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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)

Note by the Executive Secretary

1. In its Decision III/10, the Conference of the Parties instructed SBSTTA to provide scientific advice and further guidance, through its thematic work on ecosystems, to the fourth meeting of the Conference of the Parties, to assist in the national elaboration of Annex I of the Convention, using as guidance the elaboration of the terms as set out in paragraphs 12-29 of document UNEP/CBD/COP/3/12.

2. In its decision III/13 it further requested SBSTTA to provide the fourth meeting of the Conference of the Parties with scientific, technical and technological advice on the status and trends of biological diversity in inland water ecosystems and the identification of options for conservation and sustainable use.

3. To assist SBSTTA in its consideration of these matters, the Executive Secretary has prepared the following Note, which discusses elaboration of the terms in Annex I to the Convention specifically with regard to inland water ecosystems.

4. Also relevant to this item are documents UNEP/CBD/SBSTTA/3/2 on freshwater biological diversity, UNEP/CBD/SBSTTA/3/8 on assessment of biological diversity in freshwater ecosystems and UNEP/CBD/SBSTTA/3/9 on indicators.

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Introduction to freshwater ecosystems

Definitions and classification.

5. Excluding the permanent ice of the polar icecaps, less than 1% of the world's water exists on land. More than half of this is groundwater (in or beneath the soil); about 0.02% occurs in lakes and inland seas, somewhat less than this amount is water vapour in the atmosphere, while rivers and streams make up a vanishingly small 0.001%.

6. Inland aquatic habitats are much more varied in physical and chemical features than habitats in the marine environment, and include systems such as: lakes, rivers, ponds, streams, springs, cave waters, cattle troughs, water in tree holes and leaf axils, and others. Waters are perennial or ephemeral, running (*lotic*) or standing (*lentic*). Other continental aquatic habitats include a variety of shallow, well-vegetated systems, such as bogs, marshes, swamps and coastal lagoons, traditionally grouped as *wetlands* (*sensu stricto*). A very significant proportion of inland aquatic ecosystems has been heavily modified by human influence and a large number of inland waters are largely or entirely artificial in construction.

7. A significant number of inland ecosystems, normally included within wetlands, are in reality hybrid terrestrial/aquatic systems. These are areas which are sometimes underwater and sometimes dry. Major examples are the floodplains of large rivers, which are typically inundated on a predictable annual basis. Such areas may be very large in extent and form highly distinctive dynamic ecosystems. Similar floodplains may be associated with smaller rivers, although these are usually more intermittent and less predictable in occurrence and extent. Other hybrid ecosystems include temporary water bodies and the edges of shallow water lakes which may vary greatly in extent in response to fluctuating climatic conditions (*e.g.* Lake Chad).

8. In consideration of inland water ecosystems it is important also to take into account associated ecosystems and habitats even if these are not strictly aquatic. Riparian woodlands and forests are examples of these.

9. Although the terms inland water ecosystem and freshwater ecosystem are often used interchangeably, it should be remembered that there is not an exact correspondence between the two, as a number of inland water ecosystems are saline, some highly so.

Introduction to freshwater biological diversity

10. Freshwater fauna and flora were derived ultimately from marine and terrestrial species, and the transition to freshwaters has frequently occurred in many different lineages.

11. There is not a precise dividing line between freshwater aquatic species and others. For example many aquatic insects have an aquatic larval phase and a non-aquatic phase, the latter may last a matter of hours only (*e.g.* mayflies) or months (*e.g.* dragonflies). Several amphibian groups have a more prolonged and wide-ranging terrestrial phase, but have larvae reliant on water. In some groups (*e.g.* otters and water snakes), aquatic habitats are used for hunting but much time is spent on land. Among non-microscopic animals, fishes (with a very few exceptions) are entirely aquatic, as are many groups of molluscs and crustaceans. The major groups of freshwater organisms are described briefly in document UNEP/CBD/SBSTTA/3/8.

Article 7 and Annex I

12. The following annotations outline some widely applicable ecological principles and practices which may assist the SBSTTA in providing advice to the Parties through the COP on the elaboration of Annex I of the Convention with particular regard to inland water ecosystems.

13. In its decision III/21, the COP decided to invite the Convention on Wetlands of International Importance (the Ramsar Convention) to cooperate as a lead partner in the implementation of activities under the Convention related to wetlands and also to explore the possibility of recommending procedures for harmonizing, to the extent desirable and practicable, the reporting requirements of Parties under Ramsar and other relevant instruments and conventions. Relevant in this regard are the Ramsar Criteria for Identifying Wetlands of International Importance along with the guidelines for interpreting these. The criteria and attendant guidelines make relatively few quantitative recommendations (where appropriate these are referred to below). A complete copy of the criteria and guidelines is appended as an annex to this document.

14. It should be noted that the Ramsar definition of wetlands, included as a footnote to the annex, includes marine and coastal ecosystems to a depth at low tide of up to six metres. This extends beyond the notion of inland water ecosystems as considered here, and includes a number of areas which under the Convention should be included within the remit of the Jakarta Mandate.

Inland water ecosystems and habitats containing high diversity

15. As noted in document UNEP/CBD/COP/3/12, diversity can be interpreted in a number of different ways. More complex ecological measures of diversity generally combine measures of richness, evenness of spread of components, and some indication of uniqueness or complementarity (in other words, how different one area or part of an area is from another). One of the most straightforward ways to deal with diversity within ecosystems and habitats (as is implicit in this definition) is to consider species diversity, of which the simplest indication is some measure of species richness. As with terrestrial ecosystems, species diversity of inland water ecosystems in general increases strongly towards the equator, although there are some local exceptions and some taxa which may not follow this rule. In tropical and warm temperate regions, fish species diversity, one of the major components of diversity in aquatic ecosystems, is highly correlated with the area of the drainage basin. This relationship does not apply in cold temperate or subarctic areas, where tundra rivers typically drain a large area but have few species. There is also a less marked but still positive relationship between area of lake and species diversity. Wetlands, although highly productive, may sometimes be less diverse overall than adjacent terrestrial or freshwater ecosystems but can nevertheless support high diversity of particular groups, notably waterbirds and some invertebrates such as dragonflies (order Odonata). Tropical wetlands are in general considerably more diverse than temperate wetlands, although some of the latter can support notably high diversity (*e.g.* of migrant waterbirds) at some times of year.

16. These general rules can be used to identify areas of high diversity at least at a coarse scale. A more detailed picture can emerge using the assessment techniques for freshwater ecosystems outlined in document UNEP/CBD/SBSTTA/3/8. It should be remembered that the identification of areas of high diversity does not necessarily require the identification of all component species.

Inland water ecosystems and habitats with large numbers of endemic species

17. In general, areas or ecosystems which have been isolated from other similar areas or ecosystems for a significant period of time contain endemic species. The number of endemic species and the percentage of the biota which is endemic are dependent on a range of factors, among the most important of which are the length of time the area has been isolated, the size of the area, and the nature of the organisms which have colonised that area or were present when it became isolated.

18. The great majority of existing lakes, of which around 10,000 exceed 1 km^2 in extent, are geologically very young, and occupy basins formed by ice masses or glacial erosion during recent ice ages. These lakes date from the retreat of continental ice-sheets some 10,000 years before present. Similarly, most shallow wetland ecosystems (marshes and floodplains) are geologically speaking relatively transient. In general these systems tend to have fairly low rates of endemism; this is particularly the case for the large number found at higher latitudes where diversity in general is low. Only about 10 existing lakes are known to be much older than 10,000 years, and most of these occupy basins formed by large scale subsidence of the Earth's crust, dating back to at most 20 million (Lake Tanganyika) or 30 million years (Lake Baikal) before present. These typically have very high rates of endemism.

19. Major river systems are not only relatively large in extent, as entities they also tend to be geologically old, even though the actual courses that individual waterways follow within these systems are constantly changing. Such systems usually have high rates of endemism.

20. There are, however, important exceptions to these generalisations, notably amongst tropical lakes where rates of endemism, particularly amongst fishes, may be high or extremely high, despite the relative youth of the ecosystem. The guidelines to the Ramsar Criteria for Identifying Wetlands of International Importance (see annex) suggest that a figure of 10% endemism of the ichthyofauna should qualify a wetland or series of wetlands as being of international importance. The guidelines also note that in areas with no endemic fish species, the endemism of genetically-distinct infraspecific categories, such as geographical races, should be used.

21. Identification of endemic species requires detailed knowledge of the taxonomy and distribution of the groups examined. Many inland water ecosystems, particularly in the tropics, remain very inadequately known. It is widely acknowledged that, amongst vertebrates, the major remaining gaps in taxonomic knowledge concern tropical freshwater fishes and deep-sea marine fishes. Improvement of knowledge in the distribution and status of tropical freshwater fishes is hampered both by a lack of field-work and a shortage of taxonomic expertise. The need for improved taxonomic expertise in general was discussed at the second meeting of the SBSTTA and the third meeting of the COP. Decision III/10 of the COP endorsed recommendation II/2 of the SBSTTA, calling for a global initiative for capacity-building in taxonomy.

Inland water ecosystems and habitats with large numbers of threatened species

22. As noted in UNEP/CBD/COP/3/12, identification of threatened species requires that the status of that species has been assessed. Assessment of the status of aquatic species poses particular problems, discussed at some length in document UNEP/CBD/SBSTTA/3/8. In consequence, globally speaking there has been less comprehensive coverage of the status of aquatic than terrestrial species. However, when they have been assessed, it has been widely found that a high proportion is threatened. Indeed overall inland water species

appear to be among the most threatened of all groups. This accords with the observation that inland water ecosystems are some of the most extensively modified of all ecosystems.

23. Generally inland water ecosystems with large numbers of threatened species are those which are both diverse and heavily modified by factors which adversely affect the native biota. Examples are Lake Victoria in East Africa and large river systems in Europe and North America. Even where the status of all species has not been individually assessed, it is possible to extrapolate from the known status of representative species.

Inland water ecosystems and habitats containing wilderness

24. As noted in document UNEP/CBD/COP/2/3, the concept of wilderness is difficult to define in any unequivocal way. However operational definitions can be used in terms of distance from human influence such as roads and settlements. In most cases inland water ecosystems may perhaps best be considered in terms of the extent to which they occur within wilderness areas, rather than contain wilderness. Indeed navigable rivers are often regarded as actual or potential avenues for human influence and therefore by definition cannot usually be regarded as wilderness.

Inland water ecosystems and habitats required by migratory species

25. Many inland water ecosystems and habitats are of great importance for migratory species. There are two major groups of these, with largely complementary habitat requirements. The first is migratory waterfowl, mostly in the orders Anseriformes (the ducks, geese and screamers) and Ciconiformes. These typically inhabit productive shallow-water wetlands, including coastal wetlands (most notably estuaries), shallow lakes, swamps, marshes and seasonal floodplains. Often they are found in very high concentrations in particular wetlands on passage or while overwintering but become dispersed when breeding. The Ramsar Criteria for Identifying Wetlands of International Importance suggest that a wetland should be so regarded if it regularly supports 20,000 waterfowl.

26. The second group is fishes[1] which spend part of their life cycle in freshwater and part in the marine environment. Those which ascend rivers to breed, generally having spent some years growing to maturity in sea-waters, are termed anadromous; those which descend to the sea to breed after spending several years in freshwaters, are termed catadromous. Examples of the former include many commercially important members of the orders Salmoniformes (salmon, trout and their kin) and Acipenseriformes (the Sturgeons). The best known example of the latter is the freshwater eel *Anguilla anguilla*. These species or populations are of necessity confined to river systems with connections with the sea.

Inland water ecosystems and habitats of social, economic, cultural or scientific importance

27. Many inland water ecosystems have long been, and continue to be, of immense importance to mankind. Uses of such ecosystems are described in some detail in document UNEP/CBD/SBSTTA/3/2. However, this importance has often been deleterious for the ecosystems involved. Socio-economically, river systems and some lakes are generally regarded as being of major importance: for transportation, disposal of effluence, generation of power, provision of water for a range of uses, as a source of food, and as areas for recreation. In contrast, shallow-water inland ecosystems ("wetlands" in the narrower sense) have traditionally been perceived as of little

1 "Fishes" is used as the plural of "fish" when more than one species is involved.

value. In both cases, however, the effects of mankind's use has generally been deleterious to biological diversity, as the value of the latter within these ecosystems has been largely neglected. In the former case, rivers have been channelised, impounded, polluted and overfished, and their waters have been abstracted. In the latter, wetlands have been drained and infilled, and the land converted to other use.

28. Realisation of the true value to humans of different inland water ecosystems and habitats will require the adoption of more comprehensive and realistic means of evaluating these systems in economic, social and cultural terms. In particular this involves taking into account the less tangible values of ecosystem goods and services, including those provided by biological diversity. A recent attempt to ascribe a global value to ecosystems (Costanza *et al.*, 1997, Nature 387: 253-260) estimated mean values per hectare of major ecosystem types, taking as many of these factors as possible into account. Of non-marine ecosystems, wetlands (average value US$ 14,785 per hectare) and lakes and rivers (average value US$ 8,498 per hectare) were several times more valuable per unit area than terrestrial ecosystems such as forests (US$ 969 per hectare) and grasslands or rangelands (US$ 232 per hectare). Taken together, inland water ecosystems were estimated to contribute more to total global flow value (US$ 6579 x 10^9 per year) than all other non-marine ecosystems combined (US$ 5740 x 10^9 per year) despite their far lesser extent. This indicates that there may be a strong argument for considering all extant inland water ecosystems to be of social, economic or cultural significance.

Inland water ecosystems and habitats which are representative

29. The concept of representativity depends implicitly on the development of a unified classification system so that representative samples of each unit in such a system can be chosen. As with other types of ecosystem, the question of scale is paramount - the more fine-grained a classification system, the greater the number of representative habitats or ecosystems there will be.

30. Inland water ecosystems may be chosen as representative on the basis of a range of different criteria, of which the two most important are biogeographic and ecological. In the first instance ecosystems may be chosen which contain representative fauna and flora of a given biogeographic region. In the second, they may be chosen because they represent a particular type of inland water system (deep tectonic oligotrophic lake, vernal pool, inland estuary).

31. Biogeographic classifications of inland water ecosystems may differ markedly from terrestrial ones, particularly for lotic (river) systems. This is because the biota of a river is usually influenced by the ocean or sea into which it flows. Thus rivers on the western seaboard of North America have a largely Pacific biota while those on the eastern seaboard have an Atlantic or Caribbean biota. In contrast terrestrial ecosystems on the two seaboards share many more species in common.

32. There are a number of ways of classifying inland water systems by type rather than biogeographic region. Lakes may be usefully classified by origin, the three major types being volcanic, tectonic and glacial agents, with a number of more minor classes including those created by landslides, dissolution of limestone, natural coastline activities, organic accumulation, animal behaviour, meteorite impact and excavation by rivers or the wind.

33. In addition, nutrient status of trophic state has proven extremely valuable in classifying and assessing lakes. Generally, lakes can be defined by being more or less oligotrophic (unproductive with low supply rates of at least one major nutrient such as nitrogen, phosphorus or silica) or eutrophic (productive with high supply

rates of all major nutrients). Mesotrophic lakes, which are extremely common, lie somewhere between the two. Dystrophic lakes are characterised by high concentrations of humic acids leached from decaying aquatic vegetation and are usually but not always unproductive. Such a classification is very useful when assessing the status of lacustrine ecosystems, as so-called cultural (that is anthropogenic) eutrophication is widely recognized as one of the most disruptive influences on these systems (see document UNEP/CBD/SBSTTA/3/8).

Inland water ecosystems and habitats which are unique

34. In terms of physical characteristics, no two inland water ecosystems are exactly alike. In this very basic sense, therefore, each is unique. Clearly this does not provide much guidance as to how particularly important ecosystems may be chosen. In terms of their importance for biological diversity, it may well be that uniqueness is best defined in terms of the possession of outstanding attributes in the other categories here outlined, such as high species diversity or a large number of threatened species. Presence of endemic species makes ecosystems *de facto* unique.

Inland water ecosystems and habitats which are associated with key evolutionary processes

35. As noted in UNEP/CBD/COP/3/12, too little is currently known of the mechanics of evolution to be able to make this criterion easily operational. However, it is noteworthy that studies of tropical freshwater ecosystems, especially Lake Victoria, have indicated that these may well be sites of exceptional evolutionary activity. There are indications that the highly diverse cichlid species swarm in Lake Victoria has evolved over a far shorter time period (perhaps as little as 12,000 years) that has hitherto been thought likely or even possible. This makes such sites not only important under this criterion, but also makes them of great scientific importance.

Inland water ecosystems and habitats associated with other biological processes

36. As noted in document UNEP/CBD/SBSTTA/3/2, inland waters play a key role in many ecological processes, perhaps most importantly in mediating the water cycle. They may thus have an influence well beyond their actual boundary. River systems in particular have an important influence on coastal and inshore marine ecosystems, through transport of sediments, nutrients (and usually pollutants) and the interchange of animal populations. The relative importance of different ecosystems will depend greatly on the scale at which they are considered. At a fine enough scale any inland water ecosystem is of importance.

Inland water species and communities that are threatened

37. As noted in document UNEP/CBD/COP/3/12, the term community is undefined but may be taken to mean assemblages of species that commonly occur together. In general, methodologies for identifying inland water threatened species are similar to those for other groups, although as noted above where fairly detailed assessments have been carried out it has generally been found that a higher proportion of freshwater than terrestrial or marine species is threatened.

Wild relatives of domesticated or cultivated species

38. The major inland water animals which have been domesticated are ducks and geese (family Anatidae). An increasing range of fish species is subject to inland aquaculture, the most important of which are a range of cyprinids, especially common carp *Cyprinus carpio*, catfishes, eels, salmonids, sturgeons and whitefish. It is a moot point whether these may truly be considered domesticated at present, as many are generally very similar to

wild genotypes. In many areas, wild fisheries (*e.g.* for sturgeons *Acipenser* spp. in the Caspian Sea and salmonids in the Colombia River system in western U.S.A.) are supplemented by farmed or ranched stock. In some cases such supplement may be an important conservation measure; in others there is concern that it may lead to disruption of wild stock, through interbreeding or transmission of disease.

39. The major cultivated inland water plant is rice, of which principally two forms are cultivated: Asian Rice *Oryza sativa* and African Rice *O. glaberrima*. Globally more than 500 million metric tonnes of rice is produced annually and the total area under rice cultivation is around 150 million hectares, the great majority in paddies, which form an important artificial wetland ecosystem in the tropics, most notably in Asia. In total there are some nineteen species in the genus *Oryza*. The precise origin of *O. sativa* is unknown, although it may be derived from selection of forms related to the perennial *O. rufipogon* with probably genetic input from the annual *O. nivara*. *O. glaberrima* is believed to have been domesticated some 3400 years ago and to be derived in part from the annual *O. barthii*. The centre of diversity of *O. glaberrima* and *O. barthii* is the swampy areas of the Upper Niger. To date little effort has been made to conserve the wild relatives of *O. glaberrima*. Wild populations of *O. rufipogon* and *O. nivara* are now rarely found, with many known populations having disappeared in the past four or five decades. Indigenous varieties of *O. sativa* are well represented in germplasm collections, notably at the International Rice Research Centre in the Philippines.

40. Other cultivated inland water plants are globally of far lesser importance, but may locally be highly significant. Most important are some forms of edible aroid, notably some cultivars of *Colocasia* (taro) and the giant swamp taro *Cyrtosperma chamissonis* which grow in flooded conditions and are important food crops in the Caribbean and Pacific islands and in West Africa. Conservation and collection of wild forms of these is considered a high priority. Sago palms *Metroxylon* spp. in South-east Asia and the Pacific and watercress *Rorippa nasturtium-aquaticum* in Europe are other examples of cultivated aquatic plants whose wild relatives merit conservation.

Inland water species and communities that are of medicinal, agricultural or other economic value

41. Amongst animals, the most important species of economic value are undoubtedly finfishes. Inland water fisheries are discussed at further length in document UNEP/CBD/SBSTTA/3/8. As well as food, in many parts of the world fishing is also of high recreational value. Locally, notably in the Amazon Basin and in parts of south-east Asia, capture for the ornamental fish trade may be an important source of income, and potential impact on wild populations. Increasingly it is becoming difficult to distinguish between truly wild fish stocks and those which are artificially managed or enhanced in some way.

42. Moreover, the importance of different species of freshwater finfishes must be assessed carefully. In terms of food security for local subsistence or mixed market/subsistence communities, particularly in the tropics, there is increasing evidence that the diversity of species harvested is in itself a major factor in ensuring a continuous food supply. Many of the species which contribute to these fisheries are often small and would be considered "trash" fishes in orthodox fisheries and far less valuable than larger (often non-native) species regarded as having market potential and which may be considered for introduction. However, these small species are easy to preserve and keep under local conditions and moreover are eaten whole, providing a valuable source of calcium and other minerals. Larger species, such as the introduced Nile Perch *Lates* sp. in Lake Victoria, cannot be easily preserved locally and are in any case not eaten whole, leading to danger of calcium deficiency. Fisheries for such species tend to become industrialised or semi-industrialised, producing fish

products for commercial high-value markets, often for export. While these may improve balance of payments for the countries concerned, they may ultimately worsen the nutritional status of local people.

43. Additionally, there are some indications that fish populations in mixed species fisheries are more stable over time, that is less susceptible to "boom and bust" than those based on a small number of often introduced species.

44. Other exploited animal groups in inland waters are far less important globally than finfishes, but may still be highly significant. These include: freshwater crustaceans, notably crayfishes and freshwater shrimps, both exploited for food; freshwater bivalve molluscs, taken for pearls and for food; frogs (chiefly family Ranidae), exploited for food; crocodilians, hunted mainly for leather; freshwater chelonians, taken for food and to a lesser extent for medicinal purposes, particularly in eastern Asia; waterfowl which are hunted for recreation and for food; fur-bearing mammals, such as beavers *Castor* spp., otters (subfamily Lutrinae) and muskrats (*Ondatra zibethicus* and *Neofiber alleni*), taken for their skins; manatees (family Trichechidae), mostly for food, although also used non-consumptively on a small scale for biological control of weeds.

45. Relatively few freshwater plants are heavily exploited in the wild state. Some (*e.g. Aponogeton* spp. in Madagascar) are collected for use as ornamentals; reeds are used as building materials (*e.g.* thatch); and some are collected for food or as medicines (*e.g. Spirulina* algae).

Inland water species and communities that are of social, scientific or cultural importance

46. As noted above, many exploited freshwater species are hunted for recreational purposes as well as to provide goods such as food or clothing. In this sense they are of social and cultural as well as economic importance - the recreational value of waterfowl hunting and sport-fishing in Europe and North America greatly exceeds the commercial value of any products derived from them. Moreover, non-consumptive uses of aquatic biological diversity, such as bird-watching, are continuously growing in importance. In some areas freshwater species have historically occupied a central position in the cultures which depended on them. This was the case with the salmonid fisheries of the Pacific coast of western North America. Until the start of the twentieth century these fisheries were the mainstay of at least four native American tribes. The collapse of the stocks in the past 100 years has meant that the fisheries are no longer economically central to the livelihood of these people. Nevertheless they remain of central cultural importance, a factor which has to be taken into account in all plans for the future rehabilitation and management of these stocks.

47. Elsewhere, particular species or populations of species may be considered of spiritual or religious significance. This applies, for example, to particular populations of Nile crocodiles *Crocodylus niloticus* in Madagascar and to some populations of mugger *Crocodylus palustris* and various freshwater chelonians in India.

Inland water species and communities that are of importance for research into the conservation and sustainable use of biological diversity, such as indicator species

48. Most of the species and communities which may be included under the other categories above may also be included here. In addition, a number of freshwater species are widely held to be good indicators of water quality, of importance not merely for biological diversity but also for human use (see for example: Chapman, D. (ed) (1992) *Water Quality Assessments*, Chapman and Hall, on behalf of UNESCO, WHO and UNEP).

Described genomes and genes of social, scientific and economic importance

49. As described in UNEP/CBD/COP/3/12, the identification of particular genes and genomes of social, scientific and economic importance is difficult, as it is the phenotypic expression of these genes and genomes which can be valued in these ways, rather than the genes themselves. Nevertheless it is clear that particular genetically differentiated populations of some inland water species may be of importance. Examples include different seasonal "runs" or spawning stocks of anadromous fishes. Many species of salmonid, for example, have different spring and autumn stocks inhabiting the same river. Management plans should take these differences, which may not be morphologically expressed in the animals themselves, into account. Similarly, wild relatives of cultivated crops such as rice, as well as land-races and indigenous varieties of these crops, are likely to contain genes of great value in improving yields. In these instances, germplasm collections are of great importance, although attention should also be given to the *in situ* conservation of plants carrying such genomes.

Recommendations

50. The SBSTTA may wish to emphasise that the elaboration of terms in Annex I should be undertaken with a view to expediting the implementation of the Convention as a whole, and in particular Articles 6 and 8. Since many inland aquatic ecosystems are highly modified and degraded, the SBSTTA may wish to stress the particular importance in this regard of the implementation by Parties of Articles 8(f) and 10(d) of the Convention concerning the restoration of degraded ecosystems.

51. The SBSTTA may wish to recommend that the COP advise Parties to prepare indicative lists of inland water ecosystems which meet the criteria of Annex I. The SBSTTA may wish to recommend the elaboration of specific criteria along the lines of the Ramsar Criteria, or alternatively it may wish to consider recommending that the COP endorse the Ramsar Criteria for Wetlands of International Importance.

52. The SBSTTA may wish to consider recommending that the COP adopt the IUCN criteria and definitions of threatened species for application, *inter alia*, to species in inland water ecosystems.

53. The SBSTTA may wish to consider recommending that the COP urge Parties to undertake, as a first priority, assessments of threatened species of vertebrates and vascular plants within their inland water ecosystems.

54. The SBSTTA may wish to consider recommending the development of an outline classification of inland water ecosystems which Parties could use in their further national elaboration of Annex I of the Convention, within the context of the implementation of Article 7.

ANNEX

The Ramsar Convention on Wetlands Criteria for Identifying Wetlands[2] of International Importance

(as adopted by the 4th and 6th Meetings of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971) to guide implementation of Article 2.1 on designation of Ramsar sites)

(Annexes to Recommendation 4.2, Montreux, Switzerland, 1990, and Resolution VI.2, Brisbane, Australia, 1996)

A wetland is identified as being of international importance if it meets at least one of the criteria set out below:

1. Criteria for representative or unique wetlands

A wetland should be considered internationally important if:

(a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region; or

(b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region; or

(c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of an major river basin or coastal system, especially where it is located in a trans-border position; or

(d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.

2. General criteria based on plants or animals

A wetland should be considered internationally important if:

(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species; or

(b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna; or

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2 The Ramsar Convention defines wetlands as: areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. This definition is a very broad one and includes coastal as well as inland areas in addition to ecosystems which may be considered hybrid inland water/dryland systems (intermittently or seasonally flooded areas, peatlands).

(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle; or

(d) it is of special value for one or more endemic plant or animal species or communities.

3. Specific criteria based on waterfowl

A wetland should be considered internationally important if:

(a) it regularly supports 20,000 waterfowl; or

(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity; or

(c) where data on populations are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

4. Specific criteria based on fish

A wetland should be considered internationally important if:

(a) it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity; or

(b) it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Guidelines for Application of the Criteria

To assist Contracting Parties in assessing the suitability of wetlands for inclusion on the List of Wetlands of International Importance, the Conference of the Contracting Parties has formulated the following guidelines for application of the Criteria:

(a) A wetland could be considered of international importance under Criterion 1 if, because of its outstanding role in natural, biological, ecological or hydrological systems, it is of substantial value in supporting human communities dependent on the wetland. In this context, such support would include: provision of food, fibre or fuel; or maintenance of cultural values; or support of food chains, water quality, flood control or climatic stability.

The support, in all its aspects, should remain within the framework of sustainable use and habitat conservation, and should not change the ecological character of the wetland.

or (b) A wetland could be considered of international importance under Criterion 1, 2 or 3 if it conforms to additional guidelines developed at regional (*e.g.* Scandinavian or West African) or national level. Elaboration of

such regional or national guidelines may be especially appropriate: where particular groups of animals (other than waterfowl) or plants are considered more suitable as a basis for evaluation; or where waterfowl and other animals do not occur in large concentrations (particularly in northern latitudes); or where collection of data is difficult (particularly in very large countries).

or (c) The "particular groups of waterfowl, indicative of wetland values, productivity or diversity" in Criterion 3(b) include any of the following:

loons or divers: Gaviidae; grebes: Podicipedidae; cormorants: Phalacrocoracidae; pelicans: Pelecanidae; herons, bitterns, storks, ibises and spoonbills: Ciconiiformes; swans, geese and ducks (wildfowl): Anatidae; wetland related raptors: Accipitriformes and Falconiformes; cranes: Gruidae; shorebirds or waders: Charadriidae; and terns: Sternidae.

or (d) The specific criteria based on waterfowl numbers will apply to wetlands of varying size in different Contracting Parties. While it is impossible to give precise guidance on the size of an area in which these numbers may occur, wetlands identified as being of international importance under Criterion 3 should form an ecological unit, and may thus be made up of one big area or a group of smaller wetlands. Consideration may also be given to turnover of waterfowl at migration periods, so that a cumulative total is reached, if such data are available.

Guidelines for the application of Criterion 4(a)

1.1 Fishes are the most abundant vertebrates associated with wetlands. Worldwide, over 18,000 species of fishes are resident for all or part of their life cycles in wetlands as defined by the Ramsar Convention.

1.2 The importance of Criterion 4(a) is that a wetland can be designated as internationally important if it has a high diversity of fishes and shellfishes even if it does not fulfil the requirements of the other criteria. Furthermore, this criterion emphasizes the different forms that diversity might take, including the number of subspecies, species and families, different life-history stages, species interactions, and the complexity of interactions between the above taxa and the external environment. Fish diversity therefore includes diversity within species, between species and between ecosystems. It also includes the diversity of genetically similiar intraspecific ecological units, for instance, salmon runs or the different geographical races of marine fishes that have been identified in many regional seas around the world. Species counts alone are not sufficient to assess the importance of a particular wetland.

1.3 In addition, the concept of the "niche" needs to be considered, i.e. the different ecological roles that species may play at different stages in their life cycles. This point is especially relevant to animals that have a marked metamorphosis in their life cycle, such as corals, barnacles, many aquatic insects, amphibians, fishes with larvae or leptocephali and birds with naked young, *e.g.* passerines, some birds of prey, and egrets.

1.4 Implicit in this understanding of diversity is the importance of high levels of endemism and of biodisparity. "Endemic species" are species that are unique to one region, often within one country or continent, and are found nowhere else. Many wetlands are characterized by the highly endemic nature of their fish fauna.

1.5 Some measure of the level of endemism should be used to distinguish sites of international importance. If at least 10% of the ichthyofauna is endemic to a wetland, or to wetlands in a natural grouping, that site should be recognized as internationally important, but the absence of endemic fishes from a site should not disqualify it

if it has other qualifying characteristics. In some wetlands, such as the African Great Lakes, Lake Baikal in Russia, Lake Titicaca, sinkholes and cave lakes in arid regions, and lakes on islands, endemism levels as high as 90-100% may be reached, but 10% is a practical figure for worldwide application. In areas with no endemic fish species, the endemism of genetically-distinct infraspecific categories, such as geographical races, should be used.

1.6 Over 977 species of fishes are threatened with extinction worldwide and at least 28 fish species have recently become extinct (Groombridge 1993). The occurrence of rare or threatened fish species in a wetland is an important attribute but is catered for in Criterion 2 of the Ramsar Convention.

1.7 The concepts of indicator, flagship and keystone species are also important. The presence of "indicator" species is a useful measure of good wetland quality. "Flagship" species have high symbolic value in the conservation movement (*e.g.* Siberian crane, flamingo, desert pupfish, sturgeon) whereas "keystone" species play vital ecological roles. The recognition of the important ecological role of keystone species, which are often abundant and widespread, and the need for their conservation, is perhaps foreign to the traditional conservation ethic, but deserve serious consideration. Wetlands with significant populations of indicator, flagship and/or keystone species would merit consideration as sites of international importance.

1.8 An important component of biodiversity is biodisparity, i.e. the range of morphologies and reproductive styles in a community. The biodisparity of a wetland community will be determined by the diversity and predictability of its habitats in time and space, i.e. the more heterogeneous and unpredictable the habitats, the greater the biodisparity of the fish fauna.

1.9 For example, Lake Malawi, a stable, ancient lake, has over 600 fish species of which 92% are maternal mouthbrooding cichlids, but only a few fish families. In contrast, the Okavango Swamps, a palustrine floodplain that fluctuates between wet and dry phases, has only 60 fish species but a wider variety of morphologies and reproductive styles, and many fish families, and therefore has a greater biodisparity (Bruton & Merron, 1990).

1.10 Measures of both biodiversity and biodisparity should be used to assess the international importance of a wetland.

1.11 The problem of invasive aquatic animals also needs to be considered. Fishes (finfishes and shellfishes) have been widely distributed, accidentally or purposely, by humankind from one catchment, ocean or continent to another, with sometimes disastrous consequences for the local fauna and ecology. In some cases, as in the Laurentian Great Lakes in North America, the indigenous fauna of the lakes has been dramatically altered even though the total species count has not declined significantly. In Suisun Marsh in the Sacramento-San Joaquin estuary in the USA, the introduction of alien species has doubled the species count in the wetland. In other cases, as in Lake Victoria in Africa, alien species, combined with overfishing and pollution, have caused a major decline in the diversity of indigenous species. Measures of biodiversity and biodisparity should only take into account representative assemblages of indigenous species, if the true intrinsic worth of the system is to be measured.

1.12 The situation is not simple, however, as many high altitude lakes that formed since the last glaciation contain only introduced fish species. Throughout the world important commercial, recreational and subsistence fisheries are based on introduced species, especially trout, carp, salmon, bass and tilapia. Furthermore, some alien species, for instance those used for biological control, have had beneficial effects on wetlands. In general, the introduction of alien species of fishes and shellfishes which may have adverse impacts on the diversity of

indigenous species or for which there are insufficient data available to make a reliable judgement should be discouraged.

Guidelines for the application of Criterion 4(b)

2.1 Many fishes (including shellfishes) have complex life histories, with spawning, nursery and feeding grounds widely separated and long migrations necessary between them. It is important to conserve all those areas that are essential for the completion of a fish's life cycle if the fish species or stock is to be maintained. The productive, shallow habitats offered by coastal wetlands (including coastal lagoons, estuaries, salt marshes, inshore rocky reefs and sandy slopes) are extensively used as feeding and spawning grounds and nurseries by fishes with openwater adult stages. These wetlands therefore support essential ecological processes for fish stocks, even if they do not necessarily harbour large adult fish populations themselves.

2.2 Furthermore, many fishes in rivers, swamps or lakes spawn in one part of the ecosystem but spend their adult lives in another inland water or in the sea. It is common for fishes in lakes to migrate up rivers to spawn, or fishes in rivers to migrate downstream to a lake or estuary, or beyond the estuary to the sea, to spawn. Many swamp fishes migrate from deeper, more permanent waters to shallow, temporarily inundated areas for spawning. Wetlands, even apparently insignificant ones in one part of a river system, may therefore be vital for the proper functioning of extensive river reaches up- or downstream of the wetland.

2.3 The adoption of this criterion for the identification of wetlands of international importance is for guidance only and does not interfere with the rights of Contracting Parties to regulate fisheries within specific wetlands and/or elsewhere.

Definitions

Catchment: The area drained by a river and all its tributaries; a drainage basin or watershed.

Endemic species: A species that is unique to one region, i.e. it is found nowhere else in the world. A group of fishes may be indigenous to a subcontinent with some species endemic to a part of that subcontinent.

Family: An assemblage of genera and species that have a common phylogenetic origin, *e.g.* pilchards, sardines and herrings in the family Clupeidae.

Fish: Any finfish, including jawless fishes (hagfishes and lampreys), cartilaginous fishes (sharks, rays, skates and their allies, Chondrichthyes) and bony fishes (Osteichthyes) as well as certain shellfish or other aquatic invertebrates, as listed below.

Fish orders that typically inhabit wetlands (as defined by the Ramsar Convention) and which are indicative of wetland benefits, values, productivity or diversity, include:

Jawless fishes - Agnatha
hagfishes (Myxiniformes); lampreys (Petromyzontiformes)

Cartilaginous fishes - Chondrichthyes
dogfishes, sharks and allies (Squaliformes); skates (Rajiformes), stingrays and allies (Myliobatiformes)

Bony fishes - Osteichthyes
Australian lungfish (Ceratodontiformes); South American and African lungfishes (Lepidosireniformes); bichirs (Polypteriformes); sturgeons and allies (Acipenseriformes); gars (Lepisosteiformes), bowfins (Amiiformes); bonytongues, elephant fishes and allies (Osteoglossiformes); tarpons, bonefishes and allies (Elopiformes); eels (Anguilliformes); pilchards, sardines and herrings (Clupeiformes); milkfishes (Gonorhynchiformes); carps, minnows and allies (Cypriniformes); characins and allies (Characiformes); catfishes and knifefishes (Siluriformes); pikes, smelts, salmons and allies (Salmoniformes); mullets (Mugiliformes); silversides (Atheriniformes); halfbeaks (Beloniformes); killifishes and allies (Cyprinodontiformes); sticklebacks and allies (Gasterosteiformes); pipefishes and allies (Syngnathiformes); cichlids, perches and allies (Perciformes); flatfishes (Pleuronectiformes)

Several groups of shellfishes:
shrimps, lobsters, freshwater crayfishes, prawns and crabs (Crustacea); mussels, oysters, pencil baits, razor shells, limpets, winkles, whelks, scallops, cockles, clams, abalone, octopus, squid and cuttlefish (Mollusca)

Certain other aquatic invertebrates:
sponges (Porifera); hard corals (Cnidaria); lugworms and ragworms (Annelida); sea urchins and sea cucumbers (Echinodermata); sea squirts (Ascidiacea)

Fish stock: The potentially exploitable component of a fish population.

Fishes: "Fishes" is used as the plural of "fish" when more than one species is involved.

Indigenous species: A species that originates and occurs naturally in a particular place.

Life-history stage: A stage in the development of a finfish or shellfish, *e.g.* egg, embryo, larva, leptocephalus, zoea, zooplankton stage, juvenile, adult, post-adult.

Migration path: The route along which fishes, such as salmon and eels, swim when moving to or from a spawning or feeding ground or nursery. Migration paths often cross international boundaries or boundaries between intranational management zones.

Nursery: That part of a wetland used by fishes for providing shelter, oxygen and food for the early developmental stages of their young. In some fishes, *e.g.* nest-guarding tilapias, the parent/s remain at the nursery to protect the young whereas in others the young are not protected by the parent/s except by virtue of the shelter provided by the habitat in which they are deposited, *e.g.* non-guarding catfishes.

The ability of wetlands to act as nurseries depends on the extent to which their natural cycles of inundation, tidal exchange, water temperature fluctuation and/or nutrient pulses are retained; Welcomme (1979) showed that 92% of the variation in catch from a wetland-recruited fishery could be explained by the recent flood history of the wetland.

Population: A group of fishes comprising members of the same species. A wetland community would comprise all the species of plants and animals that live in that wetland.

Significant proportion: In polar biogeographical regions a "significant proportion" may be 3-8 subspecies, species, families, life-history stages or species interactions; in temperate zones 15-20 subspecies, species, families, etc.; and in tropical areas 40 or more subspecies, species, families, etc, but these figures will vary between regions. A "significant proportion" of species includes all species and is not limited to those of economic interest. Some wetlands with a "significant proportion" of species may be marginal habitats for fish and may only contain a few fish species, even in tropical areas, *e.g.* the backwaters of mangrove swamps, cave lakes, the highly saline marginal pools of the Dead Sea. The potential of a degraded wetland to support a "significant proportion" of species if it were to be restored also needs to be taken into account. In areas where fish diversity is naturally low, *e.g.* at high latitudes, in recently glaciated areas or in marginal fish habitats, genetically-distinct infraspecific groups of fishes could also be counted.

Spawning ground: That part of a wetland used by fishes for courting, mating, gamete release, gamete fertilization and/or the release of the fertilized eggs, *e.g.* herring, shad, flounder, cockles, and many fishes in freshwater wetlands. The spawning ground may be part of a river course, a stream bed, inshore or deep water zone of a lake, floodplain, mangrove, saltmarsh, reed bed, estuary or the shallow edge of the sea. The freshwater outflow from a river may provide suitable spawning conditions on the adjacent marine coast.

Species: Naturally occurring populations of fishes that interbreed, or are capable of interbreeding, in the wild.

Species interaction: Exchanges of information or energy between species that are of particular interest or significance, *e.g.* symbiosis, commensalism, mutual resource defence, communal brooding, cuckoo behaviour, advanced parental care, social hunting, unusual predator-prey relationships, parasitism and hyperparasitism. Species interactions occur in all ecosystems but are particularly developed in species-rich climax communities, such as coral reefs and ancient lakes, where they are an important component of biodiversity.

Wetland benefits: The services that wetlands provide to people, *e.g.* water purification, supplies of potable water, fishes, plants, building materials and water for livestock, outdoor recreation and education.

Wetland values: The roles that wetlands play in natural ecosystem functioning, *e.g.* flood attenuation and control, maintenance of underground and surface water supplies, sediment trapping, erosion control, pollution abatement and provision of habitat.
