UNEP

CBD

CONVENTION ON BIOLOGICAL DIVERSITY

Distr.
GENERAL

UNEP/CBD/SBSTTA/8/8/Add.1
29 November 2002

ORIGINAL: ENGLISH

SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL AND TECHNOLOGICAL ADVICE
Eighth meeting
Montreal, 10-14 March 2003
Item 5.1 of the provisional agenda*

INLAND WATER ECOSYSTEMS: REVIEW, FURTHER ELABORATION AND REFINEMENT OF THE PROGRAMME OF WORK

Status and trends of, and threats to, inland water biological diversity

Note by the Executive Secretary

EXECUTIVE SUMMARY

In paragraph 8 (a) of the programme of work on inland water ecosystems (decision IV/4, annex I) the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) was requested to use existing information and draw upon relevant organizations and experts to develop, as part of its work plan, an improved picture of inland water biological diversity, its uses and its threats, around the world, and to highlight where the lack of information severely limits the quality of assessments.

To assist SBSTTA in implementing this task, the Executive Secretary commissioned the World Resources Institute (WRI) to prepare an assessment of the status and trends of inland water biodiversity. The report prepared by WRI will be published in the Technical Publication Series of the Convention. In addition, the Executive Secretary prepared a short version of the WRI report highlighting essentially the gaps in information that limits the quality of the assessment of the status of inland water biodiversity. In this context, the present note addresses the distribution and extent of inland water ecosystems, and presents a short review of inland water species, major pressures on them, and some conclusions on gaps in information.

The note indicates that, in general, the extent and distribution of inland water ecosystems are not properly documented at the global or regional scale and, in some cases, there is no comprehensive documentation even at the national levels. Several inventories have been published listing the major river systems with their drainage area, length and average runoff. The International Lake Environment Committee (ILEC) and the UNEP-World Conservation Monitoring Centre (WCMC) global map of

* UNEP/CBD/SBSTTA/8/1.

/…

For reasons of economy, this document is printed in a limited number. Delegates are kindly requested to bring their copies to meetings and not to request additional copies

wetlands, among others, maintain geographic descriptions, and/or physiographic, biological and socio-economic information on lakes. They do not provide comprehensive information on the distribution and extent of lakes at the global level. There are about 10,000 lakes with a size of over 1 km^2 worldwide. Location and distribution of *stricto sensu* wetlands, i.e., areas that are often transitional and can be seasonally or intermittently flooded, and other classes of inland waters, including categories such as underground water and human-made systems, are not well documented except in North America and western Europe. Information on the status and trend of water availability and quality is also generally lacking.

Major microbial groups present in inland waters include viruses, bacteria, fungi, protozoa and algae. Aquatic plants include angiosperms (flowering plants), pterophytes (pteridophytes, ferns), bryophytes (mosses, hornworts, and liverworts) and a few number of tree species that tolerate waterlogged soil. Information on invertebrate species diversity is fragmentary. With regard to vertebrates, most global and regional overviews of inland water biodiversity include more information on diversity of fishes than any other inland water group, including, *inter alia*, amphibians, reptiles, waterbirds and small mammals.

In general, information on species and genetic resources, important for conservation pursuant to Annex I of the Convention, is generally fragmentary and, in a number of countries and regions, lacking for some categories of inland water biodiversity, particularly for species and genes/genomes of socioeconomic, scientific and cultural value. This information needs to be improved to be more useful to policy and decision-makers. Microorganisms are rarely part of biodiversity status assessments, in spite the fact that their role in nutrient cycling, water purification and the food web is well known. Information on the conservation status of plants and animals was synthesized from Internet checklists of specific animal and plant families and existing databases, mainly those of threatened species such as, *inter alia*, the 2002 IUCN Red Lists of Threatened Species and previous IUCN Red Lists, the WCMC Threatened Plants Database and the BirdLife International Threatened Birds of the World. In every group of organisms considered, including aquatic plants and invertebrate and vertebrate animal species, examples of extinct, critically endangered, endangered, and vulnerable taxa were given as well as some of the main threats to these taxa.

Major threats to inland water ecosystems highlighted in the note include inter alia modification of river systems, water withdrawals for flood control or agriculture, introduction of invasive alien species, pollution, over-fishing and impact of climate change. These pressures occur all over the world. Their reported impacts vary from one watershed to another and are often considered to be underestimated.

In conclusion, it is noted that:

(a) Additional efforts and financial commitments are needed to improve national, regional and global data on components of inland water ecosystems, their availability, functioning and response to pressures and related socio economic information;

(b) Most data on water availability and use, including ground water, and such variables as river flow, water withdrawals, aquifer recharge rates are generally only available at the national level, which makes management of river basins, especially those that cross national borders, difficult;

(c) New initiatives will assist in filling the large information gap regarding inland water species, especially at lower taxonomic orders. They include, *inter alia*, the monitoring projects sponsored by the European Space Agency; the IUCN freshwater biodiversity assessment and species mapping programs; the work being done by BirdLife international on the location, distribution and population status of birds; the OECD Global Biodiversity Information Facility (GBIF); the *State of the World's*

Plant and Animal Genetic Resources for Food And Agriculture report of the Food and Agriculture Organization of the United Nations (FAO) and the Global Taxonomy Initiative (GTI) of the Convention on Biological Diversity. These initiatives could also assist in mapping seasonal wetlands and forested wetlands which are difficult to map;

(d) Most species inventories are organized by taxonomic group. It would be useful to also carry out inventories by ecosystem type to allow an assessment of the condition of inland water ecosystems;

(e) In order to obtain information of trends, baseline information will have to be gathered. Without population trends of species, it is hard to assess the effects of pressures or the risk of extinction of species. An agreement on outcome targets such as the ones defined in the Convention Strategic Plan and in the Global Strategy for Plant Conservation of the Convention would facilitate the development of monitoring mechanisms that could provide information on trends in inland water biodiversity;

(f) Because of the large impact that introduced species can have on inland water ecosystems, information on the location of introduced species as well as the presence or absence of invasive alien species is urgently needed.

SUGGESTED RECOMMENDATIONS

The suggested recommendations regarding the status and trends of, and threats to, inland water biodiversity are included in the consolidated suggested recommendations under item 5.1 as contained in the note by the Executive Secretary on elements for the further elaboration and refinement of the programme of work (UNEP/CBD/SBSTTA/8/8/Add.2).

CONTENTS

Page

I. INTRODUCTION

1. In paragraph 8 (a) of the programme of work on inland water ecosystems contained in Annex I to decision IV/4, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) was requested to use existing information and draw upon relevant organizations and experts to develop, as part of its work plan, an improved picture of inland water biological diversity, its uses and its threats, around the world. The output should identify areas where the lack of information severely limits the quality of assessments so that this can be considered in the further elaboration and refinement of the programme of work.

2. In paragraph 9 (e) (iv) of the same annex, the Conference of the Parties recommended that Parties undertake assessments in inland water ecosystems which may be regarded as important in accordance with the terms of Annex I of the Convention, and assessments of threatened species.

3. As background documents for the deliberations that led to the development of the programme of work and decision IV/4, the Executive Secretary prepared g notes on:

(a) Biological diversity of inland waters (UNEP/CBD/SBSTTA/3/2) in which paragraphs 6 to 11 describe the status and trends, including the value of inland water ecosystems in terms of goods and services, and the pressures impacted by human interventions;

(b) Identification and monitoring of components of biological diversity of inland water ecosystems: consideration of Article 7 and elaboration of terms in Annex 1 of the Convention (UNEP/CBD/SBSTTA/3/7), which describes components of inland water biological diversity important according to the terms of Annex I to the Convention;.

(c) Methodologies for the assessment of biological diversity in inland water ecosystems (UNEP/CBD/SBSTTA/3/8), which provides information on the principal components of freshwater biological diversity in paragraphs 6-19 and in tables 1 and 2, and describes the direct and underlying causes of biological loss;

(d) Status and trends of the biological diversity of inland water ecosystems and options for conservation and sustainable use (UNEP/CBD/COP/4/4), which describes the main characteristics and functions of inland water ecosystems, human interventions and the resulting threats to biological diversity. It also emphasizes the importance of the biological diversity of inland waters for the three objectives of the Convention.

4. To assist SBSTTA in implementing paragraph 8 (a) of the programme of work, the Executive Secretary commissioned the WRI to prepare an assessment of the status and trends of inland water biodiversity that would review recent literature and complement the information he has been able to gather in the documents referred to in paragraph 3 above. The report prepared by WRI will be published in the Technical Publication Series of the Convention. In addition, the Executive Secretary prepared a short version of the WRI report highlighting essentially the gaps in information that limits the quality of the assessment specifically of threatened species.

5. The present note first describes briefly the distribution and extent of inland water ecosystems (section II), then presents a short review of inland water species (section III) and major threats (section IV) and finally some conclusions on gaps in information.

II. DISTRIBUTION AND EXTENT OF INLAND WATER ECOSYSTEMS

6. Inland water ecosystems encompass habitats with a variety of physical and chemical characteristics, including bogs, marshes and swamps, which are traditionally grouped as inland wetlands, and inland seas, lakes, rivers, ponds, streams, groundwater, springs, cave waters, floodplains, backwaters, oxbow lakes, pitcher plants and even tree holes. In general the terms inland waters and freshwater are used interchangeably, however, some inland water ecosystems, such as saline lagoons, are not freshwater ecosystems at all. The extent and distribution of inland water ecosystems is not properly documented at the global or regional scale, and in some cases, even at the national levels.

7. With respect to the distribution of rivers, there are several published inventories, listing the major river systems with their drainage area, length, and average runoff. 1/ The most commonly used descriptive variable to classify rivers is the virgin mean annual discharge (VMAD), an estimate of the discharge "before any significant human manipulation" of the river system has taken place. 2/ Calculating drainage area requires defining watershed boundaries. The Eros Data Center from the United States Geological Survey has delineated basin boundaries at 1:1 million. This database, called HYDRO1k, is one of the most detailed global databases on river basins.

8. Information on the distribution and extent of lakes is deficient at the global level. There are about 10,000 lakes with a size of over 1 km^2 worldwide.3/ The International Lake Environment Committee (ILEC) maintains a database of over 500 lakes worldwide, with some physiographic, biological and socio-economic information. 4/ The major limitation of the ILEC database is that it is questionnaire-based and thus the information is largely descriptive, often incomplete, and is not regularly updated. In terms of geographic location and extent, the WCMC global map of wetlands, for example, includes several thousands records classified as lakes or salt pans, many of which have information on the name and a very brief description of the site. Lake and pond boundaries are mapped in the 1992 ESRI ArcWorld database.

9. The location and distribution of other classes of inland water ecosystems, in particular underground waters, human-made systems and wetlands—defined as habitats that represent a variety of shallow, vegetated systems such as bogs, marshes, swamps, floodplains, and coastal lagoons that are often transitional areas and can be seasonally or intermittently flooded—are not well documented at the global, regional, or even national levels. A 1999 review of wetland resources commissioned by the Convention on Wetlands of International Importance Especially As Waterfowl Habitat (Ramsar Convention) concluded that reliable global estimates of wetland extent could not be produced with currently available data, and that regional data for Oceania, Asia, Africa, Eastern Europe, and the Neotropics allow just a cursory assessment of wetland extent and location. Only North America and Western Europe have published robust estimates of wetland extent. 5/ In terms of mapped information, one of the best global geographic information system (GIS) databases of wetlands currently available is the WCMC Global Wetland Distribution. Wetland characterization and level of detail vary from region to region, with Africa being the most comprehensively mapped, while mapping of most of North America is much less accurate.

1/ Baumgartner and Reichel 1975; Shiklomanov 1997, and Gleick 1993 which compares several estimates.

2/ Dynesius and Nilsson 1994.

3/ Groombridge and Jenkins 2000.

4/ Kurata 1994; ILEC Web site 2002.

5/ Finlayson and Davidson 1999.

III. STATUS OF INLAND WATER SPECIES 6/

A. Microorganisms

10. Major microbial groups present in inland waters include viruses, bacteria, fungi, protozoa and algae. Their general functions are known but they are rarely part of biodiversity status assessment, although their role in nutrient cycling, water purification and the food web is important. 7/

B. Plants

11. Aquatic plants include angiosperms (flowering plants), pterophytes (pteridophytes, ferns), bryophytes (mosses, hornworts, and liverworts) and a few number of tree species that tolerate waterlogged soil. The conservation status of aquatic angiosperms has not been comprehensively assessed. The 1997 Red List of Threatened Plants 8/ listed 315 aquatic plant families as threatened. There are 10 bryophytes listed in the IUCN Red List 9/ as threatened. These include critically endangered species of tropical lowland riverine systems. Other groups of aquatic plants such as ferns and fungi have not been comprehensively assessed for status. However, an Internet-based global checklist of lichens 10/ and lichenicolous fungi is being compiled, including more than 120 checklists for Africa, South America, Australia and many countries of Asia, North and Central America. Compiled checklists of continental Africa and South America are scheduled to be available in 2002, with a scheduled completion of the global list in 2003. 11/

12. Aquatic plants include a number of species of socioeconomic and cultural value. Cultivated plants for food and agriculture are being inventoried through an initiative of the FAO. The next *State of the World's Plant Genetic Resources for Food and Agriculture* report will be published in 2007.

C. Animals

1. Invertebrates

13. Information on invertebrate species diversity is fragmentary. IUCN reports 191 freshwater species of insects as threatened with extinction 12/ The conservation status of aquatic insects has not been comprehensively assessed except for Odonata (dragonflies and damselflies) in some regions. The order Odonata has been widely considered as a biological indicator of environmental health. 13/ Comprehensive published global checklists of dragonflies exist. There are at least 14 families of Coleoptera that are either entirely or partially aquatic. 14/ World catalogues for some of the better known families in this order (i.e., the Hydraenidae family (moss beetles), the Hydrophilidae (water scavenger beetles) and the Dytiscidae (predaceous diving beetles)) were recently published 15/ However, the status of known species has not been comprehensively assessed. The 17 threatened aquatic beetles listed in the IUCN Red List are almost entirely Dytiscidae species in Europe. 16/ In general, although no major global

---

6/ This section adds to the information in Table 1 in UNEP/CBD/SBSTTA/3/8.

7/ See Table 1 in UNEP/CBD/SBSTTA/3/8.

8/ Walter and Gillette 1998.

9/ Hilton-Taylor 2000.

10/ http://www.biologie.uni-hamburg.de/checklists/world_l2.htm.

11/ Feuerer 2002.

12/ Hilton-Taylor 2000.

13/ Nixon *et al*. 2001; Sahlén and Ekestubbe 2001.

14/ Mandaville 1999.

15/ Hansen 1998 and 1999; Nilsson 2001 and 2002.

16/ Hilton-Taylor 2000.

extinction crisis of aquatic insects has been reported, many groups are threatened by a number of factors and some face local extinction. Habitat destruction due to impoundments is the greatest threat to rare aquatic insect, followed by water pollution and siltation resulting from loss of riparian vegetation and deforestation.

14. The available lists on inland water molluscs are not comprehensive for the world, although there are many lists and databases at national or regional levels. There are around 6,000 known species of gastropods and bivalves that live in inland water habitats. In terms of the distribution pattern of this group, UNEP-WCMC highlighted 27 known areas of special importance for inland water mollusc diversity worldwide. 17/ IUCN lists 340 freshwater species of gastropods as threatened with extinction—representing over 40 per cent of all known gastropods (including terrestrial groups). 18/ Ninety-six bivalves were also listed as threatened with most of them reported from North America. 19/ Snails that inhabit springs are the most threatened.

15. There are about 40,000 living crustacean species, of which 10,000 are estimated to occur in freshwater sediment, with 8,000 of these described to date. 20/ IUCN reports 428 freshwater crustacean species as threatened with extinction, including 73 Amphipoda, 28 Anostraca, 185 Decapoda, and 45 Isopoda. There are nine recorded species that have gone extinct. With the exception of the United States, no country or region has comprehensively assessed the status of known inland water crustaceans.

2. Vertebrates

16. Most global and regional overviews of inland water biodiversity include more information on diversity of fishes than any other inland water group. 21/ In general, the status of fish in Africa, Latin America and tropical Asia has not been comprehensively assessed. However, there are a well-studied cases, such as the disappearance of over 300 haplochromine cichlids in Lake Victoria. 22/ Much of fish fauna in tropical Asia still needs to be explored and discovered. Significant differences in ichthyological knowledge and nomenclature among regions and countries make access and harmonization of existing information a challenge in Asia. A comprehensive assessment of the threatened fishes does not exist in Asia except in Japan. In Latin America. The *Catalog of Fishes* 23/ is a useful list of the Neotropical ichtyofauna and the museum collections of South American fishes are far more advanced than that of African and Asian fishes. Of the 25,000 total living fish species described worldwide, the vast majority belong to the group Actinopterygii or ray-finned fish, of which 41 percent or about 10,000 species are primarily freshwater species, with an additional 160 species regularly migrating between fresh and salt waters. In terms of species numbers and overall distribution, the Otophysi dominate freshwater fish diversity. The most recent IUCN Red List of Threatened Animals includes 665 freshwater fish species classified as critically endangered, endangered, or vulnerable. These include 645 Actinopterygii, 3 Cephalaspidomorphi, and 17 Elasmobranchii. 24/ .In all, over 80 percent of the total number of threatened fish species, which include marine species, are freshwater fish. 25/ There are indications that there has been a steady increase in the number of possible extinctions over the last 50-100 years. 26/

17/ Groombridge and Jenkins 1998, CBD 2001.

18/ Hilton-Taylor 2000.

19/ Hilton-Taylor 2000.

20/ Palmer *et al*. 1997.

21/ Cushing *et al*. 1995; Gopal and Junk 2000; Groombridge and Jenkins 1998; Taub 1984.

22/ Stiassny 1996.

23/ Eschmeyer 1998.

24/ Hilton-Taylor 2000.

25/ Hilton-Taylor 2000.

26/ Harrison and Stiassny 1999.

17. Amphibians are strictly freshwater animals, classified into three orders: Anura (frogs and toads), Caudata (newts and salamanders), and Gymnophiona (cecilians). A recent estimate 27/ lists approximately 5,379 amphibians in the world. The IUCN Red List of Threatened Animals 28/ lists 135 "freshwater-dependent" amphibian species as critically endangered, endangered, or vulnerable to extinction, of which 106 are frogs or toads and 27 are salamanders. AmphibiaWeb 29/ recently compiled information on worldwide amphibian declines and its possible causes. It notes that:

(a) Globally, over 200 amphibian species have experienced recent population declines and 32 species extinctions have been reported. Possible factors implicated in these declines include habitat destruction, climate change, contaminants, introduced species and disease agents (viruses, bacteria and fungi);

(b) Many of these declines have occurred in protected areas without obvious human impacts, possibly due to airborne contaminants, introduced species, and emergent diseases. The Declining Amphibian Populations Task Force of the IUCN/Species Survival Commission is assessing these incidents worldwide.

18. Scientists count 8,051 reptiles 30/ including 160 amphisbaenians (Amphisbaenia); 4,636 lizards (Sauria); 2,930 snakes (Serpentes); 300 turtles (Testudines); 23 crocodiles (Crocodylia); 2 tuataras (Rhynchocephalia). Of these groups:

(a) Turtles are harvested and used by humans throughout their range as food (both flesh and eggs) or for products such as souvenirs, traditional medicines, aphrodisiacs and the international pet trade. These pressures in combination with habitat loss are causing declines in turtle populations worldwide, and the number of critically endangered freshwater turtles has more than doubled in the last four years. 31/ There are more than 100 freshwater turtles listed as threatened with extinction in the 2000 IUCN Red List;

(b) Crocodiles, alligators, caimans and gharials are widespread throughout tropical and subtropical aquatic habitats. They are top predators in freshwater habitats. The two major threats to crocodilians worldwide are: habitat loss and degradation, and overexploitation. Of the 23 species, 15 are traded commercially for their skin; all 23 species are listed in CITES Appendices; four are critically endangered, three endangered, and three vulnerable;

(c) There are two species of aquatic snakes in the world that are strictly limited to freshwater. They belong to the family Acrochordidae—wart or file snakes. 32/ There is not much information on their conservation status, however, it is known that hunting for its skin, which is used in the manufacturing of leather goods is making the Javan wart snake increasingly rare. In addition there are other snakes that are considered semi-aquatic. These include among others, mud snakes, cottonmouths, colubrids, water snakes, the green anaconda, the giant garter snake, and the rainbow snake. The large-headed water snake (Natrix megalocephala) found in Azerbaijan, Georgia, the Russian Federation and Turkey is listed as vulnerable to extinction by IUCN. 33/

27/ According to AmphibiaWeb (March 25, 2002) at http://elib.cs.berkeley.edu/aw/ .

28/ Hilton-Taylor 2000.

29/ http://elib.cs.berkeley.edu/aw/declines/declines.html.

30/ As of June, according to the EMBL reptile database at http://www.embl-heidelberg.de/~uetz/db-info/SpeciesStat.html.

31/ van Dijk *et al*. 2000.

32/ Uetz and Etzold 1996.

33/ Hilton-Taylor 2000.

19. Global information on waterbird population status and trends is compiled and regularly updated by Wetlands International through its International Waterbird Census (IWC), and published as *Waterbird Population Estimates*. A third edition will be published in November 2002. 34/ More detailed information is also available for some regions and some waterbird taxa. For instance, Europe-wide national population trends for all birds species, including waterbirds, have been compiled by BirdLife International. 35/ Waterbirds—bird species that are ecologically dependent on wetlands—and particularly migratory waterbirds are probably the most comprehensively studied group of animals on Earth. The trends in waterbird populations are better known in Europe, North America and the Neotropics than in Africa, Asia and Oceania. Of the 792 waterbird populations with known trends, 35 have gone extinct, 311 are decreasing, 168 are increasing and 278 are stable. Although there is information on migratory birds by species, detailed analyses at the biogeographic population level for the different flyways are not readily available. Flyways in the Americas, and in Europe and Africa, are better known and monitored than those in Asia.

20. Only a small number of mammals are considered aquatic or semi-aquatic mammals. These species spend a considerable amount of time in freshwater and usually live in the riparian vegetation close to rivers, lakes, lagoons, ponds, etc. Many species, including, *inter alia*, river dolphins and porpoises, freshwater seals, manatees, hippopotamuses, the Asian water buffalo, otters, the European mink, the fishing cat and the flat-headed cat, the desmans (*Desmana moschata* or Russian desman and the Pyrenean desman (*Galemys pyrenaicus*)) and the well known semi-aquatic beavers, are threatened or endangered, mainly from habitat loss and degradation, pollution, overexploitation or entrapment in nets and other fishing gear.

21. FAO is preparing for publication in 2005 a first *State of the World's Animal Genetic Resources* report, which is expected to contain information on inland water animal species for food.

IV. MAJOR THREATS TO INLAND WATER ECOSYSTEMS

22. Despite their value, inland water ecosystems are being intensely modified and degraded by human activities in many parts of the world. Major threats include, *inter alia*, modification of river systems, water withdrawals for flood control or agriculture, introduction of invasive alien species, pollution, over-fishing and impact of climate change. These pressures occur all over the world, although the particular effects of these stresses vary from watershed to watershed. The combination of pressures on freshwater systems has resulted in more than 20 percent of the world's freshwater fish species to become extinct, endangered, or threatened in recent decades. 36/ This number, however, is considered to be a major underestimate 37/ Environmental impact assessment has been used in some cases to prevent or correct the environmental impacts of development projects such as the construction of dams, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse.

A. Modification of river systems

23. Modifications include river embankments to improve navigation, drainage of wetlands for flood control and agriculture, construction of dams and irrigation channels, and the establishment of inter-basin connections and water transfers. These physical changes in the hydrological cycle disconnect rivers from their floodplains and wetlands, and slow water velocity in riverine systems, converting them to a chain of connected reservoirs. This, in turn, impacts the migratory patterns of fish species and the composition of

34/ Wetlands International 2002.

35/ BirdLife International 2000.

36/ Moyle and Leidy 1992:140.

37/ Bräutigam 1999:4.

riparian habitats, opens up paths for alien species, changes coastal ecosystems, and contributes to an overall loss of inland water biodiversity, in particular fishery resources. 38/

24. Humans have built large numbers of dams all over the world, most of them in the last 35 years. Today, there are more than 40,000 large dams (more than 15 meters high) in the world. They affect the seasonal flow and sediment transport of rivers downstream. Direct impact of dams on diadromous fish species such as salmon are well documented. Indirect impacts of flow alternation on fish species assemblages have also been documented for several artificial reservoirs in Africa. 39/ Cases of adverse impacts of dams, embankments and canals on the structure of riparian vegetation and morphology are also widely reported. 40/

25. River fragmentation, which is the interruption of a river's natural flow by dams, inter-basin transfers, or water withdrawal, is an indicator of the degree of modification of rivers by humans. Of the 227 major river basins considered, 37 percent are strongly affected by fragmentation and altered flows, 23 percent are moderately affected, and 40 percent are unaffected (Revenga et al. 2000).

B. Water withdrawals

26. Today, more than 40 percent of the world's population lives in water-scarce river basins. With growing populations, water scarcity is projected to increase significantly in the next decades, affecting half of the world's people by 2025. 41/ Experts predict that water availability will be one of the major challenges facing human society in the twenty-first century. Widespread depletion and pollution also extends to groundwater sources, which account for about 20 per cent of global water withdrawals. Information on the condition and location of groundwater aquifers is limited.

27. At present, irrigated agriculture accounts for 40 per cent of global food production even though it represents just 17 percent of global cropland. 42/ . Agriculture is society's major user of water, withdrawing 70 per cent of all water used. 43/ Land use and tenure influences the type of agricultural systems adopted and related irrigation requirements. Most irrigation systems are relatively inefficient. Even though the distribution of irrigated agriculture significantly influences current and future water use, detailed information on the irrigated areas are not available at the global level. 44/

C. Invasive alien species 45/

28. The introduction of invasive alien species is the second-leading cause, after habitat degradation, of species extinction in freshwater systems. These species cause predation, competition, disruption of food webs, and introduction of diseases. The spread of invasive alien species is a global phenomenon, one that is increasing with the spread of aquaculture, shipping and global commerce.

29. Although the comprehensive data on non-native species, in particular the invasive ones, and their effects on biodiversity and ecosystem condition are not available at the global or regional level, there is much anecdotal evidence of widespread cases that document the disruptive impacts of some exotic species introductions. Some examples include documented cases of non-native fish introduction in

---

38/ Revenga *et al*. 2000.

39/ Lévêque 1997.

40/ Nillson and Berggeron 2000; Dudgeon 2000; Pringle *et al*. 2000.

41/ Revenga *et a*l. 2000.

42/ WMO 1997:9.

43/ WMO 1997:8.

44/ Wood *et al*. 2000.

45/ See also document UNEP/CBD/SBSTTA/6/INF/11.

Europe, North America, Australia, and New Zealand. 46/ In the past 100 years, North America has seen the extinction of 27 species and 13 subspecies of fish. The introduction of alien species was found to be a contributing factor in 68 per cent of these extinctions, although in almost every case there were multiple stresses contributing to each extinction, such as habitat alteration, chemical pollution, hybridization, and over-harvesting. 47/

30. The adverse effects of introduced species on the native fauna are also documented in Africa, Asia and South America. 48/ The introduction of exotic predator fish to Lake Victoria is the best known example of high species loss. Before the 1970s, Lake Victoria contained more than 350 species of fish in the cichlid family, of which 90 per cent were endemic, giving it one of the most diverse and unique assemblages of fish in the world. 49/ Today, more than half of these species are either extinct or found only in very small populations. 50/ Although other pressures factored in, the collapse in the lake's biodiversity was caused primarily by the introduction of the Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*), which fed on and out-competed the cichlids for food.

31. Aquatic plants, such as water hyacinth (*Eichornia crassipes*), and invertebrates such as the zebra mussel (*Dreissena polymorpha*) are other examples of widespread exotics that are causing considerable economic and ecological damage in numerous aquatic systems around the world.

D. Fisheries overexploitation

32. Inland fisheries from rivers, lakes, and wetlands are a major source of animal protein for a large part of the world's population. In 1997 the catch from inland fisheries totalled 7.7 million metric tonnes, or nearly 12 per cent of all fish directly consumed by humans from all inland and marine capture fisheries. 51/ The catch from inland fisheries is believed to be greatly underreported by a factor of two or three. 52/ Most inland capture fisheries that depend on natural production are being exploited at or above their sustainable yields. 53/

33. Assessing the pressure on inland fisheries and the consequences for inland water ecosystems is difficult partly because of the paucity of reliable and comprehensive data on fish landings and watershed condition, and because of partial and incomplete reporting by countries.

E. Impact of climate change on inland waters

34. The major impacts to inland waters described by the Intergovernmental Panel on Climate Change, include warming of rivers and the resulting changes in chemical and biological processes, reduced ice cover, reduced dissolved oxygen in deep waters, altered mixing regimes, sea level rise affecting coastal wetlands, change in nutrient recycling, and impacts on growth rates, reproduction and distribution of organisms and species. 54/ There are several predictions of the impacts of climate change on fish-species ranges, with a reduction on the ranges of cold water fish species and an expansion of the ranges of warm-water fish. The effects of El Niño can amplify these impacts. Less mobile aquatic species will be more at risk because they will be unable to keep up with the rate of change in freshwater

---

46/ Ross 1991:363.

47/ Miller *et al*. 1989:22.

48/ Kaufman 1992:846–847, 851, Witte *et al*. 1992:1, 17, Lévêque 1997.

49/ Kaufman 1992:846–847, 851.

50/ Witte et al. 1992:1, 17.

51/ FAO 1999b:7.

52/ FAO 1999a:4.

53/ FAO 1999a:23.

54/ Gitay *et al*. 2001 and 2002.

habitats. 55/ It is also predicted that with warmer conditions, the establishment of invasive species will become a bigger problem. Birds and fish may also lose important staging, feeding and breeding grounds.

35. The combined effect of climate change, El Niño and human-induced alterations to inland water systems has not been studied in detail. It will be difficult to discern the effects of climate change from other existing pressures, but it can be assumed that large-scale change to these habitats will result in species changes and could lead to biodiversity loss.

V. CONCLUSIONS AND RECOMMENDATION ON DATA GAPS AND INFORMATION NEEDS

36. Governments, international agencies, non-governmental organizations, river basin authorities, and civil society need data and information on the condition of inland water resources and functions in order to formulate and implement policy options that are sustainable. To fill in the gaps, much effort and financial commitment would have to be made to improve national, regional and global data on inland water ecosystem goods and services, and their uses; basic hydrological information; and the threats to which they are subjected.

37. In general, all areas related to inland water ecosystems require more data and information, from water availability and quality to the status and trends of the species inhabiting these ecosystems. Among the different datasets on land cover, there is currently a lack of biogeographic characterization and standard classification schemes, especially as it relates to inland water ecosystems. Mapping seasonal wetlands and forested wetlands has been difficult. The European Space Agency has initiated a programme by which they are assessing the application of earth observation products to managing wetlands, especially as it relates to the Ramsar Convention. Results from this programme can prove useful to the wider water resources community. A similar effort 56/ is under way to cover all the thematic areas addressed by the Convention on Biological Diversity.

38. With regard to information of species and populations of inland water biodiversity, most countries, with a few exceptions, have a large information gap when it comes to inland water species, especially the lower taxonomic orders. In addition, the existing species inventories are organized by taxonomic group and not by ecosystem type, which makes it hard to assess the condition of inland water ecosystems. Inland water species have traditionally been less studied, and because of their distribution within water bodies they are harder to map than terrestrial species. There are currently several new initiatives that may help identify, catalogue, and map species around the world. Some of these activities include the IUCN freshwater biodiversity assessment and species-mapping programmes, the work being done by BirdLife International on the location, distribution and population status of birds, the OECD Global Biodiversity Information Facility (GBIF) and the Global Taxonomy Initiative (GTI) of the Convention on Biological Diversity. This knowledge and monitoring would allow for more complete assessment of the condition of inland water system. There is also great potential to improve the available information on species distribution and richness by drawing from the existing museum collections and databases around the world.

39. In order to obtain information of trends, baseline information will have to be gathered. There exist various mechanisms developed to assess the status of components of inland water biodiversity periodically. These can serve as sources of information on trends that is particularly needed by policy and decision-makers. Without population trends of species, it is hard to assess the effects of pressures or the risk of extinction of species. An agreement on outcome targets such as the ones defined in the Global

---

55/ Gitay *et al*. 2001.

56/ "Programme for Global Ecodiversity Monitoring (ProGEM)" under the European Space Agency (ESA) sponsored Global Monitoring of Environment and Security Services Element of the ESA Earthwatch programme.

Strategy for Plant Conservation 57/ of the Convention would facilitate the development of monitoring mechanisms that could provide information on trends in inland water biodiversity.

40. Because of the large impact that introduced species can have on inland water ecosystems, information on the location of introduced species as well as the presence or absence of invasive alien species is urgently needed. There are some examples of global initiatives that try to document the occurrence of invasive alien species. The FAO Database on Introductions of Aquatic Species (DIAS) compiles and maintains information on the degree of international introductions of fishes by country, which, as of 1998, contained 3,150 records worldwide. It should be noted however, that DIAS considers only species introduced from one country to another and not from one site to another within the same country.

41. Most data on water availability and use are generally only available at the national level, which makes management of river basins, especially those that cross national borders almost impossible. Data and information on basic variables, such as river flow, water withdrawals, aquifer recharge rates, etc. are not available at the basin level. The amount of information on water quality is also very limited, especially for ground water resources, ground water quality as well as the storage capacity at the global, regional and national levels.

42. Finally, socio-economic variables at the basin level would highly improve the knowledge needed for a more integrated approach to water resource management. Some of the socio-economic variables needed at the basin level are: population density and income distribution; degree of dependence on the inland water resource; and food production in the basin.

57/ Decision VI/9 of the Conference of the Parties to the Convention on Biological Diversity.

VI. REFERENCES

Baumgartner, A. and E. Reichel. 1975. The World Water Balance: Mean Annual Global, Continental, and Maritime Precipitation, Evaporation, and Runoff. Elsevier Amsterdam, The Netherlands.

BirdLife International. 2000. *Threatened birds of the world.* Lynx Edicions/BirdLife International, Barcelona, Spain/Cambridge, UK.

Bräutigam, A. 1999. "The freshwater crisis." *World Conservation 30 (2)*: 4-5.

CBD (Convention on Biological Diversity) Secretariat. 2001. *Global Biodiversity Outlook*. CBD Secretariat, Montreal, Canada.

Cushing, C.E., K.W. Cummins, and G.W. Minshall. 1995. *Ecosystems of the World 22: Rivers and Stream Ecosystems*. Elsevier Science Publishers, Amsterdam, The Netherlands.

Dudgeon, D. 2000. "Large-scale hydrological changes in tropical Asia: prospects for riverine biodiversity." *BioScience 50(9)*: 793–806.

Dynesius, M. and C. Nilsson. 1994. "Fragmentation and Flow Regulation of River Systems in the Northern Third of the World." Science 266: 753–762.Ellis, S. et al. 1993. "Baiji (*Lipotes vexillifer*) population and habitat viability assessment - preliminary report." *Species* 20:25.

Eschmeyer, W.N. 1998. The Catalog of Fishes. San Francisco: California Academy of Sciences. Online at: http://www.calacademy.org/research/ichthyology/catalog/)

FAO (Food and Agriculture Organization of the United Nations). 1999a. Review of the State of World Fishery Resources: Inland Fisheries. FAO Inland Water Resources and Aquaculture Service, Fishery Resources Division, FAO Fisheries Circular No. 942. Rome, Italy: FAO.

FAO (Food and Agriculture Organization of the United Nations). 1999b. The State of World Fisheries and Aquaculture 1998. Rome, Italy: FAO Fisheries Department.

Feuerer, T., 2002: Checklists of lichens and lichenicolous fungi. Version 1, February 2002. Online at: http://www.checklists.de

Finlayson, C.M. and N.C. Davidson. 1999. Global review of wetland resources and priorities for wetland inventory: summary report. In Finlayson, C.M. and A.G. Spiers eds. Global review of wetland resources and priorities for wetland inventory. 2nd edition. Wageningen, The Netherlands: Wetlands International and Jabiru, Australia: Environmental Research Institute of the Supervising Scientists. Online at: http://www.wetlands.org/inventory&/GRoWI/welcome.html

Gitay, H., Brown, S., Easterling, W., Jallow, B. et al. 2001. Chapter 5. Ecosystems and Their Goods and Services. In: Climate Change 2001: Impacts, Adaptations, and Vulnerability. Contribution of Working Group II to the Thirds Assessment Report of the International Panel on Climate Change. McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K.S. (eds). pp. 235-342. IPCC/Cambridge University Publication Press

Gitay, H., Suarez, A., Dokken, D.J. and R.T. Watson. 2002. Climate change and biodiversity. IPCC Technical Paper V. IPCC, CBD and WMO

Gleick, P.H. 1993. Part II: freshwater data. In Gleick, P.H. ed. Water in crisis: a guide to the world's fresh water resources. New York, NY: Oxford University Press.

Gopal, B. and W.J. Junk. 2000. Biodiversity in wetlands: an introduction. Pages 1-10 in B. Gopal, W.J. Junk, and J.A. Davis eds. Biodiversity in wetlands: assessment, function, and conservation, volume 1. Leiden, The Netherlands: Backhuys Publishers.

Groombridge, B. and M. Jenkins. 1998. Freshwater Biodiversity: a preliminary global assessment. Cambridge, UK: WCMC-World Conservation Press.

Groombridge, B. and M.D. Jenkins. 2000. Global biodiversity: Earth's living resources in the 21st century. Cambridge, UK: WCMC-World Conservation Press.

Hansen, M. 1998. *World Catalogue of Ins*ects: *Volume 1 Hydraenidae (Coleoptera)*. Apollo Books Stenstrup, Denmark.

Hansen, M. 1999. *World Catalogue of Insects*: *Volume 2 Hydrophiloidea (Coleoptera)*. Apollo Books, Stenstrup, Denmark.

Harrison, I. J. and M. J. Stiassny. 1999. "The Quiet Crisis: A Prelimminary Listing of the Freshwater Fishes of the World that Are Extinct or 'Missing in Action'." Pages 271–331 in R.D.E. MacPhee, ed. *Extinctions in Near Time*. Kluwer Academic/Plenum Publishers. New York, New York, U.S.

Hilton-Taylor, C. 2000. 2000 IUCN Red List of Threatened Species. Gland, Switzerland and Cambridge, UK: IUCN. Downloaded on 05 May 2002.

ILEC (International Lake Environment Committee) Web site available on-line at: http://www.ilec.or.jp/database/database.html.

Kaufman, L. 1992. "Catastrophic Change in Species-Rich Freshwater Ecosystems: The Lessons from Lake Victoria." *Bioscience* 42 (11): 846–858.

Kurata, Akira. 1994. Data book of world lake environments: a survey of the state of world lakes. 5 volumes. Kusatsu, Japan: International Lake Environment Committee, and Nairobi, Kenya: United Nations Environment Programme (UNEP). Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals*. Academic Press, London, UK. pp. 465.

Lévêque, C. 1997. Biodiversity dynamics and conservation: the freshwater fish of tropical Africa. Cambridge, UK: Cambridge University Press.

Mandaville, S.M. 1999. Bioassessment of freshwaters using benthic macroinvertebrates- a primer. First ed. Feb. 1999. Halifax , Canada: Soil & Water Conservation Society of Metro Halifax. Online at: http://www.chebucto.ns.ca/Science/SWCS/ZOOBENTH/ BENTHOS/benthos.html.

Miller, R. R., J. D. Williams, and J. E. Williams. 1989. "Extinctions of North American Fishes During the Past Century." *Fisheries* 14 (6): 22–38.

Moyle, P.B. and R.A. Leidy. 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish faunas. Pages 127–169 in P.L. Fiedler and S.K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation, and management. New York, NY: Chapman and Hall.

Nilsson, A. 2001. World catalogue of insects: volume 3 Dytiscidae (Coleoptera). Stenstrup, Denmark : Apollo Books.

Nilsson, A. 2002. Catalogue of Palearctic Dytiscidae. Umeå, Sweden: University of Umeå. Online at: http://www.bmg.umu.se/biginst/andersn/Dyt_inae.htm. Updated on 15 February, 2002.

Nilsson, C. and K. Berggren. 2000. Alterations of riparian ecosystems caused by river regulation. BioScience 50(9): 783–792.

Nixon, C.P., D.B. Stoeckel, and M.R. Jeffords. 2001. Stream quality indicators. Illinois Department of Natural Resources. Online at: http://dnr.state.il.us/orep/inrin/ctap/bugs/.

Palmer, M. A., A.P. Covich, B.J. Finlay, J. Gilbert, K.D. Hyde, R.K. Johnson, T. Kairesalo, S. Lake, C.R. Lovell, R.J. Naiman, C. Ricci, F. Sabater, and D. Strayer. 1997. Biodiversity and ecosystem processes in freshwater sediments. Ambio 26 (8): 571-577.

Pringle, C.M., M.C. Freeman, and B. J. Freeman. 2000. Regional effects of hydrologic alterations on riverine macrobiota in the New World: tropical-temperate comparisons. BioScience 50(9): 807–823.

Revenga, C., J. Brunner, N. Henninger, K. Kassem, and R. Payne. 2000. Pilot analysis of global ecosystems: freshwater systems. Washington DC: World Resources Institute. Online at: http://www.wri.org/wr2000/freshwater_page.html

Ross, S. T. 1991. "Mechanisms Structuring Stream Fish Assemblages: Are There Lessons From Introduced Species?" *Environmental Biology of Fishes* 30: 359–368.

Sahlén, G. and K. Ekestubbe. 2001. Identification of dragonflies (Odonata) as indicators of general species richness in boreal forest lakes. Biodiversity and Conservation 10: 673-690.

Shiklomanov, I.A. 1997. Comprehensive assessment of the freshwater resources of the world: assessment of water resource and water availability in the world. Stockholm, Sweden: World Meteorological Organization and Stockholm Environment Institute.

Stiassny, M.L.J. 1996. An overview of freshwater biodiversity: with some lessons from African fishes. Fisheries 21: 7-13.

Taub, F.B. ed. 1984. Ecosystems of the World 23: Lakes and reservoirs. Amsterdam, The Netherlands: Elsevier Science Publishers.

Uetz, P. and T. Etzold. 1996. The EMBL/EBI Reptile Database, Herpetological Review 27 (4): 174-175. Available on-line at: http://www.reptile-database.org. Accessed May 2002.

van Dijk, P.P., B. L. Stuart, and A. G.J. Rhodin. 2000. *Asian Turtle Trade: Proceedings of a Workshop on Conservation and Trade of Freshwater Turtles and Tortoises in Asia* Chelonian Research Monographs, No. 2, Chelonian Research Foundation in association with WCS, TRAFFIC, WWF, Kadoorie Farm and Botanic Gardens and the US Fish and Wildlife Service. Chelonian Research Foundation Lunenburg, Massachusetts, USA. 164pp.

Walter, K.S. and H.J. Gillette, eds. 1998. 1997 IUCN Red List of Threatened Plants. Compiled by the World Conservation Monitoring Centre. Gland, Switzerland and Cambridge UK: IUCN.

Wetlands International. 2002. WAterbird Population Estimates. 3rd Edition. Consultation Draft available on-line at**:** http://www.wetlands.agro.nl.

Witte, F., T. Goldschmidt, J. Wanink, M. van Oijen, K. Goudswaard, E. Witte-Mass, and N. Bouton. 1992. “The Destruction of an Endemic Species Flock: Quantitative Data on the Decline of the Haplochromine Cichlids of Lake Victoria.” *Environmental Biology of Fishes* 34:1-28.

Wood, S., K. Sebastian, and S.J. Sherr. 2000. Pilot analysis of global ecosystems: agroecosystems. Washington DC: International Food Policy Research Institute and World Resources Institute. Online at: http://www.wri.org/wr2000/agroecosystems_page.html

World Meteorological Organization (WMO). 1997. Comprehensive Assessment of the Freshwater Resources of the World. Stockholm, Sweden: WMO and Stockholm Environment Institute.
