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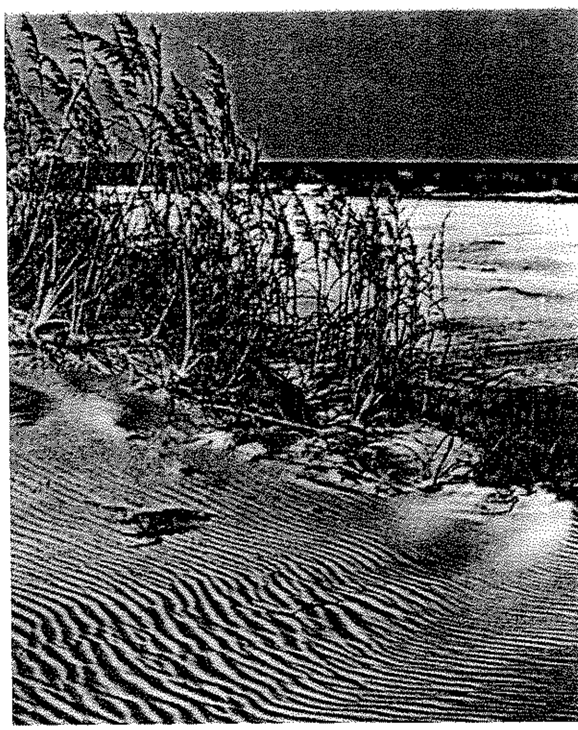
National Parks from Coral Reefs to Wetlands to Glaciers May Be Vulnerable to Climate Change

The following article is a condensation of a report on Climate Change and the National Parks prepared by the Climate Institute at the request of the National Parks and Conservation Association.

Special Report by Nancy C. Wilson

The national parks as they exist today could be described as "patches and tatters," protected islands in a great continental mass. Ecologically they bear a resemblance to South Pacific atolls. What was once an unbroken expanse across the United States of woods, jungle and grassland, home to innumerable species of plant and animal life has now been sliced up into industrial parks, housing developments, farms, parking lots, malls, roads, with here and there a nature preserve.

The threat of climate change places added stress on the remaining preserves and parks beyond their increasing fragmentation; they may be buffeted by sea level rise, changed rainfall patterns, warming or aridity. As the nation makes investments in our parks, restoring, maintaining and expanding them, we need a better understanding of the probable impact of climate change, knowledge that we can then factor into our forward planning. Bringing the attention of local people to potential climate change impacts will help them in making plans.



NPS Photo

A Coastal Barrier

This report describes the threats and the gaps in our information about the parks. It examines what steps organizations such as the National Parks and Conservation Association can take to contribute to improving park research and management for adaptation and mitigation of future change.

Shifting Perspective

When Yellowstone National Park was established in parts of Montana, Idaho and Wyoming in 1872 it was the world's first national park and was set up — as were later additions to the national park system —to protect what was there at the time. As understanding of ecosystems developed in the 1960s, park management began to shift from taking care of such special attractions as Old Faithful to managing processes and eventually to undertaking a major research initiative to understand, predict and detect possible effects of global change. The "stable" communities that many of our parks were set up to save we now know are dynamic systems composed of many varieties of species each responding to

(Continued on page 3)

Guest Column

Moving the Goal Posts

By Paul Pritchard, President of the National Parks and Conservation Association and Founding Chairman of the Climate Institute

Paul Pritchard

Change is not new to the national parks, but reminders of its power and prevalence are often surprising.

In dramatic testimony to the forces at work in our parks, an enormous granite slab fell thousands of feet from Washburn Point to the floor of the Yosemite Valley in early July of this year. As soon as it touched down, the granite exploded into a fine powder.

The rockfall caused an air blast that leveled 50 acres of the Yosemite National Park's forest, took the life of a park visitor and injured more than a dozen others. For days following the rockfall, the pulverized granite rose into the air before the slightest breeze and, at times, blocked out the sun.

Yosemite's unpredictable rockfall reminded me that even the interminable silence of stone is no match for gravity. Unfortunately, the forces that drive global climate change appear to be just as powerful, and may have far greater consequences for the parks. We do, however, play a much greater role in global climate change than we do in matters of gravity.

For many years, I have witnessed the power of fire, disease, mismanagement, overuse, abuse, and short-sighted politicians to harm the parks. But the damage climate change may do, even compared to the most misguided Congress, is simply frightening. As Nancy Wilson reports in this issue, the very features that define many of our parks may be erased as human-caused climate change increases.

What would Glacier National Park become if its glaciers melted away during hotter and drier summers? What will become of the barrier islands protected within Gulf Islands National Seashore and Assateague Island National Seashore as sea level rises and tropical storms grow stronger and more frequent? And what of Virgin Islands National Park's coral reefs, soon to be stranded beneath rapidly deepening seas?

All of these national treasures are at risk as anthropogenic emissions of greenhouse gases drive global climate into uncharted territory. Even the best park rangers and the most dedicated citizens will be ill-equipped to protect parks as sea levels rise, glaciers retreat, temperatures increase, and rainfall patterns shift faster than ever before.

I invite you to study the body of evidence, to consider its meaning for national parks, protected areas, and the diversity of life that they harbor. The fate of our national parks is an omen for our cities, for people who live and work in low-elevation areas near the sea, and for our entire society. I encourage you to ask yourself how you can become involved in affecting change and protecting our future.

It is my hope that this issue of *Climate Alert* and the continued work of the Climate Institute will help our society and those of the developing world find ways to reduce our mindless impacts on the climate and on our greenhouse emissions. Global warming is set to move the goalposts, to change the rules of the conservation game, according to leading scientists.

While we would never succeed in a battle against gravity and the changes it causes, we can and we should work to limit the effects of human-caused climate change. So it is with a good measure of both consternation and hope that I introduce this special issue of *Climate Alert*.

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Parks

(Continued from page 1)

climate in its individual way.

Added to the perspective of continual change we get from paleoecology (the study of fossils to determine past history), we have learned that today's rate of climate change is unprecedented. Mountain glaciers are shrinking, snow cover is decreasing, there is a decline in Arctic sea ice, sea surface temperatures have increased. When sea level rises, it floods wetlands and shrinks the marshes waterbirds rely on. As these habi-tats decline, become more fragmented and communities less di-verse, the rate of climate change is likely to increase. Parks and other natural systems lose resilience, the threat from climate impacts be-comes more acute and the environment is more severely stressed.

Climate Change Predictions

Predictions of future climate change are imprecise, based on General Circulation Models (GCMs). The Intergovernmental Panel on Climate Change Second Assessment Report Synthesis, released last December, predicts average temperatures are likely to increase between 1 and 3.5 degrees C by the year 2100 and sea levels are likely to rise between 15 and 95 cm. But the scale of models used by the IPCC is too large to be useful for individual parks. While the prediction of climate change is imprecise, the prediction of ecosystem response is even more uncertain.

Climate Change Research

The fact that they were established to preserve refuges relatively unspoiled for future generations makes the parks ideal laboratories for long-term ecological research. They contain diverse and well-preserved ecosystems representing each of the nation's major biogeographic areas. Many of them have long-term data sets that can provide an historical framework for interpreting existing conditions and predicting future changes.

The National Park Service has been seriously concerned with climate change research since the late 80s, when a multimillion dollar program was launched. NPS made a major investment in the long-term future, but the global change program has recently suffered heavy cuts and is now concerned about how to keep support continuing. The NPS climate change research program has been shifted to the National Biological Service (NBS) whose continued existence is somewhat precarious, although a national biological survey would provide an essential database for measuring change. Some in Congress want to abolish NBS entirely. By Congressional mandate, the NBS will become the Biological Resources Division of USGS on October 1.

An NPS spokesman says it is difficult to maintain the integrity of the science in the program with all the cuts and changes. The climate change research staff would like to persuade those making budget decisions to adopt a long range view that projections of climate change cannot be made without long-term funding.

Because specific NBS climate change preparations have been hard to obtain, much of the rest of this article is based on plans started before NPS global change research was folded into NBS.

NPS "thematic" initiatives, cover the dynamics of coastal barriers and coral reefs and overlap specific park boundaries.

Coastal Barriers

These very dynamic islands and spits stretch in an irregular chain along the Atlantic and Gulf coasts from Maine to Texas, protecting the whole eastern coastline from storm surges and severe weather. Composed of sand, water and loose sediment, a shoreline in constant flux, under the thrust of waves, currents, storm surges and winds, the barriers encompass ecosystems of estuaries and lagoons, which are nurseries for marine species, and also include wetlands, open water and small sand dunes around the beaches.

The coastal plain of the East and Gulf coasts is a broad, gently sloping surface. A small rise in sea level floods a broad band of land. Sea level rise has averaged about one foot per century; resulting horizontal retreat of land is at the rate of 100 to 1,000 feet per century.

With the onslaught of the sea, the barrier islands march toward the lagoons behind and the land beyond. While sea level rise is the driving force behind landward migration, especially during storms, when there is overwash, it is not enough to drive barrier beaches toward land; storm surges from hurricanes and northeasters are the greatest movers of sand.

The barriers are very susceptible to human disturbance, and development has increased markedly since 1960. Research by Stephen Leatherman, Director of the University of Maryland's Coastal Research Laboratory, and others have concluded that attempts to stabilize the highly dynamic barrier islands will ultimately fail as sea level rises. Success in local areas ultimately creates long-term problems. The substantial, continuing maintenance costs incurred by even artificial beach nourishment, the most favored alternative for stabilization, is expensive and self-defeating. Without unlimited funds, says Leatherman, barrier islands will continue to migrate landward and the eventual loss of buildings should be expected and accepted.

Barrier islands which will be affected by the above climate change forces include parts of the following national parks:

° Assateague Island
° Cape Hatteras
° Cape Lookout
° Canaveral

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- Gulf Islands
- Padre Island

Besides the barrier islands the park system along the coasts includes the National Seashores such as Cape Cod and Fire Island. The Cape Cod National Seashore, established in 1966, stretches 40 miles from Chatham to Provincetown. It too is on the move; the parking lot has been completely destroyed by overwash surges. If sea level rises one foot in the next 50 years, the shoreline is likely to retreat even more rapidly.

There is no active research program covering Cape Cod and the other national seashores, another knowledge gap. The seashores merit careful monitoring of the impacts of future climate change.

Coral Reefs

Coral-reef research is critical to understanding the impact of global change on marine systems. Although coral reefs are among the most stable ecosystems, during the last 10 or 15 years coral bleaching and local extinctions have increased, and the reefs themselves have declined in abundance. Coral-bleaching episodes damaged reefs in Florida and the Caribbean during 1980, '83, '87 and '88 when water temperatures were high, a World Wildlife Fund report has noted. They may be showing the effects of a one-degree F global temperature rise over the past century.

The NPS Coral Reef Systems Thematic Initiative, covering a 200-mile arc through the Florida keys and the Virgin Islands, has planned studies of physiology and stress in reef-building corals to assist in determining the predictability of future survival if sea temperature and UV radiation increase.

The parks involved are: Biscayne National Park, Fort Jefferson National Monument, and Virgin Islands National Park.

Glaciers

Glacier National Park, an area 175 miles by 100 miles in the northwestern part of Montana, contains pristine examples of floral provinces and three major watersheds converging under maritime and continental climates. Changes in glaciers may be one of the earliest indicators of climate change. High-elevation glaciers in the park may be greatly reduced or disappear with increased warming.

The elements involved are so complex and interrelated that systems modeling is an essential component of the area's climate change research. The goal is to predict how these dynamics will change with a shifting climate.

Alaska is likely to be one of the first places climate changes could be measured with confidence, according to a report of the Alaska Research Development Project. Climate change may be most quickly detected in fluctuations at the edge of the huge tidal glaciers and by changes in their mass balance. The receding glaciers would affect sea level, biodiversity, water supply and recreation. Increased warming is expected in the winter, with spring snowmelt earlier and spring run-off greater. More water vapor in the air most of the time will reinforce the warming trend. The surrounding water's ice cover would be substantially thinner and in summer this would enhance the warming trend, as the dark ocean water would absorb much of the solar energy now reflected by ice and snow. While glaciers and permafrost will melt along with the sea ice, glacial melting may be partially offset by increased snowfall because of the greater amounts of water vapor in the air.

Warm waters will lead to changes in the location and amount of upwelling that now feed rich fisheries, and glacial melting caused by climate change may have tremendous impacts on subsistence fisheries in downstream areas. Biologically important zones at the edge of the sea would move, and we would probably see a decline in some of the present fish population.

There is at present no NBS climate change research program studying recession of glaciers at Glacier Bay in Alaska, an example of a significant gap in our present knowledge gathering.

GNP Photo

Glacier National Park

Wetlands

The U.S. has a very large area of wetlands — 32,330 km^2 — 1.6 percent of the country's total area. (Only Southeast Asia, the Caribbean and the large islands of the Pacific Ocean have larger percentages.) The two large wetlands in the National Park System, the Everglades National Park and Big Cypress National Preserve in south Florida, and the Big Thicket National Preserve in the Gulf Coastal Plain, contain an array of flora and fauna under threat of global change.

The Everglades, a broad freshwater marsh only a few meters above sea level, is maintained by runoff from the interior of the state; saltwater wetlands on its edges are dominated by mangrove swamps which are limited by the range of tides. NPS research in the South Florida Biogeographic Area has focused on the global change impact on the mangrove system including, besides the effects of sea level rise, increased storm frequency and intensity, changing temperature and increased variability of other climatic factors. The devastation in the Everglades from Hurricane Andrew in 1992 is a sober warning of what may happen if climate change brings frequent or more intense storms.

Mangrove colonies probably could not shift inland fast enough to keep up with rising sea levels and would be killed, according to a 1992 World Wildlife Fund report, eliminating ecosystems that are among the world's most productive fish hatcheries. Salt water might inundate freshwater areas and land near sea level.

The growing population on the fringes of the Everglades ecosystem depends on water from the inland freshwater. The area's six million residents — a number that has doubled in 20 years and may triple in the next 50 — are likely to be there to stay. Global-change research may help determine how to manage the fragile relationship between humans and nature in this environment.

Climate Change Impacts

The recently released assessment of climate change impacts by the Intergovernmental Panel on Climate Change lists ways the assessment has been improved in the past five years by:

- adding the effects of sulphate aerosols to models.
- making simulations of coupled atmospheric-ocean models more complete,
- shifting the focus from global mean changes to modeled and observed patterns to allow for more precise consideration, for example, of the fact that climate change in high latitudes may be bringing prospects for changes in droughts and floods which may be more severe in some places, less severe in others
- An increase in the intensity of precipitation and a possibility of more extreme rainfall events

Climate Change Science

- In winter at the Earth's surface, greater warming of land than sea
- Maximum surface warming in high northern latitudes in winter; little surface warming over Arctic in summer
- Changes in total precipitation and its frequency and intensity will affect the magnitude and timing of runoff, although specific regional effects are uncertain.
- Increased precipitation and soil moisture in high latitudes in winter
- Decreased strength of North Atlantic ocean circulation which depends on the joint effects of temperature and salinity, and widespread decrease in daytime range of temperature
- Inclusion of aerosol effects will lead to smaller estimated magnitudes of temperature and precipitation changes. The distribution of aerosols is expected to have a strong influence on estimated regional projections.
- General warming is expected to lead to an increase in the occurrence of extremely hot days and a decrease in the occurrence of extremely cold days.
- Warmer temperatures are projected to lead to a more vigorous hydrological cycle, bringing prospects for changes in droughts and floods which may be more severe in some places, less severe in others.
- An increase in the intensity of precipitation and a possibility of more extreme rainfall events
- There is still not enough knowledge to predict changes in the occurrence or geographical distribution of severe storms such as tropical cyclones

Source: IPCC WG I, Summary for Policymakers: The Science of Climate Change, 1995

Table: Potentially Bewildering Impacts

Forests A one degree C increase in global temperature affects the growth and capacity to regenerate of forests in many regions, in some cases altering the composition significantly. One-third of existing forested area of the world will undergo major changes in broad types of vegetation, affecting the rate of speed at which forest species grow, reproduce and reestablish themselves. The greatest changes will occur at high latitudes, least in the tropics. Entire forests may disappear; new ecosystems may be established. Outbreaks of disease will be more frequent; the ranges of pests and pathogens will be extended. Fires will be more frequent and intense. The amount of rainfall will change and the season in which it falls may shift, leading to increased evaporation from the soil and transpiration from plants. Shifts in temperature and precipitation in temperate rangelands may lead to altered growing seasons and in boundary shifts between grasslands, forest and shrublands.

Deserts are likely to become hotter but not wetter. Temperature increases will pose a threat to organisms which are near their heat tolerance limits. Desertification is likely to become more irreversible.

Cryosphere One-third to one-half of mountain glaciers could disappear in the next 100 years, affecting river flow. A decrease in sea-ice could lead to longer navigation seasons on rivers and in the Arctic. Other Arctic changes include a decrease in glaciers, permafrost and snow cover.

Mountain Ranges Similar changes in mountain ranges will affect the surface, ground and atmospheric

(Continued on page 6)

(Continued from page 5)

circulation of water and the stability of the soil. Species limited to mountain tops could disappear. Recreational industries are likely to be disrupted.

Lakes, streams and wetlands could have altered water temperatures, flow and water levels. Biological activity could increase at high latitudes, while at low latitudes cold and cool water species would suffer the greatest harm.

Coastal systems would have varied responses:

a rise in sea level or change in storms or storm surges would lead to shore erosion and change in habitat, increased salinity of estuaries and freshwater aquifers, altered tide ranges in rivers and bays, changes in sediment and nutrient transport, change in the pattern of chemical and microbiological contamination in coastal areas and increased coastal flooding

particularly at risk would be: saltwater marshes, mangrove ecosystems, coastal wetlands, coral atolls and river deltas

major negative effects would be on tourism, fisheries, biodiversity

effects would add to modification in the functioning of coastal oceans and inland waters that already have resulted from pollution and physical changes

coastal populations would be increasingly vulnerable to flooding and the loss of land by erosion

Oceans The effect of climate change on oceans would lead to a change in sea level, altered circulation, vertical mixing, wave climate and a decrease in sea-ice cover. This would have a major impact on fisheries. It is possible an abrupt climate change itself would result if freshwater influx from melting sea ice or ice sheets significantly weaken ocean global circulation which depends on connections between temperature and salinity.

Source: IPCC WG II, Summary for Policymakers, Scientific-Technical Analyses of Impacts, Adaptations, and Mitigation of Climate Change, 1995

Implications

Our nature reserves face the combination of different rates of migration, extinction and unpredictable interactions from both climate change and destroyed habitat. Our lack of understanding of the structure and function of ecosystems and how they interact with changing climate limits our ability to predict the consequences of human-induced climate change on species and communities.

ENP Photo

Alligator in Shark Slough, Everglades

It is very difficult for parks to perpetuate communities and species today. The ability of species to adapt depends not only on genetics but also on capacity to disperse and migrate. It is often difficult to predict how long it will take for a species to respond to climate change by colonizing new areas. A species may be protected by a specially created preserve, but limits in the range of the species may still doom it. The Kirtland's warbler depends for nesting solely on certain young jack pine forests in the lower peninsula of Michigan. Turning these forests into a preserve cannot save the warbler if climate change leads to the replacement of the jack pines by white pine and red maple. While the rates of climate change are expected to exceed any that present flora and fauna have ever experienced, the actual impacts are largely unknown. Some change will be adverse, some beneficial. Some climate-induced environmental changes cannot be quickly reversed; some are irreversible.

The faster the rate of climate change, the higher the probability of disruption of the ecosystem, the greater the risk of surprise, and the greater the risk of serious ecosystem degradation. As ecosystems will not move in one piece, with each species reacting differently, species associations will break up and new communities form. The response will depend on competition among species to maintain themselves in new areas or under changing conditions.

Natural disturbances like hurricanes and fires are not only likely to occur but are sometimes the inevitable result of climate change. And some like wildfires in certain areas may be critical elements in the sustained functioning of ecosystems.

Besides climate, many non-climate influences stress ecosystems and the projections of their interaction do not always follow a straight line. Most projections are based on an arbitrary assumption of a doubling of CO_2; few have considered dynamic responses to steadily increasing concentrations of greenhouse gases or have assessed the implications of a combination of stress factors.

Managing Our Parks

In view of the continual shifts and interactions, Adam Markham of the World Wildlife Fund suggests a gradual shift in priorities from species-based conservation to an approach based on whole ecosystems.

Conclusion

A preliminary look at the current status of our parks based on the primitive knowledge we have suggests they have a high degree of vulnerability. Sea level rise will endanger our coasts — the barrier islands, beaches and wetlands. Higher temperatures may melt glaciers; changing patterns of storms and hurricanes may increase the likelihood of droughts and floods. The impacts on habitats could be devastating. A change in soil moisture would harm trees and plants, and forests may be unable to migrate fast enough to adapt to new conditions. There is increasing landscape fragmentation.

Assessing regional and local impacts of climate change requires much more detail than the complex information used in the GCMs of the IPCC and other operators of world climate models. The databases are orders of magnitude greater, and it is here that our greatest knowledge gaps exist. We need radically improved models to predict regional climate change and to quantify threats to biodiversity and conservation on a local scale. We need higher resolution models that deal better with annual rainfall both during the year and between years, with seasonal changes and with extreme events — especially drought —to improve our ability to assess ecosystem vulnerability to climate change.

The data gathering and model development present a daunting proposition, requiring cooperation of local and regional institutions and agencies — both government, academic and private — to satisfy the needs of local and regional decisions makers. We need to persuade those setting funding policies to adopt a longer range view and to realize that we cannot make long-term projections without longer range funding.

Although good research programs have been started, their low status among national priorities combined with Federal budget cutbacks have left us without a very good handle on what impact climate change is likely to have or what future dangers impend.

Many gaps exist in our knowledge. Although we understand in general that loss of diversity and complexity diminishes the stability of ecosystems, we rarely know enough to predict how the loss of a particular species will affect the capacity of a particular system to resist or recover from disturbance. More monitoring and research should help to clear up some of this uncertainty. In quantifying ecological limits to climate change, we need to identify key areas for concentrating biodiversity and conservation efforts. Nevertheless, uncertainty about climate change and the rate at which it is happening is no excuse for inaction.

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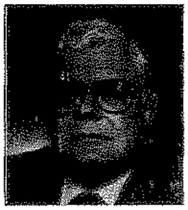
MacDonald Becomes New Director of IIASA in Vienna



Gordon J. MacDonald

Institute Board member Gordon J. MacDonald has been appointed as the next Director of the International Institute for Applied Systems Analysis in Laxenburg, near Vienna, Austria, beginning August 1996 for a three-year term.

Established in 1972, IIASA is a non-governmental research institution. At the end of the Cold War in 1989 it negotiated a new strategic plan for policy-oriented research on the human dimensions of global change.

Dr. MacDonald is currently professor of international relations at the Graduate School of International Relations and Pacific Studies, University of California, San Diego. His distinguished career has included serving as Chief Scientist and Vice President of the MITRE Corporation and executive vice president at the Institute for Defense Analysis. He has served on the President's Council on Environmental Quality and has led a large number of interdisciplinary efforts focusing on issues of the environment, global change, and U.S. national security policy.

Board Member Noyce Dies

Philip J. Noyce

Philip J. Noyce, of the Institute Board of Advisors and former member of the Board of Directors, died in Mildura, Australia, on December 30, 1995 at the age of 50. At the time of his death he was director of the United Nations Global 500.

We first became acquainted with Phil in 1988 when he was the energy behind Australia's Greenhouse 88 meetings which drew 8,000 participants in ten Australian cities. Phil brought a large Australian delegation to the Institute's 1989 Cairo World Conference on Preparing for Climate Change, and it was during this meeting that he was elected to the Board of Directors. He organized a Greenhouse Action for the Nineties Conference in Melbourne in July 1991 supported by the Climate Institute and the United Nations Environment Programme; John Topping and other Institute members attended.

A year later Phil became Director of the newly established Global 500 Forum, an organization originally set up by UNEP to honor outstanding achievements in protection and improvement of the environment. He was in the midst of organizing Global 500's second international conference, Urban Futures, to be held in Sydney, Australia, in October when he died. His idealism and passion for the environment will be sorely missed.

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