Adaptation Options on Natural Ecosystems.
A Report to the UNFCCC Secretariat Financial and Technical Support Division

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1. Introduction

Natural ecosystems, if humans are taken as being “apart from” nature, can be defined as systems in which there has been no modification by humans (Calow, 1998). All ecosystems are affected directly and/or indirectly by humans and so in the context of this study, natural ecosystems are taken as systems with minimal human interference. Observation evidence from all continents and oceans show that many natural ecosystems are responding to regional climate changes, especially increase in temperature (IPCC, 2007a). This shows that species are already adapting autonomously to current climate change. It is also projected that the resilience of many ecosystems will be exceeded in the 21st century as a result of a combination of climate change, associated disturbances and other drivers of global change. This will require human planned adaptation to work alongside the autonomous adaptation. While there are a range of postulated adaptation options the effectiveness of many individually or as a portfolio of actions are largely untested. Thus it is very difficult to define a coherent operational adaptation strategy for natural ecosystems. It is even more difficult, therefore, to estimate the financing needs for adaptation, although investment in current conservation can provide some guidelines as to costs and to financing opportunities.

1.1 Climate change impacts and adaptation

Climate change is already impacting natural ecosystems (Parmesan and Yohe, 2003; IPCC, 2007a) and research indicates that many ecosystems and species could be adversely affected by increases in global mean temperatures of 1 to 2^{0}C not just in terms of their range or existence, but also their ability to deliver various services to humans (Leemans and Eickhout; 2004; Table 1). It has also been suggested that a rise beyond 2°C was unacceptable for ecosystems and biodiversity (Gitay *et al*., 2002; Reid *et al*., 2005), while Van Vliet and Leemans (2006) suggest it should be limited to 1.5°C above pre-industrial levels and the rate of change to 0.5°C per century. Under a BAU (A1B or B2) scenario global average surface warming relative to 1980-1999 could be ~1.8^{o}C, while under the mitigation scenario (B1) it could be ~1.4^{o}C (IPCC, 2007b). In order to try and avoid such increases, mitigation is needed in the medium to long term, but due to the time-lag in the effectiveness of such measures, adaptation is required to combat short to medium-term changes.

1.2 Climate change adaptation

Adaptation in natural ecosystems can take two forms: autonomous (or spontaneous) adaptation, for example, where species and ecosystems change in their distribution based on their capacity to move within a landscape and planned adaptation which involves societal responses through planning and policy. In the case of the former, the ability to adapt can be affected by the quality, quantity and nature of the landscape and its is here that most human planned adaptation occurs.

A number of planned adaptation options have been suggested for natural ecosystems and protected areas (Korn *et al*., 2003; Hulme, 2005; Pöyry. and Toivonen, 2005; UNESCO-WHC) including:

1. Reduce and manage stresses from other sources and activities, such as pollution, over-harvesting, habitat conversion and species’ invasions. This may be difficult in densely populated areas like Asia, Europe and Africa (IPCC, 2007), but some of these measures have been considered as part of the Finnish National Adaptation Strategy (Carter, 2007) and for management of the Cape Flora, South Africa (CBD, 2005).
2. Habitat restoration (CEFAS, 2005).
3. Increase size and/or number of reserves (e.g. IUCN *et al.,* 2003).

Impacts to unique and threatened ecosystems by Region affected (GCM used where known)	Δ Temperature °C										
	1.0	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.0**
Australia and New Zealand	At least 10% of land species facing extinction (according to one estimate) 80% bleaching of coral reefs, including Great Barrier Reef (stern)				>50% loss Kakadu in Australia HadCM2/3 (Hare 2005)	Coral reefs regionally functionally extinct in Great Barrier Reef (Hoegh_Guldberg, 1999)		Extinction reptiles (7-14%) frogs (8-18%) birs (7-10%) mammals (10-15%) in Queensland as 47% of habitat loss (Thomas et al 2004; Williams et al, 2003)	Extensive loss/conversion of habitat in Kakadu wetland due to seal level rise and saltwater intrusion – Australia (Eliot etal 1999) Risk functional extinction of Golden Bowebird habitat reduced by 50% - Australia (Rutherford et al, 2000)		
	Many eucalypts out of range - Australia (Hughes et al. 1996) Significant loss Alpine zone - Australia (Busby 1988) Risk extinction frogs/mammals (40% loss World Heritage Rainforest area) - Australia's most biodiverse region (Queensland wet tropics) (Williams et al.2003)										
Asia					Extinction of coral reefs in Indian Ocean (Sheppard 2003)	Coral reefs regionally functionally extinct SE Asia (Hoegh-Guldberg, 1999)					Severe damage (59% loss) to boreal forest (Ni, 2001)
Africa											
	2050 Severe loss of extent of Karoo - S Africa - HadCM2, HADGGAX50 (CO2 doubling) (Rutherford et al. 1999)										
Polar Regions											15 – 40% of species facing extinction (according to one estimate) High risk of extinction of Arctic species, including polar bear and caribou (stern)
	Severe damage to Arctic ecosystem - Arctic (ACIA 2004) Loss of aerobic capacity, potential for local extinction of key mollusc species from the Southern Ocean at local T rise of 2°C - Antarctic (Peck et al. 2004) 60% loss lemming (for local T rise 4°C) affecting whole ecosystem, including snowy owl - Arctic - GISS GCM; (Kerr & Packer, 1998)										

	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Europe											Extinction of plants (3-14%) (Thomas et al 2004)
	Moderate stress Alpine zone - Europe (Hare 2005)										
North America						Coral reefs regionally functionally extinct in Carribean (Hoegh-Guldberg, 1999)		8% loss freshwater fish habitat, 15% loss in Rocky Mountains, 9% loss of salmon Preston, 2007)			16% freshwater fish habitat loss, 28% loss in Rocky Mtns, 18% loss salmon
	Large impacts to salmonid fish - N America - Range of GCMs (Hare 2005 based on Keleher & Rahel 1996)										
Latin America								Extinction of mammals (2-18%), birds (2-8%) and butterflies (1-11%) (Thomas etal, 2004) Extinction of plants in Cerrado (38-45$, no dispersal only			
Global							9-31% (mean18%) all species extinct (Thomas et al 2004)	10% Global Ecosystems transformed; loss 47% wooded tundra, 23% cool conifer forest, 21% scrubland, 15% grassland/steppe, 14% savannah, 13% tundra, 12% temperate decide forest Leemans & Eickhout, 2004)			
	Risks for many ecosystems (Leemans & Eickhout 2003) Functional extinction of most coral reefs (Hoegh-Guldberg, 1999) Up to 15–20% of ecosystem areas worldwide will shift. Some protected areas of global importance and hotspots are likely to suffer severe losses of both area and species.										

Δ Temperature °C

4. Increase habitat heterogeneity within reserves e.g. by including gradients of latitude, altitude and soil moisture and by including different successional states.
5. Maintain ecosystem structure and function as a means to ensure healthy and genetically diverse populations able to adapt to climate change.
6. Increase landscape connectivity through use of corridors/stepping stones to link areas of habitat or reserves e.g. Meso-American corridor and binational corridors in Latin America, the Wildlife Trust plans for the Great Fen, UK, which include plans for sufficient water storage to support critical habitats for up to 3 consecutive years of summer drought. In Europe, a multi lateral initiative to establish a stronger (i.e. 'climatically robust') network of ecological areas is the Pan-European Ecological Network PEEN. The Netherlands have a similar ecological network (Ecological hoofdstructuur) that is being implemented and is intended to be a climate change proof.
7. Increase landscape permeability through reduction in unfavourable management practices and increasing area for biodiversity e.g. through agri-environment schemes.
8. Translocations/re-introduction of species especially those providing key services such as pollination (Hodder and Bullock, 1997; Carter and Newbury, 2004).
9. Ex situ conservation e.g. seed banks, collecting germplasm and zoos, including captive breeding for release into wild (e.g. IUCN *et al.,* 2003).

These options could be applied singly or in combination and they are based largely on ecological theory and potential management alternatives. They have not been tested for their effectiveness in practice. Although some studies have examined the effect of different management strategies on the ability of ecosystems to deliver services.

Examples of different national adaptation strategies for biodiversity and conservation can be found at: http://adaptation.biodiv.org/default.shtml and for the UK at
http://www.ukcip.org.uk/resources/tools/search_results_sec.asp?sector_id=4

Comparatively few of the options have been applied in a climate context, although coastal management may include ecosystems as part of an adaptation strategy. In a review of climate change vulnerability and adaptation in Europe, Brooker and Young (2006) suggest that very few countries go beyond the list of general adaptation options for biodiversity protection, showing that there is an inadequate knowledge of potential impacts in terrestrial ecosystems and practical guidance for planned adaptation. Williams (2002) did devise a planned system for adaptation in Australia's forests and observations on how nature is currently adapting to climate change can provide guidance on appropriate adaptation strategies (IPCC, 2007a).

Adaptation is vital to avoiding unwanted impacts of climate change, especially in sectors, such as ecosystems, vulnerable to even moderate levels of warming, (Stern, 2006; IPCC, 2007a). It is also seen as a means maintaining or restoring of ecosystem resilience to single or multiple stresses (Convention on Biological Diversity, 2005). Existing adaptive measures in other sectors which also impact on biodiversity are primarily focused on flood and coastal defences, with few examples of implemented adaptation policies, measures and practices and their effect on biodiversity outside this area (Brooker and Young, 2006).

Increasingly the integration of nature conservation (and also adaptation) into broader social, environmental, economic and political objectives and plans for other sectors, especially agriculture, forestry fisheries and other economic activities is being stressed (IUCN *et al.,* 2003; IPCC, 2007a). Many of the options for enhancing natural ecosystems and their adaptive capacity can involve negative trade offs or positive synergies with other ecosystem services (Millennium Ecosystem Assessment, 2005).

A particular current interest in ecosystems is their value in providing goods and services (Millennium Ecosystem Assessment, 2005) and identifying the impacts of climate change. The ability of natural ecosystems to maintain valuable services, particularly provisioning (e.g. agriculture and forestry) and regulatory (e.g. prevention of soil erosion, water regulation) should not be ignored and some of these aspects are covered in other papers (e.g. Lal). The creation and effective management of a comprehensive protected area (PA) network, therefore, is vital not only for the protection of biodiversity, but also for the numerous market and non-market benefits that intact nature provides (Balmford *et al*. 2002, Rodrigues *et al*. 2004). Thus, if conservation is able to maintain or enhance natural ecosystems then their ability to provide a range of services should be secure.

It should not be forgotten that "There are clear limits to adaptation in natural ecosystems. Even small changes in climate may be disruptive for ecosystems (especially vulnerable ones, such as coral reefs, mangrove swamps) and will be exacerbated by existing stresses, such as pollution. Beyond certain thresholds, natural systems may be unable to adapt at all, such as mountainous habitats where the species have nowhere to migrate." (Stern, 2006, Chapter 18 p10).

1.3 **Methodology to assess adaptation costs**

The possible costs of the impacts of climate change for natural ecosystems have been assessed globally (Tol, 2002; Table 2), in individual countries (Metroeconomica, 2004) or for particular ecosystems (Winnett, 1998; Tol, 2002), but these are often based on crude assumptions in the absence of relevant data. Given the difficulty of establishing the costs of impacts, no factual studies have established the effectiveness and costs of adaptation options in ecosystems (IPCC, 2007a, p54). Some adaptation opportunities and costs were identified in the IPCC report for certain ecosystems and for each region, but these were very limited qualitative assessments (Chapters 4, 9-16, 2007a), and without any valuation.

There are both methodological and data issues when trying to cost adaptation in natural ecosystems. A number of techniques exist for valuing natural ecosystems and the services they supply, although there is debate about their application (Brouwer *et al*., 2000; IUCN *et al*., 2003; Pagiola *et al*., 2005; Eftec, 2006). Also, there is a question of the relationship between these services and the more traditional conservation of species and ecosystems. Whether adaptation in the latter will cover some (all) of the necessary adaptation to maintain services in the former?

Few of the adaptation options identified (Section 1.2) have as yet been applied in a climate change context, but many of them are part of current conservation practice for protecting the future of species and ecosystems. Expenditure on conservation, therefore, could be seen as implicitly embracing climate change, but given the level of projected climate change impacts (Section 1.1) it is unlikely to be sufficient.

Given the paucity of financial data there are various possible approaches to estimating the costs of adaptation in this paper. Firstly, there are the costs of maintaining natural ecosystems and their services in the face of climate change. Secondly, there are the additional costs to conservation of maintaining/enhancing not just the PAs network, but also the planned adaptation actions necessary for facilitating autonomous adaptation (a zero direct cost action).

Table 2: Estimates of impact of climate change and $C0_2$ fertilization on forestry and natural ecosystems for a 1^{o}C increase in global mean temperature (US$ millions). From Tol, 2002

	Forestry	**Ecosystems**
OECD-A	218 (24)	-17.4 (17.4)
OECD-E	134 (16)	-14.7 (14.7)
OECD-P	93 (20)	-11.5 (11.5)
CEE&fSU	-136 (17)	-5.4 (5.4)
ME	0 (0)	-0.3 (0.3)
LA	-10 (2)	-0.5 (0.5)
S&SEA	140 (34)	-0.1 (0.1)
CPA	0 (0)	-0.1 (0.1)
AFR	0 (0)	-0.1 (0.1)

Source: Own calculations, after Perez-Garcia *et al* (1996), Fankhauser (1995) and Manne *et al*. (1995)

In order to provide a guide to the costs of adaptation in natural ecosystems, the following methodology was adopted:

i. Estimate current global expenditures on conservation;
ii. Estimate shortfall in current conservation expenditure;
iii Estimate levels of additional expenditure needed for climate change adaptation.

The current global expenditure on conservation was taken from two published sources (UNEP, 1992 and James *et al*., 2001). The UNEP figures were based on a selection of biodiversity country studies, but as James *et al*. (2001) point out the data and assumptions underlying these estimates are generally unclear. James *et al*. (2001) used a World Conservation Monitoring Centre (WCMC) survey to obtain PA expenditures in 108 countries that manage 3.7 million square kilometers, or more than 28% of the global PA system (James *et al*. 1999). Additional data from the grey literature produced budgetary information for another 2.55 million square kilometers of global PAs. Overall, they obtained budget information for 47.5% of the global PA system. To obtain a global estimate of expenditures on PAs they divided the countries of the world into 10 economically and ecologically similar regions. Within each region, the available data were extrapolated to obtain an estimate for the entire region. Global cost estimates represent a sum of the 10 regional estimates (Table 2).

In order to estimate shortfalls in the existing reserve network, James *et al*. (2001) used estimates of funding shortfalls from PA managers in 52 developing countries and from 14 developed countries from the WCMC survey. These estimates formed the basis for an extrapolation of PA budget shortfalls for the developing countries and for Europe. The data were not sufficient to make similar estimates for the remaining developed countries, so it was assumed that their budgetary shortfalls averaged 10% of actual expenditure (James *et al*., 2001). The cost of purchasing land to expand the network for ecological representation; the cost of effectively managing these new areas in the future and the scale of compensation required to meet the opportunity costs incurred by local people living in or near reserves were also calculated. These were added to the current and shortfall sums to obtain the annual cost of adequate biodiversity conservation within a global reserve system.

The shortfall in current conservation expenditure was supplemented by two other sources (Balmford *et al*., 2002 and Bruner *et al*., 2003). Balmford *et al*. (2002) used data on the recurrent management costs per unit area of effective terrestrial field-based conservation programs (57 sites) from James *et al*. (1999), from correspondence with local experts (21 sites), from the published and unpublished literature (20 sites), and from the World Wide Web (41 sites). The data covered 37 nations from all major landmasses except Antarctica, consisted mostly of reserves but also covered conservation programmes in the wider landscape, and included 64 projects from less developed countries. These variation in costs were compared with a suite of measures of development, and these were used to build a simple model for predicting costs elsewhere, and to explore global variation in likely conservation benefits. The findings on conservation costs and benefits were compared with the current global distribution of conservation investment, thus allowing an estimate of global shortfall in funding. The sources of data used by Bruner *et al*. (2003) has not been established, but probably included existing cost studies such as are used in their 2004 paper (Bruner *et al*., 2004)

All the above studies are limited, being based on different samples of countries due lack of adequate data, involve extrapolation to obtain global figures and contain no estimate of margins of error. They all have inherent assumptions, which vary according to the methodology used. Thus a strict comparison is not possible, although they do give estimates of similar orders of magnitude.

The greatest limitation for application to costing climate change adaptation in natural ecosystems is that their work is focused on PA, which form only part of the range of adaptation options and does not explicitly include climate change. An additional component therefore is needed. This could be most simply done by adding a percentage to current costs of obtaining an improved PA network, but such a figure would be entirely arbitrary, as there are no guidelines as to how this might be estimated and it is likely to vary by country and region according to the sensitivity of the natural ecosystems and the current state of conservation. James *et al*. (2001) do, however, explore two scenarios. Using the IUCN recommendation that at least 10% of the land area of each nation or ecosystem, be set aside for conservation (IUCN, 1993), they develop two scenarios. These are based on expanding the reserve network in region to 10%, in relation to different IUCN categories (Box 2). Once again this involves the use of the informed but arbitrary 10% figure for scenario development.

The scenarios give different levels of protection and hence cost. In this paper it is assumed that the scenario giving a greater level protection should be associated with the BAU projection where climate change impacts will be greater in number and magnitude (Table 1). These costs represent the absolute minimum cost of adaptation to climate change.

2. Overview of current financing of climate change impacts on natural ecosystems

Current financing of climate change impacts, and thus potentially some adaptation, is met from a variety of sources, including international funding, national conservation budgets and local or site-based schemes. These will be examined before estimating the investment needed for adaptation (Sections 3-6) and examining possible financing sources (Section 7).

2.1 Current sources of financing

A comprehensive review of sources of financing for PA was carried out by the Financing Protected Areas Task Force of the World Commission on Protected Areas (WCPA) of IUCN (2000). It is used here to be indicative of funding sources for all conservation and adaptation (Box 1), although focus will be given to international and some national level-mechanisms, as providing the greatest sources of funding for adaptation. It should also be noted that there is overlap in the funding provided by these different sources.

Box 1: Source of financing for Protected Areas

International sources of funding for protected areas
1 Multilateral banks etc.
2 Global Environment Facility (GEF)
3 Bilateral development co-operation agencies etc.
4 Foundations with an international remit
5 International non-governmental organisations with an international remit
6 Alternative financial mechanisms

National-level mechanisms
1 Taxes, levies, surcharges and tax incentives
2 Tax deduction schemes
3 Grants from private foundations
4 National environmental funds
5 Debt swaps
6 National and provincial lotteries
7 Public-good service payments
8 Workplace donation schemes

Site-level mechanisms
1 User fees
2 Cause-related marketing
3 Adoption programmes
4 Corporate donations
5 Individual donations
6 Planned giving
7 Site memberships and friends schemes

2.1.1.1 Multilateral banks

In total, development banks provided more than US$1.25 billion funding for international conservation in 2002.

2.1.1.1.1 World Bank

The World Bank is the world's largest financier of biodiversity. Between 1988 and 2004, World Bank funding for biodiversity has involved over 426 projects with about US$1.5 billion of IBRD/IDA resources, over US$964 million of GEF funds and an additional US$2.2 billion in co-funding from other donors, governments, NGOs, foundations and the private sector; a total Bank-managed biodiversity portfolio of US$4.7 billion (World Bank web site). In 2002, the World Bank provided US$300 million funding for biodiversity projects through its regular portfolio and an additional US$250 million for biodiversity projects through the International Development Association. Its current support for biodiversity involves the establishment and strengthening of PAs (including activities in buffer zones), sustainable use of biodiversity outside PAs, eradication of alien species, and biodiversity conservation through improved management and sustainable use of natural resources in the production landscape. In the future, it is expected that the Bank's activities in support of conservation and sustainable use of biodiversity will further emphasize mainstreaming of biodiversity in the production landscape, including agriculture, fisheries, and other rural development activities. While many of the activities could help with climate change adaptation they are not undertaken explicitly for this purpose.

2.1.1.1.2 Other banks

Among regional development banks, both the Asian Development Bank and the Inter-American Development Bank have significant biodiversity-related project portfolios, providing approximately US$250 million and US$500 million respectively in 2002 (quoted in Emerson *et al*., 2006).

2.1.1.2 Global Environment Facility (GEF)

The GEF is one of the main sources of funding for biodiversity conservation in developing countries and between 1991-2000, the GEF provided about US$1.1 billion in grants and leveraged an additional US$2.5 billion in co-financing for biodiversity-related projects (Good, 2003). Most of this funding is in the form of grants to developing country governments and NGOs, used to support more than 1,000 protected sites covering 226 million hectares in 86 countries[1]. Much of the work with the private sector is over seen by the International Finance Corporation (IFC), whose existing biodiversity portfolio to date amounts to approximately US$118 million, including co-financing and other instruments (from Bishop *et al*., 2006). The GEF funded portion amounts to US$24 million; other donors provide around US$31 million, while the private sector provides a further US$63 million (including from IFC credit).

Article 6 of CBD requires parties to develop National Biodiversity Strategies and Action Plans (NBSAPs), which integrate consideration of the conservation and sustainable use of biological resources into national decision-making, and mainstream issues across all sectors of the national economy and policy-making framework. The GEF is a means of financially enabling developing countries to devise their NBSAP. Developed country parties are required to provide new and additional financial resources to enable developing country parties to meet the costs of implementing CBD measures; this can be through bilateral, regional and other multilateral channels.

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[1] GEF Working Document "*GEF Strategy to Enhance Engagement with the Private Sector*", available at
ww.gefweb.org/Documents/Council_Documents/GEF_C28/documents/C.28.14PrivateSectorStrategy_000.pdf

The Secretariat for the Convention on Biological Diversity is financed from contributions made by Parties and non-Parties to the Trust Funds, two of which could be considered relevant to adaptation funding if climate change is integrated into NBSAPs:

(i) General Trust Fund for the Convention on Biological Diversity

(ii) Special Voluntary Trust Fund

For (i), about US$9.23 million had been pledged as of end of May 2007, of which 81% had been received, whereas for (ii) the similar figures are US$1.13 million and 98%.

A table is being collated by UNFCCC for funding from GEF projects

2.1.1.3 Bilateral funding

Estimates of total environmental spending as a share of bilateral aid flows range from 2% to 14% (Swanson and Lund, 2003). This translates into significant funding channelled to developing country PAs. For example, between 1998–2000, bilateral aid for biodiversity, sustainable use or "aid targeting the CBD objectives" provided by 19 donor countries averaged some US$995 million per annum (OECD, 2002). The World Heritage Fund provides about US$4 million annually to support activities requested by States Parties in need of international assistance (UNESCO-WHF, 2006). It includes compulsory and voluntary contributions from the States Parties, as well as from private donations.

2.1.1.4 Foundations with an international remit

One of the largest sources of such funding for conservation is the Gordon and Betty Moore Foundation, which has given nearly $300 million to Conservation International to fund work in both terrestrial and marine spheres[2], in addition to funding other conservation related projects. Charitable giving and other private spending on conservation are not well documented but probably account for less than half of public spending on biodiversity (Pearce and Palmer, 2001). Other philanthropic foundations include the Ford Foundation, Rockefeller Foundation and United Nations Foundation, which seem to have smaller funds for conservation related issues. In 2006, for example, the Ford Foundation approved nearly $530 million in grants and gave about $1 million for projects involving biodiversity, but most are not involved directly in its conservation. United Nations Foundation has received contributions totalling over US$10 million for "World Heritage sites recognized as containing the most important habitats for biodiversity conservation".[3]

2.1.1.5. International non-governmental organisations

A number of non-governmental organisations (NGOs) such as Conservation International, World Wildlife Fund and The Nature Conservancy have significant funds to leverage for conservation activities and work. The former has already been mentioned (Section 2.1.4). The WWF had an operating income of nearly US$109.5 million in 2006[4], with about 5 million supporters, ranging from individuals to corporations and foundations, making financial or in-kind contributions that add up to around 70% of WWF's global yearly income. Similarly in 2006, The Nature

[2] http://www.moore.org/init-grants-awarded.aspx?init=110

[3] www.unfoundation.org/programs/environment/priorities.asp

[4] http://www.panda.org/about_wwf/who_we_are/organization/finance/index.cfm

Conservancy had total current assets of nearly US$380 million and total assets of US$4,828 million[5]

2.1.1.6 Balance between public and private funding of conservation

Pearce (2005) comments that in most countries, and at the global level, the share of public spending allocated to biodiversity conservation is trivial, with spending on PA financing often being less than 1% of national budget. Pearce and Palmer (2001) suggest that while charitable giving and other private spending on conservation are not well documented, they probably account for less than half of public spending on biodiversity. There is, however, some contradiction about the relative contribution of public and private sources of funding in Emerton *et al*., 2006. Citing Lapman and Livermore (2003) they suggest that although non-governmental and private sector funding is becoming an increasingly important component of PA finance, two sources – domestic government budgets and international donor assistance – provide the bulk of PA funding. In contrast, on page 11 they say that significant funding for PAs comes from private sources, including business and philanthropic foundations as well as non-governmental organizations and local communities.

Funding for biodiversity projects involving the private sector has been relatively limited and focused on 'capacity building and technical assistance in eco-tourism, agro-forestry, … certification of commodities, payments for environmental services, and conservation of medicinal and herbal plants'. In 2006 the GEF Secretariat developed a revised strategy to enhance engagement with the private sector. Key elements include: (i) a new US$60 million 'public / private sector partnership fund'; (ii) increased use of 'non-grant / risk mitigation instruments' (such as loan guarantees, concessional credit, insurance, debt-for-nature swaps); and (iii) various communication activities to promote private sector engagement[6]. If the strategy is successful, it could lead to significant new investment by the private sector in biodiversity conservation in developing countries.

2.1.2 National sources of financing for conservation

Domestic government budgets are the single largest source of PA financing in most countries (Emerton *et al*., 2006). As a share of total government spending, the sums involved are relatively small, often less than 1% of GDP. Few figures are available to quantify the amounts available via national sources of funding, although since 1987, over US$1 billion in environmental funding has been generated through debt-for-nature swaps in nearly 30 countries[7]. These have the potential to safeguard the existence of ecosystems thus "increasing" their area and preventing fragmentation both of which can contribute to adaptation.

Since 1990, national environmental funds have been established in more than 30 countries, with combined assets of more than US$500 million (World Commission on Protected Areas, 2000), although these are not necessarily used for adaptation related activities and can be used for such things as pollution mitigation, or the

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[5] http://www.nature.org/aboutus/annualreport/files/arfinancials2006.pdf

[6] GEF Information Document "*Additional Information to Support the GEF Strategy to Enhance Engagement with the Private Sector*", available at www.gefweb.org/Documents/Council_Documents/GEF_C28/documents/C.28.Inf.4PrivateSectorStrategy.pdf.

[7] Financing Protected Areas Task Force of the World Commission on Protected Areas (WCPA) of IUCN, in collaboration with the Economics Unit of IUCN, 2000.

development of new environmental technologies and businesses (as in the case of Colombia's ECOFONDO and the Polish ECOFUND). Some biodiversity conservation funds have been created by grants from international donors plus a host country government counterpart contribution. For example, the Mexican Government contributed $10 million to the Mexican Conservation Fund; the balance was contributed by USAID and the GEF. The funds can operate in different ways and can provide a significant input to national conservation. The Bhutan trust fund, for example, has an endowment of more than US $27 million contributed by international donors, including the GEF, WWF, the Governments of Norway, Denmark, Switzerland and the Netherlands and produces a $4 million annual income (World Commission on Protected Areas, 2000).

Since 1987, over US$1 billion in environmental funding has been generated through debt-for-nature swaps in nearly 30 developing countries (World Commission on Protected Areas, 2000). These swaps also may lead to setting up of trust funds and can contribute to the safeguarding of areas of biodiversity importance, preventing their loss and thus habitat fragmentation.

2.1.3 Local sources of financing for conservation

Again there is limited case study information on the amounts raised by such means as identified in Box 1, but they are likely to be low in global terms and to contribute little overall to the financing of adaptation. They can be important as they provide a complementary source of funding and a more direct link between the donor and the area/species. They are not, however, realistic in poorer countries or inaccessible areas.

2.2 Current expenditure on conservation

Data on current biodiversity expenditure is sketchy and often contradictory as can be seen both from the above and from the following figures, and it is important to differentiate total spend on conservation from spend on PAs. It has been estimated that globally approximately US$10 billion per annum is spent on ecosystem conservation (Pearce, 2005), while the UNEP 1992 figures for the global costs of conservation are between $680 million to $42 billion, with a mean about $20 billion. Global spending on biodiversity includes an estimated US$6.5 billion devoted to managing PAs, of which about US$2.5 billion is spent in the USA alone (James *et al.*, 2001). Developing countries as a whole are thought to spend between US$1.3 billion and US$2.6 billion per annum on their national parks (Molnar *et al.*, 2004).

There are a number of different figures for investment in biodiversity. Pearce (2005) estimates it is about $267 million (Table 3), but investigation of different sources of funding suggests that the amount is greater.

Table 3: Total biodiversity investment

Total biodiversity investment ($million) as per latest World Bank Sources

	Year	
Funding source	2000	2005
Total GEF	52.11	89.64
IDA	13.85	55.45
IBRD	49.68	49.4
Trust Funds	6.9	4.78
Total WB funding	122.54	199.27
Total Co-financing	53.58	67.44
Total Biodiversity funding	**176.12**	**266.71**

Pearce (2005) analysed flows of global funds for conservation (Table 4) which cover only some of the categories described above, for example they do not include national expenditure, which is significant in developed countries. Also, they exclude opportunity costs, which is important for PA expenditure. It should be noted that the figures cannot be summed, as they are not mutually exclusive.

Table 4: Flows of biodiversity conservation funds ($ million p.a.), from Pearce, 2005.

Debt-for-nature swaps	140
Protected Areas	6000
Bio-prospecting	Small
GEF biodiversity	315
GEF all areas	1000
Bilateral aid	1000

At a global level, there is little up-to-date or reliable information on PA finance (Emerton *et al*., 2006). Multilateral funds, which combine contributions from various sources, such as the Global Environment Facility (GEF), have over the last decade come to the forefront of international efforts to finance biodiversity conservation, as have funds earmarked for broader sustainable development and poverty reduction (Emerton *et al*., 2006).

2.3 Shortfall in current conservation expenditure and costs of adaptation

Currently terrestrial and marine reserves currently cover only around 7.9% and 0.5% of the Earth's land and sea area respectively (IUCN, 1997; Kelleher *et al*., 1995), which is below that thought necessary for maintaining wildlife into the future. The expenditure on global conservation, therefore, is inadequate for current conditions. The UNEP figures were re-evaluated by James *et al.* (2001). They explored the global biodiversity cost of conservation within an ecologically representative reserve network and conservation within the wider matrix of landscapes, including agriculture, forestry, freshwater, and marine systems. They regarded these two strategies as largely sufficient to maintain the flow of benefits from global biodiversity into the future. This is without any explicit incorporation of climate change, but the strategies are themselves a part of the adaptation options for dealing with climate change impacts and thus are regarded as giving a indication of the mimimum costs of climate change apaptation. Additional investment will be required to cope with these, but it is difficult to determine the amount.

The details of the methodology are provided in James *et al*. (2001), but they examined two scenarios. Firstly, increasing the PA network in all regions by 10%, while maintaining the current proportions of IUCN categories of PAs in each category (scenario 1). Second, increasing the network of more strictly PAs (IUCN categories I, II, and III – see Box 2) to 10% in each region without expanding existing category IV–VI areas, thus giving a stronger overall level of protection (scenario 2). Their estimates of expenditure for global PAs is given in Table 5. The effective conservation costs vary among regions because of differences in population densities, level of economic development, and geographic characteristics of PA systems (James *et al*., 1999). Similar factors along with differing ecosystem sensitivities and vulnerability could apply to adaptation costs for climate change.

Box 2: IUCN Protected Area Categories

Category I - PA managed mainly for science or wilderness protection (Strict Nature Reserves and Wilderness Areas). Category II - PA managed mainly for ecosystem protection and recreation (National Park). Category III - PA managed mainly for conservation of specific natural features (Natural Monument). Category IV - PA managed mainly for conservation through management intervention. Category V - PA managed mainly for landscape/seascape conservation and recreation (Protected Landscape/Seascape). Category VI - PA managed mainly for the sustainable use of natural ecosystems (Managed Resource Protected Area).

The above figures suggest that current expenditures on reserves run at about $6.0 billion per year (James *et al*., 2001). They project that improving protection, expanding the network in line with IUCN guidelines, and meeting the opportunity costs of local communities could all be achieved for an annual increase in expenditure of $12.0 billion (scenario 1) to $21.5 billion (scenario 2). Also a globally representative and adequately managed nature reserve system could be accomplished for about 2% of the annual expenditure on perverse environmentally harmful subsidies (see Section 7 for further discussion).

Balmford *et al*. (2002) used similar calculations to James *et al.* (2001) to estimate the costs of properly managing existing PAs and expanding the network to cover 15% of the area of each region. They found it would require an annual outlay of between $20 to 28 billion. To cover 30% of the total area of the seas with marine PAs would cost at most about $23 billion a year, with about $6 billion a year in start costs for 30 years. Once again they point to the diversion of perverse subsidies as a means of funding this. This is less than those from the Durban Accord from the Fifth World Parks Congress, where concern was expressed that existing PAs suffer an annual funding gap of some US$25 billion, *excluding* additional resources required to expand PA systems.

Balmford *et al*. (2003), using data from 139 terrestrial programs worldwide, found that the annual costs of effective field-based conservation vary across seven orders of magnitude, from <$0.1 to >$1,000,000 per km^2. There is a positive correlation between costs per unit area and various indices of local development while measures of conservation benefit show an opposite global trend, being higher in less

Table 5: Funding shortfalls in the global protected area network James *et al*. (2001). (All figures are in millions, except those in italics, which indicate per-square-kilometer costs in dollars; all costs are annual (survey and purchase annual payment calculated at 5% interest over 30 years).

	Protected area (1996 dollars)	**Current spending (1996 dollars)**	**Estimated shortfall (sq. km)**	**Survey cost (1996 dollars)**	**Scenario 1 Added area (1996 dollars)**	**Scenario 1 Cost (1996 dollars)**	**Scenario 2 Added area (sq. km)**	**Scenario 2 Cost (1996 dollars)**	**Scenario 1 Management (sq. km)**	**Scenario 2 Management (1996 dollars)**	**Compensation Payment (1996 dollars)**
					Developed Regions						
North America	3.92	3,350 854	335 85	76	0.00	0	0.03	104	0	33	0
Europe	0.60	1,171 1,941	505 837	53	0.00	0	0.34	3,001	0	943	0
Australia/ New Zealand	1.11	297 268	30 27	9	0.03	29	0.23	218	9	68	0
East Asia (developed)	0.04	453 12,308	45 1,231	26	0.01	595	0.03	1,445	187	454	0
					Developing Regions						
Latin America	2.12	216 102	297 140	17	0.03	31	1.17	772	10	242	1,243
Russia and CIS	0.66	51 78	57 86	14	1.55	808	1.79	930	254	292	268
North Africa/ Middle East	1.04 207	43 41	195 188	11	0.25	182	1.15	839	57	263	231
Africa	2.07	245 118	253 122	26	0.63	721	1.57	1,392	227	437	1,896
Asia (developing)	1.58	105 67	567 359	32	0.51	648	1.07	1,407	204	442	1,283
Pacific	0.01	35 2,673	7 500	7	0.04	430	0.05	549	135	172	25
Developing regions total	7.48	695 93	1,375 184	106	3.01	2,820	6.8	5,888	886	1,850	4,947
Developed regions total	5.67	5,271 929	915 161	164	0.04	623	0.64	4,768	196	1,498	0
World total	13.16	5,967 453	2,290 174	270	3.06	3,443	7.44	10,656	1,082	3,347	4,947

developed parts of the world. Thus the benefit-to-cost ratio of conservation is far greater in less developed regions. This highlights one of the difficulties of applying global figures to regional or local situations.

James *et al*. (2001) point out that their estimates would be insufficient to ensure the maintenance of ecological and evolutionary processes. These are an important part of species' autonomous adaptation to climate change. Also, reserves, especially smaller ones, are subject to edge effects, and they may be vulnerable to extreme events too. Lastly some species are dependent on areas outside reserves and thus require a biodiversity friendly landscape matrix, pointing again to the need for any actions to be integrated into a broader landscape framework. The additional costs involved in establishing a wider matrix is explored by James *et al*. (2001) and is discussed below.

The current and shortfall in conservation expenditure is summarised in Table 6. A comparison of the UNEP and James *et al*. (2001) estimates suggest that only about one third of the current spend on conservation is on reserves, although this is comparing figures from two different sources. For reserves, taking the James *et al*. (2001) figure of US$6.0 billion it appears that there is about a three to four fold shortfall in expenditure and when marine PA are taken into account (using Balmford *et al*., 2002) this rises to seven to nine fold.

Table 6: Estimates of the current and shortfall in expenditure

Source	Conservation action	Current spend (US $ billion)	Annual Shortfall (US $ billion)
UNEP, 1992	Global current cost of conservation	Mean 20	
James *et al*, 2001	Current spend on reserves	6.0	
	Additional spend (scenario1)		12.0
	Additional spend (scenario 2)		21.5
Balmford et al. 2002	Manage existing terrestrial PA and 15% expansion		20 to 28
	Manage and expand marine PA		23 (29 for 1st 30 years)
Bruner *et al*, 2003	Annual funding gap for PA (excluding costs of expanding PA network)		25

Bruner *et al*. (2004) estimate annual total management costs for PAs in developing countries of approximately $1.8 billion. This differs slightly from those of James *et al*. (1999) – $2.3 billion and Vreugdenhil (2003) – $1.1 billion due to the inclusion of different component costs. Bruner *et al*. (2004) also estimate that an expansion of the PAs systems to include the highest priority sites in developing countries could increase management costs by $1.8 billion per annum, which, if combined with James *et al*. (1999) suggestion that creating new PAs in non-OECD countries could cost as much as $9 billion per annum for the next 10 years, then a total of $13 billion is needed for developing countries. Based on the above, the Poverty Environment Partnership (2005) estimated a $7.6 billion shortfall in funding for PAs in developing countries

Reserves are only one part of the range of conservation actions and adaptation options so questions remain as to the magnitude of the current shortfall for these conservation actions and how much is needed for all adaptation options, given that the improvements in reserve funding do not allow for additional actions needed for climate change. This is complicated by adaptation in other sectors such as forestry, agriculture and fisheries may impact adversely or beneficially on natural ecosystems and costs incurred by adaptation in these sectors could complement adaptation funding for natural ecosystems (see Lal).

In order to estimate conservation in a wider landscape matrix, James *et al*. (2001) extrapolate the costs of protecting biodiversity in UK agriculture to obtain an estimate of $240 billion for global agricultural remediation. This is combined with figures from Agenda 21 (United Nations, 1993) advisory groups which puts annual global conservation- related needs at $34 billion for forests, $14 billion for marine and coastal areas, and $1 billion for freshwater ecosystems (in 1996 dollars). When added together they suggest that conserving biodiversity in the wider matrix of landscapes would cost about $290 billion a year, in addition to the PA network costs. Such a figure would include more of the adaptation actions identified, although options such as *ex situ* conservation would not be included.

The closest to actual adaptation costs is an example for the Netherlands, where it has been estimated that in 1billion euros are spent on nature conservation, with 285 million euros going on managing national parks and reserves and 280 million euros for new reserve networks and habitat improvement. This is in order to reduce the threat from habitat fragmentation and other sources. The planned national reserve network will reduce the vulnerability of ecosystems and species to climate change and thus a significant proportion of the above costs could be considered as climate change adaptation costs (IPCC, 2007b). Another example is from Naidoo and Rickets (2006) who considered the opportunity costs and ecosystem service benefits of three hypothetical corridors linking areas of forest reserve in the Mbaracayu Forest Biosphere Reserve, Paraguay.

In order to cost adaptation for natural ecosystems, appropriate adaptation strategies would need identifying for the different ecosystems, but, as with impacts, these are likely to be case and regionally and locally specific, depending on factors such as sensitivity, current reserve network and state of the environment. The adaptation options identified above mostly rely on the purchase of land, more appropriate management of existing sites and off-site (ex situ) management and would fit alongside current conservation objectives. In that case, the figures of James *et al*. (2001) and Balmford *et al*. (2002) could provide a rough guide, if it was assumed that a certain percentage of extra costs would be incurred in order to adapt to climate change under different scenarios.

3. Impacts and adaptation needs under BAU scenario for 2030

“Protecting natural systems could prove particularly challenging” (Stern, 2006). He goes on to say that this is because the impacts are expected to be harmful for most levels of warming, because of the limited ability of species to move fast enough to new areas with suitable climate. Given the perceived limited autonomous adaptation ability of most species, planned adaptation will be crucial. Under the BAU scenario with ~1.8°C rise in temperature, global impacts of climate change are more numerous and severe than the mitigation scenario. The best assessment of the impacts of such a rise is provided by the IPCC (2007a), but even this is not fully comprehensive and many of the impacts are not associated with a particular temperature increase (Table 1). Many ecosystems could show shifts in their distribution and there is an increased possibility of species' extinction. Using a mid-range scenario for the 2050s with a 1.8 to 2.0°C increase in temperature, Thomas *et al*. (2004) calculated that species committed to extinction with dispersal into new climate space could be 15-20% and without dispersal 26-37%.

Regions, ecosystems and species identified as being particularly at risk under such a ~1.8°C rise (IPCC, 2007a) include:

1. Globally - 9-31% (mean 18%) of all species could be committed to extinction. Possible loss of 47% wooded tundra, 23% cool conifer forest, 21% scrubland, 15% grassland/steppe, 14% savannah, 13% tundra, 12% temperate deciduous forest (Leemans & Eickhout, 2004).
2. Australia - large-scale loss of Kakadu wetlands and functional extinction of Golden bowerbird due to habitat loss
3. North America – loss of river habitat and fish
4. Caribbean – corals functionally extinct
5. Latin America – extinction of 9-18% mammals, 5-8% birds and 6-11% butterflies, if no dispersal occurs.

In all these cases, pressures from other land uses (see Lal, this report) particularly need to be addressed to facilitate autonomous adaptation and to prevent habitat loss and fragmentation, but the full range of adaptation options identified in Section 1.2 are appropriate given the potential widespread loss of ecosystems and species in some areas.

4. Impacts and adaptation needs under mitigation scenario for 2030

Under the mitigation scenario with ~1.4°C rise in temperature, global impacts of climate change are continuing, with ecosystems showing shifts in their distribution and some species facing possible extinction. Certain regions and ecosystems have been identified as potentially being particularly affected by a ~1.4°C rise:

1. coral reefs, especially in the Indian Ocean at risk of extinction,
2. Arctic ecosystems
3. European Alpine zones
4. Australia - at least 10% of land species facing extinction; 80% bleaching of coral reefs, including Great Barrier Reef.

In each of these cases, the reduction and management of stresses from other sources, e.g. pollution and over-exploitation in the case of reefs, and increased protection are particularly relevant planned adaptation options, but they could apply to any ecosystem. The former will require the integration of adaptation with other sectors and both actions are likely to impose costs for activities in these other sectors, unless win-win situations can be identified, such as the restoration of reef ecosystems which would increased protection to coastal areas from storms and provide a local resource, while protection in the Arctic could provide greater opportunity for ecotourism. A more ecosystem specific adaptation for the European Alpine zones is resumption of grazing to prevent colonisation of Alpine pastures by forest.

5 An estimation of total investment needed for adaptation under the BAU scenario

Dietz and Adger (2003) investigated the relationship between measures of economic growth, biodiversity loss and conservation efforts for tropical terrestrial biodiversity. They concluded that an environmental Kuznets curve[8] between income and rates of biodiversity loss does not exist in this case, so economic growth continues to cause biodiversity loss even at high levels of income per capita. Also, that the extent and effectiveness of government environmental policy (as measured by state PAs and the regulation of trade in endangered species) increases with economic development, but only results in a partial decrease in biodiversity loss. Thus without the higher impacts identified in Section 3, the greater increases in economic growth associated with the BAU scenario alone could lead to greater need for investment in adaptation.

As was discussed in Section 2 it is difficult to obtain regional or global estimates of the costs of adaptation to climate change, as many of the adaptation actions are site and/or ecosystem specific and there is little information on their costs. Box 3 gives a few costed examples of various current conservation actions which overlap with those proposed for
Box 3: Selected examples of costed conservation actions, which overlap with climate change adaptation options (Section 1.2)

1. Prevention of habitat conversion (adaptation 2 Section 1.1). In Costa Rica, the Government is paying rural residents about $35 annually per hectare of forest protected and in Guyana, Conservation International is protecting 81,000 hectare of tropical rain forest through a conservation concession costing $1.25 per hectare (quoted in Ferraro and Kiss, 2002).

2. Habitat restoration (adaptation 2 Section 1.2). Pagiola *et al*. carried out a cost-benefit analysis of a coastal reforestation conservation project in Croatia. They found that although the benefits varied by several orders of magnitude, there could be an average benefit in terms of ecosystem services of US$790/ha (discounted at 10%).

3. Corridors (adaptation 6 Section 1.2) Mbaracyau Forest Biosphere Reserve, Paraguay. Naidoo and Ricketts (2006) undertook cost-benefit analysis benefits for the construction of three alternative corridors for linking two forest reserves. They showed that although local costs were negative (US$ 89,995 too 9,000), the overall benefits (based on net present value) were positive, ranging from US$ 1,668, 835 to 1, 447,787. Another example of corridors is from the Wildlife Foundation in Kenya who are securing migration corridors on private land through conservation leases at $4 per acre per year (quoted in Ferraro and Kiss, 2002).

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[8] The environmental Kuznets curve (EKC) hypothesis suggests that there is an inverted U-shaped curve for environmental quality when measured against income per capita.

climate change adaptation (section 1.2). These show the considerable variation in costs of different actions and add to the conclusions of Balmford *et al.* (2003) that conservation costs can be highly variable across regions and countries.

The above reinforces the difficulties of assessing current costs of conservation and such difficulties are transferred to assessing future conservation and adaptation costs. In the absence of any comprehensive data this report takes as a first estimate the figures of James *et al*. (2001) and assumes that, under BAU, scenario 2 (increasing the network of more strictly PAs (IUCN categories I, II, and III) to 10% in each region) is the minimum conservation requirement. Thus giving an annual increase in expenditure on reserves of $21.5 billion or $50.5 billion, if marine PA as calculated by Balmford *et al* (2002) are included. Given the caveats associated with the figures and that they do not include climate change, they are very conservative, but it is impossible at this stage to estimate what additional investment would be needed.

If the estimate that about one third of the global conservation budget is spent on reserves is accepted and it is assumed that this will continue into the future, then it could be argued that $64.5 billion is needed for adaptation to climate change under the BAU scenario ($83.5 billion with marine PA). The addition of the $290 billion for conservation in a wider landscape matrix (again without any adjustment for climate change or scenario) would raise this to $355.5 billion additional annual costs ($384.5 billion with marine PA).

6 An estimation of total investment needed for adaptation under the mitigation scenario

Based on the assumptions and caveats under 5, it could be assumed that scenario1 (increasing the PA network in all regions by 10%, while maintaining the current proportions of IUCN categories of PAs in each category) of James *et* al. (2002) can be used to assess the investment needed under the mitigation scenario. This equals an annual increase in expenditure on reserves of $12.0 billion.

If, as with BAU the same assumptions are made, and the same estimate that about one third of the global conservation budget is spent on reserves is used, then it could be argued that $36 billion is needed for adaptation to climate change under the mitigation scenario ($65 billion with marine PA). The addition of the $290 billion for conservation in a wider landscape matrix (without any adjustment for climate change or scenario) would raise this to $326 billion additional annual costs ($355 billion with marine PA).

7 Assessment of needed changes in financial arrangements to meet the requirement of additional costs

Some of the needed financing of adaptation could come from current funding of conservation, as many actions are part of current conservation practice and thus would be include in existing costs, or they can be adjusted to include adaptation options and this has been explored in Section 2. In order to have a robust PA network, adequate management and scope for other adaptation actions, especially the wider landscape matrix is to be included, considerable additional investment will be required. Two “ new” possiblities are the removal of perverse subsidies and new business investment in biodiversity.

7.1 Perverse subsidies

The Convention on Biological Diversity (CBD) describes a perverse incentive as "*...a policy or practice that encourages, either directly or indirectly, resource uses leading to the degradation of biological diversity.*" (SCBD, 2000). In the Durban Accord from the Fifth World Parks Congress, concern was expressed about perverse subsidies and their impacts on PAs. A strong argument has been made for the diversion of perverse subsidies into conservation (James *et al*., 2001; Balmford *et al*., 2002) and certainly if an integrated approach is taken to adaptation, including its financing this may be possible.

Much work has been developed on perverse subsidies by, for example, the OECD (OECD, 1996, 1997 and 1998) and the European Commission has just received the report it commissioned on "Removing Environmentally Harmful Subsidies" (IIEP, 2007), but for case studies it focuses on the energy and transport sectors. The CBD is compiling examples of incentive measures for submission to the Conference of the Parties. These demonstrate successful examples of types of subsidy reform, for example, in the United States measures, which included direct subsidies for wetland drainage, tax incentives for buying machinery for draining wetlands and assistance for agricultural expansion led to the destruction of up to 50% wetlands in the US to other uses since 1780. These have mostly been removed and a number of positive incentive measures have been implemented, including Government purchase of land for protection and restoration of wetlands (UNEP/CBD/COP/5/INF/14). One of the earliest examples of tackling subsidies is New Zealand, where almost all agricultural subsidies were removed from in the mid-1980s, with few problems and many benefits for the economy and the environment (Shepherd, 1996).

It has been estimated that environmentally perverse subsidies total between $950 billion (van Beers and de Moor 1999), $1000 billion (UNDP, 2005) and $1450 billion per year globally (Myers 1998). The former figure attributes $325 billion to the agriculture sector, $225 billion to automobile users, $205 billion to energy users, $60 billion to water users, $55 billion to manufacturing industries, $35 billion to forestry, $25 billion to mining, and $20 billion to fisheries. James *et al*. (2002) point out therefore that, on the basis of their figures of US$12 to 21.5 billion, a globally representative and adequately managed nature reserve system could be accomplished for about 2% of the annual expenditure on such environmentally harmful subsidies and estimate that "A truly comprehensive global conservation program that addresses conservation issues in all the major natural resource sectors", including conservation in a the wider landscape matrix, could be established for only one-third of the cost of these subsidies.

7.2.1 Mechanisms for the redistribution of perverse subsidies

The Convention on Biological Diversity provides both a mechanism for such a redistribution of funds and the legal basis for the removal of environmentally perverse subsidies, as Parties to the convention are required to identify processes and activities that have significant adverse impacts on the conservation and sustainable use of biodiversity and to regulate or manage these activities with a view to ensuring adequate *in situ* conservation. Also the CBD convention requires developed country parties to provide additional financial resources for biodiversity conservation to the developing countries and savings on perverse subsidies may be a means of doing this. This would avoid the need for "new" capital but it is questionable whether countries would re-distribute the money saved in this way.

7.2 Biodiversity and business

While business already contributes to biodiversity funding (Section2), a scoping study has identified potential *new* business opportunities and market-based mechanisms to conserve biodiversity (Bishop *et al*., 2006). The report suggested that there are three broad, complementary options for additional funding biodiversity conservation, namely: (i) establishing legislation, norms and standards to discourage environmentally harmful activities; (ii) taxing private wealth or soliciting private charity for governments, NGOs and other non-profit groups to invest in conservation; and (iii) making biodiversity conservation a viable business proposition. It focuses on the latter, while exploring the other options. The authors suggest that the significant funding gap for biodiversity conservation, as identified in Section 2, could be reduced by increased engagement of the private sector in pro-biodiversity business, but no figures are given. This is partly because currently active biodiversity-oriented investment funds have typically been in existence for less than five years, but generally those surveyed had less than US$10 million as loan or investment capital. A selection is given in Table 7 and these show that the sums involved a small, but potentially significant part of global conservation budget. The report concluded that viable biodiversity business opportunities exist in most regions of the world, which are *not* fully realised, and, while there are many issues to be addressed, what is lacking is motivation for increased investment in biodiversity. This needs to be harnessed as one viable means of funding adaptation in natural ecosystems, but the amounts that could be raised are unknown.

7.3 Adequacy of new investment

While on the face of it perverse subsidies could supply the shortfall in funding needed for adaptation in natural ecosystems, it would require a considerable re-organisation of a number of sectors of the economy across the globe and this is unlikely to be achieved and certainly not in the time-scales necessary for adaptation funding to come online. Also, the distribution of these perverse subsidies does not match onto the areas of greatest conservation need, with only about 25% of them being in developing countries and about 90% of these are attributable to countries of the former Soviet Union (van Beers and de Moor, 1999). In addition, they do not match onto areas with greatest climate change impacts on natural ecosystems, so there will a need for additional funds from developed countries for adaptation.

Other relatively more minor means of funding conservation and thus some adaptation have been identified, especially for the national to local level (World Commission on Protected Areas, 2000). These should not be neglected, but what will be needed is substantial new international and national investment for adaptation in natural ecosystems.

Table 7: Overview of selected biodiversity funds (from Bishop *et al*. 2006)

BioCarbon Fund (BioCF) Tranche 2 (World Bank)	**Brazilian Biodiversity Fund (FUNBIO)**	**Natural Capital Investment Fund (NCIF)**	**EcoEnterprises Fund (EcoEmpresas, TNC)**	**Ecologic Finance (EF)**	**Sustainable Land Fund (EBX & Oxbow Land Management)**		**Verde Ventures Fund (CI)**	**Equator Ventures**	**Central American Markets for Biodiversity (CAMBio)**	**Corporación Financiera Ambiental (CFA)**	**Seachange**
Geographic Focus	Global	Brazil	USA – Rural West Virginia	Latin America and Caribbean. 14 projects in TNC sites and 6 in World Heritage Sites	Mexico, Guatemala, Honduras, Belize, Nicaragua, Costa Rica, Ecuador, Peru, Bolivia, Brazil, Kenya, Uganda and Rwanda	USA	Latin America, Caribbean, Africa and Asia	Projects that contribute to biodiversity in CI and Equator Initiative priority areas are eligible.	Central America: Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua	Central America	Not known.
Sectors Invested in	LULUCF. Window 1 (consistent with the Kyoto Protocol rules): afforestation and reforestation in developing countries; any LULUCF activity in economies in transition. Window 2: any LULUCF activity beyond afforestation and reforestation in the CDM, e.g. forest restoration or management, revegetation, avoided deforestation, and agriculture.	In 2004: 44% non-timber forest management; 41% agro-biodiversity; 10.3% conservation and environmental education; 3.97% management of fish and animal resources; 0.59% timber forest management. 37% invested in community and producers' associations and cooperatives, 42% in NGOs, 16% in private companies and 5% in government organisations.	Sectors of particular interest include: heritage and recreation-based tourism, value-added and sustainable agriculture, water / wastewater treatment, sustainable forestry and forest products, integrated waste management, and recycling.	Focused on 'green' sectors, such as sustainable agriculture, aquaculture, forestry, ecotourism and NTFPs.	Target sectors include agroforestry (shade-grown and sustainable agriculture), wild-harvested products, certified wood, sustainable fisheries, and ecotourism.	Market-based and incentive programs: Wetland Mitigation Banking, Stream Mitigation Banking, Conservation (Endangered Species) Banking, water leases and water quality trades, sustainable (certified) timber and agriculture, recreation – hunting, fishing, tourism, limited development, conservation easement sales, CO_2 sequestration – forestry	Coffee, cocoa, tourism, NTFPs. Looking at other sectors such as cotton and carbon.	Viable small and medium sized biodiversity businesses.	SMEs that sustainably use or protect natural resources – these may include renewable energy, energy efficiency, sustainable forestry, alternative / organic agriculture and aquaculture, ecotourism, and recycling.	Environmental businesses in the following sectors: -Organic agriculture. Sustainable forestry, -Renewable energy -Energy efficiency. -Recycling, reduction and treatment of pollution, in addition to clean technologies and products. -Sustainable tourism, esp related to biodiversity.	Companies that avoid: - Damage to aquatic habitats through the use of destructive fishing gear, pollution, the introduction of invasive species; - Mismanagement through overfishing of targeted stocks or a lack of regulatory oversight and enforcement; - Wasteful use of marine resources (e.g. bycatch or for aquaculture); and, - Accidental threats to species of special concern

Fund size(US$)	Tranche 2 would be declared operational at a minimum of approximately US$10M. Maximum size of ~ US$50M. Participant chooses in which Window to participate. The minimum contribution to a Window is US$1 million.	FUNBIO received a US$20M grant from GEF. GEF resources complemented by fundraising and partnership with private sector to ensure long-term activities. FUNBIO can receive donations from corporations & other institutions.	Fund size not known. NCIF will consider loans in the range of US$15,000 to US$250,000. NCIF equity investments range from US$50,000 to US$250,000.	There is US$5.2m risk capital in the 10 year closed-in fund made up with US$2.6M IADB and US$2.6M TNC money; generated US$20M (leveraged finance).	Not known	US$125M – not yet operational	US$6.5M - would like to grown this to a US$15M fund in the next 2 years.	launched in January of 2005 with a US$1M million pilot fund. Pending success of the pilot, the fund will be expanded.	US$30M	US$10M	Not known

8 Conclusions

Climate change will continue to affect natural ecosystems, necessitating mitigation of greenhouse gases and adaptation in the short-term to avoid undesirable impacts. While a range of adaptation actions has been identified, few of these have been tested in practice or costed. Thus there is a paucity of data for estimating adaptation costs, especially globally. Many adaptation actions, however, are part of current conservation practice and so estimates of current global conservation budgets and management were used to derive indications of the costs of adaptation to climate change. These estimates for an adequate PA network amount to US$21.5 billion for a BAU scenario and US$12 billion for a mitigation scenario. These are minimum costs as there are a number of factors that have not been taken into account. If the assumption about the proportion of conservation budgets spent on PA is used, then additional annual costs amount to US$64.5 billion for a BAU scenario and US$36 billion for a mitigation scenario. These figures rise to US$355.5 billion and US$326 billion if conservation in a wider landscape is included. These last two figures are unadjusted for climate change and scenario. These figures all rise by $29 billion if the costs of marine PA in included, again without any adjustment for scenario.

A large number of assumptions are involved in the above figures and thus they must used with great caution. Whichever figures are used, current conservation financing is not adequate to cover such costs, but the removal of perverse subsidies and investment in biodiversity business could provide additional sources of financing. The former in particular could easily cover the increased costs of future climate change adaptation in natural ecosystems and thus should be explored, as in many instances their removal has been shown to have net economic benefits.

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