss, CITES, target taxa, plant breeder, bioprospecting, genetic drift phytochemist, gene pool, keystone species, DNA sequences

Contents

Summary

The challenge facing the world’s biologists is threefold: to describe biological diversity at the ecosystem, species, and genetic level; to halt the rate of loss of this diversity; and

to feed the ever-increasing human population. Conservation impinges on all three of these activities; as it facilitates description, preserves diversity for future generations, and provides novel diversity for potential users. A brief introductory section outlines what constitutes biodiversity, how it is measured, and how wild species and crop species are distributed geographically around the world. The various factors which threaten biodiversity are described, the historic and current rates of loss of biodiversity are reported, as is why it is important for humanity to halt the careless loss of biodiversity.

A model for the conservation of plant biodiversity, and in particular plant genetic conservation, is discussed. The model discusses how target taxa are selected for conservation, how background ecogeographic data is used to establish conservation strategies and priorities, and then how an effective and appropriate conservation strategy is implemented using the range of *ex situ* and *in situ* techniques in a complementary fashion. The need to link conservation with sustainable utilization is discussed. Finally, the need for a sustainable and integrated approach to the conservation of botanical diversity is stressed, along with the need to link genetic conservation to use.

1. Introduction

The challenge facing the world's biologists is threefold: to describe biological diversity at the ecosystem, species, and genetic level; to halt the rate of loss of diversity; and to feed the ever-increasing human population. It is generally agreed that a rapid loss of plant diversity is occurring: ecosystem, species, gene, and allelic diversity is being lost forever, and the processes of habitat destruction, species extinction, and genetic erosion show no signs of slowing down.

The economic and social consequences of such an irredeemable loss of plant diversity, combined with rapid population growth, could potentially be devastating. The conservation of plant diversity is thus of critical importance for the survival of the human race, not to mention to its economic and spiritual development.

The importance of these issues was recognized at the UN Conference on the Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992. The Convention on Biological Diversity (CBD) which has subsequently been ratified by 178 countries has as its objectives: "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources . . . ." An explicit link was thus made by the CBD between conservation of biodiversity and its use for development.

The purpose of this article is to briefly introduce what constitutes biodiversity, how it is measured, and how it is distributed geographically around the world. The various factors that threaten plant genetic diversity are described and also why loss of that diversity needs to be halted. A model for the conservation of plant biodiversity, and in particular plant genetic diversity conservation, is discussed. Finally, the need for a sustainable and integrated approach to the conservation of botanical diversity is stressed, along with the need to link genetic conservation to use.

2. Diversity in Biodiversity

2.4. Definition of Biodiversity

Biological diversity or biodiversity is the result of 3 000 million years of evolution of life on Earth. Widespread use of the terms began in the 1980s, initially promoted by the American entomologist, naturalist, and conservationist Edward O. Wilson. A key part of the concept is the recognition that biological diversity is organized in hierarchical levels, the genetic, species, and ecosystem levels. Wilson's own definition of biodiversity is: "The variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families, and still higher taxonomic levels; including the variety of ecosystems, which comprise both communities of organisms within particular habitats and the physical conditions under which they live." The Convention on Biological Diversity uses the following definition: "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

2.5. Measuring Biodiversity

Perhaps the most commonly seen estimate of biodiversity is in terms of the numbers of species or other taxonomic units (e.g., genera or families) in an area, as given in Table 1 for species in the world as a whole. Whatever the level of biodiversity being considered, however, two components may be recognized, i.e. richness and evenness. Richness refers to the total number of different biological entities found in an area, whether alleles, species, or ecosystems. Taking into account the distinctiveness of the entities involved may further refine estimates of richness. Evenness refers to the relative abundance of the different entities. As an example, imagine two areas with the same total number of species (i.e. equal species richness), but different relative abundances and different species complements. The area in which the abundances of the different species are more nearly equal will have the higher species diversity. Similarly, the area in which the species are more different among themselves will have the higher species diversity, other things being equal. Various indices have been developed which are combined measures of richness, evenness, and distinctiveness.

	Described Species	Working Number of Estimated Species
Viruses	5000	500000
Bacteria	4000	400000
Fungi	70000	1000000
Protozoans	40000	200000
Algae	40000	200000
Plants	250000	300000
Nematodes	15000	500000
Mollusks	70000	200000

Crustaceans	40000	150000
Arachnids	75000	750000
Insects	950000	8000000
Vertebrates	45000	50000
	1604000	12250000

Table 1. Species diversity for different taxonomic groups

Biological diversity is not only apparent in the number of different species and of different combinations in which they exist and interact among themselves and with the physical environment (i.e. communities and ecosystems). It can also be observed among individuals within a population of a given species and among populations of the species. Such genetic diversity is “differences among individuals in the presence of particular DNA sequences or their location in the genome (nuclear and cytoplasmic).” Variation at the genetic level among individuals and populations is caused by an interaction of the five evolutionary forces of selection, genetic drift, migration, recombination, and mutation. There may be variation in DNA regions controlling protein-coding regions, or genes, but also areas controlling gene expression and in so-called neutral regions.

-
-
-

Bibliography

CBD (1992). *Convention on Biological Diversity: Text and Annexes*, 34 pp. Proceedings of the UNCED meeting in Rio de Janeiro, 1992. Montreal: Secretariat of the Convention on Biological Diversity. [The full text that resulted from the UNCED meeting in Rio de Janeiro in 1992 and that has now become the defining text for biodiversity conservation and use.]

Crucible Group (1994). *People, Plants, and Patents: TheImpact of Intellectual Property on Trade, Plant Biodiversity, and Rural Society*. Canada: IDRC. [An excellent introduction to the social and political issues associated with biodiversity ownership and exploitation, and the equitable sharing of benefits arising from exploitation.]

Food and Agriculture Organization of the UN (1998). *The State of the World’s Plants Genetic Resources for Food and Agriculture*, 510 pp. Rome: FAO. [A comprehensive compendium of conservation information with a focus on crop species, including information on their conservation status, utilization, national program activities, regional and international collaboration activities, and resource access issues, with educational and technical annexes.]

IUCN (1994a). IUCN *Red List Categories*. Prepared by IUCN Species Survival Commission. Gland: IUCN. [A guide to the IUCN red list categories.]

IUCN (1994b). 1993 *United Nations List of National Parks and Protected Areas*. Prepared by WCMC and CNPPA. Gland: IUCN. [A guide to the various kinds and locations of protected areas where biodiversity is conserved around the world.]

Maxted N., Ford-Lloyd B.V. and Hawkes J.G., eds. (1997). Plant Genetic Conservation: The *In Situ* Approach. London: Chapman and Hall. [This book with twenty-three contributions gives the first comprehensive review of the *in situ* conservation of plant genetic diversity.]

UK Department of the Environment (1996). *Towards a Methodology for Costing Biodiversity Targets in the UK*. London: UK Department of the Environment. [A detailed case study of how one nation is addressing the problem of assigning conservation priorities to its native biodiversity.]

Walters K.S. and Gillett H.J. (1998). *1997 IUCN Red List of Threatened Plants*. Compiled by the World Conservation Monitoring Center, 862 pp. Gland, Switzerland, and Cambridge, UK: IUCN, The World Conservation Union. [The most comprehensive review of international plant species conservation status available.]

Wilson E.O. (1992). *The Diversity of Life*. London: Penguin Press. [An introduction to the concept of biodiversity and its conservation by the man who coined much of the terminology and who proved to be an innovative thinker.]

World Conservation Monitoring Center (1992). *Global Biodiversity: Status of the Earth's Living Resources*. London: Chapman and Hall. [A comprehensive compendium of conservation information, including information on the status, distribution, management, and utilization of the world's biodiversity.]

WRI, IUCN, and UNEP (1992). *Global Biodiversity Strategy*. Washington, DC: WRI. [Guidelines on how to save, study, and use biodiversity in a sustained and equitable manner.]

Biographical Sketches

Nigel Maxted graduated from the Polytechnic, Wolverhampton, UK, in 1981 and undertook further postgraduate degrees at the University of Southampton in 1984 and 1990. He has been a consultant for the Food and Agriculture Organization, the Consultative Group on International Agricultural Research (IBPGR and ICARDA), and the World Bank for the past 16 years. In 1991 he became a lecturer, then senior lecturer, in plant genetic conservation at the University of Birmingham, UK. He is a plant genetic conservation and conservation training specialist. His areas of interest include conservation methodologies, taxonomy, and conservation training, often using as exemplars groups of temperate or tropical legumes. He is author of 6 books and more than 120 assorted publications.

Luigi Guarino graduated from the University of Cambridge in 1980, and did graduate work at the same university, followed by a germplasm collecting position for the International Board for Plant Genetic Resources in the Middle East and North Africa for five years. He has been a genetic diversity scientist for the International Plant Genetic Resources Institute in Africa and Latin America since 1992. He edited 3 books and has authored about 25 scientific papers.