



NO PLACE TO HIDE: Effects of Climate Change on Protected Areas

FOR THE PAST DECADE, WWF has identified the potential threats to biodiversity posed by climate change¹. We have argued that protected areas offer a limited defence against problems posed by rapid environmental change and that protected areas will themselves need to be changed and adapted if they are to meet the challenges posed by global warming². Recent research suggests that the types of environmental changes predicted in climatic models are now taking place. Studies of many animals and plants that show significant alterations in range or behaviour find that the most consistent explanation for these is climate change³. Global warming is also linked to observed impacts such as coral bleaching⁴ and melting glaciers. Such changes are taking place widely and as a result, global warming is already impacting protected areas.

These impacts may necessitate a fundamental rethinking in the approach to protection. Protected areas are rooted in the concept of permanence: protection works best as a conservation tool if the area remains protected for the foreseeable future. Protected area agencies have rightly resisted attempts to move protected area boundaries or de-designate protected areas for periods of time. But under climate change, species for which a particular protected area was established may no longer survive there. Some protected areas—for instance in coastal, arctic and montane regions—may disappear altogether in their current form. The current extinction crisis⁵ is likely to become more intense as environmental conditions change and fluctuate at an unnatural rate.

- 1 See for example: Markham A (guest editor) (1998); Climatic Change Special issue on potential impacts of climate change on tropical forest ecosystems; Malcolm, Jay R, Canran Liu, Laurie B Miller, Tom Allnutt and Lara Hansen (2002); Habitats at Risk: Global warming and species loss in globally significant terrestrial ecosystems, WWF, Washington DC
- 2 Markham, A, N Dudley and S Stolton (1993); Some Like it Hot: Climate change, biodiversity and the survival of species, WWF International, Gland; Loh, Jonathan (1997); Ecological Impacts of Climate Change on National Parks and Protected Areas of the World, WWF International, Gland; Malcolm, Jay R and Adam Markham (1997); Climate Change Threats to the National Parks and Protected Areas of the United States and Canada, WWF-US, Washington DC
- 3 Santer, B D, T M L Wigley, T P Barnett, and E Anyamba (1996); Detection of climate change and attribution of causes, in Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change [edited by] J T Houghton, L G Meira Filho, B A Callander, N Harris, A Kattenberg, and K Maskell, Cambridge University Press, Cambridge, UK and New York: 407-33
- 4 Urban, F E, J E Cole and J T Overpeck (2000); Influence of mean climate change on climate variability from a 155-year tropical Pacific coral record, Nature 407: 989-993
- 5 Chapin III, F. S., E S Zavaleta, V T Eviner, R L Naylor, P M Vitousek, H L Reynolds, D U Hooper, S Lavorel, O E Sala, S E Hobbie, M C Mack and S Díaz (2000); Consequences of changing biodiversity, Nature 405: 234-242



WWF Climate Change Programme
Nigel Dudley, Equilibrium
July 2003

Lagoon with islets
ALDABRA ATOLL, Seychelles
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Protected area agencies could be faced with the massive task of having to shift protected areas to keep up with moving habitats and ecosystems. Some protected areas may have to retrench onto higher ground as water rises. The practical difficulties should not be underestimated. Protected areas do not exist in an empty landscape and replacement land and water will often not be available. “Moving” protected areas would have enormous implications for their infrastructure, surrounding human communities and the many businesses associated with parks. Shifting reserves would have cultural implications; societies build powerful emotional bonds to national parks and nature reserves that mean they cannot simply be swapped and replaced lightly.

We are still learning about climate change and there have been relatively few studies of impacts within protected areas to confirm or disprove the modeling exercises and speculation. Ecosystems are often quite resilient but while some climate change problems are likely to be surmountable through management, adaptation or evolution, others are likely to be more intractable.

Disappearance of habitats and ecosystems

The most intractable threats come from the total disappearance of habitat. For instance the Intergovernmental Panel on Climate Change confirms that sea level rise is already affecting coastal ecosystems, including coral reefs, mangroves and salt-marshes.

A third of the **BLACKWATER NATIONAL WILDLIFE REFUGE** marshland on Chesapeake Bay, USA, has disappeared since 1938 and the rest of the marsh, which provides winter habitat for many waterfowl species, is expected to be flooded within 25 years. While half the existing loss is thought to be due to extraction from aquifers, the rest is believed to be due to sea-level rise⁶. In **WACCASASSA BAY STATE PRESERVE**, in Florida, researchers concluded that cabbage palms and other trees are falling victim to saltwater exposure tied to global sea level rise, exacerbated by drought and a reduction of freshwater flow⁷.

Rising seas are said to have flooded 7,500 ha of mangroves in the **SUNDARBANS NATIONAL PARK** of Bangladesh, although sea-level rise is aggravated by subsidence in the delta⁸. In Vietnam, mangroves are reported to be undergoing species change because of increased salt intrusion⁹, including those in **DAO BACH LONG VI**, a proposed marine protected area¹⁰.

Several Pacific island states are threatened with total disappearance and two uninhabited islands in the Kiribati chain have already disappeared due to sea level rise¹¹. The people of Funafuti, in Tuvalu are lobbying to find new homes: salt water intrusion has made groundwater undrinkable and these islands are suffering increasing impacts from hurricanes and heavy seas. When they disappear, not only will a unique culture

6 Leatherman, S P, R Chalfont, E C Pendleton and T L McCandless (1995); Vanishing Lands: Sea level, society and the Chesapeake Bay, Laboratory of Coastal Research, University of Maryland

7 Williams, K, K C Ewel, R P Stumpf, F E Putz, and T W Workman (1999); Sea-level rise and coastal forest retreat on the west coast of Florida, USA Ecology 80:2045-2063

8 Huq, Z et al (1999); Vulnerability and Adaptation to Climate Change for Bangladesh, Kluwer Publishers, The Netherlands; and Huq, S, S I Ali and A A Rahman (1995); The implications of sea-level rise and Bangladesh: A preliminary analysis, Journal of Coastal Research 14: 44-53

9 Granich, S, M Kelly and Nguyen H N (1993); Global Warming and Vietnam: A briefing document, University of East Anglia, International Institute for Environment and Development and Stockholm Environment Institute

10 Anon (2001); Sourcebook of Existing and Proposed Protected Areas of Vietnam, Birdlife International, European Union and the Forest Inventory and Planning Institute, Hanoi

11 Anon (1999); Environmental News Network, July 14th 1999

Coral reef,
NATIONAL PARK OF AMERICAN SAMOA
 © Eric Mielbrecht

vanish but the **FUNAFUTI MARINE CONSERVATION AREA** will be dramatically altered by loss of surface reefs.

The Great Rann of Kutch in Gujarat is one of the emptiest places in India: the vast area of seasonal salt lakes supports huge populations of flamingos and is the only remaining habitat for 2000 Indian wild asses. The area is likely to become inundated by the sea, thus destroying the habitat¹² and threatening the **WILD ASS SANCTUARY** and the **KACHCHH DESERT SANCTUARY**.

Catastrophic, probably long-term changes to ecosystems

Even if ecosystems do not disappear altogether, they may undergo serious and irreversible changes.

Ocean temperature and coral reefs

In 1998, tropical sea surface temperatures were the highest on record, the culmination of a 50-year trend, and simultaneously coral reefs suffered the most extensive and severe bleaching (loss of symbiotic algae) and death on record. This is believed to be due to global warming. Its wide geographical spread and regional severity are apparently due to a steadily rising baseline of marine temperatures, combined with temperature peaks associated with increasingly frequent El Niño and La Niña events. Climate change threats are compounded by pollution and over-exploitation. Even those reefs in marine sanctuaries are threatened by global climate change¹³.

The Seychelle Islands are justly famous for their coral reefs and the remote **ALDABRA ATOLL** is the largest raised atoll in the world. It supports a huge coral diversity and rare land species like the giant tortoise (*Aldabrachelys elephantina*), vast seabird colonies and important sea turtle breeding beaches. Its status is recognised by its listing as a natural World Heritage site by UNESCO. Apart from a handful of scientists at a research station, the atoll is visited only by occasional passing yachts: the post boat takes 12 days from the mainland. Yet despite its remoteness and protected status, the Seychelles suffered a severe coral bleaching event in the late 1990s¹⁴ and a recent assessment by the Seychelles Foundation judged climate change to be the most important threat facing the atoll¹⁵.

In March 2003, WWF reported that coral bleaching was occurring at all its seven research sites in American Samoa, including within the **NATIONAL PARK OF AMERICAN SAMOA, FAGATELE BAY NATIONAL MARINE SANCTUARY** and **MALOATA BAY COMMUNITY RESERVE**¹⁶.

Cold seas

Warming affects cold seas and polar communities as well. Decreased weight in polar bears, which can lead to decreased adult fitness and reproductive success, in the Hudson Bay area of Canada is attributed to earlier spring ice break-up and consequent loss of two weeks hunting¹⁷. Loss of sea ice due to climate change is a conservation concern

12 Clark, B and P Duncan (1992); Asian wild asses—hemionides and kiangs, in Zebra, Asses and Horses: An Action Plan for the Conservation of Wild Equids, The World Conservation Union (IUCN), Gland, Switzerland: 17-22

13 Reaser, J K, R Pomerance, and P O Thomas (2000); Coral Bleaching and Global Climate Change: Scientific Findings and Policy Recommendations, Conservation Biology 14 (5): 1500

14 Spencer, T, K Teleki, C Bradshaw and M D Spalding (2000) "Coral bleaching in the southern Seychelles during the 1997 - 98 Indian Ocean warm event" Marine Pollution Bulletin 40: 569-586

15 Unpublished report to the UNESCO/University of Queensland Enhancing our Heritage project

16 Information from L Hansen, senior scientist, WWF Climate Change Programme

17 Stirling, I et al. (1999); Long-term trends in the population ecology of polar bears in Western Hudson Bay in relation to climate change, Arctic 53 (3): 292-306

Grus leucogeranus, Siberian crane in the
**BHARATPUR WETLANDS KEOLADEO
 NATIONAL PARK**, India
 ©WWF–Canon/Michel Terrettaz

for polar bears of **WRANGEL ISLAND ZAPOVEDNIK**, a Russian nature reserve, as well. Rising temperatures are also affecting **ANTARCTICA**; for instance Adélie Penguin populations have shrunk 33 per cent in 25 years due to declines in winter sea ice habitat¹⁸, despite the continent having special protected status through the Protocol on Environmental Protection to the Antarctic Treaty.

The case of tropical montane cloud forests

As average temperature increases, optimum habitat for many species will move to higher elevations or higher latitudes. Where there is no higher ground or where changes are taking place too quickly for ecosystems and species to adjust, local losses or global extinctions will occur. Observations suggest that tropical montane cloud forests are highly at risk due to fewer, higher clouds and warmer temperatures, with serious impacts already underway¹⁹. Amphibians may also be especially susceptible²⁰. Many amphibious species already appear to be declining²¹, and serious losses have been recorded for example in Australia²² and Central America²³.

Climate change associated with an El Niño/Southern Oscillation-related drought in 1986/7 is thought to be a cause of amphibian losses in **MONTEVERDE CLOUD FOREST RESERVE**, a well-managed protected area in Costa Rica²⁴. The golden toad (*Bufo periglenes*) and the harlequin frog (*Atelopus varius*) disappeared, and four other frog and two lizard species suffered population crashes²⁵. A detailed survey in a 30 km² study site found that 20 out of 50 frog and toad species disappeared at that time²⁶.

Catastrophic, temporary changes to ecosystems

Other changes may be temporary, although the cross-over between temporary and permanent changes is sometimes hard to judge. Drought is a particularly good example of these types of climate change related catastrophies.

Impacts of droughts on wetlands and other ecosystems

Increased drought is having a measurable impact on many species. For example, drought related decreases in the density and persistence of Green Leaf Warblers (*Phylloscopus trochiloides*) have been recorded on their wintering grounds in the Western Ghats of south India²⁷, including protected areas such as **INDIRA GANDHI NATIONAL PARK**. Unusual drought is already undermining other protected areas in

18 Fraser, W (1998); personal communication from the Antarctic Biology and Medicine Programme, University of Montana cited on Climate hotmap organisation website

19 Still, C J, P N Foster and S H Schneider (1999); Simulating the effects of climate change on tropical montane cloud forests, *Nature* 398: 608-610

20 Lips, K R, (1998); Decline of a tropical montane amphibian fauna, *Conservation Biology*, 12: 106-117

21 Houlahan, J E, C S Findlay, B R Schmidt, A.H. Meyer, and S L Kuzmin (2000); Quantitative evidence for global amphibian population declines, *Nature* 752: 752-755

22 Laurance, W F (1996); Catastrophic declines of Australian rainforest frogs: is unusual weather responsible? *Biological Conservation* 77: 203-212

23 Berger, L, R Speare, P Daszak, D E Green, A A Cunningham, C L Goggin, R Sloccombe, M A Ragan, A D Hyatt, K R McDonald, H B Hines, K R Lips, G Marantelli, and H Parkes, (1998); Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America, *Proceedings of the National Academy of Sciences of the United States of America* 95: 9031-9036

24 Pounds, J A and M L Crump (1994); Amphibian decline and climate disturbance: the case of the golden toad and the harlequin frog, *Conservation Biology* 8: 72-85

25 Pounds, J A, M P L Fogden and J H Campbell (1999); Biological response to climate change on a tropical mountain, *Nature* 398: 611-615

26 *ibid*

27 Katti, M and T Price (1996); Effects of climate on palearctic warblers over wintering in India, *Journal of the Bombay Natural History Society* 93: 411-427

India. **KEOLADEO NATIONAL PARK**, near Agra, is a wetland area famous as one of the few wintering sites of the highly endangered Siberian crane (*Grus leucogeranus*). It was created as a duck shoot by manipulating a small existing area of wetland and then later declared a national park and World Heritage site. The park is dependent on fresh input of water during each monsoon. Other demands on water have increased and droughts have become more regular, leading to serious water shortages; in the 2003 season, water levels are damagingly low²⁸.

In 2002, Australia experienced its worst drought since reliable records began in 1910, coupled with the highest average temperatures in a drought year; this has been linked to climate change²⁹ and created an unprecedented likelihood of fire³⁰. A series of severe forest fires occurred in late 2002 and early 2003. In **KOSIOSKO NATIONAL PARK**, New South Wales, over fifty separate fires started in an hour due to lightning strikes from an electric storm after months of drought³¹, creating an unstoppable firestorm that burnt alpine vegetation, which is already stressed through being trapped on mountain tops where average temperature is changing fast.

Dramatic changes to habitats and ecosystems

Some of the most intense climate change-related habitat alterations are those that affect glaciers and ice-fields. Loss of glaciers changes the whole nature of a park, although impacts on biodiversity are less well known.

Melting of icecaps and glaciers

Glaciers are retreating at an unprecedented rate, changing the entire ecology of mountain habitats. Protected area managers can do nothing to prevent this loss and have to stand by as the ecology changes before their eyes.

In the **HOHE TAUERN NATIONAL PARK** in Austria, the Pasterze Glacier has retreated several hundred metres since the 1970s and a similar pattern is seen throughout the European Alps. Areas are expected to experience extra water flow as the glaciers melt, but then a longer term decline³². The glaciers in the Blackfoot-Jackson Glacier Basin of **GLACIER NATIONAL PARK**, Montana USA, decreased from 21.6 km² in 1850 to 7.4 km² in 1979. And scientists measuring ice changes in **MOUNT KILIMANJARO NATIONAL PARK**, containing Africa's highest mountain, predict that the glaciers will be gone by 2020³³.

Distributional changes towards the poles and to higher altitudes

On the ground observations confirm the theories: species are already shifting their territories because of climate change. Analysis of 143 studies showed a consistent tem-

Parteze Glacier. Grossglockner.
HOHE TAUERN NATIONAL PARK. Austria
©WWF–Canon/Michèle DÉPRAZ

28 Unpublished report to the UNESCO/University of Queensland Enhancing our Heritage project

29 Karoly, D L (2001); Interannual and longer-term variations of Australian mean climate parameters from observations and model simulations, Understanding the Climate of Australia and the Indo-Pacific Region: 13th Annual BMRC Modeling Workshop, BMRC Research Report number 84, Bureau of Meteorology Australia: 49-52; and Karoly, David, James Risbey and Anna Reynolds (2003); Global Warming Contributes to Australia's Worst Drought, WWF Australia, Sydney

30 Williams, A A J, D J Karoly and N Tapper (2001); The sensitivity of Australian fire danger to climate change, Climate Change 49: 171-191

31 Information from M Hockings, University of Queensland

32 Haeberli, W and M Beniston (1998); Climate change and its impacts on glaciers and permafrost in the Alps, Ambio 27 (4) 258-265

33 Thompson, L G, E Mosely-Thompson, M E Davis, K A Hardman, H L Brecher, V S Zagorodnov, T A Mashiotta, Ping-Nan L, V N Mikhalenko, D R Hardy and J Beer (2002); Kilimanjaro ice core research: Evidence of Holocene climate change in tropical Africa, Science 298: 589-593

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While climate change will impact protected areas globally, this map indicates the location of those sites listed in the text.

- 1) Blackwater National Wildlife
- 2) Waccasassa Bay State Preserve
- 3) Sundarbans National Park
- 4) Dao Bach Long Vi
- 5) Funafuti Marine Conservation Area
- 6) Wild Ass Sanctuary
- 7) Kachchh Desert Sanctuary
- 8) Aldabra Atoll
- 9) National Park of American Samoa
- 10) Fagatele Bay National Marine Sanctuary
- 11) Maloata Bay community reserve
- 12) Antarctica
- 13) Monteverde Cloud Forest Reserve
- 14) Indira Gandhi National Park
- 15) Keoladeo National Park
- 16) Kosiosko National Park
- 17) Hohe Tauern National Park
- 18) Glacier National Park
- 19) Mount Kilimanjaro National Park
- 20) Tehuacán-Cuicatlán Biosphere Reserve
- 21) Swiss National Park
- 22) Triangle Island
- 23) Jasper National Park
- 24) Lake Constance
- 25) Richtersveld National Park
- 26) Assateague Island National Seashore
- 27) Galapagos National Park
- 28) Xingu National Park
- 29) Wrangel Island Zapovednik

Pygoscelis adeliae, Adélie penguin,
ANTARCTICA
 ©WWF–Canon/Sylvia Rubli

perature-related shift in species ranging from molluscs to mammals and from grasses to trees³⁴. A similar study of 1700 species also confirmed climate change predictions, with average range shifts of 6.1 km/decade towards the poles³⁵.

Detailed examples illustrate a general trend. Insect dispersal to more favourable areas is a common response to changing climate³⁶ and for example this has recently been recorded in Japan³⁷ and the ranges of European and North American butterflies are shifting northwards and upwards³⁸.

Changes have been recorded in the height at which several bird species are found in Monteverde³⁹. These mirror more widespread shifts in bird ranges towards the poles⁴⁰ in Antarctica⁴¹, North America⁴² and in Europe where the spring range of Barnacle Geese (*Branta leucopsis*) has moved north along the Norwegian coast, correlated with a significant increase in days with temperatures above 6°C⁴³.

Modeling studies suggested that under likely climate scenarios, cacti currently protected in the **TEHUACÁN-CUICATLÁN BIOSPHERE RESERVE** in Mexico would undergo a drastic population reduction and fall almost entirely outside the reserve area⁴⁴. Climatic warming observed in the European Alps has been associated with upward movement of some plant species of 1-4 m per decade and loss of some taxa that were restricted to high elevations, posing direct threats to protected areas such as the **SWISS NATIONAL PARK**⁴⁵.

Individual changes to species and local food webs

Rapid temperature changes affect the seasons, including shorter winters and variations in season length. For example, this can lead to changes in bud break and bird nest building; and also changes in the growing season, as seen in Europe⁴⁶. Climatic records have been put together with long-term records of flowering and nesting times

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- 34 Root, T L, J T Price, K R Glass, S H Schneider, C Rosenzweig and J A Pounds (2003); Fingerprint of global warming on wild animals and plants, *Nature* 421: 57-60
- 35 Parmesan, C and G Yohe (2003); A globally coherent fingerprint of climate change impacts across natural systems, *Nature* 421: 37-42
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- 44 Téllez-Valdés, O and P D Vila-Aranda (2003); Protected Areas and Climate Change: a Case Study of the Cacti in the Tehuacán-Cuicatlán Biosphere Reserve, México, *Conservation Biology* 17 (3): 846
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Bufo periglenes, golden toad,
MONTEVERDE CLOUD FOREST RESERVE
©WWF–Mike Wright

to record trends. In Britain there are records of flowering time and leaf-break as far back as 1736⁴⁷, which provide solid evidence for climate-related changes. Long term trends towards earlier bird breeding⁴⁸, earlier spring migrant arrival⁴⁹ and later autumn departure dates⁵⁰ have been observed in North America, along with changes in migratory patterns in Europe⁵¹. In the UK, the blackcap (*Sylvia atricapilla*) and chiffchaff (*Phylloscopus collybita*) warblers increasingly stay all winter instead of migrating, giving them first choice of nesting sites and disadvantaging migratory warblers⁵². Climate change may also be causing a mismatch in breeding of Great Tits (*Parus major*) with other species⁵³.

Such changes can reduce food availability. In California, a 90 per cent decline in sooty shearwaters (*Puffinus griseus*) from 1987 to 1994 has been linked to a warming of the California Current⁵⁴. In **TRIANGLE ISLAND**, an ecological reserve off Vancouver Island, the 1.1 million breeding colony of Cassin's auklet (*Ptychoramphus aleuticus*) is declining; probably because of a long-term decline in zooplankton, itself caused by warmer sea temperatures⁵⁵. Salmon running in the Fraser River, British Columbia, which rises in **JASPER NATIONAL PARK**, have experienced over 50 per cent mortality in several runs, with highest losses in years with warm river temperatures, themselves linked with climate change⁵⁶.

Warmer temperatures in Europe have been stimulating an increasing number of frogs and toads to spawn before Christmas⁵⁷. In mild winters this may be an advantage in that the tadpoles have longer to mature, but a cold snap can kill the eggs.

In **LAKE CONSTANCE**, a Ramsar site at the border of Germany, Austria and Switzerland, the proportion of long-distance migrant birds decreased and short-distance migrants and residents increased between 1980 and 1992, during a period when winter temperature increased, suggesting that warmer winters may pose a more severe threat to long-distance migrants than to the other bird groups⁵⁸.

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- 47 Dudley, N (2001); A Midsummer Nightmare? The UK's forests under climate change, The Woodland Trust, Grantham, Lincolnshire citing information from Tim Sparks of the Institute for Terrestrial Ecology
- 48 Brown, J L, S H Li and N Bhagabati (1999); Long-term trend towards earlier breeding in an American bird: an early response to global warming? Proceedings of the National Academy of Sciences of the United States of America 96: 5565-5569
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Drought/ Mangrove in parched land, Guyana.
©WWF–Canon/Roger LeGuen

While some species will adapt their behaviour to new conditions, others will remain trapped in lifecycles that no longer work in the new climatic regime. For example, sea level rise will adversely impact breeding seabirds that nest on island beaches, including those in the **GALAPAGOS NATIONAL PARK**⁵⁹.

Studies of protected area systems

As data accumulate, researchers are able to make ecosystem analyses of climate change impacts. Climate change, for example, is identified as a third major factor in accelerating problems in the Amazon, which includes several national parks, among them **XINGU NATIONAL PARK**, along with logging and changes in deforestation patterns⁶⁰.

Attempts are now being made to predict changes for protected area networks. A study of Canada's national parks found that in virtually all climate scenarios, substantial vegetation change will occur in over half the protected areas, with loss of tundra and increase in temperate forests. The authors concluded that: "Climate change represents an unprecedented challenge to Parks Canada and its ability to achieve its conservation mandate...⁶⁰". Important, changes relate to hydrology, glacial balance, waning permafrost, increased natural disturbance, shorter ice season and range changes⁶².

Analysis of South African protected areas suggests that increased drought and aridity could lead to huge losses of biodiversity⁶³. For example there could be potentially large losses of plant species diversity in semi-arid regions with low landscape heterogeneity⁶⁴. **RICHTERSVELD NATIONAL PARK** in the Succulent Karoo, one of seven protected areas in this region, covers 21 per cent of the remaining habitat and has been identified as being highly at risk of damage from climate change⁶⁵.

In the United Kingdom, the Institute of Terrestrial Ecology estimates that 10 per cent of nature reserves could be lost (e.g., to climate change-induced habitat degradation) within 30-40 years⁶⁶. In the USA, 7000 miles of protected shoreline, including 80 coastal parks such as **ASSATEAGUE ISLAND NATIONAL SEASHORE**, are at risk from sea-level rise⁶⁷. Studies in Australia identify the need for major changes to protected areas conservation strategies⁶⁸.

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68 Pouliquen-Young, O (1999); The implications of climate change for land-based nature conservation strategies, Australian Greenhouse Office, Canberra

Addressing the problems

The predictions that WWF, and others, have been making about the impacts of climate change on protected areas are coming true. Most protected area authorities are still not taking this issue seriously: in many countries the immediate pressures on parks and shortages of resources mean there is no time to worry about future impacts, even if they are already becoming manifest. Clearly, protected area agencies and managers need to consider climate change in future plans⁶⁹. But what exactly should they do? WWF suggests that four urgent steps are needed:

PREVENTING CHANGE: the optimum way to reduce the impacts of climate change on protected areas is to dramatically reduce the heat-trapping gases that cause climate change. Carbon dioxide, the main heat trapping gas, is emitted by the burning of fossil fuels (coal, oil and natural gas). If these emissions are not cut deeply and quickly, there will be little chance of saving many protected areas. The power sector is responsible for 37% of those emissions globally and has many opportunities to switch from coal to clean power. To learn more go to www.panda.org/climate.

MANAGING FOR CHANGE: many climate change impacts are exacerbated by other pressures: even climate-related phenomena like coral bleaching and dieback are increased by pollution and mechanical damage. WWF is publishing a guide to adaptation strategies, "Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems",⁷⁰ the first comprehensive account of how protected areas might be managed in a rapidly changing climate.

PLANNING FOR CHANGE: Protected area agencies need advice—and political support—for planning protected area networks to withstand or adapt to change as much as possible. This needs to be a collaborative, global exercise. WWF proposes that the World Commission on Protected Areas would be one obvious body to coordinate such an effort, perhaps as a task force under its theme on management effectiveness.

LEARNING ABOUT CHANGE: we are still in a transition from theory to observation in terms of climate change impacts on protected areas. Information comes from a very limited number of examples. Along with an urgent need to learn more, we also need a series of controlled exercises in addressing and hopefully mitigating pressures when they arise.

Rhizophora mangle, Red Mangrove.
Sanibel Island, Florida, USA
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⁶⁹ Halpin, P.N. (1997); Global climate change and natural-area protection: management responses and research directions, *Ecological Applications* 7: 828-843

⁷⁰ Hansen, L.J., J.L. Biringer and J.R. Hoffman (2003); *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change on Protected Areas*, WWF, Gland

WWF Climate Change Programme

Climate change poses a serious threat to the survival of many species and to the well-being of people around the world.

WWF's programme has three main aims:

- to ensure that industrialised nations make substantial reductions in their domestic emissions of carbon dioxide—the main global warming gas—by 2010
- to promote the use of clean renewable energy in the developing world
- to reduce the vulnerability of nature and economies to the impacts of climate change

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WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans can live in harmony with nature, by:

- conserving the world's biological diversity
- ensuring that the use of renewable resources is sustainable
- promoting the reduction of pollution and wasteful consumption

www.panda.org/climate/pa_manual