THREATS TO WATERBIRDS AND WETLANDS: IMPLICATIONS FOR CONSERVATION, INVENTORY AND RESEARCH

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The world has undergone major social, economic and demographic changes in the last two centuries. Predictions suggest that during the next 100 years, even greater changes will occur and this will put increasing pressure on wetlands and their biodiversity. This paper examines the changes that have occurred, and the nature of threats facing waterbirds and wetlands as a result of human activities. The need for specific areas of research is identified, particularly in relation to detecting and measuring change and the need to provide solution-oriented research to underpin conservation action.

Key Words: threats, wetlands, waterbirds, conservation, inventory, research.

A changing world

During the last half of the 20th Century, the notion of development has been at the heart of many social and economic changes in almost every country around the world. However, 'development' is both ambiguous and difficult to define, as it is used in many different contexts and covers many different activities (Goulet 1992; Cowan & Shenton 1995). In the western world, most models of development have involved striving for technological advancement, and social and economic 'progress'. The latter has often been linked to the overall goal of economic growth, generally measured by changes in Gross National Product. A considerable amount of money has been invested by organisations and governments in funding infrastructures that lead to development under this model, and the exploitation of natural resources has often been an integral part of development planning (Adams 1998).

Within the same time period during which these models of development came to the fore, enormous changes in human populations have occurred. The total human population has risen to nearly six billion, and demographic forecasts suggest it will continue to rise during the 21st century, with the potential to reach over ten billion by 2052 (Jeffries 1997). Although many of the social and economic changes occurring in the 20th Century have benefitted some individuals, poverty still affects a large proportion of the human population. There are currently eight hundred million people who are classified as malnourished, and two billion people who do not have access to adequate sanitation (Watson 1999). More than one billion people do not have access to safe and seasonally constant supplies of water, and this leads to two million child deaths every year. The 20th Century also saw accelerating rates of urbanisation in many parts of the world. In 1970, there were about 190 cities with a population of over a million, but by 1999 there were over 400 of this size. Agriculture has also undergone enormous changes. Farming methods have become industrialised and intensified, and the conversion of ecological systems into agricultural land has been a common practise across the globe. When measured together, urban and agricultural areas now impact three quarters of the world's habitable surface (Hannah *et al.* 1994).

The effects of change on wetlands

Not surprisingly, the changes described above have put the natural environment under increasing pressure. A range of human activities now pose potential threats to wetlands and their biodiversity (**Table 1**), and operate at a variety of levels and scales (**Table 2**). Unfortunately, assessing and quantifying the extent, rate and nature of habitat changes resulting from anthropogenic impacts remains a difficult task at almost any spatial or temporal scale. The collation and provision of an accessible inventory for different species and bio-types will be one of the greatest challenges for conservationists in the 21st Century (Finlayson & Davidson 2000). The inventory data that are available, paint a bleak picture, and for global wetlands, it has been estimated that since 1900 approximately 50% of inland sites have been lost (this figure would be greater if coastal wetlands were included) (Dugan 1993; OECD 1996). The principal cause of this loss has been the conversion of wetlands to agricultural systems, a process that is continuing and accelerating in many regions, particularly Africa, Asia and the neo-tropics. In Europe, 65% of sites identified by *Birdlife International* as Important Bird Areas (IBAs) are affected by agriculture (Heath & Evans 2000). Of the 3619 IBAs listed, 69% contain wetland habitats, and 42% are considered as being under 'high impact' threat.

Wetland inventories are lacking for most regions, but by using the data that are available, Spiers (2000) collated a range of examples of wetland loss and degradation from around the world (summarised with additional references in **Table 3**). Alarming as these examples are, they tell only a small part of the story, because the commonly referenced figures for habitat loss often relate to 'flagship' sites where large scale changes have been adequately documented. However, the cumulative loss of smaller wetland areas across the globe probably represents an equally large total loss of wetland habitat. In all of the literature relating to the loss and degradation of wetlands and their biodiversity, there are three common themes that describe the problems for the conservation community:

1. A lack of quantitative data for wetland loss or degradation from most regions of the world,

Table 1. Human activities and associated potential threats to wetlands and their biodiversity (adapted from Williams 1993 and Vives 1996). The threats are categorised by five types of effects that each activity can produce (see footnote).

		WA	WR	WQ	UE	AS
Water use	Abstraction	*	*			
	Diversion	*	*			*
	Channelisation	*	*			
	Impoundment	*	*	*		*
	Flood defences	*	*			
Agriculture fisheries & forestry	Reclamation	*	*		*	
	Drainage	*	*			
	Abstraction	*	*			
	Diversion	*	*			
	Channelisation	*	*			
	Toxic chemicals			*		
	Organic inputs			*		
	Nutrient inputs			*		
	Atmospheric deposition			*		
	Use of non-native species			*		*
	Harvest of natural resources				*	
	Coastal defences	*	*			
Industry	Reclamation	*	*			
	Atmospheric deposition			*		
	Chemical deposition			*		
	Disturbance	*				
	Coastal defences	*	*			
Urbanisation	Reclamation	*	*		*	
	Atmospheric deposition			*		
	Abstraction	*	*			
	Nutrient inputs			*		
	Effluent inputs			*		
	Chemical deposition			*		
	Waste	*	*	*		
	Disturbance	*				
	Non-native species			*		*
	Coastal defences	*	*			
Mining	Reclamation	*	*		*	
	Drainage	*	*			
	Chemical deposition			*		
Recreation	Water sports	*		*		
	Hunting			*	*	*
Others	Peat removal	*	*	*	*	
	Aquaculture	*		*		*

WA = changes in wetland area; WR = changes in water regime; WQ = changes in water quality; UE = unsustainable exploitation; AS = introduction of alien species.

Table 2. The range of impact levels and scales associated with potential effects of human activities on wetlands and wetland biodiversity.

Spatial scale	Site → local → regional → national → international → global
Temporal Scale	Discrete event Short → long term Slow → rapid
Severity	Slight → moderate → substantial → severe → extreme
Type	Changes to numbers of individuals at site → in population Changes to species diversity → community composition Changes to hydrology, chemistry and ecosystem function Changes species' range Changes species' behaviour Changes to habitat diversity Habitat fragmentation Habitat or species loss

2. A continued loss of wetlands, and in some areas an accelerating loss,

3. A need for greater capacity to develop sustainable strategies to halt wetland losses while incorporating the needs of local people.

This latter feature will be further discussed later in this paper.

The effects of change on waterbirds

The loss and degradation of wetlands across the globe has had a major effect on the bird species that utilise these systems for all or part of their life cycle. Considering the Anseriformes (ducks, geese, swans and screamers) as an example of the broader picture, it is known that 12 species or subspecies have become extinct since 1600. Of the 228 extant species or subspecies, 19% are currently threatened with extinction to some degree (i.e. are considered by the IUCN Red List to be Critically Endangered, Endangered, or Vulnerable), and a further 8% are listed as Near-Threatened (Green 1996; BirdLife International 2000). Within these categories, different threats affect different proportions of species and subspecies (**Table 4**). The primary threat is from loss or degradation of habitat which affects 84% of the listed groups, followed by unsustainable hunting (64%) and the effects of introduced species (31%). Of course there are waterbird species where available population data suggest that they are stable or increasing, and indeed some have become numerous enough to be considered pests. Nevertheless, given the current pressures on wetlands in many parts of the world, some caution should be employed in assuming that these species are 'safe' or not of conservation concern. A more historical perspective is often needed when assessing the conservation status of species, and the maintenance of current abundance must also be seen as an important conservation objective running

Table 3. Examples of wetland loss and degradation in different regions of the world.

Africa	● Ghana: several major rivers being polluted by domestic & municipal waste, agrochemicals and mining discharges. ● Lake Chad: up to 30% choking by aquatic weeds. ● South Africa: 90% and 58% of wetlands resources lost from Tugela and Mfolozi basins. ● Tunisia: 84% loss of wetlands from Merjerdah catchment.	Denny 1985 Dugan 1993 Gopal & Wetzel 1995 Taylor *et al.* 1995 Moser *et al.* 1996 Spiers 2000
Asia	● Bangladesh: 3.7 million hectares of wetlands threatened by diversion of water in India. ● Indonesia: 37 million hectares (31%) of mangrove habitat lost. ● Japan: almost all rivers affected by impoundment for reservoirs and eutrophication. ● Malaysia: currently 1% of mangrove habitat lost per annum (considered conservative estimate). ● Vietnam: 1.7 million hectares of Red River flood plains lost.	Mori *et al.* 1984 Scott 1993 Gopel & Wetzel 1995 Spalding *et al.* 1997 Spiers 2000
Europe	● Britain: 84% of lowland raised bog lost. ● Finland: 5.5 million hectares of mires drained and 4 million tonnes of fuel peat extracted. ● Norway: 40% of lakes showing signs of severe acidification. ● Poland: 1.4 million hectares of mires have been exploited and degraded.	Aselmann & Crutzen 1989 Williams 1990 Dugan 1993 Spiers 2000
Middle East	● Iraq: 3 million hectares of Al Huweizah marshes seriously affected by drainage. ● Israel: almost all natural freshwater wetlands drained for agriculture. ● Lebanon: almost all natural freshwater wetlands drained for agriculture. ● Syria: almost all natural freshwater wetlands drained for agriculture.	Dugan 1993 INC 1998 Spiers 2000
North America	● Canada: utilisation of northwest wetlands rapidly expanding since 1980s. ● Mexico: 35% of original wetland area lost. ● USA: 54% of original wetlands lost, with 80% of these known to have been as a result of agriculture.	Dugan 1993 Moser *et al.* 1996 Spiers 2000
Neo-tropics	● East Caribbean: 50% of 220 coastal wetlands damaged. ● Columbia: 80% of mangrove wetlands lost in Magdalena delta.	Bacon 1993 Moser *et al.* 1996 Spiers 2000
Oceania	● Australia: up to half of the continent's wetlands lost since European settlement. ● New Zealand: 90% of wetlands lost since European settlement. ● Tonga: many areas of mangrove already lost and all other significant sites allocated for clearance.	Ellison 1994 Moser *et al.* 1996 Spiers 2000

in parallel with conservation efforts to save species in imminent danger (Avery *et al.* 1994; Gibbons *et al.* 1996).

Conservation responses to change

Just as 'development' is difficult to define, encapsulating what constitutes conservation is equally difficult. Although the external perception of conservation may be of a community of organisations with a common set of goals, actions, and ideals, conservation has always been a dynamic movement and had to evolve in response to the demands of a changing world. As human populations, technology, agricultural practices and social orders changed dramatically during the 20th Century, there was a need to adapt and extend established conservation methodologies. For example, the establishment of national parks in many parts of the world up to the 1970s was intended to protect areas of wilderness and the biota they contained. By the 1980s, it became clear that conflicts were arising regularly between the interests and rights of local people and the conservation objectives of organisations involved in steering park policies. It was quickly recognised that gaining the consent of governments to designate national parks was only the first stage, and that local consent, understanding and integration were also needed (Blower 1984; Cartright 1991; Kemf 1993; Gichuki 2000). Since the 1970s, changes to conservation philosophy and practise have resulted in a general movement away from a 'fortress conservation' stance, towards an arena in which conservationists have embraced economic, political and social issues.

This more integrationist approach has included the idea that a country's development could be achieved without compromising its conservation objectives, a notion that has subsequently pervaded international programmes and strategies relating to biodiversity conservation (Adams 1998). This type of philosophy was also a fundamental premise of the United Nations Conference on Environment and Development (more widely referred to as

Table 4. The number of Anseriform species and subspecies listed by the IUCN as Critically Endangered, Endangered and Vulnerable, that are affected by particular types of human induced threats (calculated from information presented in Green 1996 and BirdLife International 2000).

	Criticially Endangered n = 7	Endangered n = 16	Vulnerable n = 22	Total n = 45
Habitat loss or degradation	5	13	20	38 (84%)
Unsustainable hunting	5	9	15	29 (64%)
Non-native species	1	9	4	14 (31%)
Physical hazards	1	2	2	5 (11%)
Disturbance	0	4	3	7 (16%)
Persecution	0	0	2	2 (4%)

the Earth Summit) in Rio in 1992. Article 1 of the Convention on Biological Diversity (CBD) that arose from the Earth Summit encapsulates these ideas. Signatories agree to: "... the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits". However, the CBD also recognises that the conservation of biodiversity has to be integrated into social and economic policy, not just conservation strategies. On the surface at least, during the 1990s many governments committed themselves gradually to achieving growth and development in order to tackle poverty, but to do so through the sustainable use of resources while meeting the basic needs of individuals and communities. But achieving this will be a difficult social and political balancing act. The need to integrate ecological principles within social, economic and development planning is largely accepted in principle, but this integration will of course take considerable time and effort, and many wetland species and habitats will continue to be lost and endangered during this time. For many conservation and research organisations, it will be difficult therefore to become involved in wider topics and yet remain effective in delivering their immediate conservation objectives.

The Earth Summit provides a good example of the problems that occur when conservation, development, politics, economics and social issues meet at a global scale. The 'Rio Declaration' that resulted from the summit was intended to be a powerful and binding 'Earth Charter' that would be a turning point in global history. However, in the end it became what many consider a compromise of self-interest between the industrialised and non-industrialised nations, where some of the key participants interpreted conservation and development goals for their own purposes. Holmberg *et al.* (1993), go so far as to claim that the Rio Declaration ended up as a "... bland declaration that provides something for everybody". This may be a rather too bleak assessment, and the CBD was certainly a huge leap forward in thinking, but developing CBD ideals into effective action at all scales, remains an enormous challenge.

In line with other areas of conservation, wetlands have also benefitted from a global multilateral agreement. In 1971, The Convention on Wetlands of International Importance Particularly as Waterfowl Habitat was created in Ramsar, Iran. The Ramsar Convention as it is commonly known, has subsequently been joined by 118 countries, and has played a vital role in protecting wetlands around the globe. The convention commits signatory nations to:

(a) designate important wetlands,
(b) include wetland conservation within national land-use planning,
(c) promote training in wetland research, management and wardening, and
(d) consult with other countries on trans-boundary wetland issues.

However, during its 30 years, the Ramsar Convention has also had to adapt to new pressures exerted on wetlands by a changing world. As well as the Convention's involvement with site designation and higher level technical issues (e.g. the wise use guidelines), it now embraces a much broader view of wetland conservation. In particular, it seeks to implement action at all scales (local to global), and seeks to place key wetland conservation issues within a framework of 'Integrated Water Resource Management' at these different scales (Pirot 2000). This change represents a recognition that conservation must be integrated with social and economic issues, and that achieving sustainable planning and development frameworks are inseparable from the long-term aim of protecting wetlands and waterbirds from threats.

Information & assumptions

The described changes in global social and economic circumstances have resulted in a dynamic interplay between conservation problems and their solutions. If current predictions for changes in human population and global climates prove to be accurate, conservationists will have to maintain the current flexibility of their strategies and engage ever more deeply with the idea of integrated solutions to environmental problems. However, even during its periods of greatest evolution, the one thing that hasn't changed within conservation is the need for baseline information and scientific methodologies. Unfortunately, information often takes time to deliver in a robust and defendable format, and takes even longer to be assimilated within social and economic practise. As a result, conservationists are often in a position of playing information 'catch-up'. A far reaching example of this concerns the term 'sustainability', which is now considered widely as the ideal vehicle for integration between conservation and development. However, saying that a natural resource is being utilised sustainably is based on two fundamental assumptions about information. First, it assumes there is knowledge of the range of effects of using a particular resource, and second, it assumes that there is knowledge of the optimal needs of the biological components of the resource that humans wish to utilise. There can be few examples where this knowledge has been based on research prior to exploitation, and all subsequent research and conservation is therefore based on systems that are already impaired.

Another example of information catch-up, concerns Article 3.2 of the Ramsar Convention. This states that "Each contracting party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the list has changed, is changing or is likely to change as a result of technological developments, pollution, or other human interference". On the surface, this is a straightforward and essential aim. However, this requirement on contracting parties makes six fundamental assumptions about information and research:

1. It assumes that adequate inventory, assessment, monitoring and surveillance are in place for species and ecosystems (see next section).

2. It assumes that methods have been developed that allow change to be detected when it occurs, and that this can be achieved at species, population and ecosystem levels.

3. It assumes an ability to measure the magnitude of change arising from different influences on species and ecosystems.

4. It assumes an ability to identify which activity has caused a change once it has been detected and measured.

5. It assumes an understanding of the full suite of consequences of a particular change at all spatial and temporal scales.

6. It assumes that there is knowledge of

what action should be taken to halt, reverse or mitigate for the change that has taken place, and to build long-term protection into the social and economic system.

For many of the contracting parties to Ramsar, meeting these assumptions simply will not be possible at the moment. Conservationists and politicians working in the international field, are of course well aware of the limitations associated with international agreements, as well as the tremendous benefits. However, these problems are also challenges for the conservation research community to engage, and some of the salient research issues are described in the next section.

Research needs

Given the assumptions identified as underlying many conservation actions, which areas require more research to provide information for the conservation of waterbirds and wetlands, while providing solutions within the context of social and economic development? There are six broad categories where research is needed:

(1) Inventory

Inventory can be defined as the collection and/or collation of core information for habitat and species management, and to inform the assessment, monitoring and surveillance (described in the next sections) within a prescribed geographical area (Dugan 1990; Finlayson 1996). Despite universal acknowledgement of the need for inventories, and repeated calls at all levels for their development, they are still not available for most wetland types in most parts of the world. In an investigation of the state of wetland inventories around the world, Finlayson & Davidson (2000) state that out of 206 countries assessed, 7% had adequate or good inventories, 69% had only partial coverage, and 24% had little or no inventory data. Where wetland inventories have been attempted, the major problems have been that information has not been collected, collated or formatted to a common standard, and the quality of data has not been assessed.

Additionally, data are often held by different organisations and are therefore inaccessible to wider audiences. What is required is research into methods to produce a centralised inventory that allows data to be accessed, visualised, queried and manipulated. The system will also need the capacity to allow updating of information linked directly to a conservation 'framework' of assessment, monitoring and surveillance. Recent advances in Geographical Information Systems (GIS) technology provide an ample suite of tools for generating this type of inventory and for addressing issues of centralisation and access. This is, of course, a major undertaking and will require a research-based approach in its development. However, the gains for so many different areas of wetland and waterbird conservation from such work would be many and far reaching. It is surprising that given recent technological advances, it is still not possible to accurately assess the total global resource of wetlands or measure how this has changed in the last century. Future generations will not thank us if this situation is not remedied.

(2) Assessment

Assessment involves two major themes: (a) identifying the status of the different biotic and abiotic components within wetlands, and (b) assessing the nature, distribution, causes and consequences of different threats to wetlands and waterbirds. Assessment can take place at a variety of levels (species, communities, populations, ecosystems), and at a variety of spatial scales (individual sites, regions, national, total global resource). For many waterbird species, their status with respect to total population size and key sites are already well known, and tested methodologies for this part of the assessment process are available. More work is required on how to assess the status and distribution of wetland habitats and to assimilate these cost-effectively into inventories. Choosing appropriate scales for assessment underlying inventory (i.e. scales that are cost-effective to assimilate and maintain, and that are also biologically meaningful) will also be an important element of this research. Scientific methods also need to be developed for quantitatively assessing the relative impact and distribution of the different threats, while linking this to an understanding of whether the impact is on species distribution and diversity, or on ecosystem function. Importantly, these types of assessment, stored within a GIS based inventory, will also provide vital information on gaps in monitoring and surveillance activities.

(3) Monitoring & surveillance

Fundamental to developing conservation strategies to protect wetland and waterbirds from anthropogenic threats, is the provision of data on the numbers and distribution of species and habitats. The terms monitoring and surveillance are often used interchangeably to describe schemes that attempt to provide this information (Wetlands International 1998; Finlayson & Davidson 2000). Strictly speaking, monitoring is defined as the collection of data in response to hypotheses about a particular species or habitat that has been derived from previous assessment activities. Surveillance is not hypothesis driven, but involves the collection of time series data for species and sites. Monitoring and surveillance data therefore provide quantitative and qualitative information about natural resources, often based on serial sub-sampling of an appropriate proportion of the total resource and tracking changes with time. An extensive body of research has been undertaken to establish sophisticated and robust methods for sub-sampling and for analysing trends in data collected over long time periods. However, much of this work has been developed in just a few countries and research is needed on how to sample waterbirds and wetlands over larger spatial scales, and in areas where access may be difficult or limited. In relation to threats, perhaps the biggest challenge will be to link the demographic and distributional changes derived from analyses of species/habitat monitoring and surveillance data, to human-induced changes in the environment. In other words, how do populations respond to changes resulting from agriculture, urbanisation, industrial activities *etc.*? This type of 'causation' research would benefit directly from a wetland inventory in which environmental assessment information (including threats) is integrated with population data from monitoring and surveillance.

In the immediate future, the broad challenge for the conservation community will be to develop systems that allow assessment, monitoring and surveillance data to be input and assimilated within a single, accessible, and multi-functional wetland inventory. This will require collaborative input from different organisations that currently collect and collate wetland information, and necessitate an integrated conservation 'framework', with relevant schemes feeding directly into a centralised information base (Baillie 1990; Kershaw & Mitchell 1999; Robinson *et al.* 1999). Only when this is achieved will countries be able to monitor threats to wetlands and waterbirds in a manner that resembles the process that they have signed up to as part of Ramsar article cited earlier.

(4) Human problems & solutions

Since the 1980s, conservation has changed from a 'fences and fines' approach to a more social integrationist stance. During this period, social and economic scientists have researched the needs of people in relation to resource use and conservation action (Zube & Busch 1990; Kempf 1993; Hill & Press 1994; McNeeley 1996). The conclusion of this work is starkly but pragmatically summed up by Adams & McShane (1992) who claimed that conservationists will either contribute to the problems of the rural and urban communities, or the biota they seek to conserve will die out. Much of the research in this area relates to the management of 'reserve' areas, but is also applicable to most other areas of conservation action. McNeeley (1996) identified ten principles establishing partnerships between conservation objectives and people's needs (**Table 5**). These ideas are now firmly established in conservation practice, although some caution has been urged in assuming that local involvement alone can actually deliver the goal of sustainable development more effectively than centralised controls on resource use (Murphree 1994; Wetsern & Wright 1994). A few have gone further than this, and explicitly challenged the current paradigm of sustainable development. Prins (1992) states polemically that "... we are closing our eyes if we think that allowing people to invade protected areas can result in a harmonious relation between them, their livestock and cattle". Despite this view, the overall weight of opinion seems to be that the concept of harnessing local involvement is the way forward. However, conservation projects based on the 'what to do' model (**Table 5**), must also focus on the how to go about it' aspects. In other words understanding that the needs of people in relation to wetland resources is of course important, but is only the first part of a longer process. Without developing local capacity and skills, or ensuring that people's insights and attitudes are harmonised with conservation objectives, the implementation of projects, initiatives and policies will ultimately fail even if they have adopted the elements outlined in **Table 5**. More projects that specifically encourage joint solution oriented research between ecologists and social scientists are needed to allow the input of useful insights from both disciplines. Finding generic themes within this research agenda may well prove a difficult task, as so many issues are specific to local areas. However, if the conservation community is serious about really trying to reduce and eliminate threats to wetlands and waterbirds in conjunction with the idea of sustainable development, such research must be encouraged.

(5) Habitat creation

Anthropogenic activities that lead to the loss or degradation of wetlands and their biodiversity, are being tackled by conservationists on a broad front, and

Table 5. Ten principles for establishing partnerships between conservation objectives and the basic needs of local people (from McNeeley 1996).

1	Provide benefits to local people
2	Meet local needs
3	Plan holistically
4	Plan protected areas as a system
5	Plan site management individually, with linkages to the system
6	Define objectives for management
7	Manage adaptively
8	Foster scientific research
9	Form networks of supporting institutions
10	Build public support

creating new areas of a particular habitat has recently received more attention (Merritt 1994; Sutherland & Hill 1994). Some habitats are more amenable to creation projects than others. Wetlands certainly present a number of challenges in this respect. Digging a hole in the ground and filling it with water may create wetland, but it does not create a diverse, self-sustaining and functioning wetland. The long term results from developed creation methods are still being tested, and much fruitful research remains to be done in this area (Rackham 1998). The use of habitat creation as part of a 'no net loss' policy (*i.e.* the creation of habitats to mitigate for loss) also requires some testing of the fundamental assumption that the biodiversity of created wetlands does actually replace the 'natural' (or relatively unimpaired) sites.

(6) Evaluating conservation strategies

The range of activities undertaken by the conservation community, are often formulated by common consent or by experts in particular fields. However, this should not mean that the efficacy of conservation action and advice are not evaluated periodically. An example of this type of research might be testing the effects of designating sites as Special Protection Areas (SPAs), by looking at species, communities and habitats before and after designation and at a variety of spatial scales. There are many other examples where monitoring and surveillance data are now adequate to allow this type of research, and to provide invaluable feed-back for the conservation process.

Conclusion

In writing a paper on research needs in relation to threats to wetland biodiversity, it is extremely difficult not to err towards a rather 'doom and gloom' view of the world. Outlining the salient problems often overshadows the positive side of contemporary conservation and the changes that have occurred in attitudes to the biosphere in most parts of the world. Nevertheless, few commentators doubt that pressures on the biosphere are likely to increase during the 21st Century, and for conservation scientists there are three key challenges arising from the present suite of anthropogenic threats affecting waterbirds and wetlands. First, there is a need to have robust scientific methods in place that allow the input of assessment, monitoring and surveillance data into a centralised and accessible inventory of the total resource. Second, research is needed that enables the detection and measurement of environmental change arising from human activities, and to understand the causes and consequences of that change. In many ways, given sufficient resources, research of this nature is often the relatively easy part of the conservation process. The third and perhaps most difficult challenge for conservation researchers, is going to be in providing information that is solution-oriented, and that can be assimilated into the social and economic agenda of a world that continues to undergo rapid change.

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