GLOBAL BIODIVERSITY DATA AND INFORMATION

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1. Introduction

Biological diversity or biodiversity, a term that first emerged some twenty years ago (Lovejoy, 1980; Wilson, 1985; Norse et al. 1986; Wilson and Peters, 1988; Reid and Miller, 1989; McNeely et al. 1990; Chauvet and Oliver, 1993), describes the variety and variability of life on Earth. It encompasses all forms of terrestrial and aquatic plants, animals and microorganisms, their genetic material and the ecosystem of which they are part.

Global biodiversity is usually divided into three categories: genetic diversity, species diversity and ecosystem diversity.

- **Genetic diversity** refers to the differences in genetic make-up between distinct species and to generic variations within species.
- **Species diversity** refers to the variety of species within a region.
- **Ecosystem diversity** is the variety of habitats, biotic communities, and ecological processes, as well as the diversity present within ecosystems.

Biodiversity is important to human being for their sustenance, health, well-being and recreation. For example, humanity derives all of its food, medical and industrial products from the components of biological diversity. The benefits of biodiversity conservation can be grouped into three broad categories: ecosystem services (conservation of water resources, soil conservation, nutrient storage and cycling, maintenance of ecosystems, pollution breakdown and absorption, contribution to climate stability, and recovery from unpredictable events), biological resources (food, medicines, forest products, breeding stocks, population reservoirs, and future resources) and social benefits (research and education, recreation, cultural, and religious/philosophical values).

Global biodiversity data and information are necessary to support well-informed decision making at the global level, yet information critical to such decisions are not available readily. Part of the problem is associated with the complex nature of biodiversity data and information given the uncertainties in terms of their existence and distribution. In addition, global biodiversity data are scattered, outdated and available in incompatible formats and resolutions.

The continued loss of biodiversity along with the reporting requirement of international conventions such as the Convention on Biological Diversity (CBD), Ramsar Convention, World Heritage Convention, etc. have called for extra efforts to generate better data and

information. Moreover, baseline information on the status and distribution of biodiversity resources is necessary that can serve as a benchmark for monitoring.

The purpose of this chapter is to examine what biodiversity data are available at the global level? who are the producers/users? Where are the main sources of data located? What are the problems and obstacles exist in current data sets? What is the Present direction? What is needed to improve the situation? And what should be the future directions? The chapter ends with a set of recommendations hopefully to influence existing and planned efforts towards better data collection, maintenance and dissemination.

2. Biodiversity Data

The scope of biodiversity data has been expanding beyond classical "conservation" or "biological" data. The latest trend, especially after the ratification of the Convention on Biological Diversity (CBD), is to embrace resource utilization and socio-economic data as well. The United Nations Environment Programme (UNEP) outlines eight major categories of biodiversity data for country studies (UNEP, 1993). These datasets will serve three main objectives of CBD namely, the conservation of biodiversity, the sustainable use of biological resources and the equitable sharing of the benefits from using those resources. The categories are as follows:

- **Biological**: Information on ecosystem, species, and genetic resources.
- **Physical:** Information on physical factors such as climate, topography and hydrology that allows biological data to be placed within a physical context.
- **Socio-economic**: Information on socio-economic attributes such as population, population distribution and transport routes.
- **Cost and Benefits**: A value of biodiversity that takes into account the cost and benefits of management options.
- **Pressure and Threats:** Information on both potential and actual threats to biological diversity.
- **Sustainable management**: Information on current and past management activities particularly the use of biological resources.
- **Sources and Contacts**: Information models, standards and technologies, and appropriate agencies or experts who can be contacted.
- **Interrelationships**: Information on the interrelationship between and among species and ecosystems so as to forecast the effects of proposed actions.

3. Users of Biodiversity Data

Crain and Reynolds (1999) divided the users of biodiversity data into three broad categories: National-level decision makers, International policy analysts; and the biological scientific community. These groupings can be further elaborated into the

following categories. **National institutions** (governments, the general public, media, political parties, national NGO's, academies), **regional groupings** (ASEAN, MRC, OECD, G-7 countries), **international institutions** (convention secretariats such as CBD, CITES, RAMSAR etc. and UN organizations such as UNEP, UNDP, UNESCO, FAO), **international funding agencies** (WB, ADB, GEF etc.), **bilateral development agencies** (DANIDA, NORAD, CIDA etc**.), international environmental and conservation groups** (IUCN, WWF, Conservation International etc), and **scientific communities**.

4. Data Availability

Increasing concern on biodiversity loss and reporting requirements of international biodiversity agreements have called for world's attention to inventory and monitor the wealth of biodiversity. Yet, to date, only a few biodiversity data and information are widely available. Part of the reason is that the terrestrial and aquatic ecosystems of planet earth encompass enormous variety of biodiversity resources, thus making it challenging, time consuming and expensive to inventory and monitor all resources on Earth. Moreover, the available data are insufficient, scattered, and often incompatible to each other. A comprehensive review of the available data and information is necessary to see how well the available biodiversity data is reflected on the statistical and biological representations.

Biodiversity data can be grouped into the following five categories:

1. Global data;
2. Conservation areas data;
3. Species data;
4. Genetic data; and
5. Biological reference collections.

These dataset are available in different data formats such as numeric, categorical (classified or coded non-numeric data), text, spatial (map and GIS data), remote sensing (photographs and drawings), and sounds (e.g. voice of certain animal species).

4.1 Global Data

Global data provides global patterns of diversity at a coarse scale. A number of global datasets have been generated following a global classification system based either on community structure and function or species composition (Fig. 1). Subsequent paragraphs below are the discussion on the major datasets.

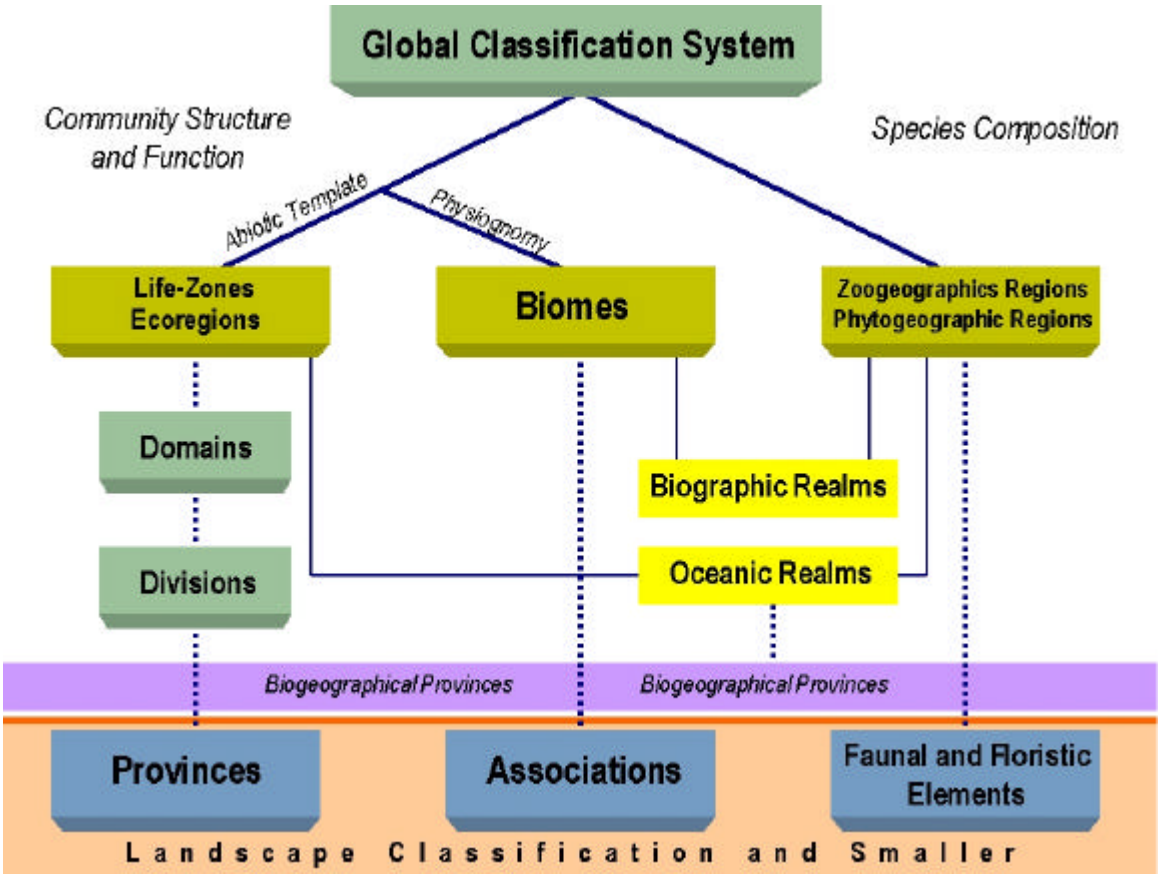

Fig. 1. Global Classification System (Adapted from UNEP -1995)

Biogeographic areas of the world have been delineated by comparing the species composition of flora and fauna in different parts of the world. Similarly, Phytogeographic areas are delineated using floral information. Zoogeographic areas, on the other hand were delineated using faunal information. Using a floristic classification schema, the entire earth has been divided into six categories: Nearctic, Neotropical, African, Palaearctic, Oriental and Australian. Similarly, in the zoogeographic map, the world has been divided into six regions (after Takhtajan, 1969) comprising of Neotropical, Cape, Palaeotropical, Halarctic, Australian and Antarctic (Cox and Moore, 1993).

Cox and Moore (1993) mapped the distribution of major terrestrial biomes of the world based on the physiognomy of the vegetation. This data is available only for terrestrial ecosystems primarily because of the lack of structural diversity of marine and freshwater vegetation. The major terrestrial biomes of the world include arctic tundra, northern coniferous forest, temperate forest, tropical rainforest, tropical seasonal forest, temperate grassland, tropical savanna, grassland and scrub, desert, Mediterranean vegetation and mountains.

The Holdridge life zones of the world are divided according to a combination of climate and vegetation (ecological) types. The life zones were mapped based on the climatic variables such as biotemperature (based on the growing season length and temperature), mean annual precipitation, and a potential evapotranspiration ratio, linking biotemperature with annual precipitation to define humidity provinces. This map provides information on

the generalized distribution of ecoclimatic zones across the globe, the underlying assumption of which is to expect similar types of vegetation under similar climatic conditions. This dataset is in raster format with a spatial resolution of one-half degree lattitude/longitude comprising a total of 38 classes. This data was prepared by the International Institute for Applied System Analysis (IIASA) in Austria. It covers from 90^o N to 90^o S latitude and 180^o E to 180^o W longitude.

The data on biogeographic realms or provinces are prepared by combining physiographic and biogeographic approaches (Udvardy, 1975). The structure of climax community has been used in identifying biogeographic provinces at the first stage, then information on the presence of distinctive flora and fauna were used to delineate boundaries. This map divides terrestrial ecosystem of the earth into eight biogeographical realms that are further sub-divided into 193 provinces. A similar approach has been adopted to prepare oceanic realms (Hyden et al., 1964).

Other datasets available under this category are presented in the Tables 1 and 2.

Table 1 List of selected global biodiversity data

Data	**Format**	**Spatial resoluton**	**Source**
Major world ecosystem (Olson et al. 1983)	Digital raster	0.5^0 x 0.5^0	GRID-Geneva
Global eco-regions (Bailey, 1989)	Digital vector	0.3^0 x 0.3^0	GRID-Geneva
Global biodiversity "hot spots"	N/a	N/a	CI
Mathews vegetation, cultivation intensity and albedo	Digital raster	1^0 x 1^0	NGDC
Mathews global vegetation, land use and seasonal albedo	Digital raster	1^0 x 1^0	NGDC
World vegetation cover (Fedorova et al. , 1994)	Digital raster	10^0 x 10^0	NGDC
Global primary productivity:phytomass, NPP, and mortmass (Bazilevich, 1994)	Digital raster	10^0 x 10^0	NGDC
World wilderness areas	Digital vector	1:2 M	UNEP
Natural wetlands (Mathews and Fung)	Digital raster	1^0 x 1^0	GRID-Geneva
World vegetation map (Murai and Honda, 1987)	Digital raster	12.7kmx12.7km	GRID-Geneva
FAO-UNESCO soil map of the world	Digital vector	1:5 M	FAO
Frontier forests of the world	N/a	N/a	WRI
Status of the worlds coral reefs	10^0 x 10^0	4 km x 4 km	WRI
Monthly global vegetation index	Digital raster	10^0 x 10^0	NGDC
Forest resources of the world	Tabular data	-	FAO
Global assessment of human induced soil degradation	Digital vector	1:10 M	ISIRC
World terrestrial biomes (Cox and Moore, 1993)	paper	-	BSL

BSL = Blackwell Scientific, London
GRID= Global Resource Information Database
FAO = Food and Agriculture Organization
UNEP = United Nations Environment Programme
WRI = World Resources Institute
CI = Conservation International
NGDC = National Geophysical Data Center
WCMC = World Conservation Monitoring Center
ISIRC= International Soil Reference and Information Centre

Table 2. Data available for Marine Resources

Data	Data Source
Coastline data	World Resources Institute
Marine fisheries data	FAO
Coral reefs data	WCMC, UNEP, and IUCN
Inshore marine fishes data	International Centre for Living Aquatic Resources Management (ICLARM), FAO and IUCN
Seagrasses	Incompletely collated
Mangrove	Available from various sources
Marine Turtles	Available from various sources

Paine (1997) prepared a world ranking of mega-biodiversity countries (see Table 3). These countries have been ranked according to the species richness of mammals, birds and flowering plants of all the countries of the world.

Table 3. World ranking of mega-biodiversity countries (Paine,1997)

Country	Mammals	Birds	Flowering Plants
Mexico	450	1,026	25,000
Indonesia	436	1,531	27,500
Zaire	415	1,096	11,000
Brazil	394	1,635	55,000
China	394	1,244	30,000
Colombia	359	1,695	50,000
Peru	344	1,678	17,121
India	316	1,219	15,000
Venezuela	305	1,296	20,000
Ecuador	302	1,559	18,250
Cameroon	297	874	8,000
Malaysia	286	736	15,000
Australia	252	751	15,000
South Africa	247	790	23,000
Panama	218	926	9,000
Papua New Guinea	214	708	10,000
Vietnam	213	761	7,000
Costa Rica	205	850	11,000
Philippines	153	556	8,000
Madagascar	105	253	9,000

4.2 Conservation areas data

There are currently about 30,350 protected areas in the world covering more than 13.23 million square kilometers i.e. about 8.83% of the land on Earth (Green and Paine, 1997). Of these, 2,149 protected areas (2.5 million square kilometers) are known to have at least some marine element, of which 824 are island-protected areas. A comprehensive list of

these protected areas can be found in "the 1997 United Nations List of National Parks and Protected Areas" (IUCN, 1998).

The UN list provides information on the protected areas of the world which are greater than 1,000 ha. and falling under one of the IUCN categories. The IUCN classification designed for cross-country comparisons omits some significant sites such as areas less than 1,000 ha., hunting reserves, and areas managed by private organizations. The World Conservation Monitoring Centre (WCMC) maintains a larger database of protected areas that includes forestry reserves, private nature reserves and other protected areas and indigenous reserves in addition to IUCN defined protected areas. Both UN list and protected areas database can be accessed through the WCMC database at www.wcmc.org.

The Man and Biosphere program (MAB) is guided by the MAB International Co-coordinating Council consisting of 34 Member States elected by the UNESCO General Conference. Programme activities are conducted in more than 100 countries under the direction of MAB National Committees or focal points. As of December 1999, there are about 357 MAB reserves worldwide. Biosphere reserves are alternative types of protected areas designed primarily for "in situ" conservation of natural and semi-natural areas, sustainable management of natural resources for local people, scientific research and monitoring, and environmental education and training. The MAB Programme is an interdisciplinary programme of research and training intended to develop the rational use and conservation of the resources of the biosphere, and to improve global relationship between people and the environment. A detailed list of the Man and Biosphere Reserves can be found at the UNESCO Biosphere Reserve Directory at http://www.unesco.org/mab/bios1-2.htm. UNESCO also operates a COastal and MARine programme (COMAR) for marine environment.

There are about 1,011 Ramsar wetlands covering an area of over 71.8 million hectares. These areas as designated following The Convention on Wetlands, signed in Ramsar, Iran, in 1971. The Convention's mission is "the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world". Detailed information on the Ramsar sites can be found at www.ramsar.org.

Currently, there are about 582 "World Heritage Sites" of which 445 are cultural, 117 are natural, and 20 are of mixed types. These areas are classified as "outstanding universal value" with the principal aim of fostering international cooperation in safeguarding these important sites. World Heritage lists are established following the convention concerning the protection of the world cultural and natural heritage in Paris in 1972. Detailed information of these sites are available at UNESCO's official website www.unesco.org/whc/heritage.htm.

4.3 Species data

Species information is considered as the basic unit of documenting and describing biological diversity. This is supported by sound theoretical as well as operational reasons (Stanton and Lattin, 1989). Microbiologists, however, are in disagreement with this approach who highlighted the importance of having a different approach in defining

biodiversity. Serious attempts are in place to use alternative basis for measuring biological diversity.

It is extremely difficult to inventory all the species on Earth. This is the reason why the exact number of species on Earth is unknown. A conservative estimate ranges from 3 to 100 million species. For practical purposes, a total of 12.5 million species has been estimated as the known species. Out of this, only 1.7 million species have been described. (see Table 4). This figure suggests that only 13% of species on Earth have yet been described. Furthermore, comprehensive catalogues of all 1.7 million species are not available and are poorly known in biological terms.

Table 4. Known and estimated total number of species on Earth (WCMC, 1992).

Groups	**Known number of species**	**Estimated total number of species**	**% known species**
Insects	950,000	8,000,000	11.9
Fungi	70,000	1,000,000	7.0
Arachnids	75,000	750,000	10.0
Nematodes	15,000	500,000	3.0
Viruses	5,000	500,000	1.0
Bacteria	4,000	400,000	1.0
Plants	250,000	300,000	83.3
Protozoans	40,000	200,000	10.0
Algae	40,000	200,000	10.0
Molluscs	70,000	200,000	35.0
Crustaceans	40,000	150,000	26.7
Vertebrates	45,000	50,000	90.0
World Total	**1,700,000**	**12,500,000**	**13.6**

The available information, in some cases, is inaccurate and biased. Inaccurate because it contains errors of taxonomic judgment and biased because a detailed and relatively accurate information is available only for some groups. As shown in the Table 4, description of species has dominated by the world of animals and plants, frequently ignoring fungi and micro-organisms. Viruses, bacteria, fungi, insects, algae and nematodes are among the least described species (Table 5.).

Table 5. Approximate number of described species, number of estimated species and working figure (in thousands) of least described species group (UNEP, 1995)

Species	**Described species**	**Number of estimated species**		**Working figure**
		low	**high**	
Viruses	4	50	1,000	400
Bacteria	4	50	3,000	1,000
Fungi	72	200	2,700	1,500
Algae	40	150	1,000	400
Plants	270	300	500	320
Nematodes	25	100	1,000	400
Insects	950	2,000	100,000	8,000
Total	**1,362**	**2,850**	**109,200**	**12,020**

Continental distribution of these described species (global total) shows that Africa, Asia and the Pacific, and Latin America has the highest biodiversity. Moist tropical forests cover approximately 8% of the world's land surface but holds more than 90% of the world's species.

The information on species richness would consist of a complete catalogue of all the species occurring in the country or area under consideration. In practice, this is extremely difficult to achieve. Species composition changes through time and majority of the species are very small and are difficult to identify and count *in situ.* Moreover, collecting and counting all micro-organisms even for a small area is extremely difficult. For this reason, country species diversity data are predominantly available for mammals, birds, reptiles, amphibians, freshwater fishes, flowering plants, conifers and cycads, ferns and higher plants. In practice, overall species counts tend to be used for terrestrial vertebrates (mammals, birds, reptiles, amphibians), for some group of fishes and for few well-known invertebrate groups such as butterflies and dragonflies. Under such circumstances, information on endemism, which refers to a species confined entirely to that area or country, is important in relation to its importance in a wider context

Out of 250,000 flowering plant species, around 200 have been domesticated as food plants of which 25-30 are a crop of major world importance, judged largely by global production and economic criteria. FAO 1984 data suggest that there are more than 100 species that are significant at the national level. However, this database does not cover crops from home-gardens and data from many countries are missing.

A list of data and information on species available from various sources are presented in the Table 6.

Table 6. A List of available data and information on Species

1.	Known numbers of invasive and native species in various countries/areas
2.	The percentage of threatened terrestrial vertebrate species affected by introductions in the continental landmasses of the different biogeographic realms and on the worlds islands.
3.	Countries species diversity (mammals, birds, reptiles, amphibians, freshwater fishes, flowering plants, conifers and cycads, ferns and higher plants) including total species, endemic species, and breeding species
4.	IUCN red list of Threatened species including endangered, vulnerable, rare, indeterminate and insufficiently known for mammals, birds, reptiles, amphibians, fishes, invertibates and plants
5.	The numbers of new species of organisms described as new to science in 1992 compared with the number of authors involved and the number of known and estimated species
6.	National red data books
7.	Major food crops with family/species, production, origin of species, major germplasm collections, no. of species in genus, species status, distribution of genus, other species in genus used and conservation notes
8.	Domestic livestock
9.	Approximate number of described species currently recognized together with number of estimated species (low and high) and working figure with accuracy
10.	The number of species of flowering plants recorded in floras of areas of different sized from all parts of the world.
11.	Number of recorded species extinctions since 1600
12.	Estimates of the number of described species and possible undescribed species of microorganisms
13.	Major groups of organisms: described species as proportions of the global total
14.	Major groups of organisms: possibly-existing species as proportions of the global total
15.	Regions of high bryophyte diversity
16.	Selected orders and families of mosses
17.	Selected orders and families of liverworts (including hornworts)
18.	Lichen diversity by specific region
19.	Orders and families of larger green algae
20.	Orders and families of brown algae
21.	Orders and families of red algae
22.	Diversity of marine algal (Seaweed) floras
23.	Stonewort diversity
24.	Distribution of higher plants by continents
25.	Species richness and endemism: higher plants (flowering plants, gymnosperms, ferns, number of endemics, %endemism)

CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, maintains a data base of the most endangered species (Appendix I) and other species at risk (Appendix II and Appendix III). Appendix I include all species threatened with extinction, which are or may be affected by trade. Appendix II includes all species that are not necessarily threatened with extinction but may become extinct in the future and other species, which are similar to these species. Appendix III includes all species that any party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation. The following table provides an update of number of species on the CITES Appendices

Table 7. Number of Species on the CITES Appendices

	Appendix I			**Appendix II**			**Appendix III**		
	Species	Sub species	Populns	Species	Sub species	Populns	Species	Sub species	Populns
Mammals	219	21	14	364	54	14	56	11	-
Birds	145	13	2	1263	32	1	149	-	-
Reptiles	62	4	5	383	10	3	19	-	-
Amphibians									
Fish	8	-	-	68	-	-	-	-	-
Invertebrates	64	5	-	2006	1	-	-	-	-
Plants (estimate)	310	3	1	24881	3	1	5	-	1
Total	**821**	**47**	**22**	**28993**	**100**	**18**	**229**	**11**	**1**

A number of international initiatives are in place to describe and document species at the global level. The WCMC provides information on globally threatened animals and plants, including searchable databases of the IUCN Red Lists. The IUCN Red List of Threatened Plants and Animals provides taxonomic, conservation status and distribution information on species that have been evaluated using the IUCN Red List categories. In general, the Red List of Threatened Plants and Animals provide information on the relative threat and risk of overall extinction. The rate of decline and population status are considered for categorizing species as "Critically Endangered", "Endangered", or "Vulnerable". The 1996 Red List also includes information on species that are categorized as "Extinct", "Extinct in the Wild", "Lower Risk", and "insufficient data". Insufficient data is for the species that cannot be assessed or information on the species in not available. Data and information on birds are available from Birdlife International. The National Red Data Books, on the other hand, provide information on the national flora and fauna that are subjected to highest risk of extinction.

The 1996 IUCN Red List of Threatened Animals includes 7,123 threatened species including Extinct, Extinct in the Wild, Critically Endangered, Endangered, Lower Risk and Data Deficient. Out of the total, 639 species are believed to be either Extinct (E) or Extinct in the Wild (EW). Similarly, 5,205 species are classified as Endangered (EN), or Vulnerable (VU) or at Lower Risk (LR). In addition, 1279 species are classified as Data Deficient (DD). Vulnerable species are further subdivided into conservation dependent (134 species), near threatened (1997 species), and least concern (973 species).

The 1997 IUCN Red List of Threatened Plants include 33,798 species that includes Extinct (Ex), Extinct/Endangered (Ex/E), Endangered (E), Vulnerable (V), Rare (R), and Intermediate. The 1997 IUCN Red Lists of Threatened Plants and Threatened Animals are presented in Fig. 2 and Fig. 3, respectively.

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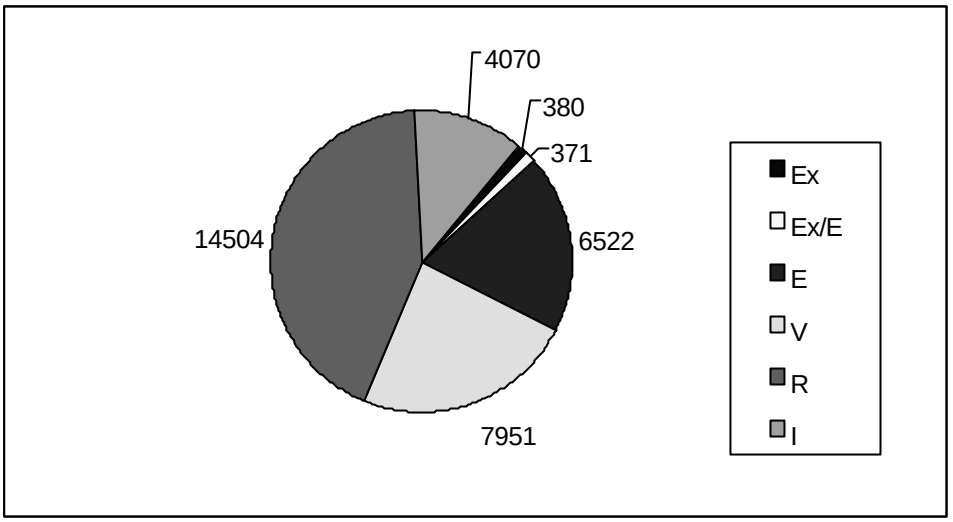

Fig. 2. The 1997 IUCN Red List of Threatened Plants (UNEP, 1999)

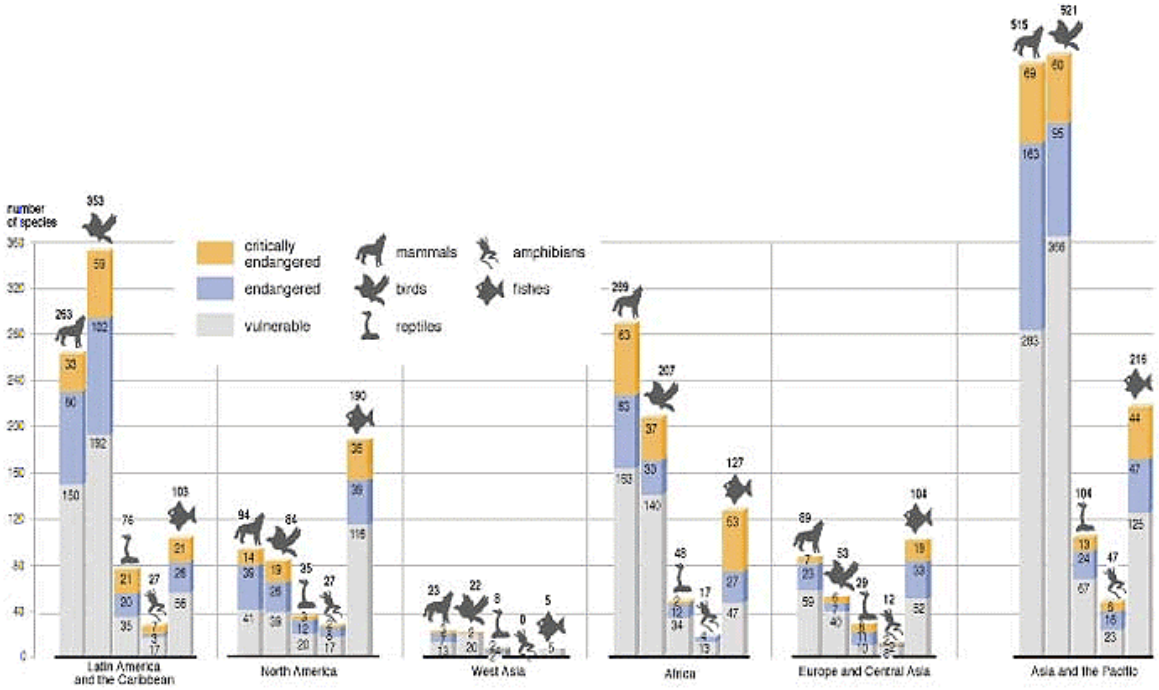

Fig. 3 IUCN Red List of Threatened Animals by Continents (UNEP, 1999)

In 1994, WCMC, in collaboration with IUCN, UNEP, and WWF, published a biodiversity data source book, available in both tabular and map format, providing information on country species diversity, threatened species by country, national red data books, major food crops by country, marine resources, forest in the tropics, and national protected areas and systematics collections.

SPECIES 2000 initiative of the International Organization of Plant Information (IOPI) provides an index of the world's known species. The project aims to provide a uniform and validated quality index of names of all known species for use as a practical tool. This is an electronic database of species list, which provides a database of species index and special annual checklist available through electronic media (i.e. internet and CD). SPECIES 2000 can be accessed in www.species2000.org

CAB International is well known for providing abstracts of internationally published scientific research literature. Plant sciences program of CAB International covers information on all "plant species of economic importance". A detailed list of species can be found in the "list of proposed species for Global Module of Forestry Compendium". The information can be accessed from www.cabi.org.

The World Species List (WSL), Plants, Animals and Microbes, established in 1994, also maintains data on species including animals, plants, microbes and endangered species that can be accessed from http://envirolink.org/species/.

4.4 Genetic Data

Data and information on genetic diversity are available at three levels:

- Genetic variability between individuals within population;
- Genetic variations among populations within species; and
- Diversity among species.

Genetic resources data are basically a repository of samples of living materials of animals, plants, fungi, or micro-organisms, generally in a dormant or other phase in which they are not actively growing (Hawksworth, 1995). Genetic resources information are collected mainly to ensure the conservation of genetic diversity in the future, the main purpose of which is to use it for breeding purposes. The collection can also be used as a source material for its characterization and evaluation. Thus, it is extremely important to conserve adequate stocks followed by regular monitoring and updating.

The collections might include stores of gametes, pollen, seeds, spores, tissue cultures and embryos (Hawksworth, 1995). The storage can be maintained in long-term storage facilities as well as in field gene banks. Materials that are not possible to maintain in the dormant form can be maintained in field gene banks, as in the case of some cultivated crops (IPGRI, 1993).

The following table provides information on the types of genetic resources collection.

Table 8. Types of genetic resources collection

Plant genetic resource collections	**Animal genetic resource collections**	**Microbial genetic resource collections**
- Seed samples - Spore samples - Pollen samples - Field gene banks - Embryos - Tissues - Cell suspensions etc.	- Embryos and semen under cryogenic storage - Groups of living animals kept under supervision in an exclusive area - Networks of breeding groups	- Cultures of algae, bacteria, fungi - Protozoa and viruses as well as materials derived from them in the form of cDNA, plasmids, vectors, cell lines etc.

The conservation of genetic resources can be managed *in situ* or *ex situ. In situ* conservation is maintained in their original habitat and reproducing within the environment in which they evolved and continue to do so. *Ex situ* conservation is maintained outside their habitats, stored in a reproductively dormant condition.

Worldwide over 150 major crop gene banks are held by international, regional, and national institutions, both public and private (Hawksworth, 1995). International Agricultural Research Centres (IARCs) by the Consultative Group on International Agricultural Research (CGIAR) concentrate on land races and cultivars of particular crops and their wild relatives while the storage of seed and other propagules of wild plants is the primary focus of most botanic garden gene banks.

Collectively, CGIAR centers hold the largest *ex situ* collection in the world with some 510,000 accessions (about 10% of the total holdings), but this is believed to correspond to approximately 35% of all accessions held in *ex situ* collections (FAO, 1994). Regional gene banks include the Nordic Gene Bank and the Southern African Development Community (SADC) Gene Bank. Few examples of national gene banks include the National Bureau of Plant Genetic Resources (India), the plant Genetic Resources Centre (Ethiopia), the M.I. Vavilov Institute of Plant Industry (Russia), and the United States Plant Germ Plasm System (Plucknett et al. 1987). A sizable number of botanic gardens and arboreta are also serving as a seed bank. There are about 528 botanic gardens and arboreta having a seed bank (Hawksworth, 1995).

What is the minimum requirements of genetic variation in wild species that need to be stored for the future is a question that has not yet been answered. However, there is a general agreement on the fact that the current system of germplasm collections (mainly seed banks) does not provide an adequate representation of the world's flora. Some species is well represented while others are not. For example, less than 1% of the world's plant species comprise more than 60% of the accessions (Halloy, 1990). Similarly, there are 333,413 accessions of rice (*Oryza sativa*) alone (WCMC, 1992). In contrary to this, the existing gene banks contain a mere 0.5% of the species actually used by humans.

The genetic resources collections of animal husbandry are poorly represented. For example, there are only a few genetic resouce collections of local wild populations of salmon (*Salmo salar*) from different rivers in Norway and Iceland (Gausen, 1993). In several countries one or more of the indigenous breeds of livestock are represented in genetic resource collections, organized in ways, which reflect the livestock traditions of that country, without having collections from other countries (Hawksworth, 1995).

Efforts are being placed to store microbial collections that are important for both biosystematics and human utilization. The World Data Center for Microorganisms (WDCM) holds a database of 786,328 microorganism strains held by 482 collections from 58 countries of which 44% are fungi including yeasts, 43% bacteria, 2% viruses, 1% live cells and 10% others i.e. plasmids, plant cells, and algae (Sugawara et al. 1993). Further 35% of all strains are held by only ten collections (Hawksworth, 1995).

The World Federation of Culture Collections (WFCC) coordinates the activities of culture collections at the global level. There are other organizations at regional and international levels, such as the European Culture Collection Organization (ECCO), Microbial Strain

Data Network (MSDN), and the Microbian Resource Centers (MIRCENs) of UNESCO, actively involved in culture collections. International Plant Genetic Resources Institute (IPGRI) is also involving in setting priorities for research and inventory and furthering development of a network of national and regional centers for plant germplasm conservation.

4.5 Biological reference collections

Biological reference collections comprise of permanently preserved specimens, recording and photographs maintained in museums, universities, botanic gardens, zoological and similar institutions or by individual scientists. Such collections are the major tools necessary for basic investigation and assessment of biodiversity. Duckworth et al. (1993) estimate that there are some 2.5 billion specimens in preserved biological reference collections, out of which around 2 million museum specimen records are now available in the Internet (Mille, 1993).

There are almost 1,600 botanic gardens and arboreta worldwide and majority of the gardens are located either in Europe or in North America (Hawksworth, 1995). A total of 431 botanic gardens are found in North America alone. This clearly indicates that the distribution and dimensions of biological reference collections is skewed towards developed countries in temperate regions. Nevertheless, significant holdings are being built up in less developed regions; for example, the natural history museum of Zimbabwe holds 5.3 million specimens representing at least 58,000 different species (Cotterill et al. 1993).

The total number of accessions of taxa held in botanic gardens is over 3.2 million consisting of 80,000 species (WWF and IUCN). This represents about 30% of the known species of flowering plants and ferns and 25% of those estimated in the world. The global database maintained by Botanic Gardens Conservation International (BGCI) has already documented holdings of 250,000 accessions and includes records from over 350 institutions, representing about 30,000 species (Leadley et al. 1993).

Data held by BGCI indicate that the floras of many major tropical and sub-tropical continental countries, such as Brazil, Colombia, Indonesia, and Zaire as well as others especially in Africa and South America are poorly represented in botanic garden collections. The floras of North America, temperate South America, and Asia, Australia and New Zealand and South Africa are well represented. Also well represented are the endemic floras of many oceanic island groups, especially Macronesia, the Mascarene Islands and Hawaii.

Usually, exotic species are given priority in many botanic gardens for aesthetic purposes. A recent trend, however, is to focus on and give priority to the cultivation of indigenous species particularly those that are threatened or endangered. This novel initiative, appreciated by many, will add significantly to the scientific as well as conservation value to the endemic species recourses.

5. Major International Conventions

The following sub-sections provides brief descriptions on the major international conventions.

CBD: Convention on Biological Diversity:

The Convention on Biological Diversity's objectives are "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." The Convention is thus the first global comprehensive agreement to address all aspects of biological diversity: genetic resources, species, and ecosystems. It recognizes - for the first time - that the conservation of biological diversity is "a common concern of humankind" and an integral part of the development process. To achieve its objectives, the Convention - in accordance with the spirit of the Rio Declaration on Environment and Development - promotes a renewed partnership among countries. Its provisions on scientific and technical cooperation, access to genetic resources, and the transfer of environmentally sound technologies form the foundations of this partnership. As of January, 2000, 176 countries have ratified the convention.

CMS: Convention on Migratory Species

The Convention on Migratory Species (CMS) aims to protect those species of wild animals that migrate across or outside national boundaries. This includes conservation of terrestrial, marine and avian species over the whole of their migratory range. The convention was concluded in 1979 and came into force on 1 November 1983. As of December 1999, 68 states have ratified the convention.

CITES: The Convention on International Trade in Endangered Species of Wild Fauna and Flora

CITES, is an international treaty drawn up in 1973 to protect wildlife against over-exploitation and to prevent international trade from threatening species with extinction. The treaty entered into force on 1 July 1975 and now has a membership of 146 countries.

Ramsar Convention: Convention on Wetlands of International Importance

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 117 Contracting Parties to the Convention.

The World Heritage Convention

The Convention Concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention) was adopted by the General Conference of UNESCO in 1972. As of October 1999, more than 158 countries have signed the convention. This is one of the most universal international legal instruments for the protection of the cultural and natural heritage.

6. International Efforts

The following are the discussion on the major initiatives of generating and maintaining biodiversity data and information at the global level.

BIONET

BONET (Biodiversity Action Network) was established in 1993. BIONET aims "to help build international agreement among governments on concrete actions and targets needed to achieve the objectives of the CBD, with a special focus on forests and marine/coastal systems and to help catalyze specific national-level action to implement the CBD". Its mission is to advocate the effective implementation of the Biodiversity Convention worldwide, primarily through coordinated, joint NGO programs and information dissemination designed to catalyze governmental action. For additional information please refer to Appendix-1.

DIVERSITAS

Diversitas programme of IUBS (International Union of Biological Sciences), SCOPE (the Scientific Committee on Problems of the Environment) of the International Council of Scientific Unions (ICSU) and UNESCO was initiated in 1992. DIVERSITAS attempts "to inventorying and monitoring of biodiversity at the global level". It has 3 main themes: (i) inventorying and monitoring of overall biodiversity at all levels from genes to ecosystems incorporating both marine and terrestrial ecosystem, (ii) identify scientific issues and promote research requiring international coordination on the ecosystem function of biodiversity, the origins, maintenance and the practical consequences of current changes on the natural and managed ecosystems that support mankind, and (iii) develop prioritized agendas for research. For additional information please refer to Appendix-1.

CENPLANK The Centre for Plankton Collection, Sorting and Identification (CENPLANK) of Szczecin and Gynia, Poland, is an international project, the objective of which is to focus on long-term changes in the status of coastal marine ecosystems using plankton as a means of inventorying and understanding variability in the species biodiversity and abundance levels of ichthyplankton (fish, egg and larvae) and zooplankton components of large marine ecosystems. For additional information please refer to Appendix-1.

FISHBASE

The FISHBASE project developed by ICLARM and FAO is a database of fishes that provides information on nomenclature, distribution, ecology, reproduction, growth and mortality. For additional information please refer to Appendix-1.

FOREST RESOURCES ASSESSMENT (FRA): FRA-2000 of Food and Agricultural Organization of the United Nations aims to perform a global analysis of the distribution of forest ecosystem. Forest resources assessment and deforestation data are available for 1980 and 1990 in a country by country basis. For additional information please refer to Appendix-1.

GBIF:

The Global Biodiversity Information Facility (GBIF) was proposed by the OECD Megascience Forum working group on biological informatics subgroups for biodiversity informatics. The broad goal of the GBIF is to provide the most up-to-date and thorough biodiversity information in timely manner to policy- and decision makers, science and society, in all countries. For additional information please refer to Appendix-1.

GOOS

Global Ocean Observing System (GOOS) was set up by UNESCO's International Oceanographic Commission. It is a permanent international system for gathering, processing and analyzing oceanographic observation from the open ocean and from coastal and shelf seas. For additional information please refer to Appendix-1.

GTOS

The Global Terrestrial Observing System (GTOS) is a joint initiative by the FAO, WMO, UNEP, UNESCO and the International Council of Scientific Unions (ICSU). GTOS aims "to provide scientific coordinated, permanent, observational framework with adequate spatial coverage and temporal continuity to produce data to enable to detect, quantify, locate and understand changes in the capacity of terrestrial ecosystems to support sustainable development". For additional information please refer to Appendix-1.

ICTVdB

The database of ICTVdB (International Committee on Taxonomy of Viruses DataBase) is an Index of Virum authorized by ICTV and has been constructed by Cornelia Büchen-Osmond, Bioinformatics Group, Australian National University. The index provides a list of approved virus names linked to virus descriptions coded from information in Virus Taxonomy and includes updates subsequently approved by ICTV. For additional information please refer to Appendix-1.

IOPI and Species 2000

The International Organization for Plant Information (IOPI) aims "to produce a checklist of the world's vascular plant species through a coordinated effort involving numerous specialists and institutions". IUBS in their 25th General Assembly in 1994 introduced SPECIES 2000 program the goal of which is "to provide a uniform and validated quality index of names of all known species for use as a practical tool". The index will be used to provide (i) an electronic baseline species list for use in inventorying projects worldwide; (ii) the index for an Internet gateway to species databases worldwide; (iii) a reference system for comparison between inventories; and (iv) a comprehensive worldwide catalogue for checking the status, classification and naming of species. For additional information please refer to Appendix-1.

ISIS

The International Species Inventory System (ISIS) is a global network designed to (i) help the management of zoological collection; and (ii) enable zoos to meet their increasing conservation responsibilities. The ISIS maintains a centralized computer database of census, demographic, genealogical and laboratory data for wild species held in captivity. For additional information please refer to Appendix-1.

LME

The Large Marine Ecosystem program **(LME)** aims to monitor Large Marine Ecosystem consisting of fish, plankton, marine mammals and birds by coastal nations. The principal focus of which, however, is on fish. For additional information please refer to Appendix-1.

MICRENS

MIRCEN (Microbial Resources Centres) program of UNESCO is a network of existing academic and/or research institutes in developed and developing countries. These centres, in co-operation with the concerned National Commissions of Member States and governmental authorities, participate in a global collaborative network effort to:

- provide a global infrastructure which would incorporate national, regional, and inter-regional co-operating laboratories geared to the management, distribution, and utilization of the microbial gene pools;
- reinforce the conservation of microorganisms, with emphasis on rhizobium gene pools, in developing countries, with an agrarian base;
- foster the development of new inexpensive technologies native to specific regions;
- promote the economic and environmental applications of microbiology; and
- serve as focal centres in the network for the training of manpower.

For additional information please refer to Appendix-1.

Systematics Agenda 2000 International

SA 2000 is a proposal of discovery and research proposed by a Consortium of three international societies of systematic biologists: the American Society of Plant Taxonomists, the Society of Systematic Biologiest and the Willi Hennig Society in cooperation with the Association for Systematic Collection.The Systematics Agenda 2000 International aims “to promote systematic/taxonomic research in all countries and regions in order to support ongoing activities to conserve and sustainably use their biodiversity”. The main activities will be to develop international programs of systematic inventorying, phylogenetic research, the creation of systematic knowledge bases, and the promotion of systematic infrastructure and training. For additional information please refer to Appendix-1.

Trichoptera World Checklist

The checklist is maintained by the Trichoptera Checklist Coordinating Committee and the searchable database is hosted by Clemson University of USA. For additional information please refer to Appendix-1.

Besides above, the following initiatives are also worth mentioning.

- Bin-21: Biodiversity Information Network;
- Biome Summaries maintained by SI/MAB program of Smithsonian Institution;
- Forestry compendium published by CAB International;
- ETI: Expert center for Taxonomic Identification, University of Amsterdem is a database describing all existing animals and plants of the world in digital form;
- The World Heritage List from UNESCO;
- Frontier forests of the world by WRI;
- Biodiversity "Hot Spots" by Conservation International; and
- Protected areas database, 1997 UN list of protected areas, conservation database of species, forest, marine and national biodiversity profiles, the world list of threatened trees, The 1996 IUCN red list of threatened animals and threatened plans of the world, world distribution of coral reefs and mangroves maintained by WCMC.

7. Selected Global Biodiversity information centres.

The following is a list of selected global biodiversity information centres. This is not a comprehensive list but provides information on the major initiatives.

1) BirdLife International
2) Botanic Gardens Conservation International
3) Conservation Inernational
4) CAB International
5) Consultative Group on International Agricultural Research
6) Clearing house mechanism of the Convention on Biological Diversity
7) European Environment Agency
8) Food and Agriculture Organization of the United Nations
9) International Council of Scientific Unions
10) International Centre for Living Aquatic Resources Management
11) International Institute for Applied Systems Analysis
12) International Plant Genetic Resources Institute
13) International Species Information System
14) IUCN - The World Conservation Union
15) National Oceanic and Atmospheric Administration
16) The Nature Conservancy
17) TRAFFIC International
18) UNEP Global Resource Information Database
19) UNEP International Environmental Information System
20) United Nations Educational, Scientific and Cultural Organization
21) United Nations Statistical Division: UNSTAT
22) United States Geological Survey
23) Wetland International
24) World Conservation Monitoring Centre

For detailed information please refer to Appendix-1.

8. Resources on the Web

Increasingly more and more global biodiversity data and information are available on the web. Appendix-1 presents a list of biodiversity resources on the web.

9. Present Direction

Considering the enormous amount and varieties of biodiversity data and information, it is difficult to generalize the present direction of these datasets, however, the general trend is that majority of the data are increasingly available in digital form. The recent trend is that many of these datasets are being collected, maintained and/or distributed using Internet. User friendly Internet mapping techniques are emerging in which a user could prepare and print a map based on his or her criteria. A sizeable number of biodiversity data are also available in CDs.

The available datasets are biased i.e. detailed datasets are available for few parameters while a limited amount of data are available for others. However, core data sets are improving, expanding and becoming more easily available. More encouragingly, a number of INGO's such as WWF, IUCN, Conservation International, and Wetland International are actively contributing to the generation and maintenance of global biodiversity data and information.

10. Problems/Obstacles

Problems and obstacles of the availability and accessibility of global biodiversity data are vast and varied. This is primarily because biodiversity data comes from different disciplines and the data volume is extremely large. Moreover, biodiversity data are represented by terrestrial, marine and freshwater ecosystems ranging from ecosystem to genetic levels, thus making it difficult to compile and distribute all the data globally.

It is hard to generalize problems and obstacles of biodiversity data and information but a common pattern observed is that the barriers to the availability and accessibility of these products are of the social characteristics rather than technical. For example, many organizations and individuals generating these datasets are reluctant to share available data and information in the fear of loosing their importance in the future. They also feel ownership of the data and reluctant to share with others.

A common bias has been observed in collecting and maintaining biodiversity data and information at the global level. Less data are available on utilization aspects of biodiversity conservation compared to conservation. Similarly, more detailed data sets are available for some species as opposed to very limited amount of data for others.

Problems and obstacles of biodiversity data and information can be summarized into the following two broad categories.

1. Technical

- Lack of capabilities: Users are unable to use the data;
- Some of the available data are outdated. In some cases we are working with 70's and 80's data in the absence of regular monitoring mechanism.
- Species data/information is inaccurate and in many cases contradictory primarily because it is extremely difficult to inventory all species on Earth;
- The availability of coarse resolution digital data with a spatial resolution of 1 KM to 16 KMs. These data sets have little meaning at the implementation level;
- Lack of basic biological knowledge on species and their variability;
- Poor understanding of genetics and population biology of the taxa in question;
- Lack of appropriate techniques for long-term preservation of specimens and genetic resources;
- Methodology/software not fully developed to collect and manage large volume of biodiversity data;
- Although collections of some of the world's major crops are extensive and relatively secure, the situation for many other crop and tree gene pools is far less satisfactory;
- Biodiversity sample surveys and validation are difficult to implement internationally;
- Unknown data quality: very little information is available about data quality;
- Data conversion is a problem because of the incompatible data format;
- Lack of data consistency including both spatial and temporal; and
- Quality control of the data available on the Internet is an issue needs closer attention. Many organizations and scientists are not willing to placed their primary data and information on the web.

2. **Management**

- Lack of knowledge of existence: available datasets are not known to the user communities;
- Lack of willingness to share: the importance of data and information is not fully realized;
- Information does not meet user requirements because of incorrect format, inadequate documentation, poor quality data, not scientifically credible etc.;
- Data acquisition is being carried out independent of the interest of end users;
- Not enough feedback and validation during the process of data collection among data collectors, collators, disseminators and users;
- High cost involved in data collection, constant update, and regular monitoring;
- Inadequate resources available to discover, describe and catalogue the species of organisms found on Earth;
- Lack of secure funding and funding mechanism especially in the long term;
- Shortage of trained people to collect and classify specimens data;
- Poor social and political awareness on the use of global biodiversity data; and
- Poor awareness of the strategic and long-term value of genetic resource collections among policy makes researchers and potential users.

Poor accessibility of global biodiversity data and information has been cited as one of the major problem for the use of the data for decision-making. The accessibility is hindered by numerous factors, including the following:

- The cost associated with the data;
- Restricted access;
- Lack of knowledge of existence;
- Lack of integration; and
- The poor channels of communication.

11. Recommendations for Future directions

The following are the set of recommendations for future directions.

1. Data generation is a long-term process that calls for constant commitment from the concerned agencies and individuals. At this point, it is necessary to assess biodiversity data and information already available within existing collections and identification and prioritization of missing or under represented species, geographic regions and environments;
2. Development of a framework and guidelines for future global biodiversity database development is necessary to improve the quality and usefulness of the data;
3. Greater efforts are necessary to generate new global biodiversity datasets, maintain the existing ones, distribute the available data dynamically and use the data appropriately;
4. It is very important to ensure that the resulting information is useful and used by their target audiences. Target audiences might include policy and decision makers, science and society across the globe. One of the basic requirements to achieve this is to improve communication between data producers and users.
5. Concerted effort is essential towards the development and use of technological, sociological, organizational tools and approaches for the dynamic acquisition, indexing, modeling, dissemination, storage, querying, retrieval, visualization, integration, analysis, synthesis, sharing, and publication of global biodiversity data and information.
6. Partnership and collaboration is necessary to maximize benefits. To achieve this, distributed data collection approach should be adopted, wherever possible;
7. Availability of higher resolution (better resolution) data is needed in many cases. This could be facilitated by the use of satellite data such as Landsat TM, SPOT, IRS WIFS, and MODIS;
8. Multi-scale approach of data generation should be adopted so as to collect 1:1 million data at the global level, 1:500K to1:250K at the regional level; 1:250K to 1:100K at the sub-regional level, 1:50K at the national level and 1:10K to 1:5K and better at the local level. Emphasis should be placed in generating data that are useful at the national level; and
9. Development of improved management methods for long-term secure conservation, including the maintenance of genetic integrity is necessary. The use of existing genetic collections as part of sustainable development is equally important.

Summary

An attempt has been made to review the availability and accessibility of global biodiversity data and information. Published reports and Internet resources were the major sources of information for the review. This is by no means a comprehensive review of all the available global biodiversity data and information.

The availability and accessibility of global biodiversity data and information have been described under five main categories, namely: global data, conservation area data, species data, genetic data and biological reference collections. Because biodiversity data and information are vast and varied, it is extremely difficult to generalize the findings. However, it was evident that majority of the data are increasingly available in digital form. The available datasets are biased i.e. detailed datasets are available for few parameters while a limited amount of data are available for others. Similarly, available datasets are concentrated in developed countries in the temperate regions. In general, core data sets are improving, expanding and becoming more easily available. More encouragingly, a number of INGO's such as WWF, IUCN, Conservation International, and Wetland International are actively contributing to the generation and maintenance of global biodiversity data and information.

Users of global biodiversity data include national institutions, regional groupings, international institutions, international funding agencies, bilateral development agencies, international environmental and conservation groups and scientific communities. The barriers to the availability and accessibility of global biodiversity data and information are of the social characteristics rather than technical. Problems and obstacles in collecting, maintaining and distributing biodiversity data and information have been listed. A set of recommendation to improve the present situation has been proposed.

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Appendix-1: List of Biodiversity Resources on the Web

Agenda 21	http://www.un.org/
Alice Software: for creating and managing biodiversity databases	http://dspace.dial.pipex.com/
Association of Systematics Collections	http://www.ascoll.org/
Australian National University Bioinformatics	http://life.anu.edu.au/
Biodiversity - World Resources Institute	http://www.wri.org/
Biodiversity Action Network (BIONET)	http://www.bionet-us.org
Biodiversity and Biological Collections WWW Server	http://biodiversity.uno.edu/
Biodiversity and Ecology Research	http://biodiversity.org/
Biodiversity Conservation Information System (BCIS)	http://biodiversity.org/
Biodiversity Information Network BIN21	http://www.csu.edu.au/
Biological Resources Research Center (BRRC)	http://www.brrc.unr.edu/
Biology Abstracts and Zoological Records (BIOSIS)	http://www.york.biosis.org/
BIOSIS; Publisher of Biological Abstracts & Zoological Record	http://www.biosis.org/
Centre for Conservation Biology Network (CCBN)	http://conbio.rice.edu/
CITES Secretariat	http://www.unep.ch/cites/
Clearing-House-Mechanism under the CBD	http://www.biodiv.org/
Commission on Sustainable Development (CSD)	http://www.un.org/
Conservation International	http://www.conservation.org/
Convention on Biological Diversity	http://www.biodiv.org/
Coral Health and Monitoring Program (NOAA)	http://www.coral.noaa.gov/
EcoDirectory (EcoDir)	http://www.rec.hu/
Ecological Monitoring and Assessment Network (EMAN)	http://www.cciw.ca/
EnviroLink's Endangered Species Act On-Line Resource Guide	http://www.envirolink.org/
ETI- Expert Center for Taxonomic Identification, Amsterdam	http://wwweti.eti.bio.uva.nl/
FAOSTAT Forestry Statistics Database at FAO	http://apps.fao.org/
Fish base	http://ibs.uel.ac.uk/
Food and Agriculture Organization FAO	http://www.fao.org/
GEF Global Environment Facility	http://www.worldbank.org/
Global Change Data and Information System (GCDIS)	http://www.usgcrp.gov/
Global Environmental Information Locator Service (GELOS)	http://ceo.gelos.org/
Global Land Cover Data for Biodiversity Analysis	http://www.conservation.org/
Global Observation of Forest Cover (GOFC)	http://lcluc.gecp.virginia.edu/
Global Terrestrial Observing System (GTOS)	http://www.fao.org/
GRID the Global Resource Information Database, UNEP	http://www.unep.org/
Integrated Conservation Networking System (ICONS)	http://www.iucn.org/
IUCN Red List of Threatened Animals	http://www.wcmc.org.uk/
IUCN--The World Conservation Union	http://www.iucn.org/
List of Bacterial Names with Standing in Nomenclature	http://www.sv.cict.fr/bacterio/
Mammal Species of the World : Smithsonian Institution	http://nmnhgoph.si.edu/
Man and Biosphere Species Database	http://ice.ucdavis.edu/
Man and the Biosphere	http://www.unesco.org/
MUSE Fish Databases	http://muse.bio.cornell.edu/
Natural History Museums and Collections (World wide)	http://cas.calacademy.org/
Overview to Natural Heritage Programs	http://www.heritage.tnc.org/
Species 2000	http://www.sp2000.org/
System- Wide Information Network for Genetic Resources	http://singer.cgiar.org/
Taxanomic Database Working Group	http://plants.usda.gov/
The Biodiversity Forum (BioForum)	http://www.worldcorp.com/
The Convention on Migratory Species	http://www.wcmc.org.uk/
The Interagency Taxonomic Information System (ITIS)	http://www.itis.usda.gov/
The International Society of Hymenopterists	http://iris.biosci.ohiostate.edu/
The International Willy Henning Society	http://www.vims.edu/
The Internet Biodiversity Service	http://ibs.uel.ac.uk/
The Missouri Botanical Garden	http://www.mobot.org/

The National Heritage Network	http://www.abi.org/
The Ramsar Convention on Wetlands (Ramsar)	http://www.ramsar.org/
The Virtual Library of Ecology and Biodiversity (VLEB)	http://conbio.rice.edu/
Mapping Global Forest Resources	http://www.whrc.org/
The World Bank (WB)	http://www.worldbank.org/
The World Species List (WSL)	http://www.envirolink.org/
TREE BASE: A Database of Phylogenetic Knowledge	http://www.herbaria.harvard.edu/
United Nations Environment Programme (UNEP)	http://www.unep.org/
United Nations List of National Parks and Protected Areas	http://www.wcmc.org.uk/
United State Global Change Research Program	http://www.usgcrp.gov/
Virus databases on-line	http://life.anu.edu.au/
WCMC Protected Areas Virtual Library (PAVL)	http://www.wcmc.org.uk/
Weeds of the World Project	http://ifs.plants.ox.ac.uk/
World Bank Monitoring Environmental Progress Database	http://www.ciesin.org/
World Conservation Monitoring Centre (WCMC)	http://www.wcmc.org.uk/
World Data Center on Microorganisms	http://wdcm.nig.ac.jp/
World Information and Early Warning System on Plant Genetic Resources (WIEWS)	http://apps.fao.org/
World Map: Measuring the Variety of Nature	http://www.nhm.ac.uk/
World Pollen Database	http://www.ngdc.noaa.gov:80/
World Resources Institute (WRI)	http://www.wri.org/
World Weeds Database	http://ifs.plants.ox.ac.uk/
World Wide Fund for Nature	http://www.panda.org/
World Wildlife Fund (WWF)	http://www.wwf.org/
Worldlife Society (WS)	http://www.us.net/wildlife