DEVELOPING NEW BIODIVERSITY CONSERVATION STRATEGIES IN RESPONSE TO GLOBAL CHANGE

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INTRODUCTION

As numerous reports and assessments have indicated, the world is having to face up to challenging problems in conserving biological diversity in the face of increasing habitat loss, fragmentation or simplication, overexploitation of resources, and threats from alien invasive organisms, all of which have led to the widespread loss of genes, populations and species. In the last few years the situation has been exacerbated by the growing acceptance of the likely effects of global change – demographic, disturbance regimes and climatic – on species, populations, ecosystems and ecosystem functioning. Although the details of global change will be worked out over the coming decades, it is already clear that out existing conservation policies and planning are not likely to be able to meet these new challenges and that novel conservation strategies will be required. These include: possible institutional changes at national and international level; more effective implementation of existing commitments/agreements; more effective application and scaling up of existing approaches; application of new techniques such as the use of complementarity techniques in reserve selection, measures for assessing the effectiveness of reserves, methods for predicting species' distributions and patterns of richnesss, incorporation of phylogenetic and molecular methods into conservation assessment and use of DNA bar-coding in identifying populations at risk, applications of spatial analysis and phylogeographic methods for a better understanding of diversity patterns and of what to conserve, application of biodiversity informatics, novel methods for asessing extinction risks, and predicting the likely impacts of invasive species and for monitoring and controlling them. In addition, priority determining mechanisms need to be revisited, the currently fashionable application of goals and targets needs critical evaluation, the desirability and feasibility of conserving cultural landscapes, and better methods are needed to measure the economics and cost-effectiveness of different conservation approaches.

BIODIVERSITY CONSERVATION – THE CRISIS DEEPENS

We have been aware for some decades of the crisis facing biological diversity, largely as a result of human action such as the degradation, simplification, fragmentation or loss of habitats through deforestation, logging, unsustainable shifting cultivation, extensification of agriculture, draining,of wetlands, industrialization, road building, tourist developments; the impacts of alien invasive species on native ecosystems and species' populations; and overexploitation of plant and animal resources such as unsustainable fishing, excessive consumption of fuel wood, overharvesting of medicinal plants (Heywood 2006). This led in 2002 to an international commitment at the UN World Summit on Sustainable Development for significantly reducing the loss of biodiversity by 2010 (paragraph 42 in the Plan of Implementation). Albeit vague, this is essentially the same target that was agreed in the Convention on

Biological Diversity in Decision VI/26 of the Conference of the Parties: 'Parties commit themselves to a more effective and coherent implementation of the three objectives of the Convention, to achieve by 2010 a significant reduction in the current rate of loss of biodiversity at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth'. This was later developed in 2003 as '2010 – The Global Biodiversity Challenge'**,** convened by the CBD Secretariat, aimed at articulating a framework of actions to address the 2010 target.

While politicians and conservationists have been digesting the implications of the 2010 target, and how to make significant progress to achieving it, growing understanding of the probable consequences of global change, and in particular climate change, has wrongfooted the conservation community. The tipping point, perhaps, was the publication of a series of reports the Stern Review on the Economics of Climate Change (Stern 2007), the IPCC Reports (IPCC 2007) and 'Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable' (2007) which together with other findings in the literature combined to present a picture of large, serious and damaging climatic impacts on our way of life and on biodiversity in the short, medium and long term. While there had been widespread acceptance of the main thrust of these reports and their implications for biodiversity, they have also faced a barrage of criticism but even so, I would argue that these documents have plunged biodiversity conservation into an even deeper crisis which calls for a rethink of our current planning and strategies.

Current conservation strategies are based on the assumption that we live in a dynamic but slowly changing world. Such an assumption has to be reconsidered in the light of the rapid rate of change now confidently predicted over the coming decades in the light of the latest IPCC and other reports. We need therefore to update existing conservation strategies and approaches and devise new technologies to meet this new situation and it is clear that some of the targets that have been set recently will have to be revisited. It should be made clear that global change, as discussed below, comprises not only climatic factors but others such as demographic about which there can be little debate as to their reality or extent. As Steffen & al. (2004) indicate, 'Global change is much more than climate change. It is real, it is happening now and it is accelerating'.

Major developments in conservation policy and strategies over the past 30 years

Conservation policy and planning has made major advances in the past three decades and some of the established approaches such as protected areas have been the subject of major developments while others such as *ex situ* conservation by botanic gardens have undergone a major reassessment, as discussed below.

Protected Areas

The main policy thrust in conservation has been the maintenance of biological diversity *in situ*, through development of protected area systems across the world, described as the cornerstone of international conservation policy (Roe & Hollands 2004). This has been accepted almost without criticism and is enshrined in the Convention on Biological Diversity in Article 8 (in situ conservation). The target of

10% coverage of each biome by the year 2000 which was set in 1992 at the 4th World Congress on National Parks and Protected Areas, is an arbitrary "back of the envelope" calculation and has been severely criticized (Soulé & Sanjayan 1998) who state that it is effectively a prescription for reducing species richness by half or more through being interpreted as a ceiling rather than as a floor.

The world's protected areas system has in fact expanded over the past 40 years from 2.4 to 118.8 km^2 and today there are now some 100,000 areas covering c. 13% of the terrestrial surface. The size of the protected area system is not, however, in itself not a satisfactory criterion and can be misleading. For example, many protected areas systems do a poor job of covering all appropriate critical habitats and their associated endemic taxa (e.g. Bergl & al. 2006). As the CBD website notes, there are substantial differences in coverage between different biomes, ecosystems and habitats. Only 5% of the world's temperate needle-leaf forests and woodlands, 4.4% of temperate grasslands and 2.2% of lake systems are protected. Furthermore, marine coverage lags far behind terrestrial coverage, with approximately 0.6% of the ocean's surface area and about 1.4% of the coastal shelf areas protected. A more detailed analysis of the 825 terrestrial ecoregions and 64 large marine ecosystems shows that for a large percentage of these ecosystems, which are characterized by distinct populations of species, the target of 10% protected area coverage is yet to be achieved A study of the global expansion of the protected area system between 1980 and 2000 revealed that various local and national factors combined with globalization processes to impact the extent, type, and location of protected-area designations, led to the creation and reinforcement of marked spatial differences (rather than tendencies toward worldwide evenness or homogenization) in the course of this expansion (Zimmerer & al. 2004).

A series of papers have recently addressed the issue of whether the global protected area system is enough and indeed what enough means (e.g. Brooks & al. 2004; Tear & al. 2005; Gorenflo & Brandon 2006) and all agree that the present system needs both expanding selectively, using gap analysis techniques and in a way that enhances its coverage of biomes, ecosystems and clusters of species.

Simply designating a site as a protected area does not of course ensure that the ecosystems contained within it will be adequately conserved, let alone the species and populations (see below). Protected areas around the world differ greatly with respect to the ways in which they are managed, and the effectiveness of these management techniques. A report commissioned by the World Bank/World Wildlife Fund (WWF) Alliance and carried out by IUCN revealed that less than one quarter of declared national parks, wildlife refuges, and other protected areas in ten key forested countries were well managed, and many had no management at all. This means that only 1% of these areas is secure from serious threats such as human settlement, agriculture, logging, hunting, mining, pollution, war, and tourism, among other pressures. WWF has developed a Rapid Assessment and Prioritization of Protected Areas Management (RAPPAM) methodology which provides protected areas agencies with a country-wide overview of the effectiveness of protected area management, threats, vulnerabilities and degradation (Ervin 2003). The Alliance has developed a simple site-level tracking tool to facilitate reporting on management effectiveness of protected areas within WWF and World Bank projects (Stolten & al. 2003) and this is being applied in several countries.

A major change in attitude to protected areas over the past 10–20 years has been a shift towards people-centred conservation, with an emphasis on local empowerment, people participation, democratization, and devolution of power (Naughton-Treves & al.2005). Although this has been reflected in the social and economic agenda for protected areas, much of it still remains rhetoric and there are serious issues to be addressed about the effectiveness of such approaches in practice (see review by Naughton-Treves & al. 2005).

Focus on the *quantity* of area protected needs to be balanced with increased attention towards *quality* (Roe & Hollands 2004) – both of biodiversity and of governance. Indeed it must give some cause for concern that despite this dramatic increase in the key indicator of biodiversity conservation, loss of biodiversity has continued unabated. There are many reasons for this. For one thing, the present protected area system is seriously inadequate in representing biodiversity at the level of species (Rodriques & al. 2004b) and it is loss of species that is often reported, but even if adequate coverage at species level were to be achieved, there is a mistaken but commonly held assumption that protected areas are effective in protecting the species that they house without further action. There seems to be a widespread belief that a hands off approach to protected area management will somehow allow the species housed within them to survive. While this is no doubt true for widespread species not facing any imminent threats, for many species some form of monitoring or management intervention will be needed if viable populations are to survive (Heywood & Dulloo 2005). A study by Deguise & Kerr (2006) of protected areas and prospects for species conservation in Canada found that the extent of protected area and density of species at risk were unrelated at either broad (countrywide) or finer spatial scales (50 × 50 km grids). They conclude that ‘although reserves will play a

useful role in conserving endangered species that occur within them, reducing extinction rates in a region with much of the world’s remaining wilderness will require integrating conservation strategies with agricultural and urban land-use plans outside formally protected areas’.

Gorenflo & Brandon (2006) note that reliance on protected areas such areas for conservation requires that the global network of protected areas cover all species requiring protection and provide conditions necessary for their longterm survival. Likewise, Larsen & al. (2006) regard ‘the in situ conservation of viable populations in natural ecosystems as constituting a cornerstone in the effort to fulfill the 2010 goal’ of a significant reduction in the current rate of loss of biodiversity. These aims are seldom spelled out or fulfilled in practice. Clause (d) of Article 8 of the Convention on Biological Diversity reads : ‘Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings’. In fact, little attention has been directed to the ‘the maintenance of viable populations’, and it seems to have been conveniently overlooked both by the Convention in subsequent decisions and work programmes and by those working with protected areas. The *in situ* conservation of target species in protected areas seldom enters into the management plan or concerns of the area, unless it is the principal motivation for setting up the area, as in the case of game reserves or those set up for the conservation of crop wild relatives or orchids, for example. In fact the only substantial investment in conservation of species *in* *situ* has hitherto been for rare and endangered/Red List species conservation in the form of recovery plans (Heywood & Dulloo 2005).

This goes to the very heart of the longstanding debate between the proponents of a species-based approach and those who espouse an ecosystem/area-based approach to conservation. There has been a tendency to dichotomize nature into species and ecosystems (Soulé & Mills 1992). Thus, ecosystem conservation is usually equated with *in situ* and protected areas while species conservation is regarded as meaning *ex situ* and associated with botanic gardens and seed banks (except of course when dealing with recovery programmes) and associated with Red Listing of threatened species., and conservation genetics, because it is a species- or population-based approach has in turn been deemed guilty by association with species chauvinists. The Convention of Biological Diversity makes it clear that *ex situ* conservation is subsidiary to in situ-conservation and 'predominantly for the purpose of complementing *in-situ* measures'. The rationale for this is presumably that *in situ* conservation allows the components to continue to develop and evolve while *ex situ* conservation is an essentially static approach.

A surely unintended consequence of this dichotomy is that *ex situ* conservation has not been taken seriously by the conservation community until recently although it has been the mainstay of genetic resource conservation by the agricultural sector for the last 50 years. It is worth noting in passing that until very recently, *in situ* conservation for the agricultural genetic resources community meant on-farm conservation of traditional landraces.

Despite their shortcomings, protected areas undoubtedly play a critical role in biodiversity conservation but there are other important fields in which practical conservationists and managers are engaged such as dealing with invasive species, habitat restoration and managing and monitoring threatened species. Moreover, we need to remind ourselves that the greater part of biodiversity occurs outside protected areas and as discussed below much greater attention needs to be focused on how to tackle this problem.

Identification of centres of biological diversity

Given that funding for biological conservation is limited, much attention has been focused on priority determining mechanisms so as to target those areas where maxiumum return can be obtained from the investment of scarce resources. Prominent amongst these have been various projects to identify centres of diversity or biodiversity hotspots. These are mainly identified on the basis of concentrations of endemic species in areas which have already suffered habitat loss and are still under threat. In the Centres of Plant Diversity project (Davis & al.), the citeria adopted for the selection of sites and vegetation types was based principally on a requirement that each must have one or both of the following two characteristics:

(1) the area is evidently species-rich, even though the number of species present may not be accurately known;

(2) the area is known to contain a large number of species endemic to it.

The following characteristics were also considered in the selection:

- the site contains an important genepool of plants of value to humans or that are potentially useful;
- the site contains a diverse range of habitat types; the site contains a significant proportion of species adapted to special edaphic conditions; and,
- the site is threatened or under imminent threat of large-scale devastation.

The close association of EBAs and CPDs reinforces the validity of mapping biodiversity hotspots, at least with respect to endemism. According to BirdLife International, 70 percent of CPDs overlap in some way with EBAs, and 60 percent of EBAs overlap with CPDs. However, some significant sites do not show any overlap, and both studies stress the limitations of using selected species, or collections of species, as proxy indicators of overall biodiversity.

Likewise plant diversity is the biological basis for hotspot designation ; to qualify as a hotspot, a region must support 1,500 endemic plant species, 0.5 percent of the global total. Existing primary vegetation is the basis for assessing human impact in a region; to qualify as a hotspot, a region must have lost more than 70 percent of its original habitat.

An updated analysis of hotspots (Mittermeier 2004) revealed the existence of 34 biodiversity hotspots, each holding at least 1,500 endemic plant species, and having lost at least 70 percent of its original habitat extent. Overall, the 34 hotspots once covered 15.7 percent of the Earth's land surface. In all, 86 percent of the hotspots' habitat has already been destroyed, such that the intact remnants of the hotspots now cover only 2.3 percent of the Earth's land surface.

The hotspots or centres of diversity approach has been severely criticized on various grounds. Brummitt & Lughada (2003), for example, point out that:

(1) Reliable quantitative data are generally only available for the most conspicuous and popular groups of organisms (vascular plants, vertebrates), which are by no means the most speciose.

(2) Without a measure of complementarity between hotspots there is no way of knowing how many species are also conserved in adjacent hotspots. The application of complementarity techniques for reserve selection techniques so as to achieve maximum representation of biodiversity within minimum land area is widely advocated (Pressey & al., 1993; Margules & al. 1988; Justus & Sarkar 2002) .

They are not without their critics. For one thing, they are dependenton precise,accurate, high quality data, far in excess of what most reserve managers dispose of or could reasonably expect to obtain Prendergast *et al* (1999). Moroever, these techniques do not necessarily ensure the long-term maintenance of biodiversity as they often ignore the maintenance of natural processes, turnover of feature diversity and the need to minimise threats within conservation areas (Reyers & al. 2002).

(3) Simply conserving maximum species numbers is not the same as conserving maximum species diversity, because distantly related taxa are worth more in terms of phylogenetic diversity than are numerous closely related species.

(4) The huge size of some hotspots makes effective conservation action impractical, because it must involve the coordination of many national governments.

Shi & al. (2005) comment that these approaches are based almost entirely on biological factors such as the numbers of endemic species and areas but exclude social factors. They therefore propose a new system based on the following criteria: the habitat's status, human population pressure, human efforts to protect habitat, and number of endemic plant and vertebrate species. On the other hand, Wilson & al. (2007) note that with few exceptions, these priority determining mechanisms fail to take into account economic costs and provide a static assessment of conservation priorities. They propose a priority setting framework to guide the allocation of funds to threat-specific actions in locations where they are likely to have the greatest conservaton benefit and apply it to 17 of the world's Mediterranean ecoregions.

MANY BOTANIC GARDENS HAVE ADOPTED CONSERVATION AS ONE OF THEIR MAIN AIMS

During the past 30 years, many of the world's botanic gardens have adopted plant conservation, especially of threatened species, as one of their main goals. Following a series of conferences (e.g Simmons & al. 1976; Stone 1977; Synge & Townsend 1979; Bramwell & al. 1987), this movement was stimulated by the creation of the Botanic Gardens Conservation Co-ordinating Body at the IUCN Threatened Plants Unit at Kew in 1978 and the Botanic Gardens Conservation International in 1987 (as the IUCN Botanic Gardens Conservation Secretariat), and the Center for Plant Conservation in the United States. The publication of the *Botanic Gardens Conservation Strategy* (WWF, IUCN, BGCS 1989) in 1989 and subsequently the International Agenda for Botanic Gardens in Conservation (2000) served as a major stimulus for botanic gardens interested in engaging in conservation activities (including education for which botanic gardens are specially suited). In addition, a great deal of networking, strategic thinking and technical planning has been carried out, and a series of handbooks and guidelines produced (see the Botanic Gardens Conservation International website: www.bgci.org/

Strong networks of botanic gardens have been created in many countries or regions e.g. Australia, Canada, China, USA, Mexico, Europe, South Africa, some of which have produced coherent plans for the conservation of the country or the regions rare and endangered species in cooperation with other conservation agencies, such as the Australian Network for Plant Conservation that has established guidelines for germplasm storage for the conservation, recovery and management of Australia's threatened flora.

Despite these developments, botanic gardens still represent an underutilized resource for plant conservation. The tasks involved are difficult and complex, both scientifically and technically, and expensive and require properly trained staff, space and facilities, and long-term commitment. This is beyond the capacity of many if not most botanic gardens and great challenges lie ahead if they are to mobilize their efforts effectively (Heywood 1999, 2002, 2007; Wyse-Jackson).

Specifically with reference to *ex situ* conservation, recent experience has shown that botanic gardens do appear to have the capacity to work on a large scale (but cf. Barthlott & al. 2000). In an assessment I made over 10 years ago (Heywood 1996), I wrote: 'What is now needed is to apply much more rigorous and effective standards and to explore the feasibility of undertaking the largescale sampling and collection of germplasm at risk and its conservation as seed, clones, growing plants (in field gene banks or in plots), tissue or cell cultures, pollen samples, in and through botanic gardens following these standards. What will no longer suffice if botanic gardens are to take their place as major centres for the conservation of wild species germplasm are the previous uncoordinated and unscientific procedures of the past'.

Although a few major regional initiatives exist, such as ENSCONET – The European Native Seed Conservation Network[1] , and GENMEDOC, An inter-regional network of West Mediterranean seedbanks[2] – the *ex situ* conservation of wild species is still largely uncoordinated in many parts of the world and I have suggested (Heywood 2002) that as a first priority the establishment of some form of inter-governmental co-ordinating authority or at least mechanism for wild species germplasm policy, should be established, comparable in some ways to the CGIAR (although with a broader remit covering *in situ* as well as *ex situ* conservation and management), that would establish a detailed policy on sampling, accessions, storage and other technical matters and determine priority species or groups of species on an international, regional and national basis. This would be a vast enterprise and not one that botanic gardens can or should attempt to undertake on their own. It would have to be organized and implemented not just by botanic gardens but in association with international conservation and biodiversity agencies and organizations such as IUCN and the CBD. International bodies such as IABG and BGCI could be charged with responsibility for particular policy, and regional and national associations will have a major part to play as implementing agencies. It is salutary to be reminded by Tuxill (1999) that as regards *ex situ* agricultural germplasm, 'only 13 percent of gene-banked seeds are in well-run facilities with long-term storage capability – and even the crown jewels of the system, such as the U.S. National Seed Storage Laboratory, have at times had problems maintaining seed viability rates', so the challenge facing botanic gardens in large-scale long-term conservation of germplasm of wild species is daunting.

Some botanic gardens in recent years have also regarded *in situ* conservation as part of their activities although they are essentially *ex situ* facilities by definition. Certainly botanic gardens can and do play an important role in recovery programmes of endangered species through growing *ex situ* material for reintroduction and for studying their reproductive biology.

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[1] http://www.ensconet.eu/

[2] http://www.genmedoc.org/eng/progetto/presentazione.htm

THE METHODOLOGIES AND TECHNIQUES OF CONSERVATION BIOLOGY

Conservation biology was developed in response to the accelerating pace of habitat loss or deterioration and exploitation of natural resources and was termed a crisis discipline. According to Soulé & Kohm (1989), the 'Conservation biologists view their main task as providing the intellectual and technological tools that will anticipate, prevent, minimize, and/or repair ecological damage'.

Conservation biology was described by Primack (1993) as 'the new, multidisciplinary science that has developed to deal with the crisis confronting biological diversity'. Since it evolved in the 1980s, it has fed on a variety of other areas of biology, notably ecology, demography, population biology, population genetics, biogeography, landscape ecology, environmental management and economics (Heywood & Iriondo 2003) and has developed a powerful battery of subdisciplines, methodologies, models and techniques, many of which were designed to make conservation choices and actions better informed and more effective, such as:

- biodiversity conservation planning tools such as application of complementarity techniques in reserve selection (see above),
- gap analysis
- population viability analysis
- metapopulation ecology dynamics and biology (Hanksi 1999; Hanski and Gilpin 1997),
- fragmentation biology and patch dynamics,
- conservation genetics (Avise & Hamrick 1996),
- measures for assessing the effectiveness of reserves,
- restoration biology and ecology (Jordan & al. 1987)
- methods for predicting species' distributions and patterns of richness,
- structural equation modelling in studying causal relationships in threatened populations,
- incorporation of phylogenetic and molecular methods into conservation assessment and use of DNA bar-coding in identifying populations at risk, applications of spatial analysis and phylogeographic methods for a better understanding of diversity patterns and of what to conserve,
- application of biodiversity informatics

It is a legitimate question to ask how far this impressive array of approaches has impacted on the biodiversity crisis. Concerns have been expressed that conservation biology is essentially an academic discipline and this has often led to a degree of disconnect between it and conservation practice. For example, some of the techniques of conservation biology are only applied in a small number of cases. Too many pilot schemes have been undertaken without subsequent large scale implementation if successful.

Moreover, many of the models or techniques were designed to address the conservation needs of a relatively stable world. For example, in conservation planning too little account has been taken of future risks and uncertainty. There is also a disconnect between conservation biology and traditional ecological knowledge (TEK).

HOW FAR IS THE BIODIVERSITY CONSERVATION CHALLENGE BEING MET?

The coming into effect of the Convention on Biological Diversity at the end of 1993 led to a major acceleration in conservation planning and action as well as raising public appreciation of the significance of biological diversity. Strategies and action plans and, more recently, targets, indicators and indices litter the pathway from Rio. Yet it is abundantly clear that biodiversity loss continues at an accelerating rate across the world as the Millennium Ecosystem Assessment (2005) and other reports indicate.

•By any reckoning, we are losing the battle to conserve and use biological diversity sustainably. As the Global Biodiversity Outlook 2 (GBO2)[3] makes clear, biodiversity is being lost at all levels:

- Ecosystems across the planet have been impacted by biodiversity loss.
  - -Deforestation continues at an alarmingly high rate. Since 2000, 6 million hectares of primary forest have been lost annually.
  - -Marine and coastal ecosystems have suffered due to human activities. In the Caribbean, average hard coral cover declined from 50% to 10% in the last three decades. 35% of mangroves have been lost in the last two decades.
- While protected areas cover some 13% of the world's land area, these are unevenly distributed, with only 2/5 of the world's ecoregions reaching the 10% benchmark. Only some half a percent of marine areas are covered. And not all of these areas are effectively managed.
- The average abundance of species is declining – 40% loss between 1970 and 2000. Species present in rivers, lakes and marshlands have declined by 50%. Declines are evident in amphibians, African mammals, birds in agricultural lands, corals and commonly harvested fish species.
- Habitats, such as forests and river systems are becoming fragmented, affecting their ability to maintain biodiversity and deliver ecosystem services.
- Yet, our understanding of how ecosystems respond to losses of biodiversity remains rudimentary, and ecologists are struggling to understand the implications of future species losses (Schindler 2007)

GLOBAL CHANGE– A PLANET UNDER PRESSURE

The term Global Change is applied to the cumulative effect of changes in the global environment and ecology as a result of human activities and changes in the human-nature relationship that may alter the capacity of the Earth to sustain life.

The main components of Global Change are demographic, land use and climatic

(Table 1). A broader approach is been taken by IUCN (2003) so as to include biophysical (climate change, sea level rise, habitat loss and fragmentation, invasive alien species), socioeconomic (growing population, intensified land and resources use, changing values of ecosystem services) and institutional change (globalization, democratization, decentralization).

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[3] Secretariat of the Convention on Biological Diversity (2006) *Global Biodiversity Outlook 2*. Montreal

Over the past few years, attention has been focused on the likely effects climate change, especially global warming, on our planet and its biodiversity following a series of reports by the Intergovernmental Panel on Climate Change (IPCC), the most recent being the Fourth Assessment published in 2007 (IPCC 2007), and other reports including the Stern Report (Stern 2007) and one by the Scientific Expert Group (SEG) entitled 'Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable' (2007) prepared for the 15th session of the Commission (CSD15), which outlines a road map for preventing unmanageable climate changes and adapting to the degree of change that can no longer be avoided.

Although the recent recognition of the very considerable dynamism shown by our ecosystems and their component species, marked a paradigm shift in ecology with major implications for conservation, the implications of global change on ecosystems, their resilience, functioning and ability to provide goods and services has injected a new sense of urgency as the timescale of change has been dramatically shortened.

Not only should the different elements of climatic change not be considered in isolation but as a multi-factor system, but other factors of global change that interact with climatic ones also need to be studied. Norby & al. (2007) insist on the need for a multifactor imperative in global change research:

Table 1. Main Components of Global Change

Population change

– Human population movement/migrations
– Demographic growth
– Changes in population pattern

Changes in land use and disturbance regime

Climate change (IPPC definition)

– Atmospheric change (greenhouse gases: carbon dioixide, methane, ozone and nitrous oxide)
– Temperature changes

Other non-climatic factors

– Distribution of Nitrogen deposition
– Global dust deposition (including yellow dust and brown dust)
– Ocean acidification
–Air pollution in megacities

'Higher air temperatures, altered precipitation patterns, increased tropospheric ozone concentrations, and N deposition are among the most prominent of the predicted changes that, along with elevated CO2, have a high potential to affect ecosystem structure and function. Although the effect of elevated atmospheric

CO_2 on ecosystem function was the primary focus of much of the GCTE effort in ecosystem physiology, each of these additional factors presents the possibility of altering the response of ecosystems to elevated CO_2 – perhaps negating the CO_2 response, enhancing it, or completely changing the nature of the response. Predictions of future ecosystem metabolism based solely on changes in a single factor are likely to be misleading'.

Population change

Population change refers to both changes in the pattern of distribution of human populations and to demographic growth. Large-scale migrations of human populations can be caused by social, economic, political and health factors.

The effects of war and civil conflict can leave large areas of land devastated or unusable and cause large human migrations, thus affecting the natural and agroecosystems involved and their biodiversity.

Today, about half of the world's population, an estimated 2.7 billion people, live in urban areas, and every day about 160 000 people move from rural areas to cities (according to the UNFPA *State of the World Population* 2001). Urbanization levels are rising especially in less developed countries: in 2000, approximately 40 per cent living in less developed countries were in urban areas but this proportion is anticipated to rise to 54 per cent by 2025.

Tourism

Another form, albeit, temporary of population migration is annual tourism. The increase of tourism has led to massive urban and tourist development with accompanying infrastructural effects. This is especially accentuated in coastal areas such as in parts of the Mediterranean and on islands, leading to the phenomenon known as 'coastalization'. This has inevitably led to an impoverishment of biodiversity, loss or fragmentation of habitats.

The Mediterranean is the leading tourist destination in the world with the twenty countries bordering the Mediterranean Sea attracting over 30% of world tourism.

The 46,000 km long coastal zone that is visited by about 183 million tourists during the 3-month summer season. 25,000 km of this total are already urbanized and have already exceeded a critical limit. An additional 100 million domestic tourists bring the total up to about 280 million visitors a year. Over 12 million tourists visit the Mediterranean islands each year.

Environmental refugees

Parts of the world are filling up with environmental refugees – people fleeing excruciating, often fatal, environmental conditions. Their tragedy is triggered by forces or combinations of forces that are predominantly elemental (such as earthquakes, extreme weather events and climate trends) or artificial, i.e., caused by humans (such as forest clearing, industrialization, urbanization, mining, erosive agriculture, and warfare).

In 2001, there were about 20 million uprooted people worldwide. Some 12 million were refugees and 5 million were "internally displaced persons"—people forced to flee their homes, but still living in their original country (UNHCR 2002).

The IPCC (2007) has suggested that the number of environmental refugees will increase by 200 million by the middle of this century. Their effects on biodiversity could be serious in that they will move into territories not able to support or feed them without large scale disruption.

As climate change translates into more intense storms, flooding, heat waves, and droughts, more and more communities will likely be affected.

- Worldwide, nearly 200 million people live in coastal flood zones that are at risk. A sea level rise of 0.5 m would flood many coastal communities, especially in the poorest developing countries, such as the Andaman Islands, Bangladesh, and the Maldives, leading to an increase in the number of environmental refugees.

- Desertification, for example, puts some 135 million people worldwide at risk of becoming environmental refugees.

- A temperature rise of 2–3º C will put between 30 and 200 million people are at risk of hunger

- With a rise of 2º C, 0.7–4.4 billion people will experience growing water shortages

Other non-climatic factors

Amongst non-climatic factors that have implications for global change is increasing dust emissions. In various parts of the world, caused in part by agricultural intensification and overgrazing leading to soil degradation. Much of east Asia is affected by sand and dust storms (often known as Asian Dust, yellow dust, yellow sand, yellow wind) during the spring. The dust originates in the deserts of Mongolia and northern China and Kazakhstan. These dust storms appear to be increasing in frequency in some areas, for example in the Korean Peninsula where data show the frequency of yellow dust storms has increased over the past 50 years[4],[5]. A recent report (by Paul Simons) in The Times (5 April 2007) was entitled 'Gobi desert is rolling into the suburbs of Beijing', reporting that in April 2006 about 330,000 tonnes of sand were dumped on

[4] http://asds.metri.re.kr/pdf/%5B3-2%5DChansu%20Kang.pdf

[5] Z. Batjargal, Yellow dust storm is indication of unhealthy environment in Asia. http://disarmament.un.org/rcpd/pdf/Batjargalkanazawa.pdf

Beijing. … the deserts are drifting closer towards Beijing each year and the nearest sand dunes are now only about 70 kilometres (43 miles) away. At this rate, Beijing could become the world's first modern city to disappear under the desert, possibly by the middle of this century'!

The dust causes air pollution and has serious effects on human health, as well as impacting environmental productivity, agriculture and transportation infrastructure, and interferes with high tech industrial operations in China, Japan, and Korea. In 2002, South Korea, China, and Japan agreed to establish a yellow dust monitoring network for sharing observation information about Chinese yellow dust to help cope with the yellow dust storms, which have been occurring frequently and intensely.

The widespread occurrence of vertically extended brown clouds over the Indian Ocean and Asia has been observed recently. They are the result of biomass burning and fossil fuel consumption and consist of a mixture of light-absorbing and light- scattering aerosols. It has been suggested that they contribute as much as recent anthropogenic greenhouse gas emissions (Ramanathan et al. 2007).

Changes in landuse and disturbance regimes

Changes in land cover and land use have accelerated in the past century, largely in line with human demographic growth, as a result of industrialization, agricultural intensification, abandonment of traditional agricultural practices, population movements away from the land, and many other factors.

Sometimes land-use practices alter the natural disturbance regimes that generate the complex patterns of habitats that native plants and animals need for survival. If land-use practices change the frequency, size, and intensity of natural disturbances, such as floods, fires, droughts, and other extreme climatic events then ecosystem functioning will be affected and communities with quite a different composition may develop.

Climate change

'Global climate change, driven largely by the combustion of fossil fuels, is a growing threat to human well-being in developing and industrialized countries alike. Significant harm from climate change is already occurring, and further damages are a certainty. The challenge now is to keep climate change from becoming a catastrophe'. *Confronting Climate Change: Avoiding the unmanageable and managing the unavoidable.* (2007)

There is now a sound evidence base that recent climate change has been largely caused by human action (IPPC 2007) that has led to a scientific consensus, although by no means unanimity, but a great deal of uncertainty remains. As Collins (2007) points out 'Model imperfections, coupled with fundamental limitations on the initial-value prediction of chaotic weather and the unknown path that society may take in terms of future emissions of greenhouse gases, imply that it is not possible to be certain about future climate'. To address these uncertainties, new approaches are being developed (Collins & Knight, 2007).

Climate change has been described as the greatest environmental challenge facing humanity and may also be the greatest economic and political challenge (Wirth, 2007). Scarcely a day goes by without some new report or assessment being published on its consequences for agriculture, the Third World, different regions or countries, environmental refugees, health, food production, the incidence of plagues, pests and invasive species.

Consequences of climate change for biodiversity

Recent evidence (IPPC, 2001; 2007) suggests that the impacts of climate change on biodiversity will vary from region to region and on the nature of the ecosystems and the species that they comprise. Not only are there still great uncertainties as to the details of likely climatic change at a local level but the effects of changing climates on ecosystems and species are difficult to predict with any degree of confidence. As Betts (2006) notes a 'Cascade of uncertainty' (IPPC 2001) makes local impact predictions highly uncertain. Moreover, climate change will interact with other factors of global change such as disturbance regimes and population movements and this will increase the vulnerability of ecosystems.

Ecosystems as such have a limited capacity to adapt to climate change: the rate and extent of climate change in many parts of the world is expected to be faster and greater than in recent history and may exceed their capacity to adapt to the new conditions, leading to loss of species, ecosystem function and ability to provide goods and services.

Because of the different capacities of individual component species populations to survive or migrate, ecosystems will not advance as a single front in response to the changing climatic factors but differentially. Some species will be left behind, especially trees, and persist or die *in situ*, while others will migrate with greater or lesser success. Various predictions of the number of species that will be lost as a consequence of climate change have been made (e.g. Thomas & al. 2004; Malcolm & al. 2006) but like earlier attempts to predict future species loss as a result of habitat destruction and degradation and other human actions, they are only ballpark figures as it is virtually impossible to estimate the global situation 50 or more years time in view of the numerous uncertainties and variables. Nonetheless it is highly likely that many species will not be able to survive in the new ecoclimatic envelopes but the problem, as discussed below, is how to predict which they will be.

The fragmentation and degradation of ecosystems that is already happening throughout the world will accelerate and this will make them even more vulnerable to the effects of climate change. As a result, new assemblages of species will be formed and at this stage we simply do not know what their composition will be, how they will compare with those that they have replaced in terms of species richness or in terms of their ecosystem functioning. The degradation of habitats is likely to increase the prevalence of alien and invasive species and pests. This makes for a great deal of uncertainty and poses acute difficulties for planning.

Given that climate is usually accepted as the dominant factor affecting the natural distribution of species, it is not surprising that recent climate trends indicate a major influence on the expansion and contraction of species as well as on time of leafing, flowering and fruiting of plants and the timing of the arrival of migratory birds.

Bioclimate envelopes (BEMs)

One of the main modelling strategies for predicting the likely impacts of climate change on the future distribution of individual species, is the use of the single-species bioclimate envelope (BEM). This approach has been severely criticized (e.g. Pearson & Dawson 2003) for not taking into account various factors other than climate, such as biotic interactions, evolutionary change and dispersal abilities, that can affect significantly the distribution of species and the rate of changes to them. As Hampe (2004) notes, 'ongoing range shifts are affected by a multitude of other constraints and processes acting on population performance… [which] differ greatly across species' ranges from their expanding to their eroding margins, and so also does the character of the respective populations'. Pearson & Dawson (2003) conclude that the bioclimate envelope models have a place to play and should not be underestimated although their predictions should be viewed as a first approximation for understanding the potential impacts of climate change on future species distributions rather than as accurate models, although the models must be carefully applied with due consideration taken of their limitations. Hampe (2004) questions this conclusion and argues that 'the strongly deterministic and reductionist BEM rely on biological assumptions that are much more commonly violated in nature than Pearson & Dawson (2003) assume. Moreover, the statistical methods currently used for model validation overestimate model fits as a result of pseudoreplication. Both features make BEM prone to produce artificially optimistic scenarios of future climate change impacts on plant distributions.

Hijmans & Graham (2006) evaluated the ability of CEMs to predict species distributions under different climates by comparing their predictions with those obtained with a mechanistic model (MM). in which the distribution of a species is modeled based on knowledge of a species' physiology. Results for 100 species suggest that some CEMs can indeed be used to predict species distributions under climate change, but individual modeling approaches should be validated for this purpose, and model choice could be made dependent on the purpose of a particular study.

A detailed review of the methods and uncertainties in bioclimatic modelling is given by Heikkinen & al. (2006)[6] who note that errors are an inherent property of bioclimate models and their primary value is likely to be more heuristic than predictive as Araújo & al. (2005) suggest (see also Pearson & al. 2006). Nonetheless, it may be that as we understand better the limitations of the bioclimate models, and are able to intergrate into them other factors such as biotic interactiuons, land cover and dispersal mechanisms, we will be in a better position to interpret the results obtained from them. What is clear is that much further work

[6] Table 1 in their paper gives examples of the statistical techniques, and their abbreviations, applied in bioclimatic envelope modelling

needs to be done on this topic and more empirical data gathered. If reliable and acceptable approaches can be developed, then they will have to be applied on a wide scale if we are to be able to obtain a reasonable picture of the likely effects of climate change on future species' distributions and ecosystem composition.

Attempts by some authors (e.g. Shoo et al., 2005;. Thuiller et al., 2005) to link the results of bioclimatic modelling to predicting extinction rates using IUCN Red List criteria have been criticized by Akçakaya et al. (2006).

In an agricultural context, it would obviously be of great importance to be able to predict the effects of climate change on the future distribution and survival of target species of economic importance such as wild relatives or crops. One of the few studies so far published (Lane et al., 2006; Jarvis et al., 2007) used current and projected future climate data for ~2055, and a climate envelope species distribution model to predict the impact of climate change on the wild relatives of the world's major food crops, peanut (*Arachis*), potato (*Solanum*) and cowpea (*Vigna*). They considered three migrational scenarios for modelling the range shifts (unlimited, limited, and no migration) and found that climate change strongly affected all taxa, with an estimated 16-22% of these species predicted to go extinct and most species losing over 50% of their range size.

Global Change and Biodiversity Conservation

Protected area systems

Given that protected area systems are the major underpinning of most national conservation strategies, it is imperative to assess how they will be affected by global change. It is clear that in some parts of the world they will come under great pressure as their component species respond to changing conditions with individual patterns of migration or inability to migrate effectively.

As Lovejoy (2006) notes, the political boundaries of protected areas are fixed but the biological landscape is not. It is clearly difficult for a fixed system of protected areas to respond to global change and considerable rethinking in the design of such areas will be needed if they are to survive and remain effective. There will need to be more flexibility in size and scale so that a connected network of patches of habitats at various scales is created so as to allow species to migrate and adjust their ranges in response to climatic and other change (Miller, 1996). A major review prepared by the IUCN World Commission on Protected Areas (Barber et al., 2004) deals with how to design protected areas for a changing world and deals with issues of governance, participation and equity, capacity building and ways of evaluating effective management.

Various papers suggest that many protected areas will suffer moderate to substantial species loss and some protected areas may disappear altogether with catastrophic species loss. An assessment by Araújo et al. (2004) of the bility of existingreserve-selection methods to secure species in a climate-change context. It used the European distributions of 1200 plant species and considering two extreme scenarios of response to climate change: no dispersal and universal dispersal. The results indicate that 6–11% of species modelled would be potentially lost from selected reserves in a 50-year period. A study by Hannah et al. (2007) on protected area needs in a changing climate concluded that protected areas can be an important conservation strategy under a moderate climate change scenario, and that early action may be both more effective and less costly than not taking or delaying action. In the three areas studied (Mexico, Cape Floristic Region of South Africa and Western Europe) the study showed that protected areas remain effective in the early stages of climate change, while adding new protected areas or expanding current ones would maintain species protection in future decades and centuries.

Options for making reserves fit for changing climates are given in a review by Shafer (1999) and are summarized in Box 1.

Box 1: Options for making reserves fit for changing climates (Shafer, 1999)

Creating new reserves
Enlarging existing reserves
Creating replicates of existing reserves
Designating "stepping-stone" or corridor reserves
Creating buffer zones of natural habitat around reserves
Increasing habitat heterogeneity within reserves (e.g. alt itudinal, latitudinal and topographic)
Restoring, regulating or maintaining disturbance regimes
Removing or reducing invasive alien species
Reducing other environmental stresses
Restoration or rehabilitation of natural habitat
Translocation, reintroduction or introduction of species
Expanding inventory, modelling, monitoring, sensitivity analysis

As global change takes effect, the need to bring different areas under protection will inevitably lead to further human displacement which raises a whole series of economic, ethical and moral issues (Redford & Fearn, 2007). In an overview of conservation and displacement, Agrawal & Redford (2007) note that 'it is remarkable that none of the major international conservation organizations has formulated a coherent, systematic, and/or effective set of guidelines to address conservation-induced displacements'.

Protected areas and centres of diversity or hotspots will also be affected by population change and movements. A study by Population Action International found that by 1995, around 1.1 billion people, or 20 per cent of the global population, were living within 25 hotspots. Moreover, the average annual population growth rate in these areas was 1.8 per cent, substantially higher than the 1.4 per cent global rate and even above the average for developing countries, at 1.6 per cent. Another study by Malcolm et al. (2006) calculated the changes in habitat and associated species' extinctions of endemic plants and vertebrates in biodiversity hotspots under doubled CO_2 climatic scenarios. They project the eventual loss of thousaands, perhaps tens of thousands of endemic plants and vertebrates under a climatic scemario with a doubling of CO_2.

One of the current set of 2010 indicators, presented by Focal Areas of the CBD is the Management Effectiveness of Protected Areas which ‘measures how well protected areas are being managed, and in particular the extent to which these areas protect the goals and values for which they were originally designated. The indicator will focus on three themes: protected area design, adequacy and appropriateness of management systems and processes, and delivery of protected area objectives’ (2010 Biodiversity Indicators Partnership, 2007).

A preliminary look at actions designed to address the consequences of the climatic aspects of Global change for plant conservation was presented in the Gran Canaria Declaration II (2007).

GLOBAL CHANGE AND AGRICULTURE

The likely effects of global change on the patterns and productivity of agriculture and wild fisheries, and on food security are complex and difficult to determine with any degree of certainty.

Some effects may be beneficial, leading to enhanced productivity in some contexts (for example in some agroecosystems with higher atmospheric CO_2); or they may be detrimental (e.g. drought and increasing aridity in Sub-Saharan Africa, failure of the monsoon in the Indian subcontinent, shortening of the lifecycle of crops leading to a shorter period for grains to fill, failure of pollen vectors, increase in growth and spread of weeds and possible reduction in effectiveness of some herbicides under conditions of elevated CO_2, increased susceptibility to root and leaf pathogens) and with major consequences for our food supply and nutritional security. Effects of temperature increases have impacts on agriculture and forestry management at higher latitudes in the northern hemisphere, such as earlier spring planting of crops.

Recent reports on Climate Change such as IPCC (2007), the Stern Report (2007), and Confronting Climate Change (2007), have identified the Mediterranean region as highly susceptible to change. While agricultural productivity is initially expected to increase in northern Europe, yields are projected to start declining if the temperature rises beyond 2°C above the pre-industrial level, increased aridity will probably lead to a loss of productivity in Mediterranean zones and an increase in marginal habitats. In southern parts of Europe, agriculture may be threatened by climate change due to increased water stress. During the heat wave in 2003, many southern European countries suffered drops in yield of up to 30%, while some northern European countries profited from higher temperatures and lower rainfall. Bad harvests could become more common due to an increase in the frequency of extreme weather events (droughts,floods, storms, hail), and pests and diseases (CEC, 2005). Yields of some of the world’s staple crops such as wheat, rice and maize could drop by up to 30% in responses to rising temperatures according to estimates by UNEP (see also Royal Society, 2005).

A major concern is our ability to feed a growing global population in the face of climate change. Trewavas (2002) notes that, throughout history increasing population has served as a driver to increase agricultural efficiency but the currently projected increase will face a restraint not seen previously – the lack of available farmland. He concludes that 'Unless we can pull of a second Green Revolution, increasing yield but limiting it to land currently used for farming, there will be further deterioration of natural habitats and biodiversity at a rate that could even threaten the further existence of humanity'

Other factors that may be affected are soil erosion, the demand for and availability of genetic resources, crop irrigation, consequences of population growth and the expansion of agriculture, feeding the cities.

STRATEGIC RESPONSES TO GLOBAL CHANGE: DEVELOPING NEW CONSERVATION STRATEGIES

As already noted, current conservation strategies are based on the assumption that we live in a dynamic but slowly changing world. Such an assumption has to be reconsidered in the light of the rapid rate of change over the coming decades now confidently predicted in the light of the latest IPCC and other reports.

We need therefore to update existing conservation strategies and approaches and devise new technologies to meet this new situation. Some suggestions of new conservation approaches and strategies are:

- assessing the effectiveness and capacity of existing national and international organizations to meet the challenges of global change
- creation of new alliances and development of partnerships with social sciences to model nature-science interactions
- Improving policy, planning, and management and integrate decision-making between different departments and sectors, as well as international institutions
- revisiting and revising existing strategies and agreements, and in particular, revisiting targets and goals
- scaling up of conservation actions e.g. accelerating the rate of IUCN Red Listing, preparation and implementation of *in situ* conservation/management plans for species and populations
- change in focus from understanding historic global change towards the current and future management of human-altered processes (Leemans, 2006)
- developing innovative concepts for conservation strategies that concentrate on managing dynamic ecosystems for maintaining their capacity to undergo
- disturbance, while retaining their functions, services and control mechanisms ecological resilience (Rubicode Project, 2007).
- facing up to the challenge of surviving in a world with fewer species
- revisiting again the notion of umbrella/keystone species

- research into how far new species assemblages/ecosystems are able to provide the goods and services on which we depend
- placing more emphasis on the 'agricultural matrix'
- creating high quality research institutions throughout developing regions

The effectiveness of our existing institutions and organizations

Given the scale and scope of the challenges posed by Global Change, we need to consider whether our existing organizations and institutions are appropriate for the task ahead.

Already there is pressure to strengthen international environmental governance UNEP or to transform it into an Organization (UNEO)[7]. Another option being considered is to create a new International Mechanism of Scientific Expertise on Biodiversity (IMoSEB[8]) following the Paris Conference for Global Ecological Governance in January 2005 and subsequent international consultations.

Both at national and international level, we need to question how effectively we have organized our approach to biodiversity conservation based on past and current performance and also consider whether it will be adequate to meet the new challenge posed by Global Change. The coming into force of international treaties and agreements such as CITES, the Convention on Biological Diversity, the Climate Convention, Migratory Species, the Leipzig Report, and the International Treaty on PGR for Food and Agriculture, the publication of a series of major reports and assessments such as the Agenda 21, the Global Biodiversity Assessment, the Millennium Ecosystem Assessment, the Global Environment Outlook series, the Global Biodiversity Outlook, the State if the World's Plant Genetic Resources for Food and Agriculture, the establishment of FAO, UNEP, UNDP, UNESCO-MAB, GEF and the growth and development of organizations such as IUCN-The World Conservation Union, WWF, WRI, CI, BGCI, WCMC, GBIF, and, at national level, the biodiversity strategy and action plans and national reports to the CBD prepared by most countries, and the setting up of Protected Area systems, all these represent a massive achievement and a major investment of resources.

Yet, one need only read the sobering assessment of the sorry state of our biological environment presented in the reports just mentioned to make one question whether we are adequately equipped to deal with the challenges that Global Change that are daily becoming clearer.

New alliances

To meet the challenges of global change, a number of new partnerships are being developed, for example:

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[7] See http://www.centerforunreform.org/node/274

[8] http://www.imoseb.net/

- The Earth System Science Partnership (ESSP), created by four global environmental change programmes – DIVERSITAS, International Geosphere-Biosphere Programme (IGBP), International Human Dimensions Programme on Global Environmental Change (IHDP), the World Climate Research Programme (WCRP) – through the 2001 Amsterdam Declaration to bridge the disciplinary gaps across environmental science
- The Potsdam Initiative: Biological Diversity 2010 of the G8 and the decision to call for a study to analyze the global economic benefit of biodiversity, the costs of biodiversity loss and the failure to take protective measures versus the costs of effective conservation.

The CBD reaction to Global change

The reaction of the CBD to imminent global change crisis has so far been somewhat restrained and focused primarily on climate change:

- The SBSTTA established in 2001 an *ad hoc* technical expert group to carry out an assessment of the interlinkages between biodiversity and climate change and produced in 2003 a Technical Report based on the best available scientific knowledge, including that provided by the IPCC.
- In 2004, the Conference of the Parties (decision VII/15) further requested SBSTTA to develop advice for promoting synergy among activities to address climate change at the national, regional and international level, including activities to combat desertification and land degradation, and activities for the conservation of and sustainable use of biodiversity.
- The Secretariat of the Convention on Biological Diversity has launched web-based guidance on the integration of biodiversity within adaptation planning, aiming to support Parties as they integrate climate change impacts and response activities into their implementation of the CBD. The guidance gathers information and tools from a number of relevant partners (http://adaptation.biodiv.org/default.shtml)
- At the 12th meeting of the SBSTTA to the CBD, held in July 2007, it was recommended that the Conference of the Parties should encourage parties to enhance the integration of climate change considerations related to biodiversity in their implementation of the Convention.

Targets

A major focus in biodiversity conservation today is on time-bound, quantitative targets. Targets can be defined as measurable or quantifiable estimates of the amount of particular elements or features of biodiversity to be included in strategies or action plans. In terms of coverage, they may be global, regional, national, subnational or local.

At a global level the 2010 Biodiversity Target was agreed by all Parties to the Convention on Biological Diversity in the Hague in 2002 'to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth'.

Targets are seductively simple and are all too often set without sufficient prior research and preparation. They can also have a distorting effect in that they risk neglecting or reducing action on topics that are not the subject of targets. Nor are they always effective. Nonetheless they are beneficial in focusing on particular problems and challenges and can stimulate action and provide leverage for finance that would not otherwise happen.

Criteria for setting targets (from Heywood, 2006).

Care should be taken to ensure that the targets are clear and unambiguous, bearing in mind the difficulties of defining biodiversity in a precise and measurable manner.

If the goals are ambiguous or susceptible to different interpretations, there is a serious risk of debate as to whether in due course they have been met or not.

They should be based on the best available scientific knowledge and there should be sufficient information about them to allow the baseline status of the target to be properly determined and meaningful goals set.

There should also be a reasonable expectation of the goals being met although equally they should not be set at such a level so as not to represent a challenge.

Unless targets are effectively monitored, it will be impossible to know if targets are feasible nor what progress is being made to halt the decline in biodiversity (EASAC, 2005).

National versus internationally agreed targets

In practical terms, a distinction must be made between internationally agreed targets (coming out of various multilateral environmental and biodiversity agreements) and national targets. National targets may be associated with, or stem from, the former or may be quite independent of them.

Achieving global targets depends of course upon action being taken at national or local levels and in many cases of numerical or quantified targets it is to be expected that developing countries will be less likely than developed ones to reach the required level, thus putting a greater burden on the former if the overall goal is to be reached.

Global Strategy for Plant Conservation (GSPC)

The GSPC represents a major advance in global conservation planning in that it applied time-bound targets to plant conservation and if substantial progress is made in achieving at least some of the goals that it set, this will make a substantial contribution to slowing the pace of biodiversity loss. The Global Strategy encompasses 16 outcome-oriented targets aimed at achieving a series of measurable results by 2010.

The strategy was, however, like most global conservation initiatives, never costed, the targets not properly defined or phased, and the baseline in many targets was not known or agreed. The Strategy, adopted by the CBD in 2002, was devised to respond to a global situation that will soon be replaced by one that is dramatically more serious as a result of global change. The strategy is now under review.

Specific responses to Global Change: application of new technologies and techniques

- mapping biodiversity dynamics in a changing climate, made possible by advances in biodiversity informatics, should allow conservation managers to envisage the impacts of climate and eventually other aspects of global change on protected areas and some of the species they contain (Hannah, 2003)
- developing species distribution models and integrated climate envelope models
- developing models for predicting shifts in ecosystem boundaries
- developing models for predicting loss of species from protected areas
- developing models for assessing the likely effectiveness of new species' assemblages ('new ecosystems') in providing goods and services
- developing monitoring systems that are specifically designed to detect the effects of climate change on ecosystems
- novel methods for assessing extinction risks
- paying much greater attention to the need to supplement protected areas by conservation activities outside reserves (Deguise & Kerr, 2006) and on private land though land trusts and conservation easements (Merenlender et al., 2004; Rissman et al., 2007);
- improved modelling of species loss and turnover (Thuiller et al., 2005)
- novel methods for predicting the likely impacts of invasive species and for monitoring and controlling them.
- incorporation of phylogenetic and molecular methods into conservation assessment
- use of DNA bar-coding in identifying populations at risk,
- applications of spatial analysis and phylogeographic methods for a better understanding of diversity patterns and of what to conserve
- assessing the role of keystone and umbrella species in the new ecoclimatic envelopes
- a research agenda for 'assisted migration'

In addition,

- priority determining mechanisms need to be revisited,
- the currently fashionable application of goals and targets needs critical evaluation, and better methods are needed to measure the economics and cost-effectiveness of different conservation approaches.
- developing models for predicting species' distributions and ability to survive in the new climatic envelopes

CONCLUSION

While great advances in conservation biology and conservation practice have been made in recent decades, and a greater sense of urgency has been generated, the challenges posed by Global Change and in particular the revised figures for climate change given in the latest IPCC reports, and the predicted consequences, strongly suggest the need for an urgent and major rethink of our biodiversity conservation strategies.

Although mitigation and adaptation should help avoid the worst effects, they will almost certainly not be enough to prevent serious dangers to the livelihood of coming generations, and radical new approaches will be needed to allow significant parts of today's biodiversity to survive.

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