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Relationship between Biodiversity and Wetlands: Threats and Solutions

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ABSTRACT

Wetlands are among the most productive life-support systems in the world and are of immense socio-economic and ecological importance to mankind. These are areas where water is the primary factors controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water. They are critical for the maintenance of biodiversity and perform a great role in the biosphere. Ironically, wetlands have been perceived as wastelands associated with disease, difficulty and danger. Emphasizing the negative impacts and ignoring their importance, these habitats were considered obstacles in the path of progress and hence drained, filled, despoiled and degraded for economic gains. The wetland loss has been responsible for bringing to the verge of extinction countless species of animals and plants. Inadequate understanding of the crucial role and utility of wetlands is a matter of serious concern. In the present paper, seven types of wetlands are compared in terms of their potentiality and economic advantages with tropical sea grass bed with highest productivity and estuarine mangrove wetland with lowest one.

Introduction

The combination of aquatic and terrestrial conditions that produce 'wet-lands' makes these ecosystems among the most complex in the world. Within a wetland, the environmental characteristics are determined largely by hydrologic processes, which may exhibit daily, seasonal or long-term fluctuations, in relation to regional climate geographic location of the site. These factors produce a great range of wetland types globally, the majority of which have extremely variable conditions in the many habitats, which they contain. As a consequence, the variety of living organisms, which has adapted to the different wetland habitats, tends to be high, with all major groups of plants and animals present.

Wetland at Bali, Indonesia

Following are Range of natural habitats within different temperate and tropical wetland ecosystems:

1. Inland freshwater lake/USA.

Rock bottom	Unconsolidated shore
Unconsolidated bottom	Emergent marsh wetland
Aquatic bed	Forested wetland
Rocky shore	

2. Basinal freshwater wetland/Trinidad.

Saturated forested wetland	Intermittently exposed unconsolidated shore
Tidally saturated forested wetland	Semi-permanently flooded aquatic bed
Permanently flooded emergent herbaceous wetland	Channels and pools
Seasonally flooded emergent herbaceous wetland	Secondary forest and disturbed marsh

3. Coastal wetland/Surinam.

Stagnant brackish and hypersaline pools	High Fiddler-crab zone of tidal mudflats
Drying up lagoons	Firm and tough clay banks
Tidal lagoons	Lower foreshore sandy beach
Soft tidal mudflats	Back slope sandy beach
Dry firm clay	

Diversity and Productivity of Wetland Plants

A variety of topographic gradients exist in wetlands and these influence the nature of the colonizing vegetation. Gradients exist between terrestrial uplands and flooded basins, lakes or riverbeds. In coastal situations they occur in relation to tidal fluctuations, which produce great habitat variability on the shoreline, as they do across lagoons and the zones of near-shore coral reefs. Wetland vegetation may respond to the topography and hydrology with a distinct zonation pattern formed by the dominant plant species, particularly in tidal situations, or produce a complex mosaic of plant communities around minor local variations in height.

Further variability is introduced to inland wetlands by seasonal fluctuations in the rainfall or inundation pattern. The area covered by a wetland may expand and contract with the seasons and thus produce a border of plant communities adapted to alternate flooded and dry conditions.

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Zonation pattern in coastal wetlands, Carriacou: from land in foreground through saline, black mangrove, red mangrove and tidal channel to the open sea.

The 'Varzea' wetlands of the Amazon floodplain, for example, extend for hundreds of kilometers and show a distinct change in the degree of adaptation of the plant species as one goes from the permanent river channel to the upland terra firma. In temperate wetlands, spring flood and summer drawdown introduce a similar variability in terms of the nature and availability of plant habitats. As a result, wetlands support diverse plant communities; particularly the inland wetlands associated with major drainage systems in both tropical and temperate regions.

This diversity is reflected at individual sites, such as the 243km^2 Cache River-Cypress Creek wetland, a Ramsar site in Illinois, USA, where 138 woody plants, 251 non-woody vascular (flowering) plants and 11 ferns are present. However, under more extreme conditions, such as the arctic Tundra, high mountain peat bogs and hypersaline saltmarshes in the dry tropics, the diversity is lower, even though a range of highly specialized plants will be present.

Many wetland plants, or hydrophytes, grow in dense and prolific stands. Following Table shows that many types of wetlands are highly productive. The ready availability of water, which transports nutrients and removes waste products, and the frequent association between plant roots and microscopic organisms able to use nitrogen, allow wetland plants to grow rapidly and produce large quantities of organic matter. In tropical wetland plants, such as mangroves, this primary production can go on all year and reach levels comparable to the most intensively mechanized agricultural production, for example sugar cane crops. Plants play a critical role in the structure and productivity of coral reefs in near-shore wetland environments. In many areas, the reefs can be described as 'cor-algal' reefs because of the close association between the corals (animals) and species of algae (plants). Other algae living in the coral tissues aid in the production of organic matter and are largely responsible, thus, for the high productivity of the reefs.

Productivity of selected wetland ecosystems.

Wetland type	Location	Annual production, tonnes per hectare per year (above ground only)
Estuarine mangrove	Sri Lanka	12
Tidal salt marsh	Louisiana, USA	14
Riparian forest	Louisiana, USA	14
Freshwater (reed) marsh	Denmark	14
Freshwater (Papyrus) marsh	Kenya	30
Freshwater (reed) marsh	Wisconsin, USA	34
Tropical sea grass bed	Caribbean	70

Recognizing the importance of wetland resources, the Convention on Wetlands of International Importance (Ramsar, 1971) has been instrumental in worldwide action at the governmental level for conservation and wise use of wetlands. In its first 25 years, the Ramsar Convention has played an important role in promoting awareness of wetlands and providing technical support to governments for conservation and management of these ecosystems on a sound ecological basis. By implementing the Strategic Plan recently adopted by the 6th Conference of Contracting Parties, the Ramsar Convention's work will become more closely related to the broader concerns of the Convention on Biological Diversity and the UN Commission on Sustainable Development.

The Ramsar Convention has adopted a Ramsar Classification of Wetland Type, which includes 42 types, grouped into three categories: Marine and Coastal Wetlands, Inland Wetlands, and Human-made Wetlands.

Five major wetland types which are generally recognized:

- **Marine** (coastal wetlands including coastal lagoons, rocky shores, and coral reefs);
- **Estuarine** (including deltas, tidal marshes, and mangrove swamps);
- **Lacustrine** (wetlands associated with lakes);
- **Riverine** (wetlands along rivers and streams); and
- **Palustrine** (meaning “marshy” - marshes, swamps and bogs).

In addition, there are human-made wetlands such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage farms and canals.

The Biodiversity of Nariva Swamp, a Tropical Wetland Basin

Within its 60km^2 basin on the east coast of the small tropical island of Trinidad, the Nariva Swamp contains some 15 distinct communities of flowering plants with over 300 species. The plants range from submerged and rooted aquatic plants in flooded marsh areas, through stands of freshwater swamp forest on elevated banks and channel margins, to mangroves lining tidal channels on the seaward side. The plant communities form the basis of a food web supporting more than 600 species of animals (microfauna not included).

Diversity of Animals in Wetlands

The species diversity and high production levels of wetland plants support even more diverse animal communities. The vegetation distribution patterns and water level fluctuations make a range of continuously changing wetland habitats available at different times of the year to aquatic, terrestrial and arboreal animals.

Wetlands support a wide variety of grazing and browsing animals, including several large mammals such as:

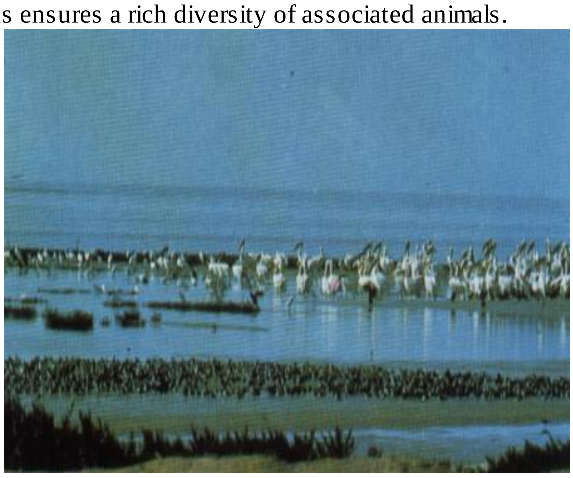
Range of plant communities in Nariva Swamp.

MANGAL	(Sclerophyll, brackish water forest; dominated by mangroves)
SWAMP WOOD	(Orthophyll, freshwater forest), Mixed Swamp Wood, Immortelle Swamp Wood
PALM SWAMP FOREST	(Megaphyll, freshwater forest; dominated by palms), Moriche Palm Swamp Forest, Royal Palm Swamp Forest, Roseau Palm Swamp Forest
EVERGREEN SEASONAL FOREST	(On islands and wetland margins)
SEMI-EVERGREEN SEASONAL FOREST	(On islands and wetland margins)
LITTORAL WOODLAND	(Tree vegetation on seaward border)
MARSH	Sedge Marsh (*Cyperus*), Aroid Marsh (*Montrichardia*), Reed Marsh (*Phragmites*), Floating Marsh (Water Hyacinth, Water Fern, lilies)

- African Buffalo (Syncerus caffer) and Hippopotamus (Hippopotamus amphibius) in Africa,
- Capybara (Hydrochaeris hydrochaeris) and Manatee (Trichecus spp.) in the Neotropics,
- Asian Water Buffalo (Bubalus bubalis) in Asia and
- Moose (Alces alces) in North America and Eurasia.

Many species of rodent, such as the Beaver (Castor spp.), Muskrat (Ondatra zibethicus) and Nutria (Myocastor coypus) in North America and Europe also depend on wetlands. A number of invertebrates, particularly snails and crustaceans, and some fish, such as Grass Carp (Ctenopharygodon idella), graze on water plants and convert these to animal biomass, in some cases impoverishing wetland vegetation.

On coral reefs, a variety of green, red and brown seaweeds provide food for a great diversity of invertebrates and fish. Some of these, such as damselfish (Pomacentridae), behave like gardeners by protecting and trimming the plants that they hide among and feed upon. The range of plant species in the different wetlands, and their flowers, fruits and seeds ensures a rich diversity of associated animals.



Wetlands support a variety of water birds - pelicans and sandpipers at Banc d'Arguin National Park, Mauritania.

Many different kinds of birds with a wide range of feeding and breeding habits are found in wetlands. Among the 104 species recorded in the Black River Morass, Jamaica, were 11 seabirds, 36 waterfowl, 7 birds of prey, a kingfisher and 49 forest birds; while 251 species have been found in the Cache River Basin, Illinois, USA. Some 40 species of birds commonly breed in the somewhat restricted wetland forests in Western Europe. In the case study of the St. Lucia estuarine system of South Africa (a Ramsar site), some 350 species of birds are reported, including 90 species of waterfowl, such as ducks, geese, two species of flamingo and 15 species of herons and egrets.

Many wetlands have such abundant food resources (both living plants and their decomposition products) that they can be utilized by species other than the permanent residents. Entry by 'visitor species' serves to increase further the diversity of animals that may be seen in wetlands from time to time. The life cycles of many species of marine shrimps include a period spent feeding in coastal estuaries or marshes. Several marine fish spawn in mangrove swamps or use these habitats as a nursery for their young because of the ready availability of small food materials and the security provided by mangrove roots. In addition, mangrove swamps are used for nursery and feeding by a range of coral reef-inhabiting species, while the reefs provide sheltered conditions along the coast which encourage mangrove establishment; this suggests that these associated wetland types are mutually supportive.

Migration into wetlands to benefit from food or favorable habitat conditions does not occur only in aquatic species, such as shrimp and fish. Many freshwater environments show seasonal fluctuations in water level, which influence grazing, and other feeding behavior. Seasonal drawdown in water level permits the movement of animals, including livestock and their herders, into wetland basins, where they utilize the abundant, lush plant resources.

In the Nariva Swamp, Red Brocket Deer (Mazama americana), Collared Peccary (Tayassu tajacu) and Agouti (Dasyprocta aguti) and smaller rodents migrate from the swamp margins and interior islands during the dry season and occupy habitats populated by aquatic species at other times. In effect, any area of the swamp basin will support two different faunas at different times of year, thus increasing the diversity of animals, which can be supported by one set of resources.

Many wetlands provide habitat for other important faunal components, serving as resting and feeding stations along migratory flyways for ducks, waders and shorebirds, which benefit from the diversity of food organisms. The seasonal influx of passage migrants serves to increase the biodiversity of many wetland sites. In a study of coastal wetland habitats in Surinam, South America, it is found that more than 75% of the foraging waterfowl were migrants of northern origin, with only a minority being local resident species.

This example shows that the migratory component of the bird life of wetlands is important, not only in terms of species diversity but in numbers of individuals. Similarly, the 24,000ha Cache River Basin in North America provided wintering habitat annually for nearly 200,000 Canada Geese (Branta canadensis), 35,000 Snow Geese (Anser caerulescens) and 26,000 ducks that would breed further north.

The Economic Value of Wetland Biodiversity

Wetland plants are a major source of materials on which large numbers of people depend, particularly in the subsistence economies of tropical countries. In addition to the variety of goods produced, the quantities exploited are impressive. Mangrove trees annually produce 7,400m^3 of charcoal and 400 tonnes of bark for tanning in Panama and

$120{,}000m^3$ of firewood in Honduras, while 80% of households in Nicaragua use mangrove wood for cooking.

Throughout the world, wetlands produce a range of animals of commercial importance, particularly as food, skins and for sport and the eco-tourism business. Thus, inland wetlands in Africa produce over 1.5 million tonnes of fish annually, with a further 1.0 million tonnes from coastal marine areas. At least one million fishermen and perhaps five million workers in processing, transportation and market activities depend on these fisheries. Twenty percent of commercial fish in Australia are caught in mangrove swamps; 45% were strictly dependent on mangrove resources, while 35% of mangrove dwelling species were food for commercial marine species.

Following table shows economic uses of tropical wetland plants (not in order of importance)

Construction materials (Housing & industry) Scaffolding, House beams & rafters, Flooring & paneling, Thatch & matting, Chipboard, Furniture, Fencing, Bridges, Posts, Tool handles, Water pipes, Packing boxes, Boats, Dock Pilings, Railroad ties, Mine pit props	Medicines (from fruit, sap, bark, leaves) Diuretics, Purgatives, Astringents, Febrifuges, Vitamins (mainly B group) Treatments for: Arthritis, Leprosy, Catarrh, Rheumatism, Skin rashes, Haemorrhage, Haemorrhoids, Snake bite, Tuberculosis
Fuel Firewood, Alcohol, Charcoal, Wood (curing fish, smoking rubber & firing bricks), Peat	*Textile & leather craft* Synthetic fiber (rayon), Dyes for cloth, Tannin for leather preparation (tanning)
Food & beverages Sugar, Vinegar, Honey, Alcohol, Cooking oil, Tea substitutes, Fermented drinks, Masticatories, Condiments from bark, Vegetables from fruit, propagules & leaves	*Miscellaneous* Contraceptives, Aphrodisiacs, Cigar substitutes, Drilling lubricant, Matchsticks, Paper (various kinds), Hairdressing oil, Waxes, Incense, Glues

Links between Wetlands and other habitats

In addition to direct economic values, through the provision of a range of goods and services, wetlands are of great indirect value through linkages with associated aquatic ecosystems. As indicated above, many species use wetlands for nursery purposes. In addition, the transfer of organic matter and biota by downstream flow or tidal export influences nutrient status and food webs outside the wetland itself.

In Australia, Banana Prawns *(Penaeus merguiensis)* require mangrove-lined estuaries if they are to complete their life cycles; in Colombia, the Cienaga Grande lagoon is thought to be responsible for rearing 70% of the fish harvested on the Caribbean coast; the organic matter and nursery environment of the Laguna de Terminos, Mexico, support a coastal fishery producing annually 15,000 tonnes of shrimp, 13,000 tonnes of shellfish and 122,000 tonnes of fish.

Mention has been made above of migratory waterfowl utilization of wetlands as staging posts, an example of a wetland in one country supporting the biodiversity and commercial harvest of resources in another, often in a different biome in a distant country. In Jamaica, the close association between mangroves and coral reefs, in terms of exchanges of nutrients and biota between the two-wetland types, suggests that the presence of mangroves greatly influences the health and productivity of the reefs, which are the mainstay of the artisanal fishing industry.

The consequences of loss of wetland biodiversity

The loss of wetland species has economic implications. The livelihood and culture of large numbers of people, in almost every country of the world, will be endangered if wetland resources become further depleted. A major portion of fisheries production, most hunting, much forest production and a significant part of eco-tourism will be lost worldwide, as well as elements of heritage and environmental quality. It is important to stress, however, that it is not sufficient just to protect the populations of plants and animals that are directly exploited: their health and survival, or sustainability, depend on maintaining the whole complex of biodiversity that characterizes wetland ecosystems.

Following table shows estimated numbers of wetland birds killed by hunters in selected parts of Asia:

Country/Region	**Bird Group**	**Numbers per annum**
China (Lake Shengjn)	Coots	3,900
	Ducks	14,300
	Geese	200
Indonesia	Ducks	2,400
	Herons	38,000
	Others	3,600
Japan (1981)	Ducks	694,646
USSR (E. Siberia)	Ducks	3,420,000
West Java (Cirebon)	Crakes and rails	170,000

Commercially exploitable wetland plant and animal species will be available only if the biological processes, which produce them, are maintained. These include primary production, nutrient cycling, pollination, flowering, fruiting, decomposition, food web interactions, grazing, predation, immigration and emigration, to name a few.

Hundreds of inter-related organisms take part in this gamut of processes and it is this diversity of wetland species, which keeps these ecosystems in ecological equilibrium and makes them so productive. Loss of any link in the web of biodiversity will reduce the goods, functions and attributes of a wetland site. For example, World trade in crocodilians from tropical and sub-tropical wetlands peaked in the 1960s at over 10 million skins per year, declining to a present volume of 1.5 million.

Decline in a wetland will impact on associated systems: loss of nursery habitat could reduce coastal fishery yields or loss of a wetland on a flyway could disrupt waterfowl migrations, threatening the capacity of individual birds to reproduce and eventually the survival of populations or species.

Finally, the real biodiversity of nature lies at the level of the genotype (the hereditary or genetic make-up). The variability, geographic dispersion and biological richness of wetlands globally mean that they contain a tremendous pool of genetic resources. This genetic diversity is important for a variety of reasons: it determines the ability of individuals and populations to adapt to changing environmental conditions, such as global warming or new diseases; it is essential for the continuing evolution of various species; it provides the basis for the selection and production of new resource organisms. Finally, it is also important for maintaining the distinctiveness of plants and animals in different locations, which has implications for our appreciation of nature. Loss of wetland habitats, which contain so much of the world's plant and animal biodiversity, thus endangers the genetic resources on which our future prosperity depends.

Conclusions about wetlands as per RAMSAR conventions

Wetlands - A New Concept

The Ancient Greeks identified four basic elements: earth, air, fire and water. Modern environmental thinking emphasizes the need to take account of traditional knowledge and wisdom, so perhaps this ancient division of the properties of the physical world is an appropriate reminder that wetlands are the meeting places of two fundamental elements, water and earth.

The way water and earth meet, the topographic gradient concerned, and the seasonal variations in rainfall or inundation patterns, account for the wide diversity of wetland types. Yet the importance of wetlands, for their intrinsic biodiversity, their productivity and their consequent value to human societies, has only recently been fully recognized. The very word 'wetland' is a recent coinage, not very elegant and difficult to translate, but which aims to sum up this new concept of the fruitful meeting of two elements.

Biological Diversity of Wetlands

The regional overviews illustrate the high levels of biodiversity found in wetlands. After tropical rain forests, they are among the richest ecosystems on this planet. **Coral reefs**, included in the Ramsar definition of wetlands, contain some of the highest known levels of biodiversity, while other coastal wetlands (including estuaries, seagrass beds and mangroves) are among the most productive.

Other wetlands also provide sanctuary for a wide variety of plants, invertebrates, fish, amphibians, reptiles and mammals, as well as millions of waterbirds. Of the world's 20,000 species of fish, approximately 8,500 live in fresh water. While many reptiles are dependent on wetlands for feeding and breeding, virtually all amphibians rely on wetlands for breeding and larval development. Wetlands support many mammals and some species, such as the hippopotamus, are highly specialized for an aquatic lifestyle.

The spectacular migrations of some of the waterbirds - which may make a return flight every year from breeding grounds in northern latitudes to wintering grounds in far southern climes - provided the spur for the establishment, 25 years ago, of the Convention on Wetlands (Ramsar, 1971), still the only intergovernmental legal instrument to deal with a single ecosystem type.

It is a sobering thought that the richness of freshwater systems is still poorly known, and that many wetland species, especially invertebrates, have yet to be described. Thus 10% of invertebrates recently sampled in the relatively well-studied Hong Kong Ramsar site of Mai Po Marshes were unknown to science.

Wetland Productivity

In parallel to this support of biodiversity, the introductory chapter by Peter Bacon, the overviews and case studies illustrate the productivity of wetlands. Wetland soils are rich in minerals and other nutrients, and Bacon quotes the example of Lake Naivasha in Kenya where papyrus swamps produced a harvestable standing crop of 30 tonnes per hectare (which furthermore was replaced after harvest in about nine months), compared with only 10 tonnes per hectare from the finest European pastures. Around two thirds of the fish consumed by human beings depend on coastal wetlands at some stage of their life cycle.

Thus there is an overwhelming case for the value of wetlands to human societies. These values may be derived from direct harvesting of fish, from hunting, grazing or agriculture, or through secondary activities like tourism and other human recreational activities; they may equally be provided, almost unrecognized and taken for granted by human societies, through essential functions performed by wetlands, such as control of floods and sedimentation, provision of water (including groundwater recharge), maintenance of water quality and abatement of pollution.

These essential goods and services explain why wetlands were often the cradle for the development of human civilizations, like those of the Nile Delta, the Valleys of the Tigris-Euphrates and the Mekong, the fertile floodplains of India and China, or Lake Titicaca; the need to share and organize these wetland benefits was the spur for human beings to coordinate and regulate their activities and their use of natural wetland functions.

The Paradox

Here, in these dual features of wetlands - richness and usefulness - lies the supreme paradox and dilemma, the challenge facing modern day efforts to achieve sustainable development. On the one hand is the extraordinary wealth and variety of living forms and physical properties that exist in wetlands, so bountiful that it seems impossible they should ever be exhausted; on the other the deplorable fact that human use (or rather overuse) has in many cases been excessive, either because the desire for short term profit is destroying the basic wetland resource or the demands of a burgeoning population lead to its over-exploitation.

While some wetlands are testimony to the positive effects of wise use of natural resources, to a large extent the overviews and case studies present abundant illustrations of the multiplicity of threats to wetlands: drainage for agriculture (often with subsequent salinization of soils); organic pollution from fertilizers or pesticides (e.g. in the English Norfolk Broads, Mai Po in Hong Kong and Tasek Bera in Malaysia); urban development, interruption of water flow notably by dams (e.g. at Djoudj in Senegal and Kelbia in Tunisia, or the Yaciretá Dam on the River Parana between Argentina and Paraguay); industrialization, overuse of groundwater (e.g. at Azraq); excessive tourist and visitor pressure.

Because of their own special features, coral reefs are vulnerable to a series of threats: sedimentation; agricultural run-off; coastal development; tourism; and overfishing. It is estimated that these threats have seriously degraded 10% of the earth's coral reefs and currently threaten many more.

One of the greatest threats to biodiversity is the introduction of alien species, whether plants (like Water Lettuce in Djoudj); or fish (such as the Nile Perch and a species of tilapia which have caused a steep decline in the former highly diverse endemic fish fauna of Lake Victoria); or mammals which have been introduced in remote Tierra del Fuego where they and alien fish are a major threat to the few native species adapted to the harsh local conditions.

While these factors may threaten the very existence of some wetlands, at a more insidious level they threaten the biodiversity held within them: the frequent references to globally threatened species within the regional chapters are evidence of the scale of this problem.

What Future Action?

This dilemma of the conservation and wise use of wetlands illustrates in a microcosm the environmental problems posed to the world at the threshold of the 21st century. How is the wealth of the earth's many ecosystems to be conserved because of their intrinsic value, and yet be harvested wisely? Wetlands can provide a blueprint and a model for activities in other fields.

The Ramsar Convention, which has now been in existence for 35 years, and has accumulated considerable experience, fortunately offers some pointers to the way forward. The Convention takes as its starting point that international cooperation is necessary for the conservation and wise use of wetlands.

In terms of substantive obligations, the Convention's two basic requirements - designation of wetlands for the List of Wetlands of International Importance, and application of the wise use principle - fit with the call, almost a cliché nowadays, to 'think globally and act locally'.

To ensure full application of these two fundamental obligations, other actions, both theoretical and practical, are necessary:

(a) Need for a holistic overview

Since the holistic recognition of the importance of wetlands is so recent, there is as yet only a dim understanding of the global scale and size of the wetland resource. The Asian overview refers to regional wetland surveys of South and East Asia and the Middle East, which identify the major wetland sites in those areas. Similar surveys of internationally important wetlands exist for other regions, while many states have carried out a national wetland survey; thus the North American overview notes that Canada holds 24% of the world's wetlands, an area covering 1.27 million square kilometers. The full area of wetlands in the world is still, however, a matter of some dispute: the World Conservation Monitoring Center has proposed an estimate of about 5.7 million square kilometers, roughly 6% of the world's land surface.

(b) Need to establish rates of wetland loss

Once there is a better idea of the overall extent of the wetland resource, and of the size of the challenge facing its managers, the figures need to be put into a world and a historical context. How many wetlands need to be given protected status through national or international conservation measures? There is as yet no clear vision of how many sites need to be protected at national or international level.

The extent of the threats needs to be defined. How does the present extent of wetlands compare with the situation in the past? There are estimates of the amount of certain types of wetland lost in certain countries: the North American overview states that, in the conterminous USA, only 47% of the original wetland coverage remains, though most of Alaska's wetlands remain undisturbed; the Asian overview notes that 85% of the wetlands in South and East Asia are threatened in some way and 50% are severely threatened. Yet there is no full understanding of the overall rate of wetland loss; it has certainly increased dramatically in the last 50 years, and more than half of the world's wetlands have been destroyed this century.

(c) Need to respect regional variation

How are solutions to be adapted to regional differences? In South America, Alaska, Africa and Eastern Europe, wetlands remain relatively untransformed, though the African section warns of the increasing impact of human population growth. In Western Europe there have been grave changes in the extent and functioning of wetlands, and in Central America, the Caribbean and USA too, major changes have come about. In the regions which have suffered major loss, wetland restoration will be a much greater priority, given that it is always much more difficult (if not impossible), and certainly more expensive, to restore lost wetlands than to conserve existing ones.

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