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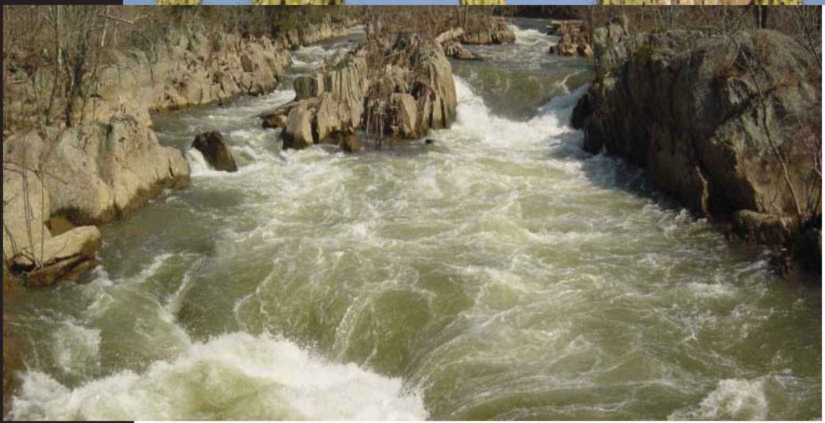
CLOSING THE GAP

Creating ecologically representative protected area systems

A guide to conducting gap assessments of protected area systems for the Convention on Biological Diversity

BY NIGEL DUDLEY AND JEFFREY PARISH



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For further information, please contact
Secretariat of the Convention on Biological Diversity
World Trade Centre
413 St. Jacques Street, Suite 800
Montreal, Quebec, Canada H2Y 1N9
Phone: 1(514) 288 2220
Fax: 1 (514) 288 6588
E-mail: secretariat@biodiv.org
Website: http://www.biodiv.org
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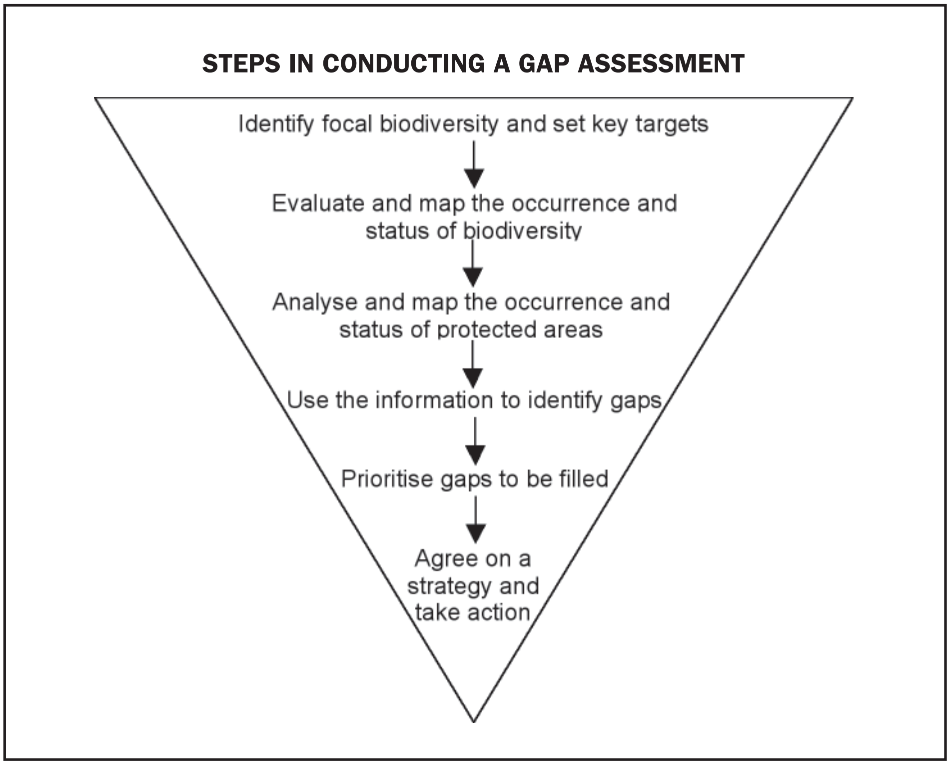

GUIDING PRINCIPLES FOR GAP ANALYSIS

1. **Ensure full representation** across biological scales (species and ecosystems) and biological realms (terrestrial, freshwater, and marine).
2. **Aim for redundancy** of examples of species and ecosystems within a protected area network to capture genetic variation and protect against unexpected losses.
3. **Design for resilience** to ensure protected area systems to withstand stresses and changes, such as climate change.
4. **Consider *representation* gaps, *ecological* gaps *and management* gaps in the analysis**. ***Representation** gaps* refer to species, ecosystems and ecological processes that are missed entirely by the protected area system; **Ecological** gaps relate to biodiversity that exists within protected areas but with insufficient quality or quantity to provide long term protection; while **management** gaps refer to situations where protected areas exist but are failing to provide adequate protection either because they have the wrong management objectives or because they are managed poorly.
5. **Employ a participatory approach,** collaborating with key stakeholders in making decisions about protected areas.
6. **Make protected areas system design an iterative process** in which the gap analysis is reviewed and improved as knowledge grows and environmental conditions change.Table of contents

Foreword

Protected areas have long been recognized as a key tool to counter the loss of the world's biological diversity. To quote from Her Majesty Queen Noor," ***these priceless places – national parks-wilderness preserves – community managed areas- together, serve as the green lungs of the planet".*** The latest statistics reveal that protected areas now cover 12 % of the Earth's terrestrial surface—nearly 19 million square kilometers, an area of the size of India and China combined. However, the existing system of protected areas is insufficient in many ways: it does not cover all types of biomes and species requiring protection; many of those areas that are already established are not properly managed or sufficiently funded to fulfill their objectives.

Protected areas are among the "best " means to achieve the 2010 biodiversity target. In that context at its seventh meeting in 2004, the Conference of the Parties to the Convention on Biological Diversity adopted a programme of work on protected areas to support establishment and maintenance of comprehensive, effectively managed and ecologically representative national and regional systems of protected areas with ambitious goals and clearly defined time-bound targets.

At this juncture, that efforts must be stepped up for achieving the 2010 biodiversity target, the important role of protected areas and the effective implementation of the CBD programme of work on protected areas, for achieving this target cannot be overstated.

The period 2004-2006 constitutes the first phase of the implementation of the programme of work on protected areas. This phase involves *inter alia* elaborating strategies for filling ecological gaps for national protected area systems. In a recent review of the implementation of the programme of work, undertaking a gap analysis was found as a significant challenge for most developing countries. Technical assistance to developing countries for the needed capacity building must therefore, be increased to effectively identify the priority areas for conservation and for establishing protected areas. In this context, this guide on conducting gap assessment of protected areas systems is timely and useful.

At this time when the activities of the Secretariat of the Convention on Biological Diversity are being enhanced towards assisting the Parties to implement the programmes of work by increasing the provision of technical support services, the publication of this guide is indeed a significant initiative. This guide explains with numerous examples, how to carry out a national gap analysis. It is intended to assist the protected area managers and policy-makers in governments, NGOs, and communities in conducting a gap analysis for national systems of all types of protected areas, within the framework of the CBD programme of work on protected areas.

I extend my appreciation to the authors, other contributors and to The Nature Conservancy for preparing this document. I thank the Government of Germany for making available the necessary financial resources to publish the document in time for the eighth meeting of the Conference of the Parties.

Dr. Ahmed Djoghlaf
Executive Secretary
Convention on Biological Diversity

PART 1 BACKGROUND

In February 2004, the Seventh Conference of Parties of the Convention on Biological Diversity drew up a comprehensive *Programme of Work on Protected Areas*, with multiple objectives and time-limited targets. The overall aim of the programme is to encourage countries **to complete ecologically-representative networks of protected areas**, both on land and at sea, providing basic protection for all national biodiversity, with a particular emphasis on threatened and endemic species.

Developing an ecologically-representative network of protected areas requires an approach to selection that is rooted more in the sciences (both biological and social science) than in chance or politics. The CBD accordingly proposes that governments carry out a **gap analysis** to find out if and where a nation's current protected area system falls short of protecting all biodiversity and hence meeting the aims of the Convention. It provides one important component of the information needed to draw up recommendations for completing the representative protected areas network. In its simplest form, a gap analysis involves comparing the distribution of biodiversity with the distribution of protected areas and finding where species and ecosystems are left unprotected or under-protected. Conceptually this is not a difficult process, but it does require assembling a wide variety of information (which is often unavailable in many countries), and using sound ecological knowledge and rigorous analysis to make meaningful conservation decisions. The gap analysis also comes with a tough deadline – countries have agreed to complete the analysis by the end of 2006. This implies that in cases where nothing has yet been done, analysis needs to start quickly and proceed rapidly. A further essential step beyond the analysis is in identifying ways in which the gaps can be filled: filling urgent gaps in the network was a specific commitment made at COP-7 with a deadline for the end of 2006.

Identifying, prioritising, and filling gaps in the national protected areas system is a core element of a protected areas master plan. Other core elements include sustainable financing and capacity development. Accordingly, Parties to the CBD included specific activities related to each of these three themes in the *Programme of Work*, and committed to completing them by 2006.

The following guide has been produced to help governments and others implement an aspect of one of these core elements: a gap analysis for a nation's current system of protected areas, within the framework of the CBD. It provides background information and a step-by-step guide, outlines tools and existing information and gives some case studies, where real-life examples can help to illustrate particular points. Perhaps most important of all, given the great variability in access to biodiversity data around the world, it lays out some generalised principles and a framework within which a variety of approaches can be accommodated. No gap analysis is ever "complete" but rather a snapshot drawing on the best information available at the time; the gap analysis should remain iterative so that as more information and experience are accumulated they can be incorporated into decision making that will ensure the conservation of a country's natural heritage. The guide is being produced in both paper and electronic form; in the latter case hotlinks provide direct access to many tools, case studies and further information. It also acts as a portal to the Earth Conservation Toolbox, an on-line source of methodologies for the ecosystem approach in development that contains a large amount of information likely to be useful in carrying out both the gap analysis and other elements in the *Programme of Work*.

CHAPTER 1 ■ The biodiversity crisis and the need for protected areas

The earth is currently facing the real possibility of permanently losing a vast number of wild plant and animal species in an "extinction crisis" that is unparalleled in history for its speed and severity. The CBD estimates extinction rate as 100-200 times higher than the historical natural level, with the greatest losses on islands and in freshwaters[1], while the United Nations Environment Programme also identifies forest species as being particularly at risk[2]. The Millennium Ecosystem Assessment is more pessimistic and believes that extinction rate may be up to a thousand times above historical levels. Drawing on IUCN Red Data List material[3], it estimates that for instance 12 per cent of bird species and 23 per cent of mammals are threatened with extinction. Just as significant, studies suggest that almost *all* species are currently declining in either range and/or population size and all ecosystems are declining[4].

Global efforts to address this crisis are accelerating with the Convention on Biological Diversity providing the political momentum behind these activities. Protected areas – such as national parks and nature reserves – are universally recognised as a primary tool in biodiversity conservation strategies. They act as refuges for species and ecological processes that cannot survive in intensely managed or altered landscapes and seascapes and provide space for natural evolution and future ecological restoration. Whilst ecosystem approaches recommend that biodiversity should be integrated into management throughout the land and sea, the role of an effectively functioning protected area system is to provide a secure base for threatened species, ecosystems and ecological process, including the many (believed to be the large majority of the total) that have yet to be described by science and for which no tailored conservation strategies are therefore possible. By conserving viable samples of whole ecosystems, we hopefully give all the species within them a fighting chance of survival.

Although the concept of protecting natural habitats stretches back almost to prehistory (for example in European hunting reserves or the complex protection systems developed under Islamic law), the modern protected area is almost wholly a phenomenon of the twentieth century. The need for protected areas rapidly increased during this time, as natural systems started to come under more intense pressure and in some cases traditional and sustainable management systems broke down. Starting from a handful of examples set up before 1900, rate of establishment accelerated over a hundred years and has continued to rise since the millennium, so that by the time of the 5th World Parks Congress in South Africa in 2003, around 11.4 per cent of the world's land surface was in a protected area recognised by IUCN The World Conservation Union. This almost certainly represents the largest conscious change in land-use in human history and an unprecedented commitment to conservation.

Early protected areas were mainly set up to preserve either particular *species* or spectacular *scenery* or sometimes water *resources*. For instance Kaziranga National Park in Assam, India, which celebrated its centenary in February 2005, was established to protect the Asian rhinoceros; since then rhino numbers have risen from less than a dozen individuals to over 1700, the world's largest remaining population (see Figure 1). More recently, the aims of protected areas have become wider and a broader *ecosystem* function has been increasingly recognised, both within a protected area itself and also as it relates to the wider landscape or seascape. In addition to their biodiversity function, people benefit directly from the genetic potential of wild species, the environmental services provided by natural ecosystems, recreational opportunities in national parks and the refuge given to traditional and vulnerable societies. Additional arguments for protection are of critical importance in building and maintaining support for protected areas.

Figure 1 ▪ Rate of growth of protected areas: The twentieth century marked a period of rapid growth in protected areas. When Kaziranga National park was set up in India in 1905 (left) there were only a handful of protected areas in the world, but by the time the Pha Tam protected area complex was agreed between Lao PDR and Thailand around the year 2000, over 10 per cent of the land surface was in protected areas: photographs by Nigel Dudley

Although the growth in number and size of protected areas is spectacular, it does not as yet come near to fulfilling global biodiversity commitments, nor the needs of species and ecosystems, given that a large number of these species, ecosystems and ecological processes are not adequately protected by the current protected areas network. These ***gaps*** come in a number of forms, which can be divided for convenience into:

- **Representation gaps:** there are either (1) no representations of a particular species or ecosystem in any protected area, or (2) there are not enough examples of the species/ecosystem represented to ensure long-term protection.
- **Ecological gaps:** while the species/ecosystem is represented in the protected area system, the occurrence is either of inadequate ecological condition[5], or the protected area(s) fail to address the movements or specific conditions necessary for the long-term species survival or ecosystem functioning.
- **Management gaps:** protected areas exist but management regimes (management objectives, governance types, or management effectiveness) do not provide full security for particular species or ecosystems given the local conditions.

In essence we are asking 3 questions of the protected area system:
(1) how much is protected? (representation gaps),
(2) is that which is protected ecologically healthy? (ecological gaps), and
(3) is that which is protected under good management? (management gaps)

This is but one way of dividing up the constituents of a gap analysis and other options exist. In

Cambodia, for example, gaps in these same critical elements of protected area system design are divided up differently – ***design***, ***institutional***, and ***operational*** *gaps* – conflating "representational" and "ecological" gaps into one criterion (design) and disaggregating "management" gaps into two (institutional and operational)[6]. What is important is that these same critical elements are addressed in a protected area system gap analysis. We describe representation, ecological and management gaps in more detail below.

Representation gaps: it might be supposed that with over a tenth of the world in protected areas then at least major species might already be included *somewhere*. But many representation gaps remain on all continents. A global analysis carried out in 2003 estimated that 6-11 per cent of mammals and 16-17 per cent of amphibians were "gap species" with inadequate cover in protected areas and the percentage was even larger for threatened species[7]. Many endemic island species are missed entirely by protected areas: for example the Flores monarch (*Monarcha sacerdotum*) and Flores hanging parrot or Wallace's hanging parrot (*Loriculus flosculus*) are both bird species endemic to the island of Flores in Indonesia[8]. However, representation gaps are not restricted to islands. For example the beira (*Dircatragus megalotis*), a small antelope confined to the Horn of Africa, occurs in no protected areas[9]. It is declining due to hunting, habitat degradation, competition from goats and an apparent slow recovery after dying in large numbers during the 1975 drought[10]. Many sites of high endemism remain unprotected. El Pozo, in Berriozabal, Chiapas, Mexico, is an example of a site with a high concentration of endemic species that had until recently been ignored by conservation agencies. At least six endemic vertebrate species occur in less than 500 ha, which is currently unprotected. Three species are apparently endemic to the site: a salamander (*Ixalotriton niger*); frog (*Eleutherodactylus pozo*); and a newly-discovered tree climbing rat (*Ototylomys sp. nov*). Three other species are endemic to Chiapas and Oaxaca: two lizards (*Anolis parvicirculatus* and *Sceloporus internasalis*); and a rat (*Tylomys* sp)[11].

Figure 2 ▪ *Adansonia suarezensis* is one of six baobab species endemic to Madagascar, with a very limited distribution in the north of the country near Antsiranana. It is currently not represented in any protected area, although this will hopefully change with the government's plans to triple protected area size over the next few years.
Nigel Dudley

The gaps that we tend to know about, which are often for large terrestrial animals, are doubtless far outnumbered by gaps in protection of terrestrial plants and invertebrates, and marine and freshwater species whose distribution and even descriptions are unknown.

Gaps not only affect individual species but also whole ecosystems and ecological processes, many of which do not yet have viable levels of protection. An analysis by The Nature Conservancy and WWF provides a very broad overview of likely representation gaps in ecosystems. It looked at the 13 terrestrial biomes and 810 associated ecoregions, providing a Conservation Risk Index by comparing the amount of conversion with level of protection. In two biomes – temperate grasslands and Mediterranean forests, woodlands and scrub, the rate of the ratio reached or exceeded 8:1, meaning that eight times more area in these systems had been converted than put under some form of protection. Temperate broadleaf and mixed forests, tropical dry forests and tropical conifer forests were all found to be at intermediate risk. Narrowing the analysis to ecoregions the study found 140 with a ratio of habitat conversion to protection exceeding 10:1. A draft threat index for ecoregions was suggested, based on the IUCN Red List, classifying them into Critically Endangered, Endangered and Vulnerable[12].

The need to fill gaps in protection is supported by analysis of the *2003 United Nations List of Protected Areas*, which shows massive discrepancies in protection for the world's biomes with for instance only 1.54 per cent of lake systems and 4.59 per cent of temperate grasslands in protected areas. Coverage of the oceans remains minimal, at an estimated 0.5 per cent of the total ocean surface and with virtually no high seas reserves of any kind[13]. Many migratory species face problems because even if their summer and winter habitats are secure, they may encounter gaps during annual movements. Ecosystem-wide statistics obscure even greater gaps in particular habitats. This is particularly true for marine species, many of which occupy distinct habitats at different life cycle stages and seasons and can sometimes even have diurnal movements in and out of protected areas. The southern Pacific island forests, Naga-Manapuri-Chin hills forests of Bangladesh, India and Myanmar, Solomons-Vanuatu-Bismarck moist forests, Cameroon highland forests and Gulf of Guinea mangroves, for instance, all had 1 per cent or less of their forests in protected areas according to analysis by UNEP-WCMC for WWF in 2001[14].

Problems of having insufficient protected areas to ensure ecological integrity are not confined to places with little conservation infrastructure or to the tropics; gaps can occur even where there are plenty of protected areas. Political considerations often mean that protected areas are concentrated in the least populated regions, or with low human occupation potential, and/or on the poorest soils; all areas which may not have the richest or most threatened biodiversity: in fact in many cases the greatest threats are precisely in the most fertile and heavily populated areas. A gap analysis of European forests found some protection varying from less than 0.5 per cent for spruce woodland and hygrophilous birch tundra, to 18.5 per cent for conifer forests in mires and bogs[15]. For example even in Finland, a country with a relatively low population, the large majority of protected areas are in the sparsely-populated far north and large forests and mires in the south are poorly represented[16]. A gap analysis in the UK found that National Nature Reserves and Sites of Special Scientific Interest (which in any case do not have complete protection) cover only 6.3 per cent of England and are generally small, with respective median areas of 1.1 and 0.2 km^2. The English PA system under-represents lowland areas and provides a median level of 2.5 per cent protection for the Natural Area (NA) types, with seventy nine per cent of NA types having less than 10 per cent protection[17].

Figure 3 ▪ Temperate grasslands are amongst the least protected and most threatened of the world's major biomes. Analysis of ecosystems also provides a simplified, coarse filter way of understanding what is likely to be happening to the species that they contain.
Tierra del Fuego, Argentina: Sue Stolton

Ecological gaps threaten the biodiversity within a protected area or protected area system even when the latter is well-managed. In these cases gaps can relate to compositional issues, the structure of the protected area(s), the function and the health of ecological processes and in having sufficient redundancy to provide insurance. Ecological gaps occur when protected areas are sited in the wrong places, are too small, the wrong shape, missing critical ecological elements or simply not themselves in a healthy enough state from an ecological perspective to function correctly.

There is a large body of evidence showing that protected areas that are too small, too isolated or the wrong shape face problems in term of the long-term survival of biodiversity. For instance, small protected areas may lose their species, however well-managed they are. In Java, the forests in the Bogor Botanical Gardens have been isolated since 1936, when clearance removed all nearby forests. The diversity of birds has undergone a steep decline. Between 1932 and 1952, 62 species of birds were recorded in the gardens, but by the 1980s 20 species had disappeared, four were close to extinction and five more had declined substantially, even though the protected forest remained reasonably intact[18]. The majority of protected areas are not large enough to support their full range of species indefinitely and rely on the presence of suitable habitat nearby or conservation measures such as ecological corridors or buffer zones. The problems are not confined to the tropics; a detailed study of US national parks found that virtually all of them had lost species since their inception[19].

Many existing protected areas miss key species, sometimes including those that they were established to protect. For instance in Sichuan, China, over half the remaining population of the endangered giant panda (*Ailuropoda melanoleuca*) live outside panda reserves[20]. Other reserves are missing critical habitat for certain stages of a species' lifecycle. This can be important in the case of migratory species, such as birds, where protection for some stages of the lifecycle can be undermined by losses elsewhere. For example, the central population of the Siberian crane (*Grus leucogeranus*) had declined to four pairs in 1996[21] and is now possibly extinct despite over-wintering in a well-managed protected area in India (Keoladeo National Park), because of poaching on its migration route, which passes through Afghanistan, Pakistan, Kazakhstan, Uzbekistan and Turkmenistan[22].

Even large protected areas can lose their ecological integrity if impacted by major changes outside. For example, Kaziranga National Park in Assam, India, is a unique ecosystem in part because it is regularly inundated by the Brahmaputra River, but now the integrity of the ecosystem is under question because of plans to dam the river further upstream[23]. Many aquatic systems are particularly at risk from functional gaps because the hydrological processes that support the healthy functioning of these systems operate over much larger scales than most protected areas, and thus, are susceptible to threats outside of protected area boundaries.

Management gaps can occur even when protected areas are in place. Here gaps can take a number of forms relating to management approaches, governance types and management effectiveness. Protected areas are not all managed in the same way, and IUCN recognises six different categories of management based on objective (see Table 1 below). These range from strictly protected areas where human visitation is strictly controlled, to protected landscapes and seascapes which contain cultural landscapes and often settled human communities. A well balanced protected area network will draw on all of these as necessary. A network that relies on only one or two types of management is likely to be unbalanced. For example, in the UK all the large protected areas are IUCN Category V, which means that there is very little space devoted to protection or restoration of wholly natural ecosystems.

Ia	Protected area managed mainly for science or wilderness protection
Ib	Protected area managed mainly for wilderness protection
II	Protected area managed mainly for ecosystem protection and recreation
III	Protected area managed mainly for conservation of specific natural features
IV	Protected area managed mainly for conservation through management intervention
V	Protected area managed mainly for landscape/seascape conservation or recreation
VI	Protected area managed mainly for the sustainable use of natural resources

Table 1: IUCN categories

In addition, it is recognised that a healthy protected area system usually needs a variety of management structures. For instance relying entirely on government owned and run protected areas is risky if government priorities change from conservation and there have been instances where community conserved areas have survived better than government-controlled areas in times of civil strife; for instance this is currently the case in Zimbabwe, where community game management areas may be surviving better than the state-run national parks. IUCN recognises four main types of governance as outlined in Table 2.

Type	Description
Government management	Protected area managed by national or local government, occasionally through an officially appointed independent body
Co-management or **collaborative management**	Involving local communities in management (active consultation, consensus -seeking, negotiating, sharing responsibility and transferring management responsibility to communities or NGOs)
Community-conserved areas	Natural and/or modified ecosystems voluntarily conserved by indigenous, mobile and local communities. Some may be official protected areas, others compatible management systems suitable for buffer zones and corridors
Private protected areas	Protected areas managed by private individuals, companies or trusts

Table 2: IUCN governance types for protected areas

Protected areas also need to be managed well if they are to conserve biodiversity. Unfortunately, this is not always the case and the presence of a protected area on paper does not necessarily fill the gap in practice. For example, Cameroon has a reasonable large system of protected areas, but the illegal bushmeat trade is currently undermining conservation effectiveness in many of these areas. Most large animals in Korup National Park are at a low density due to hunting. Lobeké National Park is a new centre for trade[24]. Officials in Dja, a World Heritage site, estimate that several tonnes of bushmeat leave each month[25]. Bushmeat trade affects virtually all protected areas in Cameroon and some have already lost key species[26].

Figure 4 ▪ Boy with wild plants collected for sale in a protected area near Hanoi, Vietnam.
Nigel Dudley

Ecological representation

To address these problems in a systematic way, the concept of **ecological representation** has been developed. This refers to the need for protected areas to represent, or sample, the full variety of biodiversity of different biological realms (freshwater, marine and terrestrial through all the ecoregions) and biological scales (ecosystems, species and within-species variation)[27]. Management gaps require better governance, capacity and enforcement in both new and existing protected areas.

This means that protected area systems should contain adequate samples of the full range of existing ecosystems and ecological processes, configured so that populations of all their species (and preferably subspecies and populations) persist in the wild over very long periods. Conservation planning must therefore address not only the ***content and location*** of individual protected areas and sets of protected areas, but also their ***design***, which includes variables such as size, connectivity and alignment of boundaries, for example, with watersheds. Once correctly designed, protected areas also need to be effectively managed to ensure persistence – i.e. the long-term survival of species and other elements of biodiversity by maintaining processes and viable populations. The CBD *Programme of Work* refers specifically to “a global network of comprehensive, representative and effectively managed national and regional protected area systems[28],” and remaining elements and commitments of the programme address issues related to effective management.

Ecological representation provides a unifying methodology to address gaps in a protected areas system. The information needed to identify a representative protected areas network draws on information about species of course, including their life-cycle requirements, but also on ecosystems and even biological realms (because in many places information on species is not complete enough to undertake a meaningful gap analysis). Gap analysis can also draw on information about enduring features such as landform and geology that can act as surrogates for biological variability.

An ecologically-representative network of protected areas is the cornerstone of national biodiversity conservation strategies and thus of immediate interest to governments. It helps to address many international commitments under the CBD, targets associated with the Millennium Goals and many other global and regional treaties and agreements. A representative network is also a key investment in environmental and therefore financial sustainability and should provide many other associated benefits, such as ecosystem services. Currently, many countries have protected area networks focused primarily on remote areas or particular ecosystems – commonly deserts, mountains and ice-caps where there is little human or commercial involvement – leaving other ecosystems such as high seas, lowland forests, freshwaters or temperate grasslands under-protected. The switch to looking at protected area systems from the perspective of ecological representation helps to ensure that countries conserve a comprehensive set of their natural heritage and of the natural resources upon which their populace depends. A good gap analysis can help countries to avoid losing natural resources before they even know that they exist.

The need to strengthen the world's protected area network is the critical factor driving the CBD *Programme of Work*. A well-designed gap analysis is the first stage in achieving the ambitious aims of the CBD's protected areas programme. The following guide aims to help governments and others to achieve this aim.

CHAPTER 2 ▪ The Convention on Biological Diversity and its Formal Commitments to Protected Areas

The Convention on Biological Diversity (CBD) was agreed at the 1992 Earth Summit and, to date, has been ratified by 188 nations. Its three main goals are: the *conservation* of biological diversity; the *sustainable use* of its components; and the *equitable sharing of benefits* arising out of the utilization of genetic resources. The CBD is governed by a Conference of Parties (COP) that meets every two years to review progress, aided by an international secretariat based in Montreal, Canada. A Subsidiary Body on Scientific, Technical and Technological Advice supports the COP, particularly in the negotiation of draft texts of decisions. Further advice comes from several Ad Hoc Open-Ended Working Groups dealing with particular issues and some more restricted Ad Hoc Technical Expert Groups, which are smaller "invitation-only" technical sessions consisting mainly of government-nominated experts. An information "clearing-house" mechanism promotes and facilitates technical and scientific cooperation. Much of the funding to promote the objectives of the CBD comes from a financial mechanism operated by the Global Environment Facility (GEF) and implemented by the United Nations Development Programme, United Nations Environment Programme and the World Bank.

At the Seventh Conference of Parties (COP-7), in Kuala Lumpur in February 2004, one important output was a decision and associated *Programme of Work* dealing for the first time directly with protected areas. The contents followed closely on recommendations from the 5th World Parks Congress in Durban in 2003; the CBD's programme can therefore be said to fairly reflect the views of many within the protected areas community. The *Programme of Work on Protected Areas* identifies four programme elements, 16 goals and 92 associated activities for state parties; many of these have tight timetables. However, although the list of expected outputs is long, they all relate back to the central objective, encapsulated in goal 1.1 as: "To establish and strengthen national and regional systems of protected areas integrated into a global network as a contribution to globally agreed goals".

The CBD emphasises that the aim is not simply to increase the number of protected areas but that these as far as possible should be designed and located in the best places to conserve biodiversity and that they should be determined by a multi-stakeholder process. An early stage in identifying new protected areas is carrying out a gap analysis of biodiversity and existing protected areas to identify what should be included in an expended protected areas network. A target has been set for completing the gap analyses by the end of 2006. The relevant text is reproduced in the box below.

Box 1: Commitment to Gap Analyses from the text of the CBD Programme of Work on Protected Areas

1.1.5 By 2006 complete protected area system gap analyses at national and regional levels based on the requirements for representative systems of protected areas that adequately conserve terrestrial, marine and inland water biodiversity and ecosystems. National plans should also be developed to provide interim measures to protect highly threatened or highly valued areas wherever this is necessary. Gap analyses should take into account Annex I of the Convention on Biological Diversity and other relevant criteria such as irreplaceability of target biodiversity components, minimum effective size and viability requirements, species migration requirements, integrity, ecological processes and ecosystem services.

The gap analysis is a key step in a larger programme. While there is no space to discuss the whole *Programme of Work* here, a summary of the main outputs is given in Table 3 below, with steps most directly related to the gap analysis highlighted in Figure 5. This is one of the most ambitious environmental programmes ever attempted by the international community and is uniting government agencies with NGOs and many other stakeholders in efforts to meet the far-reaching goals and tight deadlines.

2006	Research	**Gap analysis**, governance options, integrated approaches to conservation, key threats, legislative gaps, climate change, capacity needs
	Document	Tools, national data
	Develop	**National targets**, participatory mechanisms, best practices
	Take action	**Identify and protect large intact areas and freshwater sites**
2008	Research	Socio-economic costs and benefits
	Document	Protected area outcomes
	Develop	Steps for integration, guidelines to genetic resources access, plans for indigenous people, enabling legal frameworks and sustainable financing
	Take action	**Identify marine areas**, recognise community conserved areas, integrate PAs into Poverty Reduction Strategy Programmes, improve incentives and remove perverse incentives, explore transboundary PAs
2009	Research	Relationship of PAs to sustainable use, restoration options, impacts of PoW
	Develop	Participatory approaches, control methods for invasive species and illegal use
	Take action	**Designate protected areas identified in gap analysis**, fill legislative gaps
2010	Document	Develop information on World Database on Protected Areas
	Develop	Management plans for all PAs, liability and redress methods, tools
	Take action	**Complete terrestrial PA establishment and transboundary PAs**, implement management effectiveness assessments in at least 30% of PAs
2012	Develop	Capacity building approaches
	Take action	**Complete marine PA network including transboundary and high seas PAs**

Table 3: main outputs and timelines from the CBD Programme of Work on Protected Areas, with commitments relating to the design of ecologically representative protected area systems and gap analysis in bold

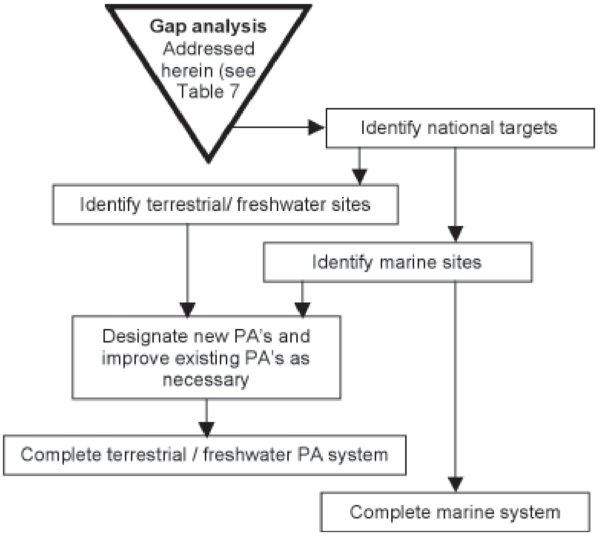

Figure 5: Key steps following completion of the gap analysis

Integrating protected areas into an ecosystem approach

The *Programme of Work on Protected Areas* is just one aspect of the CBD's overall scope and needs to be seen in a wider context. The CBD recognises the limitations of protected areas as the sole tools for conservation and promotes an ecosystem approach that seeks to mainstream biodiversity conservation into broader landscapes and seascapes. Protection takes place alongside, and hopefully in harmony with sustainable management and often also restoration. The overall concept is that good biodiversity conservation involves the integration of protection, sustainable management and where necessary restoration in the context of sustainable development and the maintenance and improvement of human well-being[29]. A conceptual model of the elements of the ecosystem approach is given in Figure 6 below.

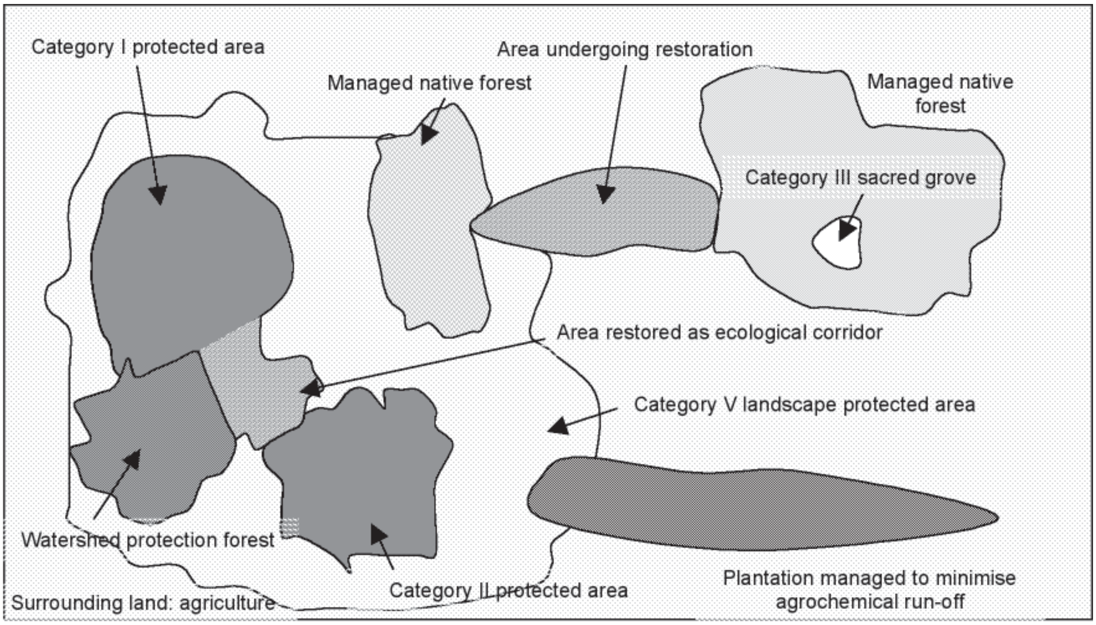

Figure 6: A landscape approach to biodiversity protection

The CBD has agreed twelve basic principles for the ecosystem approach, which stress social and cultural issues alongside those relating to biodiversity[30].

Principles of the Ecosystem Approach

<table>
<tr><td>1: The objectives of management of land, water and living resources are a matter of societal choice</td><td>6: Ecosystems must be managed within the limits of their functioning</td></tr>
<tr><td>2: Management should be decentralized to the lowest appropriate level</td><td>7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales</td></tr>
<tr><td>3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems</td><td>8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term</td></tr>
<tr><td rowspan="3">4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:
· Reduce those market distortions that adversely affect biological diversity;
· Align incentives to promote biodiversity conservation and sustainable use;
· Internalize costs and benefits in the given ecosystem to the extent feasible</td><td>9: Management must recognize that change is inevitable</td></tr>
<tr><td>10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity</td></tr>
<tr><td>11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices</td></tr>
<tr><td>5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach</td><td>12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines</td></tr>
</table>

The fact that the expanded protected area sits within a broader CBD commitment to the ecosystem approach has implications for both the gap analysis and the subsequent design of a protected area system. It means that protected areas should never be regarded as separate from the wider landscape or seascape. For example, it argues strongly that protected areas should be integrated into wider management systems, to ensure both the long-term survival of the biodiversity contained within the protected area and that any additional benefits (e.g. ecological services, economic development through ecotourism etc.) are equitably shared amongst the population. The ecosystem approach also opens up the possibility of using restoration to fill gaps where existing habitat is already too degraded to support biodiversity. This is particularly important in terms of designing the protected area system following the gap analysis and is returned to in section 4 below.

CHAPTER 3 ▪ What does gap analysis mean? A simple framework for assessment

In a conservation context, gap analysis is a method **to identify biodiversity (*i.e., species, ecosystems and ecological processes*) not adequately conserved within a protected area network** or through other effective and long-term conservation measures[31]. It has developed over the past 15 years in response to recognition that protected area systems of all types and in all parts of the world currently do not fully protect biodiversity[32].

Gap analysis is usually applied to fairly large areas. In an ideal situation it would be applied across the whole of an ecologically defined region (such as an ecoregion), because this allows decisions about conservation to be made with the best available information and on the basis of ecological rather than political boundaries in order to ensure that the needs of biodiversity are met. In practice however gap analyses are also frequently carried out for countries or even smaller areas such as states or provinces. Although running potential risks of not capturing critical ecological processes that transcend political borders, national gap analyses are in fact powerful conservation tools at this scale, particularly if they collaborate with neighbouring countries where appropriate. Gap analyses can vary from quite simple exercises based around a comparison of biodiversity with existing protected area networks to complex studies that require detailed data gathering and analysis, mapping and the use of software decision packages to determine optimal protected area networks. However simple or complicated, cheap or expensive, all gap analyses should follow the following steps:

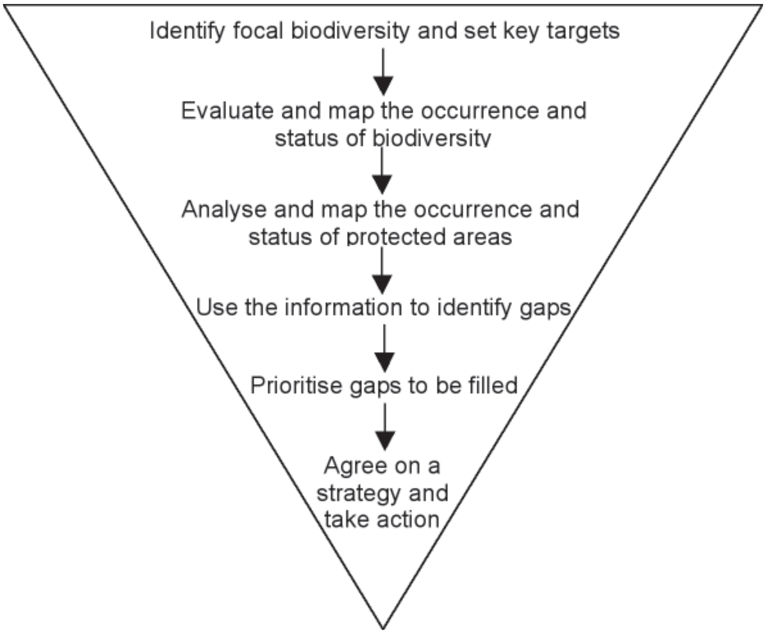

Figure 7: Key steps in a protected area gap analysis

Each of these steps is discussed in detail in chapters 6 – 11; the following section provides a summary of what is required.

- **Identify focal biodiversity and set key targets** (see chapter 6): most protected area networks are defined and measured by a set of quantitative targets. These goals can relate in a fairly simple way to area planned for protection or may be specified for the conservation of specific targeted species or ecosystems ("focal biodiversity") and descriptive of the desired number and distribution of occurrences or populations. At the simplest level, IUCN The World Conservation Union has suggested that countries set aside at least 10 per cent of their terrestrial area into protected areas and some nations or parts of nations have gone much further in their commitments, e.g., Mongolia (30 per cent) and Sakhalin Republic in the Russian Federation (25 per cent of all forests). More sophisticated targets come from the development of regional or national biodiversity visions or directly from gap analyses. For example, a series of conservation targets have been set for the Forests of the Lower Mekong Ecoregion Complex, including 26 priority areas for conservation and priorities amongst mammals, birds, forests and fish[33].

- **Evaluate and map the occurrence and status of critical biodiversity** (see chapter 7): Although this step can seem difficult in many countries where surveys of biodiversity are still very incomplete, all countries can proceed in an iterative way with available data and biodiversity surrogate information that can be improved over time as additional data become available. Information is needed on both what ought to be listed and what can be mapped. This stage therefore needs to draw on existing information from all reputable sources, backing this up with new surveys and quality control if time and funds allow. Mapping all species is impossible – most countries have only identified a small proportion of their plants and invertebrates for example. Gap analysis therefore often has to rely on data (1) for well-known species (such as mammals, birds, amphibians and fish) (2) for a few key species from other groups that are representative of particular habitats and (3) for ecosystems. Mapping therefore usually draws on a series of coarse or fine filter approaches to build as good a picture as possible of the distribution and status of biodiversity. Coarse and fine filter approaches are complementary rather than alternatives. "Coarse filter" means use of a unit of biodiversity to capture many other elements, while "fine filter" refers to species and fine-scale special elements (a category that catches everything that species and habitats may not catch like nesting cliffs, caves azonal habitats like wetlands, etc.)[34]. Studies will therefore usually involve consolidating diverse data sets (including relevant international data sets such as the Red List) using geographic information systems (GIS); and standardising habitat and land-use classification systems for the area being studied. Predictive models based on habitat affinities for key indicator species may be useful in some cases although they have clear limitations in terms of accuracy[35].

- **Analyse and map the occurrence and status of protected areas** (see chapter 8): Basic data on protected areas are usually available at national level although precise spatial information is frequently lacking as is information on protected areas in other governance systems (e.g. private protected areas or indigenous areas). Information about status of protected areas is generally less available, including issues relating to management objectives, governance and management effectiveness, although studies and data on these are starting to emerge. This information however is important for inclusion in a gap analysis, even if it only exists in approximate form, as protected areas may exist on paper, but their governance, management, or management objectives may mean that no biodiversity conservation is afforded. Coupling maps of protected areas with even cursory knowledge about their management status is central to any gap analysis.

- **Use the information to identify gaps** (see chapter 9): maps of occurrence and status/ecological need of species and ecosystems are then overlaid on maps of occurrence and management status of existing protected areas and any gaps identified – ideally including representation gaps, ecological gaps, and management gaps as discussed above. Such a gap analysis can only approximate to total biodiversity.

- **Prioritise gaps to be filled** (see chapter 10): strictly speaking the gap analysis itself stops with part 2. But a gap analysis is carried out primarily as a tool to expand and strengthen the protected area system and the filling of urgent gaps is an explicit commitment cited in the *Programme of Work* agreed to at the Seventh Conference of the Parties. Further analysis is needed – of threats, opportunities and to some extent also capacity – to identify a series of priorities for action; that is the gaps where action is most urgently required. Priorities should be developed on the basis of conservation status and viability of the targets, threats, opportunities and capacity; and balanced with stakeholder needs and societal interests.

- **Agree on a strategy and take action** (chapter 11): there are many different ways of filling the gaps in a protected area network. There is a range of different management objectives within protected areas, varying from strict protection and other management types that still leave room for human activities. There are also many different opportunities for how these areas can be governed. Furthermore, some viable options for protecting biodiversity and filling gaps may lie outside the protected area network altogether. This last stage therefore involves analysing the gaps and making proposals for how these could be filled through developing new protected areas, enlarging existing protected areas and through other forms of land and water management including easements, development of ecological corridors, buffer zones and in some cases introduction of sustainable management approaches in land outside protected areas.

This is a generalised and quite basic approach: a number of different variations exist, with their own tools, protocols and body of experience. Some other gap analysis methodologies are listed in the tools section. A first and important step for governments intending to carry out a gap analysis will therefore be deciding on the level of detail that is appropriate and the amount of financial, data, and time resources that are available and can be devoted to the gap analysis.

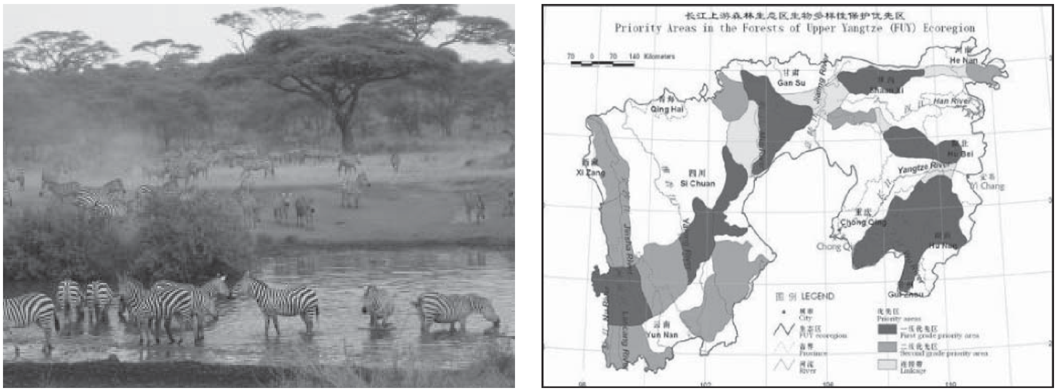

Figure 8 ▪ Gap analysis can either draw directly on use of key species (those that are wide ranging (area sensitive), typical of particular ecosystems, or all species within well-known taxa) or on biomes and ecosystems. For example in Serengeti, Tanzania migratory herbivores can help to determine the boundaries of protected area networks while in Sichuan, China, priority conservation landscapes have been identified and compared with protected areas.
Photo of Serengeti by Sue Stolton, map of Min Shan from the WWF China Programme Office

Carrying out a gap analysis fulfils a near-term CBD commitment. More importantly, it provides some of the essential information for making the best possible decisions about conservation strategies. Furthermore, a gap analysis identifies needs and focuses programmes that aim to strengthen capacity to address the gaps in representation, ecology, and management. Finally, it often creates a first opportunity for engaging with stakeholders around the country and discussing if new protected areas are needed, where they might be located and how they will be managed.

CHAPTER 4 ▪ Six Guiding principles for Gap Analysis

Whatever the precise details of methodology used, gap analyses should be driven by a series of scientific, social and political principles.

1. **Representation**: ***Choose focal biodiversity across biological scales (species and ecosystems) and biological realms (terrestrial, freshwater, and marine) for use in the gap analysis to capture the full array of biodiversity in the protected area system.*** The goal of full representation, as identified in the *Programme of Work*, is to have representative samples of all species and ecosystems within the protected area network, at a sufficient scale to ensure their long term persistence. This principle is at the core of the commitments within the Convention on Biological Diversity. Protected areas can only ever cover a small part of the whole; the key to a successful gap analysis is to identify shortfalls in protection and thus help ensure that protected areas are located in the optimal places to capture as much sensitive biodiversity in need of protection as possible.

2. **Redundancy**: ***include sufficient examples of species and ecosystems within a protected area network to capture genetic variation and protect against unexpected losses.*** All species and ecosystems remain under varying degrees of threat as a result of direct human pressures and/or natural stochastic events. A strong protected area network will therefore include additional sites to provide, wherever possible, some measure of insurance against losses elsewhere[36]. Furthermore, biodiversity elements exhibit genetic or compositional variation that ensures evolutionary potential and is necessary for conserving those species in the long term. This variation *within* a single species or ecosystem needs to be captured through conservation where applicable of more than one occurrence of that biodiversity element. These occurrences should ideally be selected across the ecological distribution of the species or ecosystem to ensure capture of that genetic and compositional variation. In places where the ecosystem is already degraded, protected area networks need to include space for restoration and therefore be established in places that are currently of low conservation value, but where there is a realistic chance of such values being regained through the passive effects of time or more active management interventions[37].

3. **Resilience**: ***design protected area systems to withstand stresses and changes.*** Resilience involves maintaining or recreating viable ecosystems by enlarging or connecting protected areas. Small protected areas surrounded by radically altered habitat are often of limited value. Recognition of this has created increased interest in protected areas as *networks*, with core areas joined by sympathetically-managed land and water providing routes or stopping off places for migratory species, buffering of protected areas against outside pressures and an opportunity for resident species to interbreed with more distant populations. Gap analysis and protected area planning are aimed as much as possible at a holistic system of protection, where necessary crossing national boundaries. This is particularly critical when designing protected areas for aquatic biodiversity. The need for resilience is increased because major climate changes now seem almost inevitable and will have serious impacts on terrestrial[38] and marine[39] protected areas. Additionally, the effects of climate change on agricultural landscapes means that protected areas will be under increased human pressure and may require active intervention. Ecological

systems and species will shift with changing climates and therefore foresight and planning for networks will be required to allow this movement over time. In some cases boundaries may have to be extended, for instance to include a broader range of landscape gradients, or new protected areas established[40].

4. **Different types of gaps**: ***analyse representation gaps, ecological gaps and management gaps in the analysis***. Different types of gaps affect protected areas, and all should be considered to strengthen a protected area system and close the ecological gaps that remain within it. *Representation gaps* refer to species, ecosystems and ecological processes that are missed entirely by the protected area system; Ecological gaps relate to biodiversity that exists within protected areas but with insufficient quality or quantity to provide long term protection; while management gaps refer to situations where protected areas exist but are failing to provide adequate protection either because they have the wrong management objectives or because they are managed poorly. All three of these gaps need to be considered by the analysis to strengthen the protected area system.

5. **A participatory approach**: ***collaborate with key stakeholders in making decisions about protected areas***. The CBD *Programme of Work* emphasises the need for participation in selecting protected areas, in particular by communities, including indigenous and traditional peoples, directly affected by protected area creation and has agreed that: "any resettlement of indigenous communities as a consequence of the establishment or management of protected areas will only take place with their prior informed consent that may be given according to national legislation and applicable international obligations"[41]. On the other hand, Article 6 of Convention (169) of the International Labour Organization, concerning Indigenous and Tribal Peoples in Independent Countries, emphasizes that Governments shall "(a) Consult the peoples concerned, through appropriate procedures and in particular through their representative institutions, whenever consideration is being given to legislative or administrative measures which may affect them directly"[42]. Such stipulations pose added challenges to protected area agencies. Trade offs between social, economic and environmental quantities and qualities are often essential at the level of the landscape / seascape and are acceptable if overall values are maintained within the broader area. This means that the pure science of identifying the best sites for protected areas will need to be integrated into the political reality of what is possible, what can be achieved quickly and what opportunities exist. While the whole point of a gap analysis is to bring science to the fore in conservation decision-making, final decisions are not only made through science and scientists will be working in partnership with many other stakeholders in designing the protected area network.

6. **An iterative process**: ***review and improve the gap analysis as knowledge grows and environmental conditions change***. While the CBD is promoting a gap analysis as a single exercise, to be completed against a short time-scale, in many cases all the information necessary to make informed choices will simply not be available by that deadline; some countries still have many years of research to undertake before having anything like a comprehensive picture of their biological diversity. The gap analysis should therefore not be seen as a one-time and only exercise but as an hypothesis that provides a series of maps and guidelines that may have to be revised and improved as time passes and we learn more.

CHAPTER 5 ▪ People matter: a multi-stakeholder approach

The past several decades of experience in establishing and managing protected areas have demonstrated that they are most likely to be successful when key stakeholders are involved in their creation, design, and management[43]. Yet, this relationship between people and protected areas is arguably one of the most challenging in conservation. It is also an area where those responsible for protected areas – governments and others – have often gotten things wrong and as has resulted in many tensions and conflicts through a failure to address peoples' needs early enough in the planning of a protected area. News of the creation of a new protected area is usually greeted with delight by conservation organisations, but people living in or around the new area may be less enthusiastic. For them, protection can mean loss of access to resources that have previously been available for little or no monetary cost – such as game, fish, non-timber forest products and agricultural land – or impose restrictions on their activities or development opportunities. People have sometimes been expelled or forcibly relocated to areas far from their traditional lands. For example, in 1872 the Shoshone people were expelled from the Yellowstone National Park, the first "modern" protected area. Other examples include the Ik from Kidepo National Park in colonial Uganda, the Vedda from the Madura Oya National Park in Sri Lanka and the Batwa of Rwanda, Uganda and DR Congo from mountain gorilla reserves[44].

Such actions, quite apart from their serious social and humanitarian impacts, achieve little for conservation. Loss of traditional rights can reduce peoples' interest in long-term land stewardship and creation of a protected area can in some cases increase the rate of damage to the very values that the protected area was originally created to preserve. For example, when the collective forests of Yuhu village were incorporated into the Yulongxueshan Nature Reserve in northwest Yunnan China, farmers responded by cutting down trees that they had previously managed on a sustainable basis[45]. When Rio Bravo Conservation Management Area, a private land reserve, was created in Belize with limited stakeholder engagement, distrust grew with surrounding farmers who believed the management of the reserve was generating locusts who were damaging their crops.

People can play a key positive role in conservation rather than being regarded as a "problem". In some cases, the presence of indigenous or local people is now virtually essential for the maintenance of the ecology. Many of the world's "natural" areas have actually been managed to some extent for hundreds or thousands of years and survival of biodiversity may rely to a certain extent on continuation of traditional management. Local communities can and do help maintain the protected area values, if they agree with them, in situations where park staff have neither the time nor resources to ensure protection.

The Programme of Work thus stresses that planning should be participatory, involving a wide range of stakeholders. One key issue to decide is exactly who is involved and who has legitimacy. There will in reality be insufficient time to talk with everyone and it is important to prioritize – to know who should have the loudest voice. Is it politicians in the capital, or tourism operators, or local villagers? Many of the lands currently being considered for protected areas are traditional homes of indigenous peoples and it is important to ensure that their voices are heard and their wishes addressed: specific funding is sometimes needed to ensure that this is possible. The following set of criteria may help to distinguish *primary* stakeholders.

Box 2: Possible criteria to prioritize stakeholders in protected area decisions[46]

- Existing legal or customary rights to the land or natural resources included in the protected area
- Continuity of relationship with such land and resources (e.g. residents versus visitors and tourists)
- Direct dependency on the natural resources in question for subsistence and survival (e.g. for food, water, medicine, housing)
- Historical and cultural relations with the land and resources
- Unique knowledge, skills and institutions for the management of the resources
- Degree of economic and social reliance (dependence) on such resources
- Losses and damage incurred in the management process (e.g. related to human-wildlife conflicts)
- Degree of demonstrated effort and interest in management
- Compatibility of the interests and activities of the stakeholder with national conservation and development policies
- Compatibility of the interests and activities of the stakeholder with international conventions and agreements subscribed to by the country concerned

Case studies – Australia: Two issues, protected area representation and the role of indigenous peoples in conservation, have resulted in the promotion of a new form of conservation management in Australia: Indigenous Protected Areas (IPAs). IPAs are created when indigenous land owners make a formal and public announcement of their intention to manage their lands primarily for the protection of natural and associated cultural values, managed in accordance with the IUCN categories and management objectives. IPAs are managed by local and resident indigenous people with government support providing resources, training and advice[47]. Such support is provided on a needs basis. There are 28 projects currently either established or being developed[48]. Today nearly 17 per cent of the total area of the terrestrial protected area estate in Australia is in IPAs.

Case study – Bolivia: In the giant Kaa-Iya National Park (34,400 km^2), the largest protected tropical dry forest in the world, the Isoseño Guaraní indigenous organization CABI has been working in partnership with the Wildlife Conservation Society since 1991. CABI administers the protected area and promotes biodiversity conservation and sustainable use of natural resources within the neighbouring Isoseño indigenous territory. Three indigenous peoples – the Isoseño Guaraní, Chiquitano, and Ayoreode – live around and participate in its management committee. The people hunt for subsistence, fish, cultivate small-scale plots, and migrate to seasonal labour opportunities in farms and ranches. A national land reform process is underway to title all lands outside protected areas in the region to indigenous groups, communities, or private land-owners, creating further opportunities for collaboration with indigenous people in the management of both federal and indigenous protected areas.

Figure 9 ▪ Stakeholder consultation is essential at every level of the process of planning protected areas, from ministries to local communities. The pictures show local officials discussing protected area plans with villagers in Madagascar, stakeholders discussing management of a Category V protected area in Lithuania and managers talking with local stakeholders in Canaima National Park, Venezuela

Photos: Grazia Borrini-Feyerabend, Nigel Dudley and Sue Stolton

Some tools for stakeholder analysis

Numerous tools exist to assist participatory processes in general and a smaller number are aimed specifically at protected areas. Some key texts are listed below:

INTRODUCTION TO PARTICIPATION AND IDENTIFYING STAKEHOLDERS

Stakeholder Power Analysis, Power Tools: Tools for working on policies and institutions series number 2, International Institute for Environment and Development: London, draft [http://www.iied.org/bookshop/index.html]

> *A tool that helps to understand how people affect policies and institutions, and how policies and institutions affect people: based around a six part process: (1) develop purpose and procedures of analysis and initial understanding of the system; (2) identify key stakeholders; (3) investigate stakeholders' interests, characteristics and circumstances; (4) identify patterns and contexts of interaction between stakeholders; (5) assess stakeholders' power and potential roles; and (6) assess options and use the findings to make progress*

Tools for Development: A handbook for those engaged in development activity, Philip Dearden and staff at the Centre for International Development and Training, Steve Jones and Rolf Sartorius, 2002, DFID: London, 142p [http://www.dfid.gov.uk/pubs/files/toolsfordevelopment.pdf]

> *Detailed manual for those involved in development work and stakeholder analysis including various matrices to help analysis; problem and situation analysis; visioning; use of logical frameworks; risk management; participatory methodologies and management; team-working; influencing and negotiating; building partnerships; conflict reduction; monitoring, reviewing and evaluating; workshop facilitation – with many different techniques described and numerous case studies*

Where the power lies: Multiple stakeholder politics over natural resources. A participatory methods guide. B Sithole, 2002, Center for International Forestry Research: Bogor, Indonesia, 87 pp [http://www.cifor.cgiar.org/scripts/newscripts/publications/default.asp]

> *Manual describing a four stage process in analysing, understanding and working with stakeholder groups*

Who Counts Most? Assessing Human Well-Being in Sustainable Forest Management, Carol J P Colfer and 5 others, 1999, Criteria and Indicator Toolbox Series number 8, Center for International Forestry Research: Bogor, 62 pp [http://www.cifor.cgiar.org/download/toolbox8.zip]

Methodology for determining most important stakeholders, using determinants such as proximity to forest, pre-existing rights, dependency, poverty, local knowledge, etc

Stakeholder Analysis and Natural Resource Management, Jacques Chevalier, Carleton University, Ottawa. [http://www.sas-pm.com/epublications/epublications_sp.htm]

An extensive review of the literature on stakeholder theory and methods

INVOLVING PEOPLE IN ASSESSMENT AND PLANNING

Anticipating Change: Scenarios as a Tool for Adaptive Forest Management, Eva Wollenberg with D. Edmunds and L. Buck, 2000, Center for International Forestry Research: Bogor, Indonesia, 44 pages [http://www.cifor.cgiar.org/scripts/newscripts/publications/default.asp]

Manual about how people can use future scenarios to plan creatively, describing several types of future scenario-based methods and providing principles to guide the reader in their use

Exploring biological diversity, environment and local people's perspectives in forest landscapes: Methods for a multidisciplinary landscape assessment, Douglas Sheil and 15 others 2002, Center for International Forestry Research: Bogor Indonesia, 106p [http://www.cifor.cgiar.org/scripts/newscripts/publications/default.asp]

A document on gathering natural resource information that reflects the needs of local communities, based on work with communities in Indonesia and including case studies and methodologies, although the authors stress that this is not a formal manual

Participatory Coastal-Zone Planning: Katrina Brown, University of East Anglia [http://www.uea.ac.uk/dev/publink/brown/analysis.pdf]

Detailed methodology aimed at coastal communities

Comunicación Efectiva para Involucrar Actores Clave en las Estrategias de Biodiversidad. Ana Puyol, CEC-UICN, Quito, Ecuador.

South American countries have ratified the Convention on Biological Diversity and governments have committed to develop national planning efforts known as National Strategies of Biodiversity. This book give ideas on how to involve key stakeholders in these processes

BRINGING PEOPLE INTO PROTECTED AREAS MANAGEMENT

Beyond Fences: Seeking Social Sustainability in Conservation, edited by Grazia Borrini-Feyerabend with Dianne Buchan, 1997, IUCN: Gland, Switzerland, vol 1 129p, vol 2 283p [http://www.iucn.org/themes/spg/Files/beyond_fences/beyond_fences.html]

Two volume manual describing the process of social sustainability covering methods for involving people, addressing local needs in conservation and managing a sustainable initiative, with volume 2 covering various concept files giving background information on key issues, a series of participatory tools and many case studies

Collaborative Management of Protected Areas: Tailoring the Approach to the Context, Grazia Borrini-Feyerabend, 1996, IUCN: Gland, Switzerland [http://www.iucn.org/themes/spg/Files/tailor.html]

A guide to collaborative management including a three stage process: preparing for partnership, developing an agreement and implementing and reviewing the agreement

Good governance, indigenous peoples, and biodiversity conservation, Janice B Alcorn, 2001, Biodiversity Support Program: Washington, DC, 27 pages [http://www.worldwildlife.org/bsp/publications/asia/120/Good_Governance_1.pdf]

Set of guidelines for running biodiversity projects in areas used by indigenous peoples

Indigenous and Local Communities and Protected Areas, Grazia Borrini-Feyerabend, Ashish Kothari and Gonzalo Oviedo (compilers 2004); IUCN, Gland

Detailed guidance about governance issues including new approaches to governance, community particularly conserved areas, with guidelines and case studies

Indigenous and Traditional Peoples and Protected Areas, Javier Beltran (editor), 2000, IUCN Gland

Guidance on integration of indigenous peoples with protected areas

Participatory Approach to Natural Resource Management, Teppo Loikkanen, Timo Simojoki and Pauli Wallenius, 1999, Metsähallitus Forest and Park Service: Vantaa, Finland, [http://www.metsa.fi/page.asp?Section=1200&Item=1644]

Guide to participatory approaches in natural resource management covering participation planning, individual and group methods, public events, instructions for facilitators etc. This is interesting because it describes techniques used in a comparatively rich, developed country where forestry remains of key importance to rural communities. Interesting because from a Northern perspective

Sharing Power: Learning by Doing in Co-management of Natural Resources throughout the World, Grazia Borrini-Feyerabend Michel Pimbert, Taghi Farvar, Ashish Kothari and Y. Renard, 2004, International Institute for Environment and Development and IUCN/CEESP, 500 pages; [http://www.iucn.org/themes/ceesp/Publications/sharingpower.htm#download]

Extremely comprehensive set of case studies and experience in various forms of co-management both inside and outside protected areas

PART 2 CARRYING OUT A GAP ANALYSIS

This section of the manual gives some information to help to carry out a gap analysis. It builds on the basic steps that have already been outlined in the introductory section:

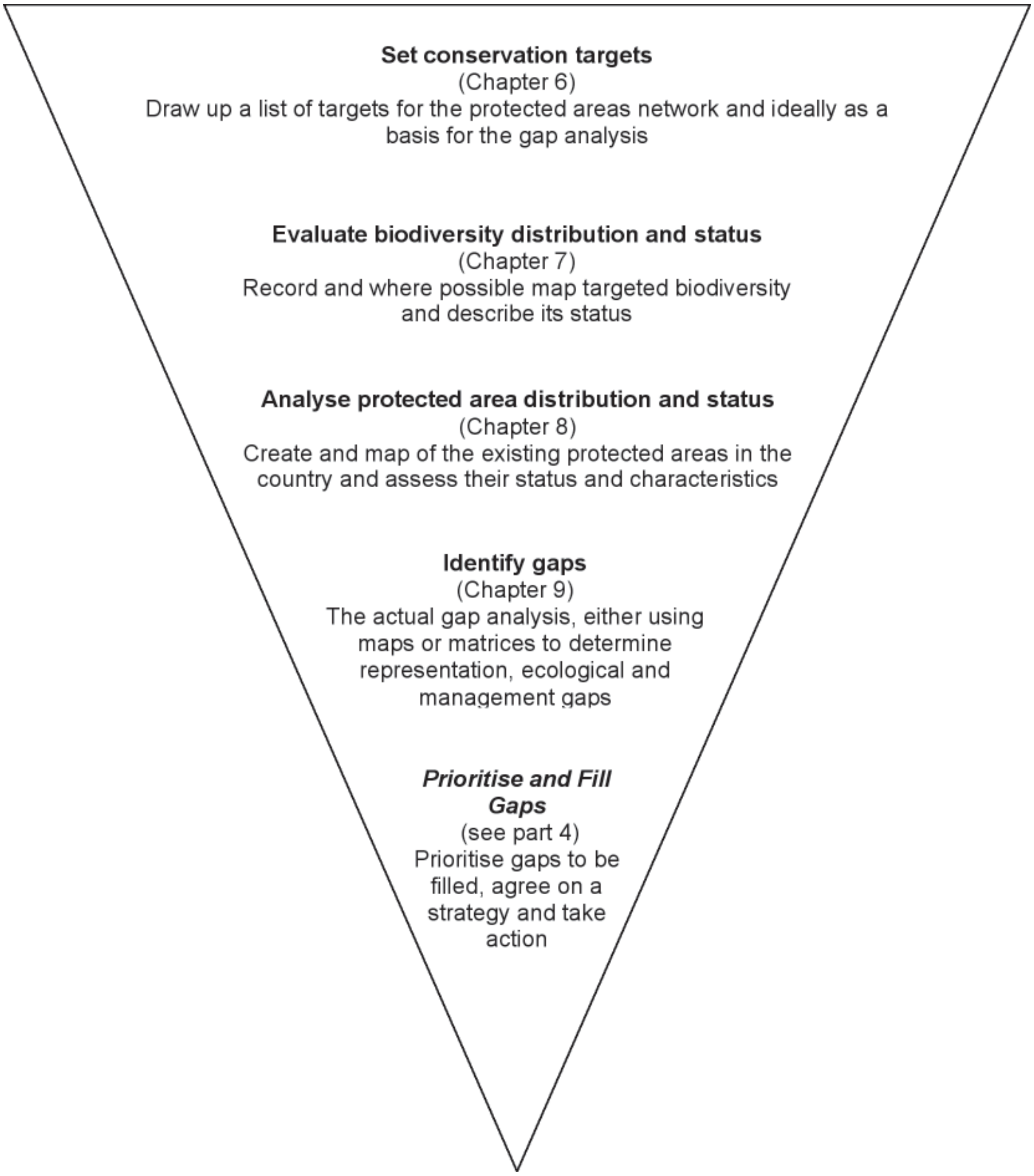

Figure 10: Steps in Gap Analysis

Each of these steps presents challenges. The following four chapters look at each stage of the gap analysis in turn, with particular emphasis on freshwater and marine issues in Part 3. Part 4 provides real-life case studies, and part 5 looks at taking the information generated and using it to help an ecologically-representative protected area system.

CHAPTER 6 ▪ Setting conservation targets for focal biodiversity

It is not practical to plan protected areas for every individual species, given the tight timetable of the CBD's *Programme of Work* and the fact that many species have yet to be discovered or described. Instead, most gap analyses focus on a representative sub-set of the nation's biological diversity. These **focal biodiversity elements** define the species, communities and ecological system to be evaluated in the gap analysis and are intended to represent the full range of biodiversity within the ecoregion (freshwater, marine and terrestrial). Coarse filter elements (e.g. all native/natural ecological systems) represent common and widely distributed species, natural communities and the ecological processes that support them. Fine filter elements are native species, species assemblages and communities that are not well captured by the coarse filter and require individual attention in order to be effectively represented in the protected area system. Guidance on choosing a set of indicators is given in Chapter 7. A gap analysis should normally list those focal species and ecosystems and describe why they were chosen and what they represent.

Most countries agree and measure against specific targets to help to develop their protected area network[49] and they are recognised as a key tool in developing representative protected area networks[50]. They range from simple targets relating to the area protected to more sophisticated targets of representation or endangerment[51], e.g.:

- **Area targets:** at the simplest level, agreeing an overall area of land or water to be protected as a national target. Many countries have officially or unofficially measured themselves against the target of 10 per cent of terrestrial area, developed by IUCN The World Conservation Union at the IVth World Parks Congress in Caracas, Venezuela in 1992. Setting targets solely based on area is probably the most direct to implement, but risks not addressing the ecological needs of biodiversity or capturing all elements of biodiversity in implementation.
- **Coarse filter targets:** targets based around the protection of broad land or water types, such as ecosystems or their components (e.g. communities and environmental surrogates). Use of such targets relies on a good enough knowledge of ecosystems to identify and measure terrestrial[52] freshwater[53] shoreline[54] and marine[55] ecosystems. For example a country might set a target to protect a proportion of mangroves.
- **Fine filter targets:** usually species of particular concern, such as threatened or endemic species. For example the European Union has used the concept of *favourable conservation status* of species and habitats, which in effect form a series of continent-wide agreed targets. All member states must use Natura 2000 to ensure that listed habitats and species are given favourable conservation status. Habitats and species populations must be maintained at viable levels[56].

Targets should ideally touch upon both the **quantity** of land or water to be protected and its **distribution**. At its simplest, a target can be a decision to protect a stated proportion of remaining valuable ecosystems or to maintain key species – Project Tiger in India is an example of the latter. More sophisticated exercises provide a framework for the protected areas programme by identifying in detail what needs to be protected. There might be hundreds of individual targets for an ecoregion, although such detail may be beyond the capacity of many national exercises running to a tight timetable. In effect the targets are often the same as the indicators or surrogates chosen for the gap analysis. Some of the discussion about biodiversity measurement in chapter 7 could relate to choice of targets. The following examples show approaches to identifying focal biodiversity elements.

Box 3: Examples of area, coarse filter and fine filter targets

Area targets: a number of countries have already set area targets for new protected areas, for instance:
- Mongolia: 30 per cent of the country's area
- Madagascar: Tripling the current area of protected areas
- Sakha Republic, Russian Federation: 25 per cent of the land area
- Chile: 10 per cent of relevant ecosystems

Coarse and fine filter targets: focal biodiversity elements in Colorado: The strategy for the Colorado plateau ecoregion, identified 361 conservation targets as follows[57]:

Colorado Plateau Ecosystem Conservation Targets Summary		
Category of target	**Details**	**Number**
Ecological systems ("coarse filter")	Terrestrial ecological systems	30
	Freshwater ecological systems	34
Rare communities/ species assemblages ("fine filter")	Rare communities (terrestrial and freshwater)	46
	Vulnerable species assemblages	3
Species ("fine filter")	Imperilled species	202
	Species of special concern	46
Total		**361**

Coarse and fine filter targets: focal biodiversity elements in Mexico: the draft targets consider ecosystem, species and genetic diversity

Diversity of ecosystems and communities ("coarse filter")
· Areas with high species richness (Alfa Diversity).
· Areas with high beta diversity.
· Areas with occurrence of relict ecosystems or biological communities
· Areas with concentration of endemic species
· Areas with unique geo-morphological features.
· Cave communities with verified biodiversity.
· Oceanic and coastal islands.
Species: ("fine filter")
· Species considered as evolutionary rarities or of particular value to biological evolution.
· Endemic species (micro-endemics, meso-endemics, etc) restricted to Mexico.
· Threatened and endangered species included in the IUCN red list and in the Mexico Red List
· Rare species.
· Highly vulnerable species
· Wild species related with cultivated or domesticated species or varieties (Agro-biodiversity)
· Umbrella and key species
· Species extirpated from the wild that have been re-introduced[1]
· Populations of species with extreme or peripheral distribution within the species range
· Species under high pressure by a high commercial demand
· Migratory species (Birds, Bats, Butterflies, etc).
· Species included in CITES
Genetic diversity: ("fine filter")
· Areas or sites with genetically viable populations of flora and fauna
· Areas or sites that allow connectivity between habitats promoting genetic flows
· Areas or sites considered as centers of origin of species important to agro-biodiversity
· Areas or sites considered as centers of origin of endemic species
· Areas with traditional or indigenous agro-ecosystems that are functional and maintains diversity of cultivated or domesticated varieties
· Populations of rare or endangered species considered "genetically pure" (with no genetic contamination by individuals of other subspecies, etc).
· Populations of commercial species heavily exploited with highly desirable fenotipic characteristics.

[1] For instance the California Condor (*Gymnogyps californianus*), the black-footed ferret (*Mustela nigripes*), the Mexican wolf (*Canis lupus baileyi*), and eventually the sea otter (*Enhydra lutris*) currently extinct in Mexico.

Some tools for identifying targets

Designing a Geography of Hope: A practitioner's handbook for ecoregional conservation planning: Craig Groves, Laura Valutis, Diane Vosick, Betsy Neely, Kimberly Wheaton, Jerry Touval, Bruce Runnels, 2000, The Nature Conservancy, Arlington Virginia (2 volumes)

Detailed handbook for ecoregional planning including guidance on choosing conservation targets

Guidelines for representing ecological communities in ecoregional conservation plans M Anderson, P Comer, D Grossman, C Groves, K Poiani, M Reid, R Schneider, B Vickery and A Weakley, 1999, Conservation Science Division, The Nature Conservancy [http://www.tnc.org/frames/index.html?http://consci.tnc.org/index.html]

Basic guidelines for drawing up targets as used by The Nature Conservancy

Systematic Conservation Planning: C R Margules and R L Pressey, Nature **405**: 243-253

Six stage planning process drawing on targets, including both quantitative and qualitative targets

CHAPTER 7 ▪ Evaluating biodiversity distribution and status

A gap analysis compares protected areas with the biodiversity to be protected. The first stage of the assessment is therefore to aggregate available information on managed areas and focal biodiversity to make this comparison. Two main bodies of information are needed:

- Current distribution (verified and/or estimated) of biodiversity in all its forms (general ecological condition and focal biodiversity)
- Current status and trends of this biodiversity, even if cursory.

Current distribution of biodiversity

A gap analysis is based on ecological representation. From a practical perspective this means choosing some focal elements of biodiversity that give a reasonable representation of whole ecosystems. There is currently a huge difference in our knowledge of biodiversity in different countries, and unfortunately the places that we know best are often those with the lowest levels of diversity. Whereas the distribution of many species in countries like the Netherlands, UK and Scandinavia are mapped down to 1 km squares, knowledge of the largest mammals remains extremely poor in for instance the Congo Basin, Indochina and much of the Amazon. Knowledge of marine and freshwater species remains particularly sparse. There is not enough time to fill these information gaps by the end of 2006, so in many cases gap analysis will rely on some form of surrogate, usually species, representative ecosystem types or even data based on landforms and geology that will serve as the focus for biodiversity gap analysis.

Figure 11 ▪
Information availability can vary widely. In Oulanka National Park in eastern Finland, rare plants are mapped so precisely that botanists monitor individual plants. In Song Thanh Reserve, Vietnam, camera surveys still regularly find mammal species new to the park and no overall species lists exist.
Nigel Dudley

Different ways of representing biodiversity

There are a number of different ways of representing biodiversity and selection will depend on how complete an available data set is already available and on the precise aims of the gap analysis. Given that no country in the world has complete data on all species, and to ensure that planning processes are efficient and as cost-effective as possible, most national gap analyses will use a combination of the options outlined below. Choosing of indicators or surrogates is often difficult from the scientific perspective and in a public process this choice also has a social and political role. Ideally, the portfolio of indicators used to identify distribution of biodiversity in a gap analysis needs to be:

- Representative of as much of the total biodiversity as possible, including biological scales and biological realms
- Recorded well enough to provide adequate and updated data on the timescale required by the CBD
- Sympathetic to other stakeholders – i.e. likely to be understood and does not give a distorted impression of conservation issues

In practice, several different kinds of information can be used in a gap analysis. A selection is listed below in increasing order of detail and accuracy, from coarse analyses that provide very general information to increasingly finer and more accurate approaches. These are not exclusive and many good analyses will use a combination of these scales of assessment. In general the level of accuracy is likely to increase with the specificity of information; i.e. a gap analysis based on accurate knowledge of many species is likely to be superior to a gap analysis based on analysis of realms. While none of these options are easy and collecting this information poses a challenge for ecologists, these investments help conservationists come closer to designing a representative protected area systems network that represent a major achievement when completed.

- **Realms**: the crudest form of gap assessment (and not suitable to be used alone), using cover of major biomes, which at least gives a picture of where the largest gaps are likely to be found. For example, at a global scale major gaps are acute in freshwater (e.g. 1.54 per cent of lake systems protected) and marine biomes (0.5 per cent protected). Table 4 below gives some approximate outline statistics. According to the World Database on Protected Areas in 2003, 4,459 protected areas contain marine and coastal elements, covering 4.2 million km^2; however many sites also contain land so the figure is a best estimate[58].

Realm or part of realm	Extent of protected areas (km^2)	Percentage biome protected
Marine	1.7 million	0.5%
Lake systems	7,989	1.54%

Table 4: Best *global* estimates for coverage of marine realm and lake systems in protected areas

Our knowledge of these under-protected biomes remains poor, particularly in the case of the high seas and deep marine waters, with rich and poorly studied ecosystems such as hydrothermal vents, seamounts, deep water, reef-forming corals[59] and submarine canyons[60], many of which have in recent years become increasingly threatened by bottom trawl fisheries[61], pollution and the long-term impacts of climate change. Even within coastal waters and smaller seas, knowledge remains extremely partial, as demonstrated by recent "discoveries" of large cold-water coral reefs that are currently suffering intense damage from fishing efforts.

Freshwater systems have traditionally been under-protected as well. Although terrestrial protected area systems may cover portions of a watershed, these systems have mostly been designed without knowledge or consideration of freshwater species, habitats, and ecological processes[62]. In addition, terrestrial protected areas often use rivers to mark their borders with this configuration leaving the river itself open to degradation associated with land cover change on its unprotected bank[63]. No global gap assessment of all freshwater habitats has been completed; however, we know from regional and habitat- and taxon-specific assessments, that the freshwater realm is in need of much greater attention[64 65 66].

- **Environmental domains and enduring features**: the use of landform, geology and climatic variables to predict likely ecosystems are suitable where data are scarce or where existing changes have removed habitats. Thus restoration must play an important role within the new protected area system. This has been carried out around the world where ecosystem and vegetation maps are not available. Existing broadscale analyses, such as the global ecoregional analysis[67], can also help to stratify major habitat types and realms to help refine assessment in these cases.

- **Ecosystems or habitats**: In parallel with assessment of species, knowledge about extent and coverage of ecosystems is also important. Particular ecosystems also contain specific interactions between species, sometimes evolving over time to great complexity, which cannot necessarily be duplicated elsewhere. In the many parts of the world where most biodiversity is yet to be described, and where the relationship between species that might be used as surrogates and other taxa is unknown, ecosystems can go some way towards indicating representative communities across a region. The CBD specifically recognises ecosystems as a component of biodiversity and therefore these should also be included in the analysis. Further, the inclusion of ecosystems as on scale of biological diversity can better ensure capturing ecological processes that support and bind populations of species and also provide critical ecosystem services to humans.

  Evaluating ecosystems is a relatively fast option, particularly if species data are scarce. Ecosystems can sometimes be represented through use of ecologically interpreted remote sensing imagery and other spatial data in conjunction with broadscale surveys. It creates a possibility of "capturing" species associated with particular ecosystems without having to cover each separately, although the potential inaccuracies in this must be recognised. Ecosystems have in practice often been used as a surrogate for species-level biodiversity in gap analysis. The principle disadvantage is that species with special needs unique within the ecosystem are likely to be missed[68] along with other small-scale differences (for example centres of biodiversity within ecosystems) and the effects of selective pressures on ecosystems (for example remaining tropical forest where large mammals have been lost to the bushmeat trade). If possible the *quality* of ecosystems should also be factored into the assessment, for example by distinguishing old-growth from managed forests. These challenges can be addressed through use of the "coarse-fine filter" approach, as described above

  Occasionally highly specialised microhabitats can also be useful if survey data exist. For instance, volumes of dead wood are now surveyed on a regular basis in some European countries and represent a key indicator of forest quality (and incidentally "capture" information about the likelihood of occurrence of saproxylic species)[69].

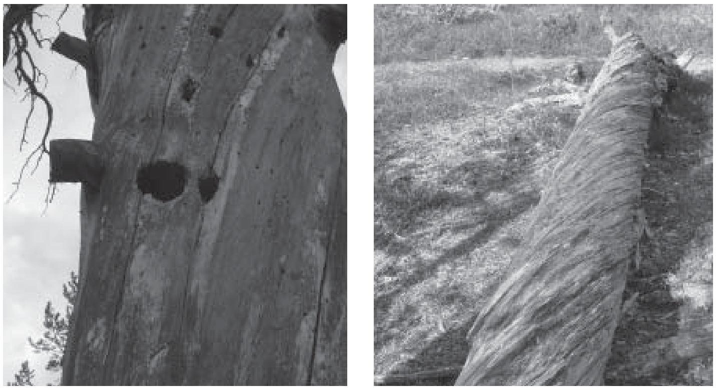

Figure 12 ·
Deadwood is a rare microhabitat for forest biodiversity in much of Europe. Surveys under the auspices of the Ministerial Conference for the Protection of Forests in Europe are gradually building a dataset on dead wood occurrence
Nigel Dudley

- **Species**: Representation assumes coverage for all species. Species are the basic "unit" of biodiversity and, once lost, can never be recreated. Along with the vast potential genetic resources and species upon which society depends that are in danger of being lost as species become extinct, most people believe that we have an ethical obligation to prevent loss of species due to our own actions. Overall, the most accurate data on which to base a gap analysis comes from knowledge of species distribution. However, almost all nations have gaps in their knowledge of species distribution and these knowledge gaps will not be filled during the timetable of the *Programme of Work*. In practice two alternatives are used: representing biodiversity through particular (1) **focal species** (e.g. previously identified targets for the gap analysis or other particularly important species such as endemics, threatened species, keystone, or wide-ranging species) or (2) **species groups** such as mammals, birds or butterflies chosen on the basis of knowledge of their distribution or ecological characteristics. Species groups suffer from the same problems; while there is evidence that distribution of birds in particular is a reasonable surrogate for all biodiversity in natural landscapes, the relationship is far less clear in altered or cultural landscapes[70]. It is desirable to attempt to represent all known species but if data are too scarce focal species will be useful. Within-species diversity is the first stage in further speciation and continuing natural evolution. As the world enters a period of rapid climatic change, it is likely that species will have to adapt quickly and a large gene pool is an essential component in such adaptation. Although most national gap analyses will not be able to take much account of variation within species on an individual level, it can be addressed to some extent by ensuring that multiple populations of species and multiple examples of ecosystems are within the protected areas network – another reason for the principle of redundancy outlined above.

In practice a combination of some or all of these will give the most comprehensive picture: indeed, these methods were each developed as components of an overall biodiversity assessment approach, not as a solution in themselves. A gap analysis that relies only on available species data in a country where this is poor, or only on higher scale environmental surrogates (such as enduring features), is unlikely to meet the guiding principles outlined in this manual. This implies measuring species, ecosystems and also sometimes microhabitats such as dead wood or sea grass beds that together provide an approximate picture of total biodiversity. All of these have their strengths and weaknesses, and are not exclusive. Many gap analyses draw on two or more of these approaches. Each country will probably be different in the types of data available and therefore the precise mix of options selected. Some pros and cons of the various methods are outlined below.

Option	Strengths	Limitations
Realms	· Quick · Provides initial broad targets · Data almost always available · Can be further defined by major habitat types and by ecoregions	· Does not distinguish between different ecosystems in biomes · Says little about environmental quality or survival of species within biomes
Environmental domains and enduring features	· Possible to survey rapidly using satellite imagery and existing maps · Useful in places where major changes have already taken place · Can find restoration sites	· Only gives a crude indication at ecosystem scale · Tells little about species' status
Ecosystems	· Helps to represent species that have not been described or surveyed · Suitable for rapid analysis · Provides data in a form easily mapped	· Can miss local centres of diversity · Misses idiosyncratic threat (e.g. poaching) and species with special ecological needs, and thus can miss losses within ecosystems
Species groups	· Possibly a good surrogate for total biodiversity where well surveyed · Coherent data sets	· Data often lacking · Extent to which particular groups like birds represent all biodiversity unproven in many habitats
Focal species	· Possibility of capturing good information · Provide measurable targets for conservation	· Depends on good data · Depends on correct choice of indicators · Expensive and time-consuming

Table 5: Options for collecting information for a gap analysis

In all cases, there are two stages in assembling data: finding information on status and then – often more difficult – finding whether this can be mapped. An ideal gap analysis will consist of maps of biodiversity that can be overlaid over maps of protected areas to geographically and spatially locate and analyse thematic gaps. If this isn't possible some simpler methods are available, but wherever possible maps of biodiversity are particularly valuable.

Realms: At present some critical biomes, including freshwater, marine and grasslands are all under-represented in protected area systems and a first analysis at biome level can provide a coarse filter that can suggest where more detailed analyses are needed.

Figure 13 ▪ Freshwater ecosystem at Royal Chitwan National Park, Nepal: Sue Stolton

Environmental domains and enduring features: where data are virtually absent or where native vegetation has disappeared, geographical features can be used to infer likely ecosystems; particularly useful in planning restoration.

Figure 14 ▪ Brecon Beacons National Park, Wales, UK: Nigel Dudley

Ecosystems: a much quicker way of collecting information over a wide area, or where an entire ecosystem is under-represented in a protected area system.

Figure 15 ▪ For example, mangrove ecosystems are generally under-represented in protected area networks and a gap analysis of mangrove ecosystems can provide extremely useful data for planning. Mexican mangroves: Nigel Dudley

Species groups: using one or more particularly well studied group – often mammals, birds or amphibians.

Figure 16 ▪ For example, birds are well studied in terms of both composition and distribution (particularly if larger species are chosen) even in many generally information-poor countries. Cape Gull, South Africa: Nigel Dudley

Focal species: using a carefully selected choice of species to provide in total as good an overview of ecosystems and species as possible.

Figure 17 ▪ For example, the elephant is a wide-ranging species that provides a good indication of whether enough of the ecosystem is being conserved. In Serengeti National Park, Tanzania: Nigel Dudley

Current biodiversity status

Just as important as the distribution of biodiversity is its overall status and trends. To capture biodiversity that will persist within protected areas, we need to know about its viability and vulnerability. Knowing the trends in biodiversity will also help later in the process when it comes to prioritising actions. The extent to which information will be available in different countries will vary enormously, and as in the case of distribution will rely primarily on the use of surrogates that provide trend data that can be extrapolated for biodiversity as a whole.

In practice, it makes sense to look at distribution and status for the same group of biodiversity elements, which in turn influences the choice of those focal biodiversity elements. Choice of focal biodiversity elements is in practice not only dictated by what is most representative, but also on existing data availability in terms of status and trends to inform the need and location of protected area system improvements. Particularly important are trends in threatened species and threatened ecosystems, using available data such as the IUCN Red List and other Red Lists, existing habitat surveys and in particular the status of irreplaceable biodiversity such as endemic species and ecosystems. Spatial data on ecosystem size and landscape / seascape context from information about land-use cover, dams etc. are useful in evaluating the status and trends of ecosystems.

This data will probably not be available for all the elements of biodiversity measured in the first part of the analysis. In many cases our knowledge of status of even quite large species is still a leap of faith. The saola (*Pseudoryx nghetinhensis*) a large mammal in the *Bovidae* family, is one of the most intensely studied species in Indochina, following its discovery in the latter part of the twentieth century. Yet even today very few people have ever seen a live animal and estimates for the Vietnamese population range from “a few hundred” downwards and the Laotian population has been estimated at 70-700, but probably nearer the lower figure[71]. Trends in such poorly understood populations are virtually impossible to do more than make educated guesses about, yet it is precisely these kinds of data that are needed to drive accurate gap analysis. The rediscovery of the Ivory-billed Woodpecker (*Campephilus principalis*) in Arkansas in the United States during the writing of this guide, after it had last been seen in 1944 and was long assumed extinct[72], illustrates the extent to which trends and status information remains shaky even in some of the best studied countries in the world. Nonetheless, information is accumulating quickly and much can be inferred. In some cases, notably amphibians, improvements in global understanding have been rapid and web-based datasets are allowing scientists to contribute and collate information in a way that would have been impossible a few years ago[73]. The IUCN Red Data lists and more detailed lists available in many individual countries can help provide a basis for examination.

Even with these measures, surrogate data may often be needed to give a snapshot into the ecological status and viability of focal biodiversity elements. Recently, advances have been made in the use of spatial data to assess condition and integrity of ecosystems and these issues are examined in the following section.

Assessing condition/integrity of ecosystems: using spatial data to develop suitability indices

Jonathan Higgins, The Nature Conservancy

Spatial data can be used to infer the relative ecological integrity of communities and ecosystems through evaluating their condition and landscape context and developing a suitability index. This is a rapid approach to quantify the relative quality and potential for persistence of specific biodiversity targets, as well as landscapes in general. A base map of communities or ecosystems, watersheds or regular polygons such as hexagons are necessary as a platform to attribute spatial units with data. Using a geographic information system (GIS), these spatial units can be attributed with tabular data such as species composition, environmental condition and management practices, expert knowledge, or spatial data such as land use/cover and other data which provide spatial patterns on natural/unnatural lands, roads, urban areas, dams and other information. Below are examples based on expert knowledge and spatial data.

Apache Highlands: Expert knowledge was used to evaluate grassland conditions in Arizona and other portions of the Apache Highlands ecoregion of the Southwestern United States[74]. Regional grassland experts were given maps of native grassland ecosystems. The experts delineated polygons of current and historic grasslands and assigned each polygon to one of the following six condition classes:

A) native grassland with low shrub cover
B) shrub-encroached non-native grassland with restoration potential using prescribed fire
C) sacaton riparian grassland
D) non-native (exotic) grassland with low shrub cover (<10 per cent)
E) non-native (exotic) grassland with 10-35 per cent shrub cover
F) former grassland that has undergone conversion to shrubland (>35 per cent shrub cover)

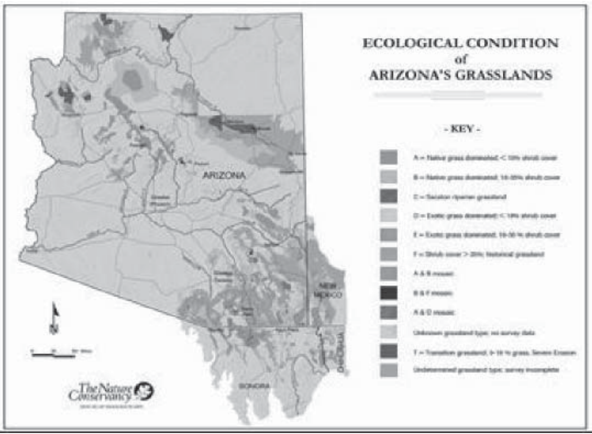

Figure 18 ▪ Ecological condition of grassland ecosystems in Arizona and a portion of New Mexico, United States, and a portion of northern Mexico

Snohomish River: Spatial data were used to develop a suitability index of freshwater ecosystems in the Snohomish River watershed in Washington, United States. This example shows how headwater and small tributary ecosystems (figure 19) were used as the spatial assessment unit. While figures 20 and 21 show patterns of road/stream crossings and land use (agriculture), similar analyses were conducted for dam storage capacity and water quality ratings. All of these factors were used to develop a single suitability index for each example of every ecosystem type (figure 22). Each factor was scored by quintile[2]. The index was an average of the sum of the quintiles of each factor. This analysis shows examples of ecosystem types that are least impacted and potentially in the best condition, and those that are clearly impacted by many factors. Those with moderate index levels should be further reviewed by regional experts.

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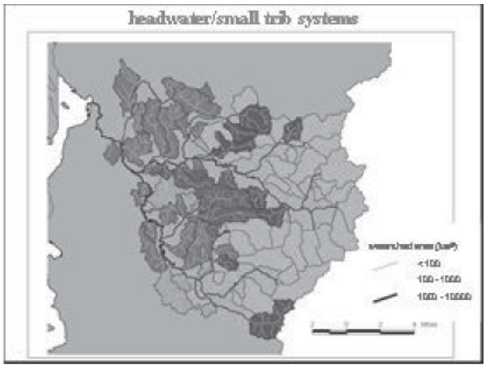

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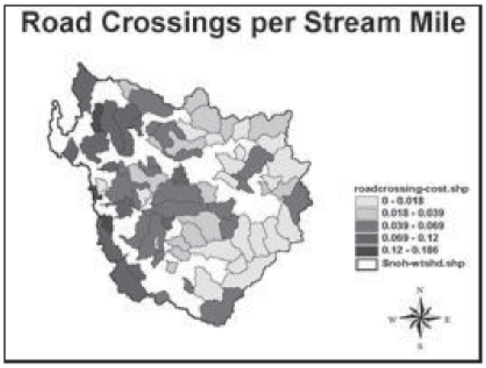

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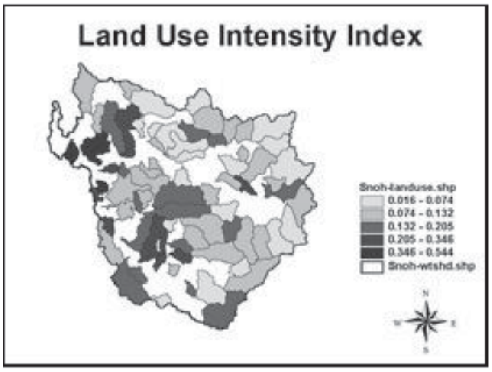

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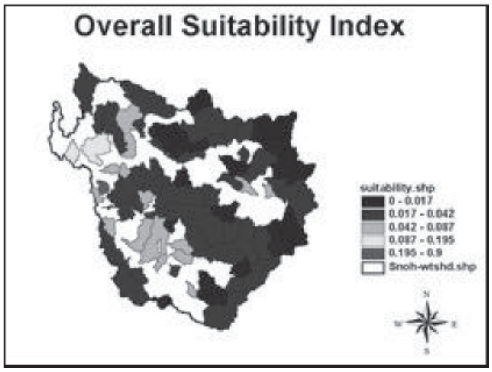


Figures 19 and 20 from *Drafting a Conservation Blueprint* by Craig R. Groves. Copyright © 2003 Craig R. Groves and The Nature Conservancy. Reproduced by permission of Island Press, Washington, D.C.
Figures 21 and 22 from "Maintaining the Ebbs and Flows of the Landscape: Conservation Planning for Freshwater Ecosystems" by Jonathan V. Higgins. Found in *Drafting a Conservation Blueprint* by Craig R. Groves. Copyright © 2003 Craig R. Groves and The Nature Conservancy. Reproduced by permission of Island Press, Washington, D.C.

Additional examples of spatial analyses of ecosystem minimum dynamic area and suitability indices:

- Anderson et al. 2004. Determining the size of Eastern Forest Reserves. An example of assessing minimum dynamic area of forest matrix blocks to withstand natural disturbances and to maintain area sensitive species. Available on line: http://conserveonline.org/2005/03/b/Eastern_Forest_Reserves;internal&action=buildframes.action

- Noss, R. F., ed. 2000. *The Redwood Forest: History, Ecology, and Conservation of the Coast Redwoods.* Washington, D. C.: Island Press. An example of using spatial and tabular source data on patch functions (patch size, road density, threatened and endangered species), neighborhood functions (concentration, age composition, fragmentation and proximity to protected areas), and watershed functions (road/stream intersections, and riparian zones). (from Groves, 2003)

[2]Quintile – The portion of a frequency distribution containing one fifth of the total sample.

What to measure to find out about biodiversity distribution and status

While many countries will have to assemble whatever they have available, others will already have enough information to select a sample of the best. By selecting surrogates a picture of overall biodiversity distribution and status can be built up. Table 6 shows a range of the elements to consider when selecting which components of biodiversity to use. However data are assembled, the end result should be capable of presentation on a map or maps, which can be overlaid onto those of existing protected areas to identify the gaps.

Elements	What the surrogate shows	Sources of information	Example
Species health			
Well studied species	Data on species or groups of species that are already well known and can provide good coverage to help provide an initial framework for the gap analysis –	Existing species records	Typically birds and mammals along with some plant species, marine or freshwater fish
Threatened species	Populations and location of threatened species, with a particular focus on species that are globally threatened[3]	Red Data lists, Species Information System, Species Survival Commission	Country and sub-national red data lists
Ecosystem health			
Landscape species	Populations of area-dependent species such as top carnivores / herbivores, which give an indication that the overall size of an ecosystem is sufficient to maintain itself over time	The Wildlife Conservation Society has a methodology for identifying landscape species[75]	Snow leopard, Asian rhinoceros, African elephant
Representative habitats	Places that are particularly rich and / or representative of given habitats	Broadscale planning exercises such as ecoregional plans or transboundary protected area studies	Priority conservation landscapes / seascapes in ecoregional plans
Ranges and connectivity	Populations of migratory species that need seasonal or connecting habitats, presence of ecological corridors and stepping stones	Existing surveys	Wildebeest, Monarch butterfly, Eurasian swift, grey whales
Ecological functioning	Species and spatial data that suggest the ecosystem is functioning in a natural and sustainable manner, such as microhabitats or food sources	Existing surveys, spatial data, monitoring programmes, including outside the biodiversity field (e.g. fishery records)	Dead wood in forests Krill and sand eels as food sources for birds and cetaceans in coastal waters, roads, dams
Ecological renewal	Maintenance of critical ecological processes	Ecological studies, forestry records	Fire ecology, senescence and renewal, coral reef recovery after bleaching
Uniqueness			
Endemic species	Species that are unique to a country or small number of countries	Existing biodiversity surveys. Red Lists. Global studies like the Endemic Bird Areas and Centres of Plant Diversity	Sao Tome little collared fruit bat (*Myonycteris brachycephala*) Ecuador fish-eating rat (*Anotomys leander*)
Endemic ecosystems and habitats	A focus on unique habitat types in countries, including ecological and evolutionary phenomena (e.g. remote islands, or with climatic anomalies, periodic disturbances)	Existing surveys, ecosystem classification	Varzea wetland Bristlecone pine forests of the White Mountains, California

Table 6: Surrogates for biodiversity

[3] This implies that species which are globally rare rank as more important than those which are only rare in a particular country, perhaps because they are on the edge of their natural range or because of particular pressures. For example the crested tit (*Parus cristatus*) and Scottish crossbill (*Loxia scotica*) both have very limited distribution in the UK but the former is common over much of Europe while the latter is endemic to Britain and therefore a much higher conservation priority

National versus ecological boundaries in gap assessments

The CBD COP is specific in asking all countries to carry out national gap assessments although it mentions regional assessments as well. The concept of a national gap assessment, whilst useful in helping to build up national protected areas systems, contains some inherent limitations in that ecosystems and species are not distributed according to national boundaries. Biodiversity assessments have been conducted using ecologically meaningful regions, from which a more logical country gap assessment and protected area design can be made. Some protected area systems simply do not make sense unless they take in land or water in two or more countries and the growing number of transboundary protected areas reflects this. For this reason, the CBD explicitly calls for more transboundary protected areas. Potential problems can be minimised by following some simple steps:

- Taking account of any existing regional or ecoregional assessments

- Liaising with protected area planners in adjoining countries regarding common issues, potential cross-border cooperation of various kinds, and including people from neighbouring countries in planning workshops

- Considering the worth of expending major effort in protecting species rare in one country that are common elsewhere. (In some cases this may be justified, e.g. if it helps recover former core range; in cases where the species is naturally rare there may be less justification.)

Figure 23 · The red squirrel has been almost wholly replaced by the North American grey squirrel in the UK: is it worth investing in conservation when it is still common in mainland Europe?

Figure 24 · Is the intense conservation effort aimed at pasture habitat and associated flora in Sweden and Finland justified when many of the species are common elsewhere?
Nigel Dudley

Figure 25 · The wolf is becoming reasonably common in Italy but extremely rare and still widely hated in Switzerland. Should the Swiss "give up" on the wolf or maintain conservation programmes?
Nigel Dudley

Tools for biodiversity assessment

Data collection for a gap analysis does not have to start from nothing. Most countries already have access to extensive albeit incomplete biological records, although these are often not collected together in one place. In addition there are many existing regional and global surveys that national researchers can draw upon to help prioritise particular places or species. Satellite images and GIS databases, some of which may be freely available, can help fill information gaps about broad vegetation patterns.

Figure 26 ▪ Many countries already have considerable information available on biodiversity although this is frequently not collected together in one place. An early stage in assembling information may therefore be to track together available information in journals, grey literature and sometimes in unpublished field notes and personal experience.
Nigel Dudley

SPECIES AND GENERAL BIODIVERSITY INFORMATION

No global dataset of biodiversity exists; in fact no truly global data are available even for most species or groups of species. The following web sites can help assemble part of the wider picture, and can frequently be enhanced by reference to national or regional data sets and species lists.

- **IUCN Red List of threatened species:** contains information on taxonomy, conservation status, and distribution of species that are defined by IUCN as under threat. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world. A species is listed as ***threatened*** if it falls in the *Critically Endangered, Endangered or Vulnerable* categories. In addition to the global list, many individual countries have produced red lists of some or all of their plant and animal groups, many of which provide large amounts of additional information. Updates to the Red List will be made every year from now on, and an updated analysis will be published at least once every four to five years. A ***Red List Launch Information Kit*** is available on the IUCN website. It includes a press release, background to the Red List, and species profiles (all in French and Spanish), as well as frequently asked questions, contacts, and a list of partners to the Red List programme. [www.iucnredlist.org]

- **IUCN Species Survival Commission:** Site contains general information on species, contacts for SSC specialist groups, and links to other SSC Web sites. Individual specialist groups, which often have their own web sites and materials, may be able to help with information on distribution of particular species. [http://www.iucn.org/themes/ssc/]

- **Animal Information Gateway**: gateway to a variety of animal species information, threat status, distribution, and links to more specific species websites.

- **Expert Center for Taxonomic Identification**: Site contains World Biodiversity Database with information on taxonomy and general information. Also contains World Taxonomist database, separated by specialization. Partly funded by UNESCO. [http://www.eti.uva.nl/]

- **Smithsonian's Mammal Species of the World**: useful for taxonomy and literature citations. [http://nmnhgoph.si.edu/msw/]

- **European Molecular Biology Laboratory reptile database**: contains taxonomic and distribution information. [http://www.embl-heidelberg.de/~uetz/LivingReptiles.html]
- **Amphibian Species of the World**: the American Museum of Natural History site contains taxonomic and general distribution information. [http://research.amnh.org/herpetology/amphibia/index.php]
- **AmphibiaWeb**: University of California at Berkeley site contains information on amphibian biology and conservation. Interactive map-driven database of all Ramsar sites, with information provided on each. [http://elib.cs.berkeley.edu/aw/]
- **NatureServe**: provides a range of biodiversity information for North America, Latin America, and the Caribbean. [http://www.natureserve.org/]
- **FishBase**: Searchable global database containing information on 25585 species (110000 common names), 71000 synonyms, 28000 photos, and 21000 references. [http://www.fishbase.org/]
- **Reefbase**: contains information system on coral reefsin 131 countries, with 4000 bleaching records since 1963, online mapping system, almost 25,000 references many downloadable. [http://www.reefbase.org/]
- **LakeNet**: site contains a vast array of information on lakes and freshwater systems [http://www.worldlakes.org/index.asp]
- **Global Register of Migratory Species**: information on migratory species: Global-scale distribution maps for 1,100 species are now available in GIS-format.
- **BirdLife International datazone**: (http://www.birdlife.org/datazone/index.html)
- **Global Amphibian Assessment**: website (http://www.globalamphibians.org/).
- **GLORIA**: a world-wide long-term observation network for alpine environments and focuses on biodiversity and vegetation patterns, and climate change in the world's high mountain ecosystems (http://www.gloria.ac.at/res/gloria_home/)
- **The Ramsar Convention**: Database on wetlands of international importance (www.ramsar.org)
- **Wetlands International**: A non-profit organization dedicated to wetlands conservation and sustainable development. (www.wetlands.org)
- **Wildfinder**: a map-driven, searchable database of more than 30,000 species worldwide, with a search tool that allows users to discover where species live or explore wild places to find out what species live there (http://www.worldwildlife.org/wildfinder/)
- **Ocean Biogeographic Information System**: (http://www.iobis.org/Welcome.htm). Also many more local sources such as MarLIN, CMARIS

GLOBAL AND REGIONAL EFFORTS TO IDENTIFY HIGH PRIORITY AREAS FOR BIODIVERSITY AND PRIORITY BIODIVERSITY

There have been several attempts to pull together global information on conservation priorities and these are categorised below. The level of detail and accuracy is variable. These are probably most useful in the current context because existence of a priority ecoregion or hot spot is likely to stimulate other more detailed surveys (referred to below) and thus countries falling into these areas are likely to have access to at least some existing prioritisation material. There are several such exercises.

- **Biodiversity Hotspots**: The key criteria for determining a hotspot are endemism and degree of threat. Plant endemism is the primary criterion. Degree of threat is measured in terms of habitat loss. Hotspots have lost at least 70 per cent and in some cases more than 90 per cent of their original natural vegetation. Thirty-four hotspots have now been identified by Conservation International[76].

- **Centres of plant diversity**: identification of major areas of plant diversity and endemism on the tropical continents, using information from hundreds of botanists who have identified some of the most important sites for plants worldwide. Each site contains descriptions of plant diversity and identifies main pressures and threats. The work is published in three volumes covering Asia/Pacific, Europe, Middle East and Africa and the Americas. The last is on a web site [http://www.nmnh.si.edu/botany/projects/cpd/about_project.htm], the others just as books. This exercise has a slightly finer resolution than either the hotspots or Global 200.

- **Endemic Bird Areas**: distribution patterns of 2,609 land bird species with restricted ranges (i.e. a historical total global breeding area below 50,000 km2) have been used to identify 51,000 "Endemic Bird Areas" (EBA). The four main criteria used to identify threatened species are: Rapid population reduction; Small range and fragmented, declining or fluctuating; Small population and declining; Very small population or range and within these birds are classified as critically endangered, endangered, vulnerable, conservation dependent, near threatened and deficient (i.e. not enough data to make a judgement).

- **Global 200**: a global ranking of the Earth's most biologically outstanding terrestrial, freshwater and marine habitats by WWF, aimed at ensuring that the full range of ecosystems is represented within regional conservation and development strategies. It is representative in its final selection. The most outstanding examples of each major habitat type are included from every continent and ocean basin. It uses ecoregions as the unit of scale for analysis. Ecoregions are large areas of relatively uniform climate that harbour a characteristic set of species and ecological communities. Roughly a quarter of the world's terrestrial ecoregions were selected within the Global 200, based on species richness, endemism, higher taxonomic uniqueness and global rarity of the major habitat type. Similar and complementary updated analyses have been conducted by The Nature Conservancy[77].

- **High biodiversity wilderness areas**: 5 areas identified by Conservation International[78].

- **Watersheds of the world**: an effort by the World Resources Institute and Worldwatch Institute to identify and describe the world's largest watersheds, with their status, pressures and conservation challenges[79].

WEB RESOURCES ADDRESSING GLOBAL ISSUES

- http://worldwildlife.org/science/ecoregions/terrestrial.cfm
- Terrestrial Ecoregions of the World (Olson et al., 2001) - http://worldwildlife.org/science/ecoregions/terrestrial.cfm (*shapefile* download at http://worldwildlife.org/science/data/terreco.cfm)

SITE-SCALE EFFORTS TO IDENTIFY PRIORITY SITES FOR CONSERVATION

The following areas vary greatly in size but include many landscapes and seascapes discrete enough to be included in protected areas. They vary from some that are well established and tested (e.g. EBA and IBA sites, see below) and others where data are starting to be assembled and much of the information remains in preliminary form (e.g. KBA and AZE sites).

- **Key Biodiversity Areas**: are identified using standardized, threshold-based criteria, driven by the distribution and population of species that require site-level conservation. The criteria address the two key issues for establishing site conservation priorities: vulnerability and irreplaceability. The process for identifying and conserving KBAs is a bottom-up, nationally led one that builds capacity and mobilizes civil society. KBAs form a superset of some of the other site scale approaches (AZE, IBAs, IPAs) discussed below.

- **Alliance for Zero Extinction sites**: The AZE is building up a global overview of key sites for protection to avoid extinction, with any selected site having to meet three criteria: **endangerment –** an AZE site must contain at least one Endangered (EN) or Critically Endangered (CR) species, as listed by IUCN - World Conservation Union; **irreplaceability** – an AZE site should only be designated if it is the sole area where an EN or CR species occurs, or contains the overwhelmingly significant known resident population of the species, or contains the overwhelmingly significant known population for one life history segment (e.g., breeding or wintering) of the species; and **discreteness** – the area must have a definable boundary within which the character of habitats, biological communities, and/or management issues have more in common with each other than they do with those in adjacent areas.

- **Important bird areas**: Birdlife International is identifying Important Bird Areas (IBAs), which represent the most significant sites for bird conservation. Safeguarding networks of such sites can effectively conserve birds of varied ecologies and distributions. Networks of IBAs have been defined for many Globally Threatened Birds. They also seek to capture significant populations of all species with restricted ranges or limited to particular biomes, and to protect migratory species by protecting critical sites along their migration routes, at which large proportions of their populations concentrate at different points in their life-cycles. IBA networks often cover only a small fraction of each species' total range. Because they conserve core populations in critical habitat, they provide an excellent means of focusing conservation effort. National IBA directories are published for over 50 countries.

- **Frontier forests**: relatively intact primary forests. The Global Forest Watch organisation maps frontier forests using some defining characteristics: free from substantial anthropogenic fragmentation; free from detectable human influence for periods that are long enough to ensure that it is formed by naturally occurring ecological processes; large enough to be resilient to edge effects and to survive most natural disturbance events; and contains only naturally seeded indigenous plant species and supports viable populations of most native species associated with the ecosystem. Maps of frontier forests exist for several parts of the world and in variable detail, some are suitable for site-level assessment.

- **Important Plant Areas**: Plantlife International and Planta Europa has developed a methodology and defined Important Plant Areas (IPAs) for Europe and the same methodology is aimed for wider application. An Important Plant Area is a natural or semi-natural site exhibiting exceptional botanical richness and/or supporting an outstanding assemblage of rare, threatened and/or endemic plant species and/or vegetation of high botanic value. To qualify as an Important Plant Area, a site needs to satisfy one or more of three criteria: holds significant populations of one or more species that are of global or regional conservation concern: has an exceptionally rich flora in a regional context in relation to its biogeographic zone; and / or is an outstanding example of a habitat type of global or regional plant conservation and botanical importance.

EXAMPLES OF ECOREGIONAL ASSESSMENTS AND OTHER BROADSCALE PLANNING EXERCISES

There is insufficient space to include all existing national or ecoregional studies, but the following list includes some of the most comprehensive and up-to-date; this list can be added to and expanded in the electronic and web-based version of the document

Regional assessments

The WWF Conservation Science Programme has provided regional ecoregional assessments at a continent scale, including:

- Terrestrial ecoregions of North America[80]
- Freshwater ecoregions of North America[81]
- Terrestrial ecoregions of Africa and Madagascar[82]
- Freshwater ecoregions of Africa[83]
- Terrestrial ecoregions of the Indo-Pacific[84]

Country or ecoregional assessments

- **Himalayas:** *Biodiversity assessment and gap analysis of the Himalayas*[85]: analysis which identified a series of recommended additions to the protected area network of the region, many maps and locations, with associated technical papers[86]

- **Eastern Himalaya**: *Ecoregion-based conservation in the Eastern Himalaya*[87]: detailed review including identification of a series of candidate priority areas with associated viability analyses

- **Tibet**: an assessment of biodiversity status and identification of priority conservation sites[88].
- **Forests of the Upper Yangtze ecoregion, China**: WWF gap analysis and ecoregional vision

- **Lower Mekong Ecoregion**: *Towards a vision for biodiversity conservation in the forests of the Lower Mekong Ecoregion Complex*: identification of priority conservation landscapes, including freshwaters, in four ecoregions – Greater Annamites, Central Indochina Dry Forests, Lower Mekong Floodlands and Cardamom Mountains[89], with detailed technical appendices[90].

- **Mongolia**: biodiversity conservation and planning assessment[91]

- **Bismarck-Solomon Seas Ecoregion: Papua New Guinea Solomon Islands**: not exactly an ecoregional assessment but an analysis of conservation status including priorities for protection[92]

- **Equatorial Pacific Marine Ecoregional Plan**: an ecoregional assessment of priority conservation sites of the Guayaquil Marine Ecoregion in southern Ecuador and northern Peru and neighbouring terrestrial ecoregions, conducted by The Nature Conservancy and local partners
.
- **Eastern African Marine Ecoregion**: covering the coasts of southern Somalia, Kenya, Tanzania, Mozambique and northern South Africa. Identified priority areas for mangroves, corals, sea-grasses, dunes, lagoons, coastal lakes, islands and particular species and groups[93]

- **Cape Province, South Africa**: systematic conservation planning exercise in the Cape Flora Kingdom

- **South Africa**: three major bioregions have had a gap analysis carried out: Cape; Succulent Karoo (SKEP) and subtropical thicket (STEP). Details can be found at: http://cpu.uwc.ac.za

- **Guinean-Congolian Forest and Freshwater Region**: biodiversity vision identifying priority areas for conservation within the region[94]

- **Carpathians**: *The Status of the Carpathians*: includes mapping of priority areas and also status of focal species[95]

- **Russian Far East ecoregion**: conservation action plan that identifies priority areas for conservation[96] and gives detailed timeline[97]

- **Primore region of Russian Far East**:[98]

- **The Alps**: map identifying conservation priority areas[99]

- **Terrestrial ecoregions of Latin America and the Caribbean**: initial identification and conservation assessment of ecoregions[100]

- **Marine ecoregions in Latin America and the Caribbean**: a ranking of marine ecoregions within the region including identification of ecoregions with the highest priority for conservation[101]

- **Mexico**: Terrestrial, freshwater and marine priority regions for biodiversity conservation (see CONABIO web site)

- **Chihuahua Desert**: *Ecoregion-Based Conservation in the Chihuahuan Desert*: a biological assessment including a gap analysis, threats assessment and list of priority sites[102]

- **Colombia**: A gap assessment carried out by WWF [103]
- **Brazilian Atlantic Forest**: designing sustainable landscapes including proposals for corridors[104]
- **Brazilian Atlantic Forest**: ecoregional assessment with gap analysis, threat assessment and action plan[105]
- **Mesoamerican Caribbean Reef**: identification of priority areas including representativeness and habitat estimates[106]
- **Ecuador**: A study of priority areas for conservation based in ecosystem and bird biodiversity[107]
- **Galapagos Islands**: biodiversity vision carried out by WWF
- **Northern Gulf of Mexico Marine Ecoregional Plan**:
- **Southern Ecuador and Northern Peru (Equatorial Pacific)**: Ecoregional assessment of terrestrial, aquatic and marine components and identification of priority areas for conservation
- **Chile and Argentina Valdivian Rain Forest Ecoregion**: detailed biodiversity vision which includes gap assessment of existing protected areas and identifies potential new sites[108]
- **Coral Reefs**: global study of status of the coral reefs of the world[109]
- **Bering Sea**: priority areas descriptions for birds, mammals, fish, invertebrates and generally for biodiversity including maps[110]
- **North-East Atlantic Shelf**: identifies areas of importance but not priority conservation areas as such[111]

Box 4: Primary or secondary data?

Should countries use "processed information" – such as existing gap analyses or ecoregional plans – or go back to the raw data? Conservation planners are divided on this issue. In theory using raw data is more accurate, because it gives the opportunity to avoid past mistakes and distortions, but on the other hand many ecoregional plans have been drawn up using more experts and more resources than many governments will have available to devote to the gap analysis thereby ensuring a higher degree of accuracy. In addition and importantly, many existing ecoregional plans cross national boundaries, providing a good chance for countries to view their own plans in a regional context. Decisions about when to use existing analyses as a basis and when to start from the beginning have to be made on a case-by-case basis.

Box 5: Developing information resources

- Collect new data only when necessary
- Draw on existing local and regional data sets
- Develop capacity in under-represented skill sets for every region
- Construct surrogate/model information to fill blanks and test (past, present, future)
- Employ expert knowledge to review model results
- Use expert knowledge to fill blanks
- Develop capacity to integrate, employ, maintain, and disseminate information

Source: **The Nature Conservancy (2005); *Building on the Past to Secure Biodiversity's Future: Learning from Conservation Planning in Latin America to Strengthen Protected Area Networks through National Gap Assessments,* Workshop Proceedings, Denver Colorado**

CHAPTER 8 ▪ Analysing protected area distribution and status

The other set of information needed to carry out the gap analysis is the current extent and location of protected areas. Ideally, three pieces of information are helpful:

- **Distribution**: the existence of a protected area network (ideally maps of the location, area and boundaries of all protected areas, including federal, state, municipal and private protected areas)
- **Protection status**: the management objectives of these areas as indicated by the IUCN management categories
- **Management effectiveness status**: the effectiveness of management of protected areas

Not all this information will be available for all countries. Even simple information about location and area is difficult in some cases.

Current distribution, location and area of all protected areas

Many countries have their own database on the location of protected areas although precise details about borders are absent in many cases even in quite well-established parks. (This last issue may not be an insurmountable obstacle for a general gap analysis.) In other cases, data on protected areas will be fragmentary or will have to be collected from different sources. Particular problems are likely if different types of protected areas are administered by different levels of government (e.g. different ministries or at both national and local levels). Private protected areas, community-conserved areas and indigenous peoples' self-declared protected areas are all often left off national lists but can contribute significantly to protection and in addition are specifically highlighted as important by the CBD.

- The largest global source of data on protected areas is the World Database on Protected Areas [http://sea.unep-wcmc.org/wdbpa/], which is updated regularly and provides basic information where available on location, area, name, data, IUCN category etc. The WDPA is being rapidly improved but still contains many gaps and inaccuracies. Confusingly, a similar but not identical list exists on the UNEP-World Conservation Monitoring Centre database [http://www.unep-wcmc.org/]. Most of the data on both these sources comes from countries, so will duplicate what is already available, but in cases where governments have not responded to requests for information, this is sometimes provided by other experts. Countries trying to piece together information where little exists would be advised to try both databases. It is highly likely that most governments will have more detailed and up-to-date information than that on international databases.

- Some protected area types tend to be omitted from global and many national databases at the moment, including particularly private protected areas and community-conserved areas. Data collection should therefore include contact with any NGOs that are known or thought to own protected areas and with indigenous peoples' organisations.

In general, data closest to the area is likely to be most accurate; i.e. national data is more likely to be accurate than global databases, which have an additional stage of processing and data handling. However, a comparison of the two is often valuable. The World Database on Protected Areas may include datasets from a wider range of sources than those of national governments, although ground-truthing with local experts is always necessary.

The databases will not always provide maps, which are explicitly needed for the analysis, although some polygon data are available. Most protected areas, once identified and located, will be able to be furnished with at least cursory maps. While these will remain inaccurate for some countries and regions, they are in most cases probably good enough for the kind of broadscale planning needed for a gap assessment. An example of key information fields in the World Database on Protected Areas is given below in Table 7 for protected areas currently with an IUCN category in Burkina Faso.

Longitude	Latitude	Name of PA	Designation	Status	IUCN category	Polygon data	Area (hectares)
2.15713	11.89593	W du Burkina Faso	National Park	Designated	II	Y	235000
-1.25591	11.47457	Kabore-Tambi	National Park	Designated	II	Y	242700
0.96467	11.67505	Singou	Faunal Reserve	Designated	IV	Y	192000
-0.58200	14.50446	Sahel	Partial Faunal Reserve	Designated	IV	Y	1600000
1.95563	11.53534	Kourtiagou	Partial Faunal Reserve	Designated	IV	Y	51000
0.76767	11.43668	Pama	Partial Faunal Reserve	Designated	IV	Y	223000
1.44341	11.54830	Arly	Faunal Reserve	Designated	IV	Y	76000
-3.12301	10.85464	Bontioli	Faunal Reserve	Designated	IV	Y	12700
1.14313	11.40049	Arly	Partial Faunal Reserve	Designated	IV	Y	130000
-2.94372	11.60078	Deux Bales	National Park	Designated	II	Y	56600
-4.14726	11.59045	Mare aux Hippopotames	Bird Reserve	Designated	IV	Y	19200
1.27912	11.35428	Madjoari	Faunal Reserve	Designated	IV	Y	17000
0.00000	0.00000	Komoe-Leraba	National Park	Designated	II	N	280000

Table 7: Example of data from the World Database on Protected Areas

Current status of protected areas

Protected areas are only as good as their management. There are, unfortunately, many protected areas that are poorly managed, or with management objectives or governance patterns that do not coincide with the needs of biodiversity. As stated above, identifying and addressing such ***management gaps*** can be critical for strengthening the national protected area system. Looking at these issues in detail may well be beyond the scope of many national gap analyses, but we suggest that they be examined in at least a cursory manner, as outlined below, looking at three key issues:

- Management objectives
- Governance regimes
- Management effectiveness and performance

All of these can provide additional layers of information in identifying gaps.

Management objectives: Setting realistic management objectives is a key need within protected areas, frequently overlooked or downgraded. Far from being a monolithic management system, protected areas vary dramatically in their form and purpose. To make classification easier, IUCN recommends that all protected areas be categorised according to their management objective, which can range from strict protection to managed cultural landscapes and seascapes. Clearly while all protected area categories are important within the overall mosaic, they have different values and implications for conservation and a sophisticated gap analysis would take these factors into account.

Category	Description
Ia	**Strict nature reserve:** managed mainly for science or wilderness protection – an area possessing outstanding or representative ecosystems, geomorphic features and/or species, available for scientific research and monitoring.
Ib	**Wilderness protection:** large unmodified or slightly modified area retaining its natural characteristics and influence, without permanent or significant habitation
II	**Ecosystem protection and recreation:** natural area designated to (a) protect ecosystem integrity, (b) exclude exploitation or occupation inimical to the designation and (c) provide spiritual, scientific, educational, recreational and compatible visitor opportunities.
III	**Natural monument:** often quite small area conserving specific natural/cultural features of outstanding value because of their rarity, representativeness, aesthetic qualities or cultural significance. Flexible category suitable for e.g. sacred sites, but limited size often reduces ecosystem value.
IV	**Conservation through management intervention:** area subject to active intervention for management purposes so as to ensure the maintenance of habitats to meet the requirements of specific species.
V	**Landscape/seascape conservation or recreation:** area where interaction of people and nature has produced a a distinct aesthetic, ecological and/or cultural value often with high biodiversity.
VI	**Managed resource protected area:** area containing predominantly unmodified natural systems, managed to ensure long-term protection, while also providing a sustainable flow of natural products and services to meet community needs through compatible management of up to a third of the total area.

Table 8: IUCN protected area management categories

The management categories are discussed in greater detail below. While no simple methodology exists for determining relative worth of different categories (and indeed this would be extremely difficult) general conclusions can be drawn for instance about over-reliance on a single category or apparently illogical choice of management objectives. For example, a sole reliance on federally managed category I areas might initially seem ideal from a conservation perspective yet is likely to be ineffective if displaced people continue to degrade biodiversity, and the government is not powerful enough to control illegal use. Similarly, if all protected areas are used for sustainable resource extraction (Category VI), few places may remain for uninterrupted ecological functions and to serve as core, nuclear areas for successful dispersal (source areas). A diversified portfolio of protected areas with varying management objectives and governance approaches is often a safer strategy, with the relative proportion and location of protected areas of a particular management type varying based on local political and ecological contexts. However at present most countries have not assigned categories to all their protected areas, so any analysis based on category is inevitably incomplete. Category assignments can be found on the WDPA and the database of UNEP-WCMC; it should be noted that inaccuracies occur and many protected areas have no category.

Governance models: A strong protected areas network usually relies on a range of different ownership and governance models as well as a range of objectives. Again, there is no methodology for assessing "correct" types of governance but rather a general need to think about how protected areas are governed and whether there are obvious gaps and opportunities. (For instance in some countries state-owned protected areas are the only legally-recognised protected area option thus reducing opportunities for expanding the system.) The analysis may also identify areas that are being managed for biodiversity protection but for various reasons are not recognised as protected areas, thus pinpointing places where early gains might be made. A breakdown of different governance types is given in Table 2 previously and these are again examined in more detail in the section on planning protected areas.

Management effectiveness

In addition, an ideal gap assessment would also consider management effectiveness: a network of poorly-managed protected areas will not fill the gaps. This may be outside many Parties' capacity in the time available, but countries have two possible options for addressing this issue:

- Identifying and using existing assessments: assessments of management effectiveness and performance in individual protected areas have been carried out in around a hundred countries although far fewer (perhaps twenty) have assessed protected area systems as a whole

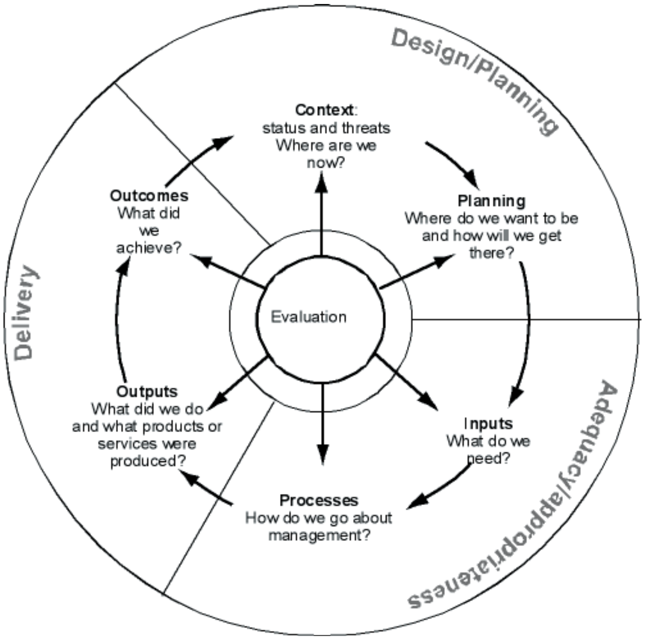
- Carrying out a rapid, system-wide assessment of management effectiveness as part of the overall gap analysis: A methodology (RAPPAM see below under tools) exists specifically for this purpose and could be used or adapted as part of the overall gap analysis; it is usually carried out in a workshop of park managers. Alternatively other systems exist for assessing individual protected areas that can be applied separately to some or all of the protected areas in a region or country.

- Strengthening capacity to address management gaps: Once strengths and weaknesses in management effectiveness have been identified using RAPPAM or a similar methodology, a series of capacity development activities should be identified to address these. Capacity development activities should aim to strengthen a range of crucial inputs for achieving management effectiveness, including skills, staffing, organisational management, public awareness, and legal framework. Such a capacity development work plan, based on this sort of a needs assessment, is a key aspect to the core element of capacity development within the *Programme of Work*.

• Designing an effective capacity development programme: One common challenge in designing protected area capacity development programmes is ensuring their activities are identified based on analysis of most urgent threats to biodiversity and critical weaknesses in management effectiveness. Basing capacity development priorities on management gaps identified through a management effectiveness methodology can be an effective means of ensuring direct correlation between capacity development, threat abatement, and management effectiveness.

From the perspective of identifying gaps, knowledge about management effectiveness can help to identify those protected areas that, although recognised within the national system, are not really contributing to biodiversity conservation.

Figure 27 ▪ The World Commission on Protected Areas has developed a **framework** for assessing management effectiveness of both protected areas and protected area systems (http://www.iucn.org/themes/wcpa/pubs/pdfs/Evaluating_Effect.pdf) to provide guidance to managers and others and help harmonise assessment around the world[112]. The framework is currently (May 2005) being revised and a new addition, tailored more specifically to the needs of the CBD *Programme of Work*, should be available towards the end of 2005



The framework can be applied at different levels depending on circumstances, resources and needs. A rough "hierarchy" of assessment systems is developing, ranging from country-level assessments of protected area systems through to detailed site monitoring. Six elements are identified in the framework as outlined in Table 9 below:

Elements of evaluation	Context	Planning	Input	Process	Output	Outcome
Explanation	*Where are we now?* Assessment of importance, threats and policy environment	*Where do we want to be?* Assessment of PA design and planning	*What do we need?* Assessment of resources needed to carry out management	*How do we go about it?* Assessment of way in which management is conducted.	*What were the results?* An assessment of the quantity of achievement	*What did we achieve?* An assessment of the quality of achievement
Criteria that are assessed	Significance Threats Vulnerability National policy	PA legislation and policy PA system design Reserve design Management planning	Resources for the agency Resources for the site Partners	Suitability of management processes	Results of management actions Services and products	Impacts: effects of management in relation to objectives
Focus of evaluation	Status	Appropriate-ness	Economy	Efficiency	Effectiveness	Effectiveness Appropriate-ness

Table 9: Elements in the WCPA framework for assessment of management effectiveness

Tools for assessing management effectiveness

Many assessment systems already exist; a few are summarised below:

- *The Rapid Assessment and Prioritization of Protected Areas Management (RAPPAM)* methodology from **WWF** provides protected areas agencies with a country-wide overview of the effectiveness of protected area management, threats, vulnerabilities and degradation [http://www.panda.org/downloads/forests/rappam.pdf]. Such as system could be used as part of a national gap analysis to gain an initial overview of how well the existing protected areas system is working[113].

- *The* **World Bank / WWF** *tracking tool* used a simple questionnaire to track progress in management effectiveness that is filled in by the protected area manager[114] [http://lnweb18.worldbank.org/ESSD/envext.nsf/80ByDocName/ReportingProgressInProtectedAreaManagementEffectivenessTrackingToolJuly2002/$FILE/PATrackingToolJune2003.pdf]

- *The Parks in Peril* approach has been applied in Latin America by **The Nature Conservancy** and several resources are available (http://www.parksinperil.org/resources/publications.html)[115] – see box

- The *Enhancing our Heritage* project is working with **UNESCO** and **IUCN** to develop detailed monitoring systems for natural World Heritage sites that could also be applied more generally [http://www.enhancingheritage.net/index.htm].

- **WWF** and **CATIE** have a management effectiveness system tested in a number of Latin American protected area sites[116] and available in Spanish [http://www.wwfca.org/wwfpdfs/Medicion.PDF] and English [http://www.wwfca.org/wwfpdfs/Measuring.pdf]

- The *Measuring Conservation Impact* initiative[117] of **Foundations for Success** provides an online guide to what conservation institutions can learn from monitoring in other fields [http://www.fosonline.org/Site_Page.cfm?PageID=42]

- The US **National Oceanographic and Atmospheric Administration**, **IUCN** and partners have produced a toolkit specifically for evaluating marine protected areas [http://effectivempa.noaa.gov/docs/Guidebook/MPA_MEI_1.pdf#search='IUCN%20MPA']

Box 6: Parks in Peril – Site Consolidation Scorecard

Four general categories with a total of 17 indicators have been identified as essential to a site's conservation capacity within The Nature Conservancy's Parks in Peril program which is designed to strengthen the management of national parks for biodiversity conservation in Latin America and the Caribbean:

A. Strategic Planning
1. Project area zoning
2. Site-based long-term management plan
3. Science and information needs assessment
4. Monitoring plan development and implementation

B. Basic Protection Activities
1. Physical infrastructure for the project area
2. On-site personnel
3. Training plan for on-site personnel
4. Land tenure issues within the project area
5. Threats analysis for the project area
6. Official declaration of protected area status within the project area

C. Long-term Financing
1. Long-term financial plan for the project area

D. Site Constituency
1. Broad-based management committee/technical advisory committee for project area
2. Community involvement in compatible resource use in the project area
3. Stakeholder and constituency support for project area
4. Policy agenda development at national/regional/local levels for project area
5. Environmental communication and education plans for the project area
6. Institutional leadership for project area

CHAPTER 9 ▪ Identifying gaps

At its simplest, a gap analysis itself literally consists of overlaying a map of biodiversity on a map of protected areas and seeing where the gaps are. But the extent to which this is possible will depend on the quality of the data. And a gap analysis also looks at various different kinds of gaps – representation, ecological, and management gaps. Two decisions are important:

- ***How*** to do the analysis?
- What to look for?

How to do the analysis
Countries are faced with a choice of three general options, with the choice generally depending on the available data quality and technical capacity:

- **Without maps**: although maps are the cornerstone of most gap analyses, a lot of information can be teased out of data even in the absence of accurate mapping. Listing all the biodiversity elements that are not adequately represented in a protected area network is itself a considerable achievement. A matrix (such as the one illustrated overleaf) can help with the ordering and interpretation of the information.

- **With maps**: if maps of protected area and distribution of ecosystems and species are all available, then a more sophisticated analysis can be undertaken, which can include not only presence or absence from the protected area network but also issues such as proximity, proportion of the population protected or unprotected, and in time also provides valuable information about how gaps might best be filled.

- **With maps plus software**: where time and technical expertise allow, several dedicated programmes exist to assist in the assessment and planning of protected areas. Such approaches are generally seen as part of a longer systematic approach to conservation planning that embraces stages from initial scoping and development of targets through to monitoring the final reserve network[118]. Systematic, algorithm-based approaches to selecting new protected areas have developed rapidly in the last few years and there has been a debate about their usefulness as compared with expert-driven processes. An integration of the two approaches may be most useful[119] if time and resources permit.

What to look for
There are several different types of gap, of varying degrees of importance, and a useful gap analysis can distinguish between these to help refine planning options. Questions about gaps fall into two main types:

- **What type of gap exists? –** i.e. whether gaps are complete (representation gaps) partial (ecological) or are gaps in objectives, governance types or effectiveness (management gaps). In the case of management gaps, this might mean that a protected area itself appears as a "gap" if it has never been properly implemented (a "paper park") or is not being well managed. Some gaps will be quite geographically precise (for instance ecological gaps referring to watershed-level threats to freshwater protected areas) while others will be more general (for instance recognition of a lack of coral reefs in protected areas will not necessarily be fixed to a particular coral reef).

- **What is the extent of the gap? –** It is important to identify the existence of protected area system gaps to pinpoint needs and raise awareness of additional conservation priorities for a protected area system. However, taking the actual gap analysis one step further and identifying the ***extent*** of the protection gap will help to chart the way forward for filling existing gaps. For example: How many populations are still needed to secure the long-term conservation of a particular species in the protected area system? How much more of the watershed needs to be protected to secure the ecological processes for the species and ecosystems within it? Are whole new protected areas necessary, or would a corridor between existing protected areas or an extension of an existing park be sufficient to address the representation or ecological gap? These questions are central to prioritising what is needed, identifying resources necessary and to smoothing the transition from analysis to action.

Mapping biodiversity against protected areas is thus only the first stage in a process of assessment. Some idea of the different types of gaps is needed, perhaps best summarised by charting the various surrogates. Table 10 gives a theoretical example of how such information might be summarised.

Element of biodiversity	Surrogate (if appropriate)	Gaps				Notes
		None	Representation	Ecological	Management	
Lake systems			Only 3 per cent protected	Some freshwater protected areas being polluted		
Lowland forest					Poaching is threatening key species	Capacity building needed
Saproxylic species	Deadwood	➽				Abundant within protected areas, little present in managed forest
Endemic frog species			Not present in any protected area			Urgent priority to capture within protected area system

Table 10: Charting the intensity of gaps

PART 3 GAP ANALYSIS IN FRESHWATER AND MARINE BIOLOGICAL REALMS

Currently, far more is known about conservation of terrestrial biodiversity than freshwater biodiversity, and we know even less about marine systems. Whilst all the principles and approaches described above hold true for all three realms, freshwater and marine biodiversity may also require some specialised approaches, tools and methodologies in addition to those used on land. The following sections of the guide therefore give particular attention to conservation in aquatic environments.

CHAPTER 10 ▪ Freshwater realm

Introduction to gap analysis

Jonathan Higgins, Senior Ecologist, The Nature Conservancy

Freshwater taxa are some of the most threatened components of biodiversity worldwide. This pattern is the result of extensive human impacts to lands and waters which sustain aquatic ecological processes, and inadequate inclusion of freshwater biodiversity in conservation planning and strategies. The primary challenges for identifying gaps in freshwater biodiversity protection are insufficient species occurrence and distribution data, lack of a method to describe and map patterns of freshwater ecosystem diversity, and a poor understanding of how conservation landscapes should be designed to accommodate the complex processes and connected nature of freshwater systems.

Given the general deficiency of freshwater species data and the urgency to move forward with biodiversity conservation, freshwater ecosystems have become primary conservation targets. Several methods, similar in approaches and outputs, have been developed independently to address the challenge of describing and mapping freshwater ecosystems. These approaches are flexible to meet the different levels of data availability worldwide. They all describe patterns of ecological processes and aquatic habitats within a larger biogeographic context. This biogeographic context can be provided by maps and descriptions of freshwater ecoregions that have been published for certain regions[120] and are drafted and will soon be made available for the rest of the world. Where they are not available, regional biogeography information should be used.

Within regions, information on freshwater biodiversity is inconsistent, but there is a wealth of information on the general relationships between freshwater biodiversity, ecological processes and physical habitat. The types and attributes of many significant ecological processes and physical habitats can be classified and mapped from readily available spatial data using a Geographic Information System (GIS). These data allow classification of freshwater ecosystems at varying spatial scales, permitting the description and delineation of patterns and interrelationships among lakes, streams and wetlands.

Spatial data that are generally used include:
- Hydrography (rivers and lakes)
- Digital Elevation Models (DEM)
- Geology
- Land cover
- Vegetation
- Climate

Other data that can be used if available include:
- Stream flow (gage station data)
- Lake depth
- Soils
- Physiography

These data are then used to generate ecological attributes of freshwater ecosystems. These attributes include:
- River/ lake size and density
- River gradient
- Lake depth, shoreline complexity
- River/ lake elevation
- River/ lake network position (e.g. headwaters, lower drainage)
- River/ lake connectivity (e.g. small streams connected to other small streams, connected to large rivers, connected to lakes, lakes isolated/connected to river systems)
- Water source and flow, temperature and chemistry regimes
- Stream and lake geomorphology

Figure 28 ▪ Freshwater Ecosystems map for the Upper Mississippi River freshwater ecoregion, United States[121]

Design of protected areas for conserving freshwater biodiversity

Robin Abell, Conservation Science Program, World Wildlife Fund

Freshwater systems present a different set of challenges compared to terrestrial gap analysis and protected area design. Freshwaters are generally linear, connected hydrologically, and their position at the lowest point on the landscape means that they may be affected by any activities occurring within their catchments[122]. A protected area overlapping with a freshwater feature of interest (e.g. a rare species' habitat) will likely confer only partial protection to that feature unless the protected area encompasses the areas providing important ecological processes, such as the entire upstream catchment and perhaps the downstream system as well. Conversely, a protected area situated in the catchment of a freshwater feature may provide some degree of protection to that feature, such as through regulation of downstream water quality and quantity, even though there may be no geographic overlap.

Identifying gaps in protection for particular freshwater species or habitat types, therefore, is not necessarily 100 per cent equivalent to identifying areas requiring protected area designation. Once gaps in protection for freshwater species and habitats are determined, the next step is ideally to identify the ecosystem processes critical to maintaining those features, the areas over which those processes operate, and the sources and scales of threats impinging on the processes. However, as the vast majority of freshwaters around the world are data-poor, we offer some possible short-cuts to assist in expedient freshwater protected area design.

First, perhaps the most important input to designing protected areas for freshwaters is a map of drainage basins (also known as watersheds and catchments). This map would preferably be in digital format and contain several layers of basins, from the largest (e.g. the Amazon) to much smaller ones (e.g. those of third or fourth-order tributary streams). In the past such maps were unavailable for large portions of the world, but soon they will be available globally at very high resolution, derived from new digital elevation data (for information and updates, see http://www.worldwildlife.org/science/freshwater.cfm). Such basin maps can be used to design protected areas that encompass, to the best extent possible, the areas draining to freshwater features of interest. Using basin boundaries as protected area boundaries has the added benefit of potentially reducing illegal incursions into protected areas via river systems[123].

Secondly, because most freshwaters systems are linear and connected, it is important to protect critical systems from fragmentation by dams, levees, and other longitudinal and lateral barriers (as well as to protect natural barriers from projects like interbasin water transfers). Designating entire freshwater systems from headwaters to mouth as off-limits to new barriers may be impossible, but key portions of those systems may be protected through designations that could simultaneously permit sustainable uses.

Design of protected areas to conserve freshwater biodiversity is a new field with ideas evolving rapidly[124]. In addition to the two suggestions provided above, we recommend consulting freshwater ecologists and conservation biologists to design the most effective and efficient protected area network within time, data and resource constraints.

Tools for freshwater gap analysis

Documents and Tools for Focusing Freshwater Efforts Across Large Geographic Areas: http://www.freshwaters.org/info/large/documents.shtml#gis

- Links to tools, methods, case studies of applying freshwater ecosystems in regional conservation planning, and other resources

A freshwater classification Approach for Biodiversity Conservation Planning.
Higgins et al. 2005. Conservation Biology 19(2): 432-445. http://www.blackwell-synergy.com/servlet/useragent?func=callWizard&wizardKey=salesAgent:1115913466769&action=show

Guide to freshwater conservation
Silk, N. and K. Ciruna, (Eds). 2004. **A Practitioner's Guide to Freshwater Biodiversity Conservation.** The Nature Conservancy. Arlington, VA. http://www.freshwaters.org/pub/

GIS tools for freshwater biodiversity conservation planning
T W Fitzhugh, 2005, *Transactions in GIS* **9**(2); 247-263. http://www.blackwell-synergy.com/links/doi/10.1111/j.1467-9671.2005.00215.x/abs/

Multi-scale river environment classification for water resources management
T H Snelder and B J F Biggs, 2002, *Journal of the American Water Resources Association,* **38**: 1225-1240. http://www.awra.org/cgi-bin/sc_jawra_reprints.cgi?view_article&630345858&01251

Case studies for freshwater conservation planning and gap assessment.

- **Australia:** Kingsford R T, H Dunn D Love J Nevill J Stein and J Tait (2005); *Protecting Australia's rivers, wetlands and estuaries of high conservation value: a blueprint;* Land and Water Australia; Canberra. http://www.ids.org.au/~cnevill/freshwater.htm.

- **Australia:** Nevill, J, and N Phillips, (eds.) (2004); *The Australian Freshwater Protected Area Resource Book: the policy background, role, and importance of protected areas for Australian inland aquatic ecosystems,* Australian Society for Limnology. http://www.users.bigpond.com/jon.nevill/FW_ProtectedArea_SourceBook.doc

- **Australia:** Nevill, J (2002); Representative freshwater aquatic protected areas: the Australian context, Paper presented to the First World Congress on Aquatic Protected Areas, Cairns Australia, August 14-17 2002. Revised 20/11/03, http://www.ids.org.au/~cnevill/ASL_State_fw_APA_summary.doc

- **Brazil:** Bryer, M T et al. (2004); *Classificacao dos Ecossistemas Aquaticos do Pantanal e da Bacia do Alto Paraguai,* The Nature Conservancy, Brazilia, Brazil.

- **South Africa:** Roux et al. (2002); Use of landscape – level river signatures in conservation planning: a South African case study, *Conservation Ecology* **6**(2): 6. http://www.ecologyandsociety.org/vol6/iss2/art6/

- **South Africa:** Nel, J et al. (2004); South African National Spatial Biodiversity Assessment, Technical Report: Volume II. River Component, CSIR-Environment. Department of water affairs and forestry, Botanical Society of South Africa. CSIR Report Number ENV-S-I-2004-063. http://www.sanbi.org/frames/nsbafram.htm

- **US – Missouri:** Sowa, S P, et al. (2005); *The aquatic component of gap analysis: the Missouri prototype,* Missouri Resource Assessment Partnership, University of Missouri, Columbia, Missouri. http://www.cerc.usgs.gov/morap/projects/aquatic_gap/sowa_etal_dod_legacy_final_report.pdf

- **US – Upper Mississippi:** Weitzell, R E, M L Khoury, P Ganon, B Scherers, D Grossman, and J Higgins (2003); *Conservation Priorities for freshwater biodiversity in the Upper Mississippi River Basin,* Natureserve and The Nature Conservancy: http://www.natureserve.org/aboutUs/upperMississippi.jsp

CHAPTER 11 ▪ Marine realm

Dan Dorfman: Senior Marine Conservation Planner, The Nature Conservancy

The marine environment is host to a broad array of biodiversity. In some respects it is even more diverse than terrestrial ecosystems, containing more orders or phyla and featuring a spatial and temporal complexity not found to the same extent on land. While marine, terrestrial, and freshwater species are all known to migrate in and out of protected areas, this movement can be particularly pronounced in marine environments and many species require different habitats for different life-cycle stages. Much remains to be learned and much of the biological diversity in marine environments has yet to be described. Most marine conservation to date has been focused on the need to protect places required for species reproduction or juvenile life-cycle stages[125] and marine resource management has concentrated particularly on protecting fisheries and maintaining sustainable yields of marine resources. However, there is now a clear shift towards ecosystem-based management (EBM) practices (e.g. COMPASS, USOPC, Pew). The emerging EBM paradigm draws on the principle that an ecosystem-based approach needs to consider management for ecological systems and ecosystem function, as well as for individual species.

When carrying out a gap analysis in marine environments, as is the case in freshwater and terrestrial systems, the "coarse filter"/"fine filter" approach is recommended to ensure that biological diversity is represented at multiple scales. Selection of focal biodiversity elements for a gap analysis therefore should draw on a range of species, ecosystems and surrogates.

Species targets

In most cases it will not be possible to draw up a comprehensive list of species in marine habitats. However, species which are threatened or are keystone species (having a disproportionate effect on their environment[126]) should be prioritized for inclusion, as should rare or endemic species. Species may sometimes be selected as focal biodiversity elements due to their vulnerability at a particular life stage, such as species that congregate for reproduction or migrate across environments. Where information is available, and in cases where it is ecologically applicable, habitats required for specific life-cycle stages should be included in gap analysis as distinct elements, targeted for representation.

Ecosystems

Corals, shellfish, sea grasses, salt marshes, kelp and mangroves are generally classified as ecological systems in regional conservation plans such as gap analysis exercises. While we are able to identify individual species of coral or shellfish and some of these species may be listed individually on a list of focal biodiversity elements for representation, ecological systems such as coral reefs, shellfish beds (e.g. oyster reefs) and sea grass meadows are generally also listed because they provide structure, habitat and processes which support a suite of other species. For example coral reefs are often used as a conservation target in part to protect the diversity of hard and soft coral species, but also to represent the diverse group of reef fish associated with coral reef systems. By ensuring representation of coral reefs in protected areas, we are also hoping to include representation of the fish, invertebrates and other species which live in association with corals.

There is a great deal of variation within an ecological system such as coral reefs. In some cases detailed information will be available on the species associated with reef systems and their habitat requirements within reef systems and beyond. However, in most cases such detailed information is still not available and the gap analysis instead needs to ensure that the full range of habitat variability is represented to "capture" species for which less detailed data are available. In reef systems this is often done by developing benthic habitat characterizations that can be used to represent different reef formations. Patch reefs, fore reefs, banks/shelves, reef crest and spur and grove are examples of types of reef formations that may be tracked as individual ecological system targets. Additionally, coral reefs are sometimes classified based on exposure to wave energy since this is known to correspond to variations in species assemblages in certain cases. Topographic complexity has been shown to correspond to greater levels of species diversity and also to abundance in coral reef systems; for this reason topographically complex reefs are sometimes included as an additional biodiversity element for analysis.

Salt marshes and inter-tidal wetlands are important and highly productive components of the marine ecosystem. These should therefore be included in marine gap analysis as applicable and may also be included in terrestrial and/or freshwater gap analysis. In some cases they may be classified into categories according to different levels of salinity such as oligohaline, mesohaline and polyhaline which are expected to correspond to variations in associated species assemblages. In cases where significant variations of wetlands are known and recorded, these ecological systems can be included as unique focal biodiversity elements; where detailed information is unavailable, it is recommended that efforts be made at least to indicate coastal areas where wetlands are present.

Shellfish play an important ecological role as filter feeders, by processing water to remove suspended nutrients. In cases where shellfish beds have been significantly reduced, it is expected that the reduction in filtration services contribute to negative feedback cycles that damage ecosystem health and may lead to a greater susceptibility to harmful algal blooms. Oysters are particularly notable in their ability to construct reefs that create habitat for additional species, not only by increasing structure, but also by altering current patterns to create eddies. Sea grass meadows and mangroves are known to play an important role as nurseries for many species of fish and invertebrates. These species form habitats that provide shelter and protection for juvenile fish and invertebrates and are often included as targets since they are important areas for representing marine diversity. Similarly, areas where algae beds are present (such as kelp forests) provide important habitats for a range of associated species. Where kelp beds are present, they are generally tracked as targets. In some cases submerged aquatic vegetation may be tracked as an ecological system, generally if it can be detected by remote sensing, but detail about species composition is unavailable. Recent advances in the processing of remote sensing information have led to new techniques for mapping the distribution of coral reefs, sea grass meadows, kelp forests and other marine systems.

Surrogate targets

Surrogate targets are developed as a strategy to address critical information gaps relating to species distributions and habitat utilisation requirements. Three distinct classes of surrogate models are generally employed:

- **Inter-tidal Systems**: based on shoreline geomorphology and sometimes submerged biological features such as kelp forests, sea grasses and shellfish beds.
- **Benthic topology**: mapping sea floor topography is typically used to delineate abiotic habitats

(often substrate and landform types) that have strong correlations to species assemblages.
- **Pelagic models**: that characterize different habitats and habitat utilization patterns in the water column or at the sea surface.

Although detailed information exists relating to the distribution of a few species in the **inter-tidal zone**, many are still poorly described or not yet mapped. However, there are often strong correlations between species assemblage patterns and coastal geomorphology, substrate type and wave energy. Based on these associations, shoreline characterisations can be created to distribute and map these variables into significant categories which, while certainly not being 100 per cent efficient in capturing the biological variability, can provide a reasonable first approximation of habitat variability. Surrogate targets are often employed to ensure that a broad range of habitat types is represented in protected areas design, but it is important to note that these "surrogates" are only estimations and it is recommended that this level of uncertainty be reflected in planning scenarios. Many surrogate target classifications are based on expected correlations between physical environments and species habitat utilization. As these assumptions are tested it is expected that the processes can be refined to increase accuracy.

Benthic topographic characterizations are often developed to enable the range of variability of abiotic habitats on the sea floor to be tracked. Benthic complexity or rugosity is well known to correspond to higher levels of species diversity and greater species abundance in many areas; for instance specific topology can indicate likely areas for spawning aggregations. While some benthic habitat characterizations are developed to track particular features of known biological significance, others are developed to define or categorize entire study areas. When developing benthic topographic surrogates, caution should be used in order to avoid overprotection or areas with uncertain biological significance.

In most cases the biology and hence the conservation needs of **pelagic environments** are not well known. Most of the management effort is focused on fisheries and sustainable fishing practices and, in consequence, current fisheries management models may offer the clearest avenues for establishing biodiversity representation in pelagic habitats. In addition to fisheries models, areas of cold water "upwelling" are generally nutrient rich and have high productivity, which often attract important biodiversity elements and these features are therefore often included in marine conservation plans as significant focal biodiversity elements. Similarly, primary productivity from algae can be tracked by satellite, and areas of high primary productivity can be employed as surrogates. Seamounts have often been found to harbour high levels of diversity and while many seamounts have not yet been surveyed, these areas are often used as surrogates for the diversity expected to exist there.

There are several species with habitat requirements in both marine environments and freshwater or terrestrial environments. These species may need to be targeted in gap analysis for each environment where they have habitat requirements. Similarly, the transition zones between marine and terrestrial, and between marine and freshwater, should be considered for ecosystem targets in each analysis.

Tools – a range of international and national resources are available, for instance

- Oceanic Biogeographic Information System (OBIS): the information component of the Census of Marine Life, a network of researchers in over 45 countries engaged in a 10-year initiative to assess and explain the diversity, distribution, and abundance of life in the oceans - past, present, and future. OBIS is a web-based provider of global geo-referenced information on marine species [http://www.iobis.org/Welcome.htm]

- Application of Natura 2000 in the Marine Environment or other Natura marine reference [http://www.bfn.de/09/natura2000marin.pdf#search='Natura%202000%20marine']

- Marine Life Information Network for Britain and Ireland (MarLIN) [http://www.marlin.ac.uk/]

- Coastal and Marine Resources Information System (CMARIS): devoted to the collection, organization, storage, retrieval and dissemination of information on coastal and marine resources in GIS format and relational databases of non-geocoded data and information [http://www.cmaris.net/theproject.html]

Protected Areas

Marine resources have been negatively impacted by human use patterns in many areas. Habitat destruction, over-exploitation and pollution are all primary concerns and many more factors are also significant threats to marine diversity and productivity. To maintain and protect marine diversity, marine protected areas (MPAs) have been established in a diverse array of geographies and for a range of purposes. IUCN The World Conservation Union defines Marine Protected Areas as any area of inter-tidal or sub-tidal terrain, together with its overlying waters and associated flora and fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment. MPAs have been found to offer considerable value for the protection and management of marine resources[127 128] and offer one effective strategy for maintaining biodiversity in the marine environment. While most MPAs offer some form of protection for certain resources, many are not comprehensive in providing protection for all species and ecosystems found there. The IUCN management categories offer one approach to classifying the different forms of MPAs according to management objectives. Marine reserves generally restrict extractive uses and activities which degrade biological habitats. They offer one important strategy for maintaining biological diversity, but should not be relied upon as a single solution for management. Reducing the effects of pollution from land and freshwater are important resource management strategies as are fishing gear restrictions, catch limits and other fisheries management techniques, such as timed closures.

When reviewing existing MPAs, it is important to recognize the level of protection provided by each designation and any weaknesses of gaps in the protection provided to biological resources. There are more than 100,000 MPAs already in existence, and these management designations have great variability both in their mandate as well as in their effectiveness.

Analysis

Marine reserves and other areas established with biological diversity conservation as part of their mandate should be included in marine gap analysis and should also serve as a starting point for developing future scenarios for marine biodiversity protection. Other forms of MPAs will need to be evaluated to determine their significance for measuring existing biodiversity representation and determining gaps. While many of the forms of existing marine protection designations may be considered inadequate for maintaining marine diversity, they do offer an existing commitment to management of marine resources and recognition of their value. With less than 1 per cent of marine habitats under protection, nearly all targets will have representation gaps in initial assessments.

While identifying the needs for adequate representation should be the top priority, efforts should be made to recognize existing designations. The World Database on Protected Areas maintained by UNEP-WCMC contains information on an existing collection of marine managed areas, many of which have boundary definitions available. Additionally, this database offers a well-developed information structure for recording and reporting management status and detailed information associated with MPAs.

Figure 29 ▪
Marine protected areas off the southern coast of Madagascar include islands with sacred sites for local fishing communities
Nigel Dudley

Network Design

Given the urgent need for protection of marine biological resources, it is recommended that high priority areas be identified and that the process of establishing management scenarios for marine resources be developed in areas where implementation can move forward. In many cases the benefits of MPAs are already well-known and the need for increased marine management is recognized. Many coastal countries have already initiated processes for establishing MPAs.

The Ecology Centre of the University of Queensland and the Great Barrier Reef Marine Park Authority have developed a tool and process for designing representative networks of MPAs. The tool, MARXAN, uses geospatial information and a set of explicit representation criteria to develop alternatives for MPA networks. The process is highly adaptable and repeatable, enabling stakeholder participation and an on-going process for refinement. While there are several tools which are available to assist in MPA site selection, it is the process of establishing which species and ecological systems need to be represented, developing representation criteria and mapping the distributions of these resources which is expected to require the largest investment of time and resources.

PART 4 FILLING GAPS IN THE PROTECTED AREAS NETWORK

The gap analysis is just the first stage in developing a representative protected areas network for a country. Although this guide rightly focuses on the gap analysis itself, the CBD and agreements at the Seventh Conference of the Parties explicitly argues that this analysis should lead to a "representative systems of protected areas that adequately conserve terrestrial, marine and inland water biodiversity and ecosystems" and suggests that interim steps to preserve highly threatened sites *should be implemented* even before the analysis is completed. The process of the gap analysis will often naturally lead to plans for developing new protected areas and this next section of the guide identifies some of the steps that will be required in this process.

Chapter 12 addresses the challenge of *identifying* priorities, and Chapter 13 looks at issues for consideration when planning an expanded protected areas system.

CHAPTER 12 ▪ Prioritise gaps to be filled

Carrying out a gap analysis is not an exercise in drawing maps in an uninhabited landscape, or designing some kind of utopian environment for biodiversity. On the contrary, protected areas are needed primarily because the pressure of human activity is threatening the biodiversity's future and therefore almost always have to be negotiated, sometimes very laboriously. The gap analysis does not produce a precise plan that can be followed, but rather a set of concerns and opportunities that have to be reconciled with other wants and needs across a nation's landscapes and seascapes. Nor does it give much information about where to begin first or what is most important. Therefore, a good gap analysis will begin to outline the ***priorities*** to be addressed and a roadmap for taking action. Identification of priorities involves a number of different assessment steps:

- Pressures and threats to both existing protected areas and unprotected ecosystems
- Opportunities for new protected areas
- Other opportunities for protecting land and water effectively outside protected areas
- Capacity to implement an expanded protected area network (including partners)

Threats

Knowledge of threats is a key step in the prioritisation process – both to identify areas where action is most urgent and to identify broad-scale threats acting across the whole protected area network.

Research on protected area planning in New South Wales Australia suggested that scheduling protected areas should be made on the basis of irreplaceability and vulnerability to loss[129] – i.e. that the highest risk and least replaceable areas should be protected first rather than rushing to protect areas that are currently pristine and under no immediate threat.

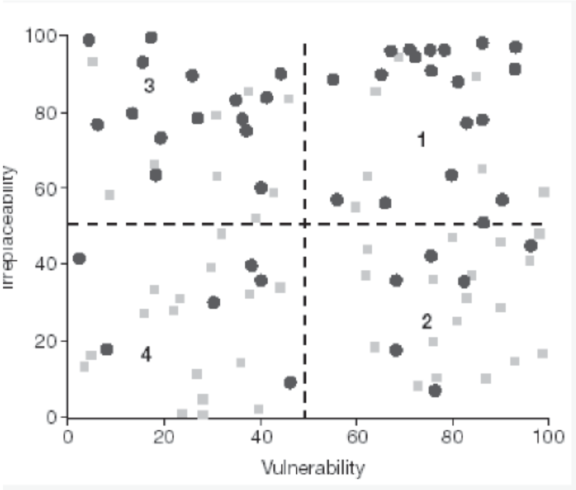


Figure 30 ▪ Comparing irreplaceability and vulnerability helps to schedule designation of protected areas[130]

Of course analyses do not necessarily need tools or complicated questionnaires; much progress can be made simply by ensuring that knowledgeable people consider all the potential areas and assess threats to the biodiversity within those areas, although a more systematic approach probably has a higher degree of accuracy. Large-scale infrastructure projects such as road or rail links, expansion of human populations, conversion to agriculture, over-fishing and the bushmeat trade are all examples of the kinds of threats that need to be considered.

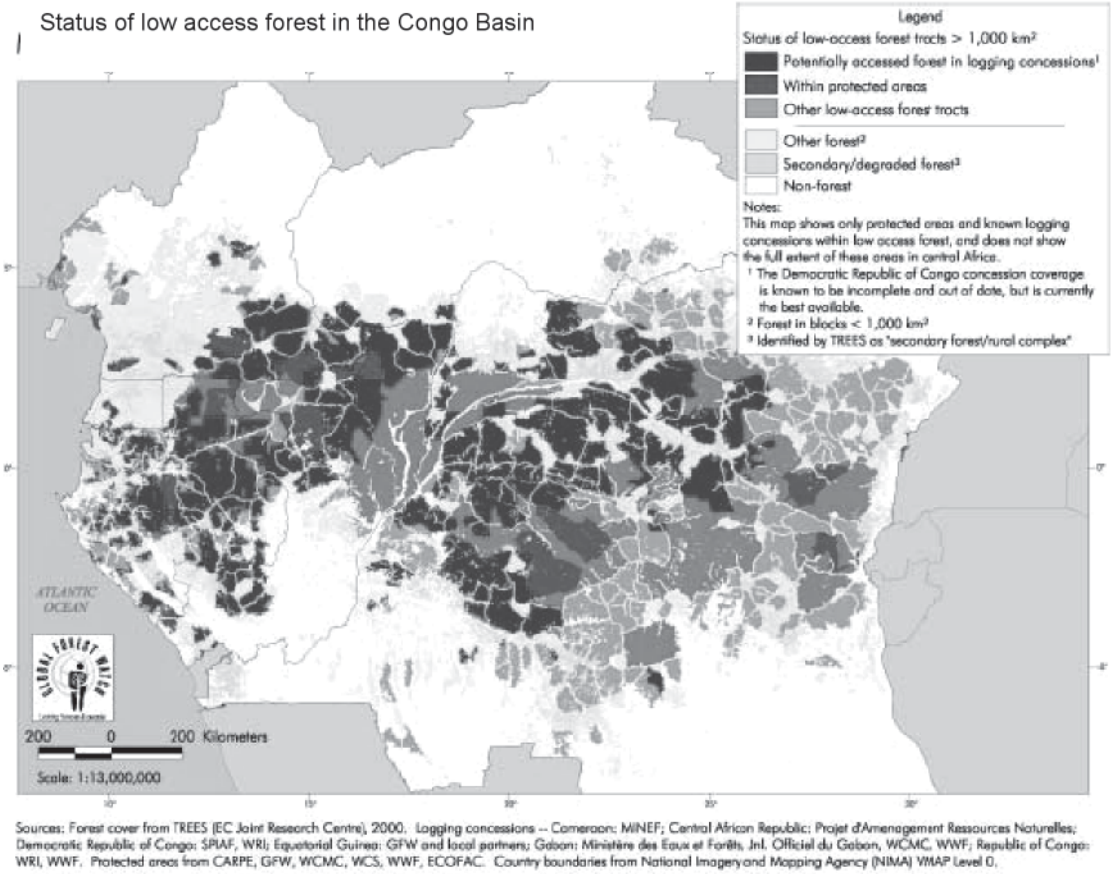


Figure 31 ▪ Maps of degree of threat from various sources, such as this one for part of the Congo Basin produced by Global Forest Watch, can provide coarse-filter data to help identify level of threat and thus prioritise actions

Opportunities

Opportunities to create protected areas are also important. Some lands may already be under consideration as protected areas or have some kind of designation that could quite easily be converted into full protection status, such as many forest reserves or no-take zones. Some community areas, including sacred sites and sites managed by major faith groups may, in some circumstances, also be suitable as protected areas if such a change in designation is supported by local stakeholders.

This local support can also be important in determining priorities. If valuable habitat exists on the traditional lands or waters of a community actively interested in seeing a protected area created and also on land where local people are implacably opposed to protection, then it makes sense to select the first, perhaps even if the biodiversity value is not quite so high. Table 11 below provides a quick way of summarising types, status and usefulness of existing opportunities for protection.

Potential new protected areas	Overlap with biodiversity gap	Potential for restoration	No obvious match
Ongoing state protected areas: *currently under development*			
Proposed state protected areas: *already identified as possible sites*			
Potential self-generated protected areas: e.g*. indigenous or community conservation areas*			
Potential private protected areas: *foundations, private owners, game reserves*			
Potential areas for conversion: *e.g. protected watersheds, forest reserves*			
Others			

Table 11: Summarising opportunities for protection

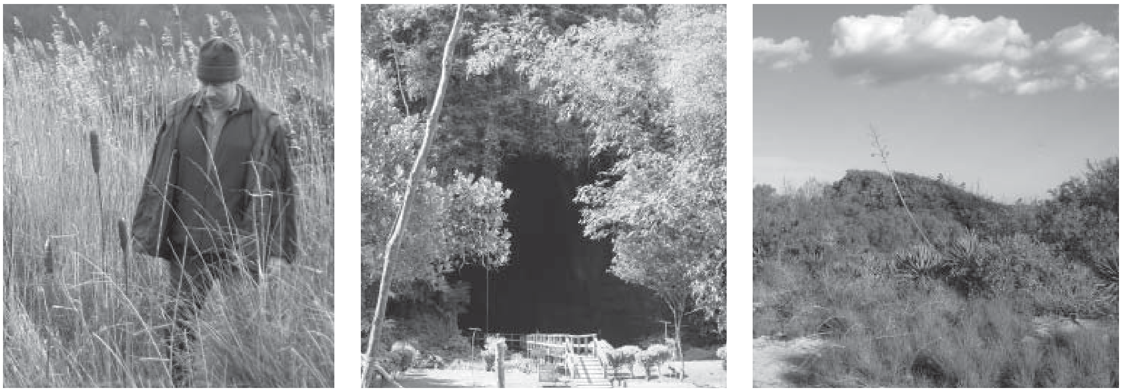


Figure 32 ▪ Collecting information on potential protected areas helps to identify easy first steps in expanding the network, although only if the proposed sites overlap with perceived priority areas.

Private reserve in Wales, UK; community conserved cave and forest in Sabah, Malaysia (to maintain populations of swiftlets that are the source of birds' nest soup); and a sacred site maintained by fishing communities on Nosey Vey island in southern Madagascar: Nigel Dudley

Box 7: forest reserves

Often predating protected areas, networks of forest reserves continue to exist in many countries. Although originally set up to protect stocks of exploitable timber for commercial use, a proportion of remaining forest reserves could help to complete protected area networks, particularly in parts of Africa and Asia. For example, details of 2688 forest reserves in Africa are held by the UNEP World Conservation Monitoring Centre in Cambridge, UK. The 1885 of these that include area data cover a total of over 30 million hectares, and the inventory is by no means complete. The quality of these reserves varies greatly from the perspectives of both timber production and biodiversity conservation. Some are pristine and fully protected forests, others heavily exploited secondary forests or plantations and some are even areas of grassland awaiting plantation establishment. Some forest reserves now only exist in name and have been replaced by agriculture. But the best provide a source of potential protected areas, with high quality forests in some of the world's priority areas for protection. Countries are now starting to classify these, identify the most important and bring them into the existing protected area network. For example, both Uganda[131] and Tanzania have well-developed programmes for classifying forest reserves and bringing the best into protected area networks. If they fulfil biodiversity requirements identified by the gap analysis, such sites also have the advantage that they generally already have legislation ensuring their protection, making legal establishment relatively easy.

Capacity to implement a protected areas system

The next stage in analysis is looking at the capacity to implement plans; there is no point in making grandiose plans if there is not the time, money, skills or resources available for making them happen. The CBD recognises this issue, and calls on countries to conduct an assessment of capacity for managing protected area systems, including the following categories of capacity needs:

- Finance
- Resources
- Legal and policy framework
- Partners
- Skills

Taking decisions about sequencing priorities

Once the various analyses have been undertaken, decisions have to be made about priorities. Governments and others are faced with a sometimes bewildering array of choices about how this can be done. Sophisticated software packages exist to help identify and prioritise protected area systems and these have proved useful in many countries. Workshops of experts have also been successful, as have larger, stakeholder-driven processes where people at all levels of society have been involved in drawing up scenarios and debating which is the most viable option. There will seldom if ever be a single model for protection, and the scale of protected area networks will also be influenced to a certain extent by what is happening outside. For example, research in Sweden has shown that the amount of strictly-protected forests required to maintain biodiversity is influenced to a major extent by how sympathetically the rest of the forest estate is managed.

CHAPTER 13 ▪ Agree on a strategy and take action

Once priorities have been set, the gap analysis as such is complete. But this document follows the spirit of the CBD by assuming that the analysis is only worth the time taken on its completion if it leads directly to the development of one or more scenarios for expansion of the protected area network. This last chapter looks at some of the options for doing so, taking into account:

- Size and location of new protected areas
- Management objectives for these protected areas
- Governance structures for the protected areas
- Opportunities for conservation outside protected areas
- Opportunities to use restoration as a tool for completing protected area systems

Size and location of new protected areas

The basis of any plan will be a series of proposals for new or expanded protected areas, possibly also linking habitats (corridors and buffer zones) outside the protected areas system. Decisions will be made on the basis of priorities (e.g. it might be worth indicating the sequence in which protected areas should be established), opportunities (such as proposed protected areas, similar designations of places where communities or others support protection) and capacity.

Figure 33 ▪ Proposed protected areas are selected on the basis of threats, opportunities and capacity, with proposed protected area networks ideally presented in a timed sequence of urgency of designation

The new Pha Tam transboundary protected area complex between Thailand and Lao PDR, agreed because of the high biodiversity in the upper Mekong: Nigel Dudley

Management objectives for these protected areas

Almost as important as the location, shape and size of the protected area are the management objectives, which can vary from strict protection to cultural landscapes that include sizeable human communities. While all have their role in a protected areas network, they are not equally applicable to all requirements of biodiversity protection so that choice of management objectives is important. As outlined in Table 8, IUCN has identified six categories of management objectives. Choice of category is based on broad management objectives and what kind of constraints and conversely what kind of management options planners and stakeholders wish to impose on the area. There is no simple decision tree or rule book to "identify" a particular category and careful reading of the guidelines will find some overlap. Different categories tend to have different levels of management objectives and different degrees of naturalness, but this does not follow a simple numerical rule as shown below in Figure 34[132].

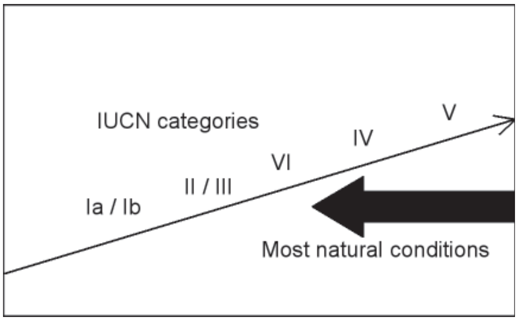


Figure 34 ▪ IUCN protected area categories and naturalness

Management objectives and categories are both relatively flexible and aim to serve as a tool to improve management rather than as a straitjacket that constrains useful options, as outlined in figures 35 to 39 below:

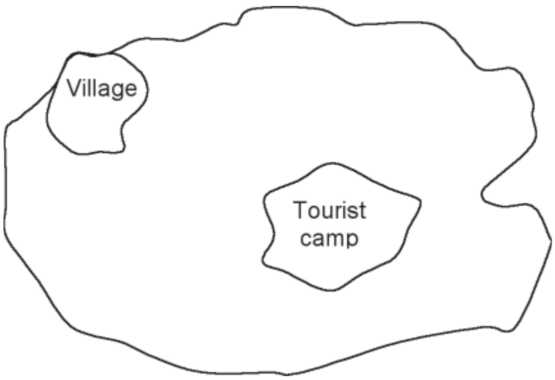


Figure 35 ▪ The category is determined by management objective but up to 25 per cent can be managed according to other objectives, for example to accommodate the continuation of existing communities, tourist infrastructure or indeed more highly protected reserves.

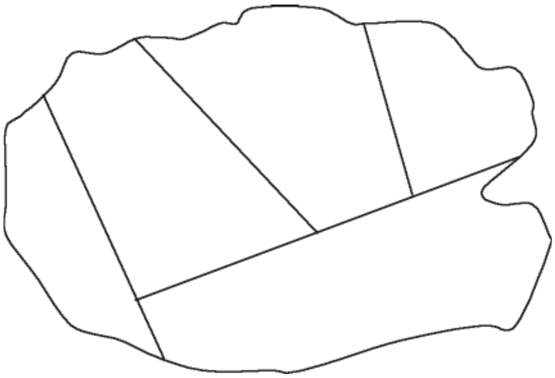


Figure 36 ▪ In a single protected area it is possible to have zones with different management objectives (for instance this is a common option in marine protected areas) and even zones under different management authorities.

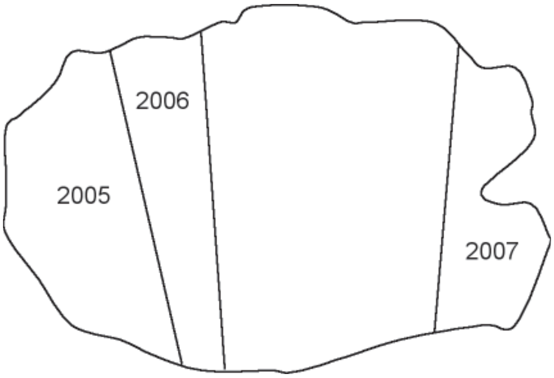


Figure 37 ▪ It is possible to have temporary zones within a protected area, for instance to allow local communities to harvest particular fish or non-timber forest products for a few years in one location and then move to another to ensure that populations do not decline.

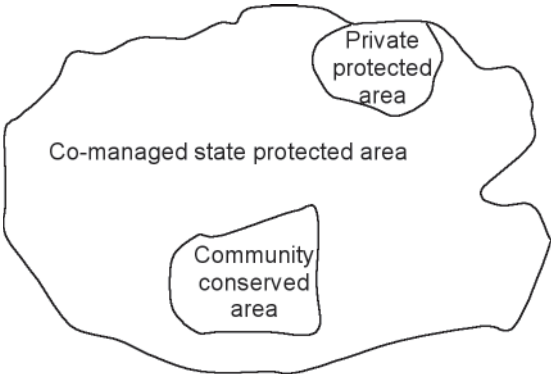


Figure 38 ▪ Different governance structures can also exist within a single protected area

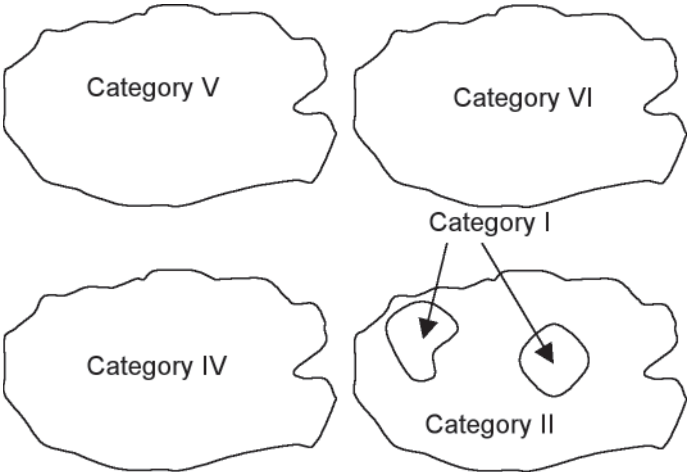


Figure 39 ▪ Selection of the IUCN category is not a mechanistic process that leads to only one possible outcome, but reflects a choice about how the protected area is to be managed.

There is no formula for deciding the "right" balance of different management categories in a protected area system. A less highly-protected area may be more effective if supported by a local community than a theoretically more pristine site that is subject to persistent illegal activity. A diversified strategy with respect to management objectives or categories is typically best, with careful attention to where the strictest protection should occur relative to source populations and life histories of biodiversity. In general over-reliance on any one category is probably inadvisable.

Governance structures in protected areas

The next set of decisions relates to who owns or manages the protected areas – as with management objectives, issues of governance can decide whether local communities and others support or oppose protection. Most government protected area agencies still base their conservation planning predominantly around the concept of state-owned (and even more precisely central government-owned) protected areas. In fact many other options exist, and these can sometimes be more effective, depending on local contexts. Possible governance structures have already been summarised on page 7, and cover various forms of management, private management, co-management between different stakeholder groups and community conserved areas. Most large protected areas are currently state-owned and managed according to a limited number of objectives, however if the six IUCN categories and various governance types are put together, a wide range of different options exists as outlined in the following matrix shown in Table 12.

Table 12: The interplay of governance structures and management objectives are shown in the matrix below, illustrating the wide range of options open within the system.

Classification of protected areas by IUCN category and governance type											
Governance type	**A. Protected areas managed by the government**			**B. Co-managed protected areas**			**C. Private protected areas**			**D. Community conserved areas**	
IUCN category (management objective)	Federal or national ministry or agency in charge	Local / municipal ministry or agency in charge	Government-delegated management (e.g. to an NGO)	Transboundary management	Collaborative management (various forms of pluralist influence)	Joint management (pluralist management board)	Declared and run by individual landowner	… by non-profit organizations (e.g. NGOs, universities, co-operatives)	… by for profit organizations (e.g. individual or corporate land-owners)	Declared and run by indigenous peoples	Declared and run by local communities
I: Strict nature reserve or wilderness area											
II: Ecosystem conservation and protection											
III: Natural monument											
IV: Conservation through active management											
V: Landscape/ seascape conservation & recreation											
VI: Sustainable use of natural resources											

Choosing management objectives and governance type

There is no simple formula for choosing the "right" management objectives and the "best" governance type for any particular area. Nor as the diagrams on management objectives make clear (figures 35 - 39) is there often a single answer; choice instead depends on many factors, including the desires of various stakeholders, the ecological condition of the land or water to be protected, the extent to which its biodiversity can co-exist with human presence etc. Decisions need to be made on a case-by-case basis. In general, we would recommend plurality, i.e. making full use of the range of management objectives and governance types available, both to make the best use of available resources and for insurance; e.g. if one governance type faces serious problems in a country others may prove more resilient. A draft tool for helping to decide on management categories is available[132].

Management principles

Over the past few years, a series of important principles have also been agreed for guiding the relationship between stakeholders – particularly local stakeholders – and protected areas, and these also help in determining which particular governance type may be most appropriate.

Box 7: Good governance principles for protected areas

The Vth World Parks Congress developed a set of "good governance" principles for protected areas:

"**Legitimacy and voice**" – ensuring the capacity of men and women to influence decisions, on the basis of freedom of association and speech
"**Subsidiarity**" – attributing management authority and responsibility to the institutions closest to the resources at stake
"**Fairness**" – sharing equitably the costs and benefits of conservation and providing a recourse to impartial judgement in case of conflict
"**Do no harm!**" – making sure that the costs of conservation are not "dumped" on some weak social actors without any form of compensation
"**Direction**" – establishing long-term conservation objectives grounded in an appreciation of ecological, historical, social and cultural complexities
"**Performance**" – meeting the needs and concerns of all stakeholders while making a wise use of resources
"**Accountability**" – having clearly demarcated lines of responsibility and ensuring a transparent flow of information about processes and institutions[134]

Figure 40 ▪ The size, location, management objectives and governance types for individual protected areas are increasingly worked out in consultation with local communities most directly affected by protection, as in this case in Madagascar.
Nigel Dudley

Box 8: Indigenous peoples and protected areas: principles and guidelines

Source: World Commission on Protected Areas and the UNEP World Conservation Monitoring Centre[135]

The following principles were identified by IUCN and WWF with the active participation of many indigenous peoples

- **Principle 1**: Indigenous and other traditional peoples have long associations with nature and a deep understanding of it. Often they have made significant contributions to the maintenance of many of the earth's most fragile ecosystems, through their traditional sustainable resource use practices and culture-based respect for nature. Therefore, there should be no inherent conflict between the objectives of protected areas and the existence, within and around their borders, of indigenous and other traditional peoples. Moreover, they should be recognised as rightful, equal partners in the development and implementation of conservation strategies that affect their lands, territories, waters, coastal seas, and other resources, and in particular in the establishment and management of protected areas.

- **Principle 2**: Agreements drawn up between conservation institutions, including protected area management agencies, and indigenous and other traditional peoples for the establishment and management of protected areas affecting their lands, territories, waters, coastal seas and other resources should be based on full respect for the rights of indigenous and other traditional peoples to traditional, sustainable use of their lands, territories, waters, coastal seas and other resources. At the same time, such agreements should be based on the recognition by indigenous and other traditional peoples of their responsibility to conserve biodiversity, ecological integrity and natural resources harboured in those protected areas.

- **Principle 3**: The principles of decentralisation, participation, transparency and accountability should be taken into account in all matters pertaining to the mutual interests of protected areas and indigenous and other traditional peoples.

- **Principle 4**: Indigenous and other traditional peoples should be able to share fully and equitably in the benefits associated with protected areas, with due recognition to the rights of other legitimate stakeholders.

- **Principle 5**: The rights of indigenous and other traditional peoples in connection with protected areas are often an international responsibility, since many of the lands, territories, waters, coastal seas and other resources which they own or otherwise occupy or use cross national boundaries, as indeed do many of the ecosystems in need of protection.

Opportunities for conservation outside protected areas

The *Programme of Work* is predicated on the development of a protected areas network. But biodiversity may be effectively conserved outside official protected areas in other land and water areas set aside for reasons unconnected with biodiversity. If the management regime is effective and secure then these areas too can play their role in the network, as buffer zones, corridors and supportive landscapes that play key roles in the life cycles of certain species. Such areas can range from Community Conserved Areas, where local communities manage land and water according to customary policies that result in biodiversity protection, to various forms of government control or private agreements.

Some different management options that could help fill gaps in biodiversity conservation beyond protected areas (and which could also provide possible new protected areas) are illustrated in Table 13 below. Few provide all the biodiversity benefits of a protected area but most provide some of these benefits and should be factored into the prioritisation process of the gap analysis.

Strategies and categories	**Types** (selection)	**Examples**
Uses that can create something very similar to a protected area		
Cultural protection		
Customary management	Community Conserved Areas	Regole d'Ampezzo in Italy
Voluntary agreements	Sacred sites	*Tembawang* in Borneo
Legally-established system	Cultural site with biodiversity	Angkor Wat in Cambodia
Marine fishing		
Legally-established system	Government no-take zones	Some Pacific islands
Voluntary agreements	Community no-take zones	East Africa, Pacific
Forest management		
Legally-established system	Forest reserves	Uganda forest reserves
Concessions for forest mgt	Government forests	BOLFOR, Bolivia
Ecosystem services		
Legally-established system	Avalanche control	Alpine countries
	Watershed management	New York, Melbourne, etc
Tax / incentive	Payment to keep forest for HEP	Costa Rica
Voluntary agreements	Retention of mangroves for fish	Madagascar
Hunting		
Tax / incentive	Protecting elephants for hunting	Campfire in Zimbabwe etc
Voluntary agreements	For-profit hunting reserves	Southern Africa
Uses that provide supporting activities around protected areas		
Agriculture		
Third party certification	Organic certification	Soil Association
Tax / incentive	Easements, set aside schemes	EU set aside
Forest management		
Third party certification	Forest Stewardship Council	Woodmark, SCS
Second party certification	ISO-14000 forest standards	Tree farm
Tax / incentive	Grants	EU woodland fencing
Voluntary agreements	Codes of practice	British Columbia code of practice
Marine fishing		
Third party certification	Marine Stewardship Council	W Australia rock lobster fisheries
Tax / incentive	Tradable fishery catch quotas	Australia Northern Prawn
Voluntary agreements	Codes of practice	FAO *Code for Fisheries*
Freshwater fishing		
Legally-established system	Fish management areas	Florida
Third party certification	Organic aquaculture certification	
Second party certification	ISO certification for fisheries	(currently being discussed)
Voluntary agreements	Voluntary landowner agreement	Freshwater reserve in Quebec
Ecosystem services		
Third party certification	Forest managed for water quality	FSC outside Stockholm
Second party certification	ISO 1400 certification for	Santa Clara
Hunting		
Legally-established system	Hunting reserves	Swiss Jura
Second party certification	Bushmeat controls	proposed by Bushmeat Crisis TF
Wildlife protection		
Tax / incentive	Paying farmers for wildlife losses	Crane in Sweden
Recreation / tourism		
Legally-established system	Recreational park with wildlife	Dyrehaven park, Copenhagen
Voluntary agreements	Protection of breeding sites	Nesting shore birds in Wales

Table 13: Examples of other land and water uses that can support biodiversity conservation

Figure 41 ▪ The forests in this watershed outside Brisbane, Australia are protected to maintain clean drinking water; level of protection is actually higher than in nearby national parks.
Sue Stolton

Bringing back what has been lost: the role of restoration in protected area networks

Restoration is required even within many protected areas, either because they have previously been degraded or because of over-exploitation since protection, often as a result of illegal use. The setting of conservation targets, or ecological goals, will help a nation decide if there are sufficient, *viable – or ecological healthy,* examples of the species (populations) or ecosystem (occurrences). When there are insufficient examples present in the nation or within the protected area system, and more cannot be identified, restoration of degraded occurrences to healthy, viable status may be necessary for conservation success to be attained in the protected area system.

Sometimes such restoration will simply require the encouragement of natural regeneration. For example temporary exclusion zones can allow natural dynamics to restore natural vegetation patterns or to build up particular species that are sensitive to disturbance. In Dana Reserve, Jordan, agreements with local communities have limited the number of grazing goats, thus stimulating rapid forest regeneration[137]. In other cases more active intervention may be needed, which can take two main forms. It will often be a time-limited process to restore specific areas of vegetation or particular animal species that have been degraded or destroyed – i.e. planned interventions to increase ecological quality. Metsähallitus, the Finnish Forest and Park Service, is currently recreating dead wood habitat in national parks where saproxylic (living dead wood) species are threatened with extirpation[137]. However, where loss of quality arises from more intractable problems, restoration may be a longer-term process that requires constant intervention both to recreate and then to maintain desired habitat. Forests in Guanacaste National Park in Costa Rica have been subject to large-scale active restoration over many decades[138]. Where species are under immediate threat, the time and expense involved in active restoration may be justified in order to speed up the process of re-establishing suitable habitat. In large protected areas, restoration will itself need to be focused on the most important places and gap analysis can help to identify the most valuable sites.

Figure 42 ▪
Restoration of dead wood in Nuuksio National Park near Helsinki, Finland to provide bridging habitat for associated species
Nigel Dudley

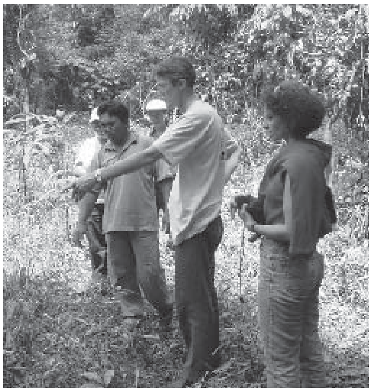


Figure 43 ▪
Replanting trees along the Kinabatangan River in Sabah, in the Malaysian part of Borneo to reconnect two protected areas
Nigel Dudley

Figure 44 ▪
Large scale forest restoration in what is now Guanecaste National Park, Costa Rica
Stephanie Mansourian

The gap analysis should help to identify places where restoration is required. Areas identified following gap analysis as possible sites for restoration within and around projected areas include:

- Fragmented landscapes capable of restoration and reconnection (e.g. recently fragmented forests, see illustration from Madagascar)
- Recently degraded areas with strong potential for natural regeneration (e.g. areas logged recently enough for buried seeds to be viable, bleached coral reef areas with remnant living coral)
- Longer-term degraded landscapes with high potential for restoration to accommodate particular threatened species (e.g. areas of *alang alang* grass (*imperata*) in former orangutan habitat in Kalimantan
- Buffer zone areas with potential to restore and maintain cultural landscapes supportive of biodiversity conservation

Tools for restoration: A number of resources focus specifically on the role of restoration in a conservation context:

The Society for Ecological Restoration International Primer on Ecological Restoration, 2004: www.ser.org/content/ecological_restoration_primer.asp

- Concise guidance on setting up a restoration project

Guidelines for Developing and Managing Ecological Restoration Projects, Clewell, A, J Rieger and J Munro (2000), Society for Ecological Restoration International: www.ser.org/content/guidelines_ecological_restoration.asp

- Covers conceptual planning, preliminary tasks, installation planning, installation tasks, post-installation tasks and evaluation

Beyond Planting Trees: Forest Restoration in Landscapes: S Mansourian, D Vallauri and N Dudley (editors) (2005), Springer, New York

- Detailed manual with over 70 authors outlining the ecological and social aspects of forest restoration at a landscape scale

Theoretical Constructs for Large-Scale Restoration: B Hargrove, T Tear and L Landon (2002); The Nature Conservancy (available on ConserveOnline)

- Guiding ecological principles and social and economic factors

Figure 45 ▪ This area of recently fragmented forest in Madagascar would be ideal for restoration within a new protected area because a substantial proportion of the original vegetation structure and biodiversity remains.
Nigel Dudley

The Gap analysis as a continuing process

Anyone reading this manual will realise that many of the issues we are addressing remain only partially understood; the global community is still learning how to agree, plan, design and manage protected areas and anyone attempting to implement a national gap analysis will be to some extent learning as they go along. It follows that initial attempts will almost inevitably be incomplete and that as the protected area system grows and develops, the gap analysis may have to be revisited for a number of reasons if:

- New information becomes available (for instance the discovery of new biodiversity hotspots or new species)

- New threats emerge to biodiversity in areas that have previously been maintaining biodiversity outside protected areas

- Social, economic or political factors prevent protection of some identified priority areas, so that planners have to look for other areas to complete the system

- Conditions change, for instance because of global warming or other forms of environmental change

- The new protected area network is not, in fact, capable of protecting all biodiversity

The gap analysis should therefore not be regarded as a one-off exercise, but instead the start of a process that needs to be carefully monitored, using the principles of adaptive management. The information used to make the analysis should also be maintained through monitoring programmes (for instance the targets and indicators selected for planning) so the decision support system remains current.

Once gaps have been identified and prioritised within the national protected areas system, a larger barrier often remains – the lack of human (i.e. skills and staffing), institutional (i.e. finances, systems and partnerships), and societal (i.e. public awareness, policies and legal framework) capacity to fill these gaps. Strengthening capacity to manage protected areas is a continual endeavour and a crucial consideration for an effective national system of protected areas. Design of capacity development programmes should be based on rigorous needs assessments, in order to ensure investments directly address gaps in representation, ecology and management. Therefore, capacity needs assessments and gap analyses are essentially and integrally intertwined. Gap analysis and capacity development plans based on needs assessments, together with sustainable financing plans, are core elements of a national protected areas master plan.

PART 5 CASE STUDIES

A gap analysis cannot be carried out according to a rigid formula, but needs to be developed and modified depending on need, data availability, expertise and the type of species or ecosystems being considered. The following part of the manual takes some examples of gap analysis around the world and shows how the principles and steps summarised in part 2 can be applied in practice.

CHAPTER 14 ▪ The Mexico Gap Analysis – A cooperative effort

Ignacio J. March: The Nature Conservancy

Background: After the COP-7 meeting at Kuala Lumpur in February 2004, a National Implementation Strategy Program (NISP) agreement was signed by by the Government of Mexico (GOM) and the World Wildlife Fund (WWF), Conservation International (CI) and The Nature Conservancy (TNC). Following this, the National Commission of Mexico for Protected Areas (CONANP[4]) was developed, and on March 17th, 2004 established an important joint effort between several agencies of the GOM and international and local NGOs, focused on conservation of biodiversity to meet the commitments agreed to by Mexico. The partnerships' objectives were threefold: 1) To develop a gap analysis of the Protected Areas (PA), 2) To assess the requirements and needs for training and capacity-building for the management of PA and 3) To design and implement financial mechanisms for the sustainability of PAs in the country.

To consolidate the resources that could be focused to accomplish this goals, CONANP sought and found the support of additional GOM agencies such as the National Commission on Biodiversity of Mexico (CONABIO[5]), the National Institute of Ecology (INE[6]) and the Geographical and Statistics National Institute (INEGI[7]), as well as the support from other major national NGOs like PRONATURA and DUMAC (Ducks Unlimited of Mexico). CONANP delegated CONABIO the responsibility to lead and organize the joint process to perform the gap analysis under strict science-based standards and procedures using the best information and data available on the biodiversity of Mexico.

The partnership: CONANP and CONABIO, as leaders and promoters of the gap analysis in Mexico, clearly understand the need for getting the best experts and data available in-country through partnerships with professionals from the NGOs, and from academia. Much of the data had been generated by research projects supported by CONABIO, and also by prioritization and conservation planning efforts performed by NGOs, including action plans developed by specialist groups focused on threatened and endangered species and in ecosystems.

During an initial workshop on September 30th, 2004, all members of the partnership explored the potential for combining their skills and resources to contribute to developing a rigorous gap

[4] CONANP, Comisión Nacional de Areas Naturales Protegidas, Secretaría de Medio Ambiente y Recursos Naturales.
[5] CONABIO, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.
[6] INE, Instituto Nacional de Ecología.
[7] INEGI, Instituto Nacional de Estadística, Geografía e Informática.

analysis that Mexico could present at the CBD COP-8 meeting in 2006. A spirit of cooperation between the GOM agencies and NGOs has pervaded this process since its initiation and the first agreements on the procedures, approaches, quality and scales of data to be used were taken at the workshop. Given the size and complexity of the territory of Mexico, as well as the relative dispersal of information and data on its biodiversity, it was clear that this joint approach was the only way to accomplish a gap analysis within a short amount of available time.

Report of progress

Sharing information, technical tools and resources: The participants in the Mexican protected area gap analysis agreed to share all available information and data, including biodiversity data, geographical databases at different scales, regional conservation action plans, prioritization exercises for conservation of species and ecosystems and other outputs generated in the last few years. Clearly, CONABIO datasets constitute the major source of information for this analysis, considering its 4.3 million geo-referenced records about flora and fauna, its dozens of studies on biodiversity throughout the country and its extensive multi-scale geographical databases. Complementing these data were those of the local and international NGOs who also had extensive datasets that provide very valuable information on specific taxa, regions and ecosystems.

Fortunately, CONABIO had previously developed several prioritization exercises to determine the terrestrial, freshwater and marine priority regions for the conservation of Mexican biodiversity. These were considered as a first approximation to the areas and sites of the highest importance for biodiversity conservation in Mexico.

Several essential information sources, such as the new geographical datasets on vegetation and land use in Mexico at a country-wide scale, were identified as major inputs to be used in the gap analysis. Conservation International will be providing important geographical datasets used to identify Key Biodiversity Areas (KBA) for northern Mesoamerica and the Gulf of California, and The Nature Conservancy has supported eco-regional planning efforts that produced important inputs in ecoregions across vast swaths of the country.

Defining scopes of work and methods: To date, several types of information analysis, ranging from procedures to technical tools, have been discussed as possible inputs to the gap analysis and these are currently under consideration by the participants. It is probable that a general analysis will first be performed on the current protected areas' distribution and coverage in the context of the ecosystems for every eco-region, in order to define the representativeness of the existing PA network in Mexico. A similar analysis developed for Colombia[8] has been of inspiration in designing this first approach.

Identification of focal biodiversity: A preliminary set of focal biodiversity for the gap analysis, which included terrestrial, freshwater and marine ecosystems, was defined using the criteria suggested in the language of the CBD *Programme of Work on Protected Areas*. Using criteria such as **irreplace-**

[8] Arango, N., D. Armenteras, M. Castro, T. Gottsmann, O.L. Hernández, C.L. Matallana, M. Morales, L.G. Naranjo, L.M. Renjifo, A.F. Trujillo y H.F. Villareal. 2003. *Vacíos de Conservación del Sistema de Parques Nacionales Naturales de Colombia desde una Perspectiva Ecorregional.* WWF Colombia (Fondo Mundial para la Naturaleza) - Instituto de Investigaciones de Recursos Biológicos Alexander von Humboldt. Colombia. 64 pp.

ability, **connectivity** and **ecological services**, a list of selected biodiversity was generated for the analysis that included species, critical habitat and ecosystems to assist in identification of high priority areas and sites.

Next steps and challenges: Two primary challenges remain:

1. To make the gap analysis for Mexico more inclusive, we are considering involvement of other participants including staff from the Mesoamerican Biological Corridor Initiative (Mexico Chapter), dozens of other local conservation NGOs spread throughout Mexico, universities and research centres where staff have worked intensively in different regions of Mexico, and experts on the conservation of particular species and ecosystems who are actively defining sites and areas to conserve.

2. There will be a major challenge in incorporating migratory species into the analysis in view of the fact that much of the information on stopover sites and migratory routes is still not well known for many species (e.g. as migratory bats).

Lessons learned

- It is increasingly difficult to establish new protected areas in Mexico. Given this fact, it is clear that additional conservation tools will be necessary to conserve as much of the biodiversity conservation portfolio identified in the gap analysis as possible. These tools will likely include conservation easements, land use planning processes (*Ordenamientos Ecológicos Territoriales*), conservation of private and community lands, new policies and legislation, ecological restoration programs, ecological services payments and economic conservation incentives.

- Many of the prioritization exercises and eco-regional conservation plans developed by NGOs have been generated through solid and science-based procedures that included the participation of the major stakeholders involved in the conservation of biodiversity of a region. These inputs should be considered of utmost importance for the gap analysis.

CHAPTER 15 ▪ Bolivia: targeting ecological processes and functionality, not the "living dead"

Pierre L. Ibisch, Christoph Nowicki, Natalia Araujo, Robert Müller and Steffen Reichle

A recent compilation of biodiversity and conservation facts shows that the under-investigated and data-poor territory of Bolivia belongs to the 10 to 15 most biodiverse countries of the world[139]. Due to a low human population density and rather recent colonisation in the lowlands, vast areas still remain in good conservation status. Formal protection efforts have also made good progress, especially during the 1990s. Twenty-two large (up to 3.44 mill. ha) protected areas of various categories cover about 17 per cent of the country. Since the end of the 1990s special attention has been paid to the development of a systematic ecoregional conservation approach. Based on several planning exercises for the regions of the Southwest Amazon[140], Chiquitano Dry Forest, Pantanal and Cerrado[141], and the Amboró-Madidi-Corridor[142] [143] an innovative conceptual framework has been developed for the first comprehensive national gap analysis. A gap analysis has been commissioned by the governmental protected area service (SERNAP), funded by GEF and carried out by a consortium of national and international institutions[9]. The Bolivian gap analysis was characterized by several distinct features:

- A complex priority-setting analysis of the complete Bolivian territory was implemented. This means that the study did not focus exclusively on areas outside existing protected sites. As a result of the systematic planning, the re-definition, re-delimitation or re-categorization of the existing protected areas was a potential option.

- The main focal biodiversity elements were large functional ecosystems. These were expected to provide: a) the best available habitat conditions for large populations of organisms (many of them should at least be MVPs); b) optimal connectivity for individual movements and species range shifts as expected from future climate change; c) the maintenance of dynamic hydro-climatic, ecological and evolutionary processes, and therefore; d) the best-possible resilience against effects of global-change and local/regional land-use change impacts. Such an approach assumed that endangered and *still viable* species and populations will survive when the conservation of functional landscape ecosystems is prioritized. Under a functional conservation approach, it is important to analyse if the biological systems really require protection or if they can adapt to the current anthropogenic pressures. An important consideration is that not all biologically distinct communities or ecosystems automatically merit a special representation within a protected areas' system, e.g. a severely degraded dry forest where less competitive endemic species, such as cacti and bromeliads, become even more abundant.

- Ecosystem blocks with a good conservation status (low human footprint) serve as surrogates for complex functionality elements for focusing the analysis. They are identified by mapping the conservation status of the ecosystems using direct (e.g. deforestation) and proxy indicators (mainly socioeconomic data, e.g., on size of cities and settlements, access, land-use poten-

[9] FAN, TROPICO, CEP, NORDECO; support by the University of Applied Sciences Eberswalde, Germany, The Nature Conservancy, Conservation International, and other international conservation NGOs

tial, land-use history, sensitivity to degradation of ecosystem structure and composition[144]), and development scenarios. The *functionality high-priority areas* (*functionality HiPs*; when not covered by effective protected areas: *functionality gaps*) provide good opportunities for cost-effective conservation activities as they are currently occupied by only a few or no local stakeholders.

- Additionally, two other main types of biological *HiPs* were taken into account: *coarse-filter representation HiPs* (ecological units, vegetation formations), and *fine-filter representation HiPs*. In the case of the fine filter, surrogates such as species-richness and endemism richness centres were considered, because many species ranges are expected to shift or even vanish due to climate change. Diversity centres were identified by mapping more than 6,000 species ranges of different plant and animal taxa (bioclimatic envelope model extrapolating ranges, among others based on a habitat suitability analysis[145]). Furthermore, the distribution patterns of some special elements were mapped. *Anthropocentric HiPs*, such as areas important for ecosystem services (e.g. watershed protection) complement the analysis acknowledging important societal functions of protected areas.

- The overlay of the different *HiPs* permitted a categorization regarding the relative priority and protection urgency. Where more different *HiPs* are overlaid, the conservation necessity was considered higher; the highest priority was assigned only when *functionality HiPs* are involved.

- The resulting categorized *HiP* map was checked against future socioeconomic scenarios and the spatial distribution of identifiable stakeholders' territories and land-use or natural resource concessions/rights to draw conclusions upon the feasibility and types of required conservation action.

- Considering the map of the existing protected areas, a proposal for the best-possible and most feasible conservation treatment of the different gap areas was elaborated. This included the amplification, re-delimitation and re-categorization of protected areas and a portfolio of new sites to be created, but additionally integrated alternative conservation instruments, such as sustainable forest management.

In the current context, focusing on functionality and ecosystem dynamics rather than on the static representation of current (and ephemeral) patterns represents a more viable and effective approach than the classic gap analysis that focuses solely on current, static representation. The approach anticipates environmental change and therefore prioritizes biodiversity viability and resilience and does not run the risk of creating a museum-like documentary that preserves any current manifestation of biodiversity that might include many 'living dead'. The main elements that guarantee a functional conservation proposal are a) the special attention paid to the still well-conserved areas; b) the consideration of socioeconomic patterns and scenarios (threats to biodiversity, stakeholder distribution and interests, including environmental services); and c) the development of an integrated conservation-compatible land-use vision for the whole territory. The latter helps to avoid a segregated approach that tends to establish isolated protected islands in an ever-degrading matrix and that as a result of predicted climate changes would very soon lose many of the target species for which they were created. The main challenge for the gap analysis was the careful communication and site-by-site implementation of the analysis' results in the context of severe political instability, governance problems and poor decreasing acceptance of protected areas.

CHAPTER 16 ▪ A Gap Analysis for South America's Threatened and Endangered Freshwater Species

R. Ayllon, M.L. Thieme, and R. Abell
WWF

Freshwater systems and their species face increasing levels of threat and pressure across the globe. For example, one recent study finds that North America's freshwater systems are losing species at rates comparable to those of tropical forests[146]. Within parts of the developing world, most freshwater species remain poorly documented, making comprehensive analyses of gaps in protection challenging. However, the recent compilation of relatively comprehensive global data sets on amphibians, mammals, and birds permits a coarse gap analysis of these taxonomic groups, which contain a number of freshwater-dependent species[147 148 149]. We used these data to evaluate how much coverage South America's protected area system is providing to this subset of Red Listed freshwater species of that region, as a test of what might be possible globally as well as at the country level. This in itself is a coarse estimate, since overlap of protected areas and species does not allow for evaluation of the adequacy of protected area design as it relates to threats to freshwater ecosystems.

Using a Geographic Information System (GIS), we overlaid protected areas (IUCN categories I through VI) from the 2005 World Database of Protected Areas with distribution maps of Vulnerable, Endangered, and Critically Endangered freshwater birds (N=12), mammals (N=11), and amphibians (N=330) from the IUCN Red List. Freshwater species were identified by selecting for that biome in the Red List database. Distribution data were obtained from the Global Amphibian Assessment and from a CD of digital distribution maps of birds and mammals of the Western Hemisphere[140]. We then calculated the percentage of each species' distribution that was covered by protected areas. Additionally, we considered a species that had a majority of its range within one country (>75 per cent) to be endemic to that country, and we calculated the percentage of each country's endemic and threatened freshwater birds, mammals, and amphibians that occurred in protected areas.

Over three-quarters of the Red-listed freshwater bird, mammal, and amphibian species in South America (N=280) have 50 per cent or less of their range covered by protected areas. About one-third (N=130) of the species receive no protection at all and 70 species have more than 50 per cent of their range covered by protected areas (20 species have 100 per cent of their range covered by protected areas). Across South America, birds receive the least amount of protection, and on average all taxa are afforded less than 30 per cent coverage (Figure 46). The standard deviation for each taxonomic group is high, indicating significant variability among species within each. Across countries, there is also a high level of variability in the protected area coverage afforded to country-level endemics. At the lowest end of the spectrum, seven of the countries provide, on average, less than 20 per cent protected area coverage for their endemic species (Figure 47).

It is important to note that the IUCN Red List is by no means comprehensive in terms of its coverage of freshwater species, particularly in places where the freshwater fauna is still poorly known. While this methodology highlights gaps in coverage for some of the most threatened freshwater species within the best-studied groups, it is not intended to represent the full range of freshwater biodiversity or to assess the quality of protection provided by these protected areas. Thus, species that are not threatened and the most numerous freshwater groups (e.g. fish, aquatic plants and invertebrates), are not covered by this gap analysis and for that reason a habitat classification may be the better option to capture those taxa and to complement this type of analysis (see page ##). However, the results do allow an initial evaluation of how well the protected area system within individual countries is capturing Red-Listed freshwater bird, mammal, and amphibian species and highlights countries that may need to redouble their efforts in order to protect the most vulnerable and irreplaceable species within the taxonomic groups analyzed.

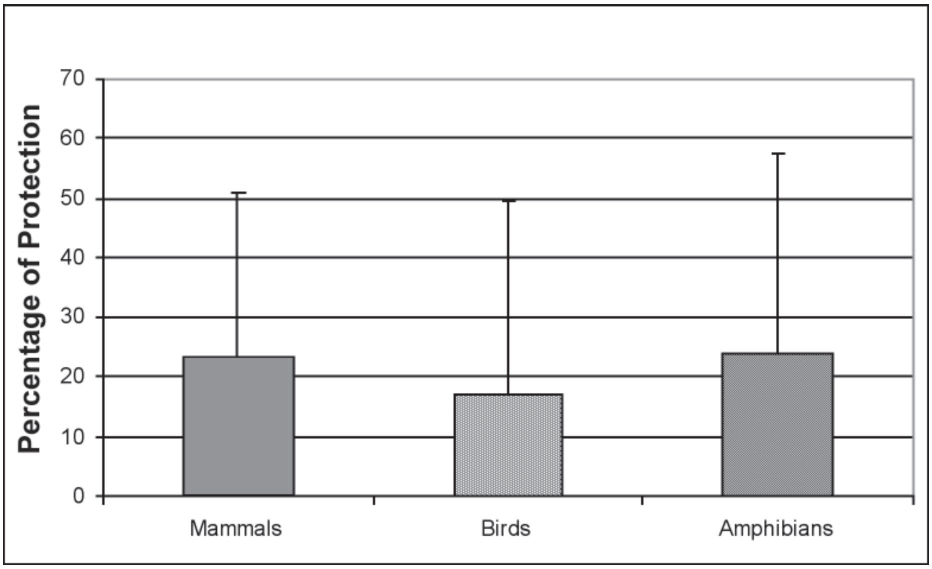


Figure 46 ▪ Average percentage and standard deviation of protection by taxa for Red-listed freshwater species

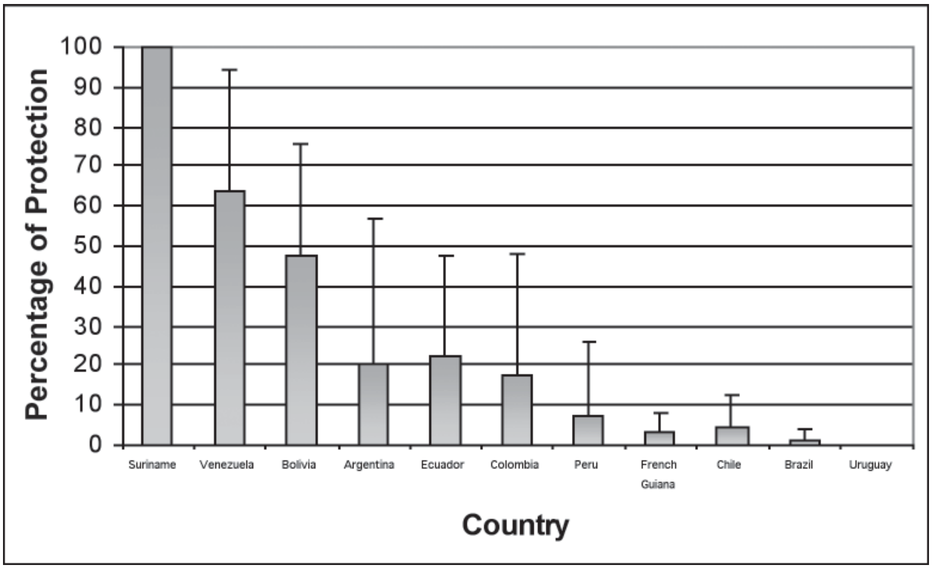


Figure 47 ▪ Average percentage of protection for Red-listed freshwater species (amphibians, birds and mammals) by country (standard deviation and number of species (N) also shown)

CHAPTER 17 ▪ Freshwater GAP Assessment in the Madre de las Aguas Conservation Region, Cordillera Central, Dominican Republic

Francisco Nuñez
The Nature Conservancy, Dominican Republic

Madre de las Aguas is a large, landscape-scale conservation area located in the Central Mountain Chain of the island of Hispaniola. Within the region, there are seven protected areas: Armando Bermúdez, Juan B. Pérez Rancier (Valle Nuevo), José del Carmen Ramírez, Ebano Verde, Las Neblinas, Eugenio de Jesus Marcano and Nalga de Maco, covering an area of more than two thousand square kilometers – around 7 per cent of the Dominican Republic. The site is a high conservation priority because of the richness and endemism of its species assemblage: for example, over 90 per cent of amphibians and reptiles, close to 50 per cent of butterflies, approximately 35 per cent of its birds, and nearly 40 per cent of its plant species (excluding ferns) are found nowhere else in the world. The region contains the best representations of coniferous pine forest, montane broadleaf and cloud forest on the island, and its high altitude reaches (Pico Duarte, up to 10,125 feet) represent the greatest elevation and ecological diversity in the entire Caribbean. The site is the headwaters for the majority of the island's rivers. The quality and quantity of water that originates from the region benefits approximately 70 per cent of the people of the Dominican Republic through agricultural irrigation, energy production, and/or water consumption.

Unfortunately, this freshwater system lacks a comprehensive biogeographic study that would permit its stratification based on the phylogenetic relationships of its major aquatic taxa. Our first step in developing a freshwater assessment was the identification of ecological drainage units (EDUs) which are groups of watersheds that share a common zoogeographic history, physiographic and climatic characteristics, and therefore likely have a distinct set of freshwater communities and habitats.

A second step was the selection of focal freshwater biodiversity elements for the analysis. They may occur at multiple spatial scales and levels of biological organization. These focal elements were of two different types:

- Aquatic Ecological Systems (coarse filter elements) which are spatial units that ensure the conservation of rare and endemic species as well as those common and widespread species.
- Species Level (fine filter elements), represented by single species or species assemblages. The aquatic species' elements for each ecoregion were identified by prioritizing imperiled, endemic and declining species.

Different habitat types represented "coarse filter elements" as they should capture the range of biological diversity and systems, as well as the natural processes that sustain them. A detailed analysis of all potential aquatic habitats allowed the elaboration of a list with those relevant and distinctive habitats for Freshwater Biodiversity. Although some of them may be divisible in smaller units, because of their physical and/or chemical characteristics, they may not represent real patterns of natural stratification of the biota.

National freshwater experts selected the focal aquatic biodiversity elements for the region in a series of workshops producing a list of those elements and their occurrences as well as their viability status.

There are a number of reasons for emphasizing ecological systems as focal biodiversity elements in this region: 1) many locations may lack comprehensive information about on-the-ground occurrences of species and natural community occurrences and the cost of obtaining such information is prohibitive; 2) ecological systems are more comparable in scale to information available from remote sensing; 3) using ecological systems reduces the number of focal biodiversity elements to a more practical number for conservation planning purposes; 4) many ecosystem processes do not operate at the scale of species and small natural community, but at the scale of ecological systems; 5) ecological systems can be used proactively in conservation to protect common species, species not otherwise a focus of conservation efforts, as well as those species that are not yet known, and 6) ecological systems provide a better linkage between site-scale and ecoregional/national planning elements.

Overlaying the Protected Areas boundaries on the freshwater biodiversity and viability status will allow us to determine the number of viable occurrences preserved by the PA Systems. This should be an effective way to evaluate how much of the freshwater system is already protected, as the focus of PA design and declaration are mainly for terrestrial and marine systems ignoring the unique properties and dynamics of aquatic systems.

CHAPTER 18 ▪ Key biodiversity areas: Identifying the world's priority sites for conservation – lessons learned from Turkey

Güven Eken, Murat Bozdoğan, Ahmet Karataş, and Yıldıray Lise
Doğa Derneği, Ankara, Turkey

Background

Over the last decade, international conservation organisations have devoted much effort to locate broad scale global priorities for conservation. These include the Endemic Bird Areas (EBAs) of BirdLife International[151], the Global 200 Ecoregions of WWF International[152] and the Biodiversity Hotspots of Conservation International[153]. Important as they are for informing the investment of globally flexible conservation resources, these large-scale analyses do not address a practical problem. They do not exactly define which sites should be protected at a fine scale. Furthermore, by virtue of their broad scale, some sites that are globally important for biodiversity would not be captured.

Parallel to this, many global obligations were set concerning protected areas under the Convention for Biological Diversity (CBD). Among these, parties to the CBD are enjoined to establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity (Article 8(a)). More recently, these site conservation obligations have been reinforced by the targets and indicators set in the Millennium Development Goals and by decisions at the World Summit for Sustainable Development (WSSD). The Convention on Wetlands (Ramsar Convention) and the World Heritage Convention are other key legal instruments established to conserve ecological site networks globally.

Since the 1980s, BirdLife International has been working with a wide range of collaborators to identify Important Bird Areas (IBAs). This work has resulted in internationally accepted standards for selecting networks of key areas that form the site-level targets for bird conservation. Regional and national IBA inventories have been produced in Europe[154], the Middle East[155], Africa[156], Andes[157] and new ones are underway in other regions.

Key Biodiversity Areas build on 25 years of experience through the BirdLife International partnership in identifying, safeguarding and monitoring of IBAs. Several projects have recently been developed to extend the IBA approach to other taxa. These include Important Plant Areas (IPAs)[158], Prime Butterfly Areas[159], Important Mammal Areas[160], Prime Dragonfly Areas[161] and Important Sites for Freshwater Biodiversity, with prototype criteria developed for freshwater fish, molluscs, odonates and crabs[162]. The KBAs framework builds on these initiatives and considers all taxonomic groups for which data exist in site identification. KBAs have already been identified in many countries around the world. These can therefore be used as a starting point for national- and regional-level gap analyses and conservation action.

Rationale of the Key Biodiversity Area method

Key Biodiversity Areas (KBAs) are places of international importance for biodiversity conservation at the global level. The overall goal of the KBA methodology is to provide universal standards for selecting sites of global significance for conservation through the application of quantitative criteria[163]. Such criteria should be easily and consistently applied across all biogeographic regions and taxonomic groups. They should also be applicable through a national- or regional-level, bottom-up, iterative process, involving local stakeholders, to maximize the usefulness of the resulting site priorities[164].

KBAs are selected to form, when taken together, a systematic network of sites throughout each target species' range. The network of KBAs may be considered as a minimum set, essential to ensure the survival of these species by means of site conservation. Four criteria are used to select KBAs: (1) Threatened species; (2) Restricted-range species, with small global ranges; (3) Congregatory species, which concentrate in large numbers at a particular site during some stage in their life cycle; and (4) Biome-restricted assemblages (sets of species confined to a particular habitat type or biome).

These non-exclusive criteria correspond to two main considerations used when planning networks of sites; vulnerability and irreplaceability[165]. The first criteria – threatened species – addresses vulnerability, while the others cover different facets of irreplaceability. To ensure global consistency, thresholds are being applied for each KBA criterion. Broadly speaking, KBA thresholds define the minimum size of the species population for which a KBA must be selected. Furthermore, definitions of two KBA criteria are directly associated with numeric thresholds: restricted-range species and biome-restricted assemblages. Thresholds may be relaxed within each criterion to identify sites of regional or sub-regional significance.

The identification process of KBAs often brings additional sites onto the conservation agenda for the first time[166]. Such sites may not necessarily require protection according to traditional definitions — they might, for example, be sustainably used and managed by local communities. The types of conservation measures needed for KBAs vary with socio-economic context. However, sites must be managed to conserve the important biodiversity that they shelter, and to allow for the continuing provision of biodiversity goods and services to people.

Key biodiversity areas – sites – are one of the main pillars of biodiversity conservation. Yet they are not the whole or the only answer, and sites will not be sufficient to conserve biodiversity in the long term[167]. Some species are not well protected by a site conservation approach (such as dispersed species occurring at low densities across wide areas). For others, site conservation may only be appropriate across some of their range or for parts of their life cycle – for example, colonially nesting species that disperse extensively during the non-breeding season[168]. Hence, KBAs should form part of a wider, integrated approach that embraces conservation not only of sites but also species and landscapes[169].

Nonetheless, KBAs, judging from the IBA example, have the potential to become a practical and effective focus for site scale conservation. They are defined using objective criteria, which helps give the results of the process weight and credibility. The criteria are simple and robust enough that they can be applied uniformly and cost-efficiently. Their application does not require complete datasets, since the method is based on individual biological values and not on relative significance. Such information has to be generated by national and local organisations, working on the ground. Therefore, the implementation process can be a powerful tool for building institutional capacity and setting an effective conservation agenda.

National identification of Key Biodiversity Areas – the pilot project in Turkey

The KBA identification process must be led at a local or national level to ensure use of the best available data and ownership of the resulting priorities. The selection process of KBAs in Turkey aims not only to identify the sites but also to:

- Develop technical and conservation capacity within the country
- Develop partnerships between key organisations – both governmental and non-governmental – concerned with site conservation
- Build broad understanding of the process, and broad ownership of the final site list
- Focus any new survey work on the most important gaps in knowledge

By working with local partners, international organisations can use the KBA approach to set fine scale targets for their conservation investment within their priority areas. For governments, KBAs provide a tool to identify national networks of globally important sites. These areas should be priorities both for national investment and for channeling resources from international instruments such as Global Environment Facility (GEF). Furthermore, KBAs can be used to objectively assess the environmental impacts of large-scale development projects funded by international finance institutions.

Turkey is a key country for global biodiversity mainly because of its exceptionally rich flora. With nearly 9,000 species of vascular plants and ferns, Turkey has the richest flora of any country in the temperate zone, with a level of endemism of almost 34% (3,022 species). Three biodiversity hotspots extend in Turkey (Irano-Anatolian, Caucasus and the Mediterranean), as a result of its floristic richness[170].

Identification of Turkey's KBAs dates back to 1989. Since then, several inventories were produced covering KBAs selected for birds, plants, marine turtles and for the globally threatened Mediterranean monk seal. Moreover, Doğa Derneği (Nature Society in Turkish) has produced a draft KBA inventory in 2003 (*www.sifiryokolus.org*), in collaboration with the General Directorate of Nature Conservation and National Parks of Turkey, BirdLife International, Wageningen University and several Turkish universities and other NGOs. Currently, this national inventory is being finalised by applying the four KBA criteria and their thresholds. The taxon groups covered by the Turkish KBA programme include plants, birds, mammals, herpetofauna, freshwater fish, butterflies and dragonflies.

Preliminary results of the KBA project in Turkey

Doğa Derneği, with the help of many experts, identified 267 Key Biodiversity Areas in Turkey covering seven different taxonomic groups. Among these areas 96 qualify as AZE sites (Zero Extinction Areas, *www.zeroextinction.org*), overwhelmingly for plants. 115 of Turkey's KBAs qualify just for one taxonomic group, while 152 trigger the KBA criteria for two or more taxonomic groups.

Taxonomic group	Preliminary KBAs with respect to taxon groups they trigger
Plants	147
Birds	188
Mammals	87
Herpetofauna	42
Freshwater fish	42
Butterflies	17
Dragonflies	13

The boundaries of KBAs and data gathered by Doğa Derneği to select the sites are entirely shared with the Turkish Ministry of Environment and Forestry, universities, national and international NGOs. Doğa Derneği and Turkish Ministry of Environment developed a national database called "Nuh'un Gemisi" (*www.nuhungemisi.web.tr*) as the first step towards biodiversity monitoring in Turkey. The full list and justifications of the KBAs in Turkey will be published as *Key Biodiversity Areas in Turkey* in early 2006. This book is expected to form the official Natura 2000 shadow list of Turkey during the European Union accession period.

Figure 48 ▪ Preliminary key biodiversity areas for Turkey
Source: Doğa Derneği Archive

CHAPTER 19 ▪ Gap Analysis in Andaman and Nicobar Islands, India: Recent Experiences

V B Mathur and Hitendra Padalia
Wildlife Institute of India, Dehradun, India

Background

In a landmark judgment, the Supreme Court of India ordered the 'consolidation of protected area system' in Andaman and Nicobar Islands (ANI) comprising seven National Parks and 99 Wildlife Sanctuaries (Figure 1) covering an area of 1217.12 km^2 on land and 349.04 km^2 in surrounding territorial sea and representing 19.65 per cent of the total geographical area of ANI. Consolidation of protected area system essentially meant conducting a gap analysis to establish an ecologically representative network of PA. The task was assigned to the Wildlife Institute of India, a research and training institution of the federal government, in the field of wildlife and protected area management.

Introduction

The Andaman and Nicobar Islands (ANI) (total 349 islands; area=8249 km^2) are an internationally acknowledged biodiversity hotspot[171], off the Indian mainland and lying isolated in the Bay of Bengal. ANI encompasses a very high degree of endemicity in all taxa, especially in plants, reptiles, fishes and corals and bears close biogeographical affinities with Myanmar, Indonesia and South-East Asia. Eighty-six per cent of the area of the ANI exists as legally notified forest. The area, design and distribution of PAs however do not cover the range of biological diversity present in ANI. The PAs in ANI have been established in an ad hoc manner considering either the remoteness or inaccessibility of the area or the presence of some charismatic species (e.g. Narcondum Island Sanctuary for Narcondum Hornbill). In other words, the existing PA system planning in ANI is inadequate to meet the criteria of comprehensiveness, representativeness and management.

The present gap analysis study was undertaken to establish a logical and scientific basis of protected area planning to conserve the representative samples of biological diversity both in the landscape as well as surrounding seascape. The identification of gaps was based on the level of protection offered to different vegetation/ land cover types, biologically rich zones and localities of conservation importance for birds and sea turtles within the PA system in ANI. The study adopted a combination of "coarse filter" and "fine filter" approaches by using two different conservation priority-setting methodologies. Spatial outputs from two biodiversity priority-setting methodologies *viz.* the Biodiversity Characterization at Landscape Level[172] (BCLL) and the Important Bird Areas[173] (IBAs) were used in the identification of gaps. The BCLL methodology scales priority areas of conservation utilizing remote sensing, landscape matrices and field data in the GIS domain. IBAs is a globally acknowledged priority setting approach of BirdLife International that aims to identify, protect and, where appropriate, manage a minimum network of sites important for the long-term viability of bird populations[174]. IBAs have therefore been used to indicate the gaps in the coverage of restricted range bird species in ANI.

Methodology

Vegetation/ land cover types both in terrestrial landscape and near shore seascape were mapped using IRS IC LISS III and Landsat TM satellite data. Biological richness mapping was carried out using the Spatial Landscape Modelling (SPLAM) package, integrating vegetation map derived landscape parameters, *viz.* fragmentation, patchiness, porosity, interspersion and juxtaposition with road and settlement buffers to estimate disturbance index. Different biological richness levels were computed by integrating disturbance index with physical (*i.e.* terrain complexity), ecological (*i.e.* species diversity), phytosociological (*i.e.* species endemism, rarity and threatened) and economical (*i.e.* species importance value) parameters[175]. Distribution of identified 19 IBAs was assessed in terms of protection to the 18 restricted range bird species within the PA. The turtle nesting sites distribution data (based on direct sightings over the last 15 years) were converted into point data (~143) records using literature citations. The current PAs were examined with respect to adequacy in surface area or size and distribution. The PAs' polygon data were spatially overlaid on vegetation types/land use maps, biological richness maps, IBAs and turtle nesting sites point coverage using Arc View 3.2a GIS software. Area statistics and ecological representation in existing the PA network was examined.

Results and discussion

58 small island sanctuaries cover only 1.2 per cent area of the total area of PAs in ANI. The largest island, Middle Andaman, has no PA. Similarly, in Nicobar, there is no PA in Central Nicobar and Little Nicobar. Out of 17 natural vegetation categories, 4 do not meet the widely-accepted criteria of 10 per cent representation of each type within the PA. Only 9.5 per cent of the remaining patches of giant evergreen forest are found in the PA system. Three unique vegetation formations in Nicobar *viz.* the syzigium swamps, hill-top grasslands and moist deciduous are not covered under the PA system. Evergreen forest in Nicobar has been reasonably well-protected (42.41 per cent of its total area) within Campbell Bay and Galathea NPs in Great Nicobar. Mangrove forests find reasonably adequate representation in Andaman compared to Nicobar. A few big patches in Katchal, Nancowry and Kamorta islands along with some of the finest coral reef areas also remain unprotected. Despite having reasonably adequate area (42.04 percent of total area mapped) inside PAs, the largest and longest coral reef barrier formation on the West of Andaman is unprotected. The high biologically-rich zones of evergreen, semi-evergreen and moist deciduous forest are also poorly represented in PAs in Andaman. Eight out of 19 IBAs are not protected under the PA system. Habitats of 4 globally threatened restricted range bird species also do not occur in the PA system. Only 4 species found >50 per cent representation in the PA system; another 4 species between 30-40% and 6 species between 30-40 per cent. Four species (all in Nicobar) are still not represented within the PA system of which two (Nicobar Megapode and Nicobar Bulbul) are vulnerable and two (Nicobar Parakeet and Nicobar Scops Owl) are near threatened[176]. The Green Sea and Hawksbill turtles are reasonably well protected while the Leather Sea and Olive Ridley turtles are poorly protected, particularly in Nicobar.

The study has recommended the expansion and creation of new PAs in ANI based on areas of ecological transition where the niches (*e.g.* vegetation types and biologically-rich areas) of species (*e.g.* birds and turtles) overlap. Protecting maximum percentage of highlighted priority localities *i.e.* unique vegetation types, offshore habitats, biologically-rich areas and bird congregation areas would certainly benefit other taxa in ANI. Our approach has examined the gaps in the conservation planning by looking at available information which needs to be further substantiated by finer scale data at species level.

Recommendations for plugging gaps in PA system

Based on this study, a comprehensive framework for the PA system[177] has been proposed, taking into account the limited resources and the extent of present and future threats in managing such areas. The study re-iterates that, if the conservation goal is to represent the uniqueness, diversity and rarity, then PA planning must account for biodiversity patterns, rather than be based on political and logistic considerations. In ANI, because of intra-archipelago speciation, a network of PAs that incorporates distinctive flora, fauna and habitats in its maximum proportion in each group of islands is essential. In fact, most of the PAs in ANI presently cover a small area from the biological / ecological standpoint. Consequently, even minor perturbations in the adjoining area can affect their viability. Such off-site effects include oil pollution, increasing turbidity due to soil erosion and dumping of waste materials. In order to regulate off-site impacts and increasing cases of wildlife offences by foreign agencies and local people, the establishment of marine protected areas (MPA) has been envisaged by grouping a set of small islands which would enhance management effectiveness. In order to protect marine life, coral reef, inter-tidal and salt marshes surrounding each island up to a specified buffer distance from terrestrial limits have been recommended for inclusion within PAs. Since, at present, fishing and tourism activities are at modest levels, the task of including marine areas within PAs does not appear to be a major impediment. Turtle species have been suggested as a focal diversity element and surrogate for protecting off shore environment, due to their vulnerability at particular life stages. We feel that, by including areas of high biological richness in the PA system, their conservation status would improve. Intensive inventory at the levels of species and communities of small island sanctuaries and surrounding offshore life is needed for examining their contribution to biodiversity representation in ANI. The establishment of a series of key quantitative targets at multiple scales is also needed for effective protected area management.

CHAPTER 20 ▪ Hawaii Marine Gap Analysis, Noelani Puniwai, Hawaii Natural Heritage Programme

Noelani Puniwai
Hawaii Natural Heritage Programme

The Marine Gap Analysis Project (MGAP) has become a preliminary step in assessing available information on near-shore waters throughout the main eight Hawaiian Islands. Collaborating with principal agencies, becoming familiar with marine modelling programmes, understanding baseline knowledge, and collecting community opinions have been our primary accomplishments. Hawaii MGAP was administered within a research agency, the Hawaii Natural Heritage Program, part of the University of Hawaii System. After three years of data compilation and integration, limited spatial data have become available to comprehensively map the near-shore environment and biological features around the main eight Hawaiian Islands. Baseline information such as habitat maps, bathymetry, rugosity and oceanographic patterns have not been completed statewide. Consequently, MGAP planners used various proxies and information sources to meet their planning needs.

Process

The principles of gap analysis are to identify those areas or habitats not in conservation by assembling available information on species and habitat distribution. Concurrently, the ideal conservation targets and species lists are being identified. These two processes must happen together or else data collected may not include the intended conservation targets. We found that first defining conservation targets, then assembling pertinent conservation information, increased the efficiency of the process. Important products of this process are an understanding of data needs, a detailed record of information gaps and an inventory of information gathered thus far. Even in the U.S., we have incomplete data and in order to reach our goals must seek knowledgeable people with whom we can collaborate and inventive proxies to map our targets.

Conservation Targets

Our ideal conservation targets included: rugosity (habitat complexity, depth of holes), oceanographic patterns (connectivity, source populations), habitat maps (at various scales), ecological structure (age, structure), unique/rare species distributions, biomass, and biodiversity. However, we have acknowledged the lack of spatial data gathered on these targets and expanded our analysis design principle to devise a scenario that *'included a representation of all biological features and regions'*. We did not have enough data to identify areas needed for conservation, but we could select a range of habitats around each island. Clearly defining the purpose of your design principle makes apparent to users and managers the intent of the analysis and focalizes the conservation targets and goals.

Our coarse filter targets reflected an attempt to identify the range of general habitats found in the islands regardless of prior research levels and spread the solution throughout the main Hawaiian Islands. We achieved this by including areas off each island, nearshore and offshore depth zones, high and low wave height shorelines, steep/gentle coastlines, broad habitat types and a few others (see Figure 49).

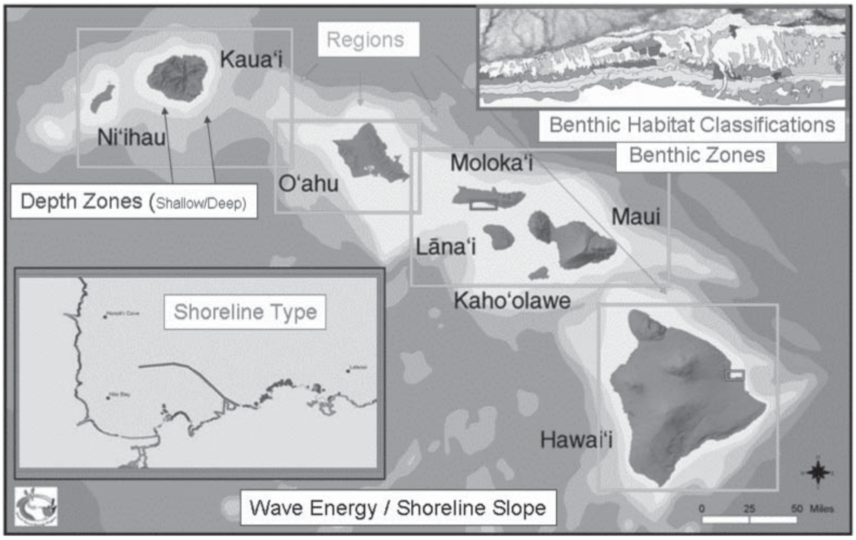


Figure 49 ▪ Examples of some of the most common community target data used in identifying a range of habitats

Water Community

Mapping of targeted species or indicators (fine filters) also had a lack of spatial data, thus much of these maps were created in-house with the assistance of "water people": knowledgeable marine tourism guides, local researchers, managers, aquarium collectors, and elders in the community. This source of alternative data was used to identify species' distributions and unique locations, information not found (or not easily shared) in most scientific research projects. Water people were more willing to contribute their knowledge then most researchers, understanding the greater need for collective data used in management (see Figure 50). Assistance from this water community also helps garner support in conservation efforts and demonstrates respect for their accumulated knowledge. The compilation of this data into one location will assist communities in the future as they seek substantiation for local management initiatives.

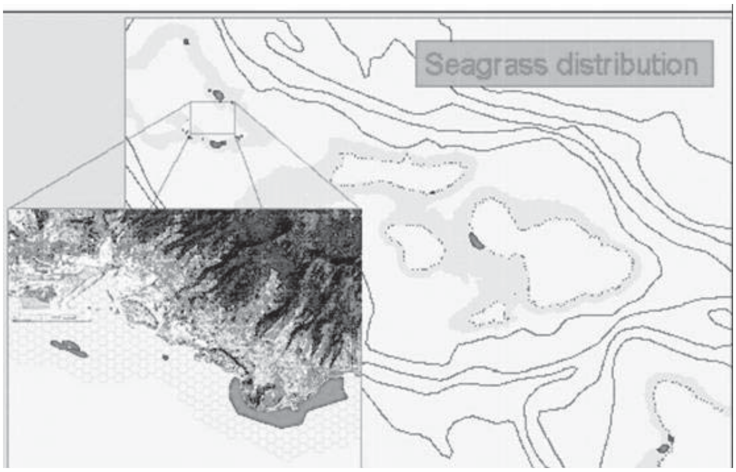


Figure 50 ▪ Seagrass distribution was mapped and used as a fine filter species target

Task

Hawaii's Marine Gap Analysis Program has begun accumulating the broad array of information needed to effectively manage the marine environment — a perpetual process. Interim goals will include developing a better understanding of human impacts on marine health, social demands on resources, accessing unsurveyed areas or locations with limited data and compiling of this information into an organized database. There is no result or finished product. Our gap analysis is a working understanding of management needs overlapped with community concerns, available information and a goal for preserving habitats in the future.

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Biographical Sketches

Nigel Dudley

Nigel Dudley is a consultant ecoloogist, working primarily with non-governmental organisations and UN agencies, with a particular focus on protected areas. Over the last few years his work has concentrated on issues of management effectiveness, tools for protected areas, broadscale planning of protected area networks and developing a series of reports looking at arguments for protection. He is chairing a task force for the World Commission on Protected Areas on revision of the IUCN protected area management categories."

Jeffrey Parrish

Dr. Jeffrey Parrish is the Technical Director for The Nature Conservancy's Global Protected Areas Strategy which aims to work with others to advance biodiversity conservation by strengthening protected area systems around the world. His career has focused on protected areas design and management, and conservation planning and monitoring work throughout Latin America, the Caribbean, Africa, and Asia and the Pacific. As a member of the World Commission on Protected Areas, his current work and interests are focused on issues of protected area gap analysis, management effectiveness, and protected area management categories.