



Pacific Island Network — Special Edition

CLIMATE CHANGE

"...climate change has certainly made things interesting. How will we choose, as the sea rises, which cultural sites we save? How do we decide that the next site for the giant sequoias is hundreds of miles north? Are those warblers here for the first time treated as exotics? These are difficult questions. More than the future of the national parks hangs in the balance, but I am confident that the NPS will play a critical role. "

**– J. Jarvis, Director,
National Park Service**
NPS Climate Change Response Strategy (2010)

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Global Climate Change

Tolerating the News

Sea level rise, melting glaciers, more invasive species, coral bleaching, global warming, more severe storms and droughts, doom, doom, doom. Admittedly, the picture is bleak for the planet. It's hard to keep up with what is mortally threatened by our dependence on the energy from coal, oil, and trees (major greenhouse gas contributors in the form of carbon dioxide-CO₂). For most of us, it's easier to dismiss it. And according to a [2011 Yale and George Mason Universities survey](#), 36% of American respondents either don't "believe" in global warming or are unsure if it even exists. Furthermore, only 47% of those who acknowledged the existence of global warming believe that it is caused by human activity. So why bother studying the problem or trying to make things better?

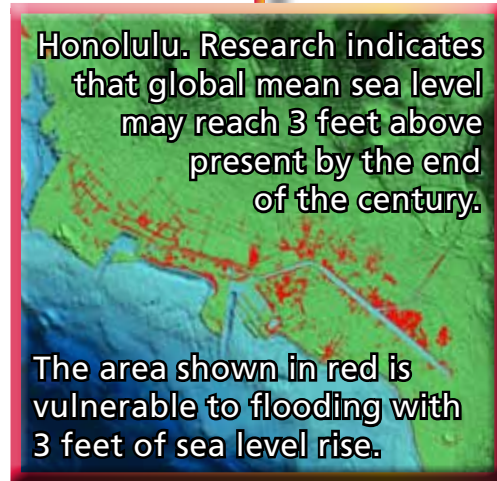
Here's the rub. If we decide to ignore the issue, it's going to sneak up on us in ways that we might not be prepared for. There is a lot we don't know about how the climate

is changing. However, an ever-expanding body of knowledge on everything from the rate of sea level rise to how certain plants and animals are adapting to altered weather patterns and seasons is helping people to understand this overwhelming issue; bit by bit.

No single organization, group, or country could gather enough data on every aspect of global climate change to be sufficient for the planet to make educated responses. As one important player, the National Park Service contributes significantly to our understanding of climate change through targeted research and cooperative efforts. The NPS is not alone in this effort.

Starting off generally and gradually working to a regional perspective, consider this publication to be a resource on some of the climate change issues, players, how our parks are affected, and what is being done about it. – C. Nash, NPS

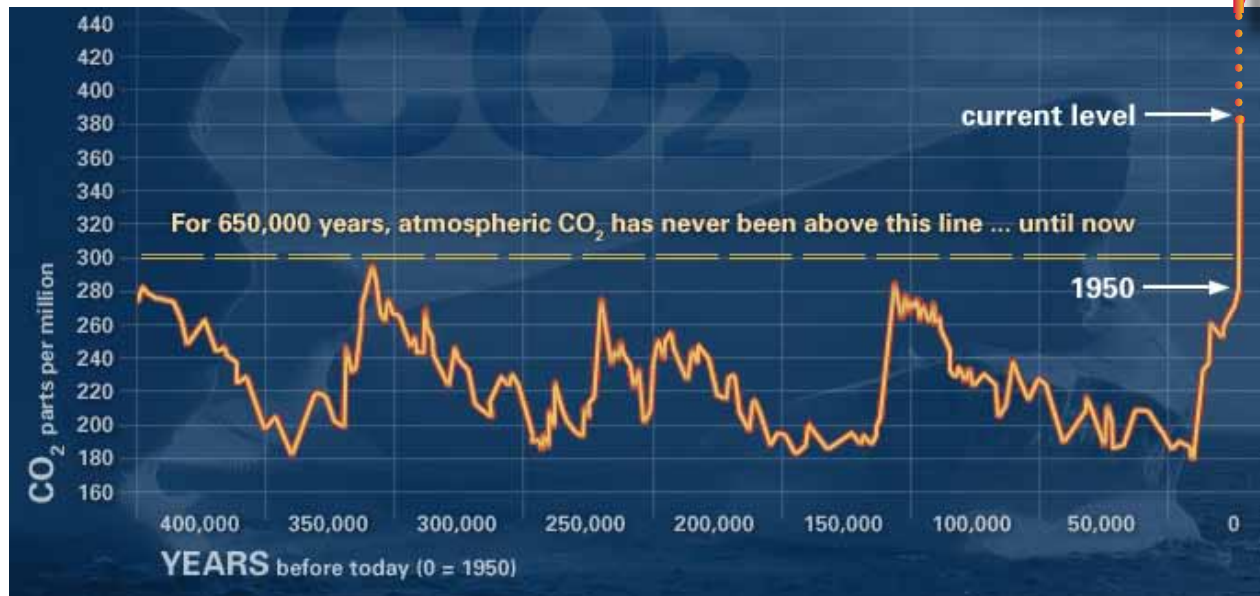
PACN Science Comm.



C. Fletcher, Coastal Geology Group, University of Hawaii (2011)

Since 1993, it's estimated that thermal expansion of the oceans has caused 57% of sea level rise, melting glaciers and ice caps contributed about 28%, and melting polar ice sheets the rest.

Eleven of the twelve warmest years on instrumental record for global surface temperature have occurred since 1995.

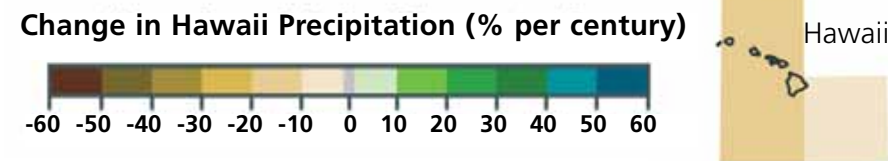
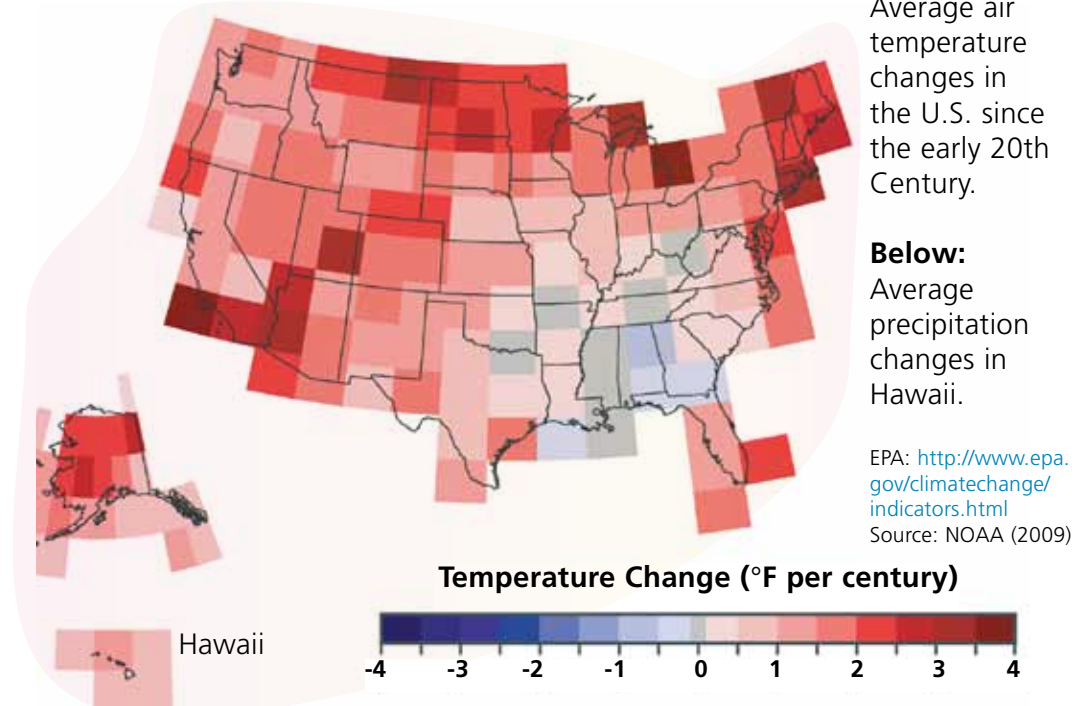


CO₂, the most abundant greenhouse gas released by humans, also has the largest total warming and climate change impact. Once emitted, the atmospheric concentration of CO₂ remains unnaturally elevated for 1000's of years.

NASA: <http://climate.nasa.gov/evidence> Source: NOAA

Temperature and Weather Changes

Warming global temperatures change weather patterns. This affects water supply and hospitable habitats for people, plants, and animals.



Sea Level Rise, Ocean Acidification, and Warming Waters

Sea level has risen by as much as eight inches in the past century and the rate is accelerating. In addition, the acidity of seawater has increased significantly since 1750. Warmer and more acidic seawater weakens and kills corals. Warmer oceans also create more powerful hurricanes.



Homeless animals too

About 25%-30% of human-caused CO₂ emissions in the atmosphere are absorbed by oceans. The CO₂ reacts with water to form carbonic acid which inhibits corals and many invertebrates from forming exoskeletons. Ocean acidification is increasing at an alarming rate.

Key Climate Science Organizations

Intergovernmental Panel on Climate Change (IPCC)

The IPCC is the leading international body for the assessment of climate change. Established by the U.N. Environment Programme and the World Meteorological Organization to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. Thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis.

<http://www.ipcc.ch/>

National Aeronautics and Space Administration (NASA)

NASA provides information on solar activity, sea level rise, the temperature of the atmosphere and the oceans, the state of the ozone layer, air pollution, and changes in sea ice and land ice.

<http://climate.nasa.gov>

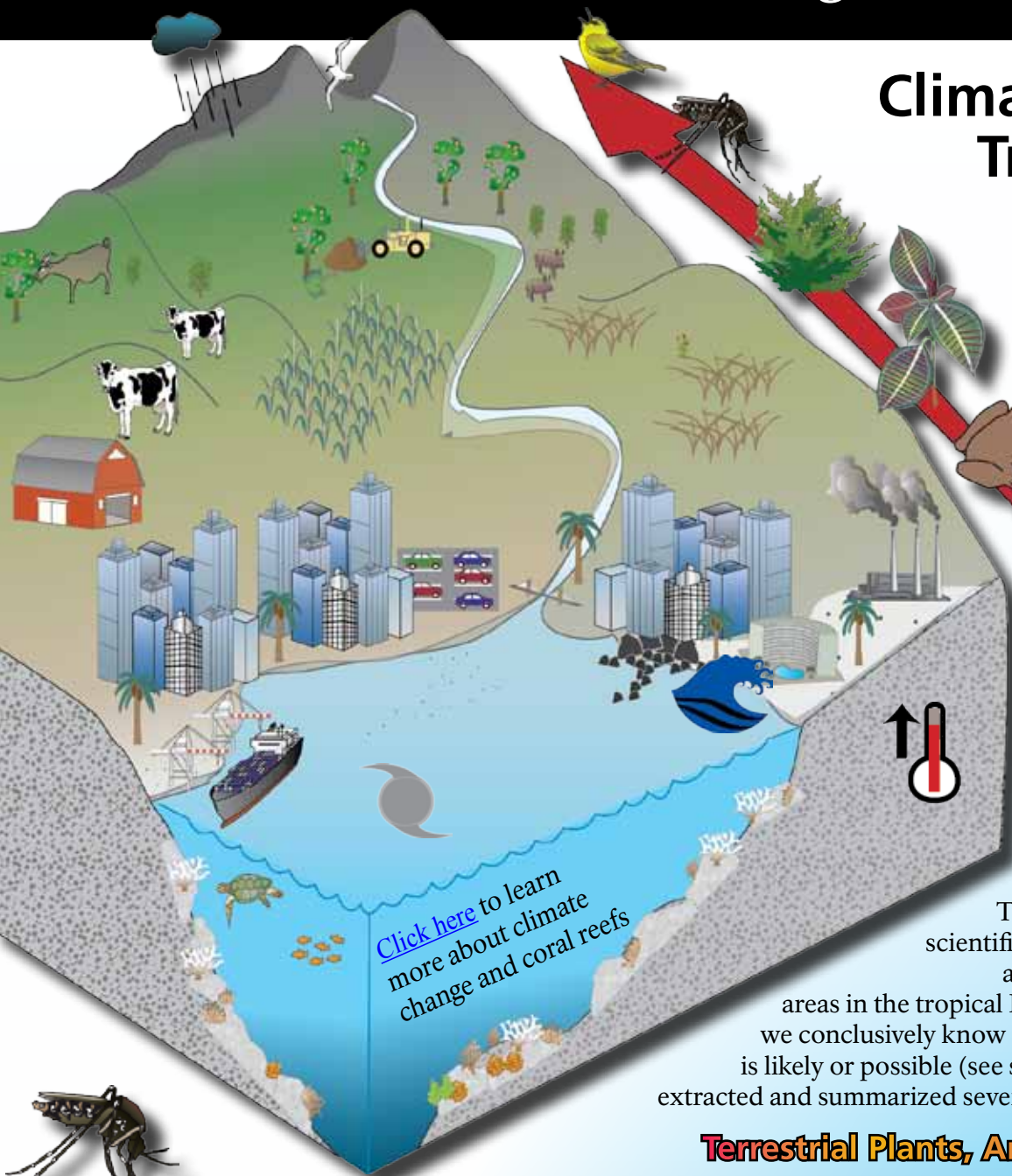
National Oceanic and Atmospheric Administration (NOAA)

<http://www.climate.gov/#climateWatch>

The National Academy of Sciences (NAS)

<http://dels.nas.edu/Report/America-Climate-Choices-2011/12781>

Many organizations not listed



Climate Change in Tropical Pacific Islands

In 2011, the National Park Service released *Understanding the Science of Climate Change: Talking Points - Impacts to the Pacific Islands*

http://science.nature.nps.gov/im/units/pacn/outreach/Understanding_the_Science_of_Climate_Change_Pacific_Islands.pdf

This publication summarizes key scientific findings about climate change and its impacts to U.S. protected areas in the tropical Pacific. It outlines some of what we conclusively know about climate change, and what is likely or possible (see sidebar on right). Here, we have extracted and summarized several points from this publication.

[Click here](#) to learn more about climate change and coral reefs

Terrestrial Plants, Animals, and Migration

~• Higher elevations on some Hawaiian islands keep many native species alive thanks to cooler temperatures and less conducive conditions for invasive species. Many of these last refuges are threatened by climate change. As the environment warms, an upslope migration of both native and invasive plants and animals is occurring.

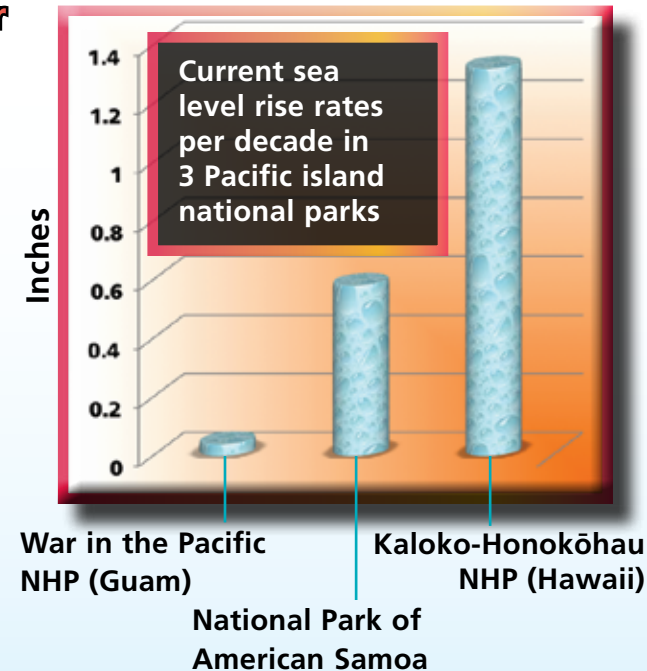
~• Warmer conditions allow avian disease-carrying mosquitoes to survive at higher elevations. This forces native birds to migrate even higher or face extinction. The incidence of avian malaria in Hawaii doubled from 1995-2005 in correlation with warmer temperatures.

~• Temperature sensitive invasive ants and amphibians move upslope as the climate warms. Collectively, they eat a tremendous amount of insects which some native birds eat, and some native plants depend on for pollination.

Temperature & Weather

~• Average temperatures on Pacific islands have risen by 0.5°F over the past century. In Hawaii, temperatures at higher elevations are now increasing by 0.48°F per decade.

~• Hawaii has experienced a statewide decline in rainfall over the past two decades. However, the amount of rain from heavy storms has increased by 12%.



Sea Level Rise

~• Due to rising temperatures, the planet's ice has dramatically melted; and when amplified by the thermal expansion of water, causes global sea level rise.

~• The low-lying French Frigate Shoals which harbor seabirds, sea turtles, and endangered seals are about 50% smaller since 1963.

~• Depending on the Pacific island, the sea level is currently rising at up to 1.5 inches per decade (see graph above for data on three coastal national parks).

~• Historical tidal measurements show that the rates of global sea-level rise over the past 100 years are ten times greater than rates over the past 5,000 years.

Ocean and Coral Health

~• Bleaching due to higher sea surface temperatures is increasing in the Pacific. In shallow back-reef pools in American Samoa, certain coral communities now experience annual mass bleaching events.

~• The concentration of CO₂ in the atmosphere has increased by 35% in the past 200 years which led to the increased acidity of the ocean.

~• Ocean areas with low surface chlorophyll are not very productive. These areas expanded globally by about 15% between 1998 and 2006 due to water layering effects from increasing temperatures.

~• The ocean has been taking up over 80% of the heat added to the climate system.

The Future of Pacific Islands

What many experts agree is likely to happen based on trends, models, and critical thinking.

Temperatures are predicted to rise an average of 4°F in the Pacific islands by 2090.

Hawaii will experience up to a 10% reduction in wet season precipitation and a 5% increase in dry season precipitation by 2100.

Acidification is predicted to reach a level where corals can no longer sustain themselves by 2050.

The regional sea level is predicted to rise 7-23 inches by 2100.

Due to sea level rise, American Samoa and Saipan could experience a 12% reduction in mangroves by 2100.

Sea level rise also threatens coastal sites such as Pelekane Bay at Pu'ukoholā Heiau NHS; and the fishponds and fishtrap at Kaloko-Honokōhau NHP.

The ocean and beach tourism and fishing industries will be seriously threatened within the next 100 years.

Climate Change Clues from Monitoring

While we all recognize our NPS mission to preserve unimpaired resources for future generations, we are unique in that we now have the ability to track the condition of these resources and changes over time. While monitoring seems to be a simple goal essential to knowing if resources are unimpaired, the task is extraordinarily complex, expensive, and has never been undertaken on a nationwide scale. It literally took an act of Congress, *The Natural Resource Challenge in 1996*, to institutionalize a scientifically rigorous effort to accurately track the resources of our great National Park System.

Now, we hope to provide some basic data to inform about what has been called, "...the greatest threat to the integrity of our national parks that we have ever experienced" by NPS Director Jon Jarvis (*NPS Climate Change Response Strategy*, 2010). Climate change is here now and evidenced by rising global air and ocean temperatures, widespread melting of sea ice, glaciers, and ice caps, rising sea levels, and species range changes. As our world continues changing, monitoring will help us accurately track status and trends in Pacific island parks to continue to meet our stewardship mission.

-G. Kudray, NPS-PACN
Program Manager



Terrestrial Vegetation and Landbirds

Higher elevation habitats in Pacific island national parks provide a primary refuge for native plants and animals. These elevations allow native birds in Hawaii to persist in areas where a threat like malaria-transmitting mosquitoes is low. Similarly, native vegetation throughout the Pacific tends to thrive where human disturbance is minimal, and conditions are not ideal for the plant and animal invaders that have transformed lower elevations.



As the climate changes, these and other habitats are no longer certain refuges. Ninety-three percent of Hawaiian birds and 62% of all U.S. Pacific island birds are considered vulnerable to climate change. The NPS is doing its part to learn about landbird population changes with the conclusion of the first landbird monitoring cycle at Haleakalā NP in early 2012, completing the suite with Hawaii Volcanoes NP and the NP of American Samoa. The cycle repeats at each park every five years.

Cloud or wet forests, mangroves, coastal strand habitats, and sub-alpine shrublands are vulnerable vegetation communities that are also monitored on a five year cycle. High elevations in Hawaii are warming faster than the global rate (about 0.5F° per decade). Correspondingly, mangroves at sea-level on Saipan may be forced to retreat inland due to sea-level rise.

Invasive plant species may become even more competitive, especially at higher elevations, as the climate changes and native species struggle to adapt. The NPS monitors both established and colonizing invasive species in the same habitats where vegetation communities are monitored.



Freshwater Animals, Water Quality, and Groundwater

Rainfall in Hawaii has declined over the past two decades, coinciding with associated rises in sea surface temperatures. Warmer temperatures could also mean more evapotranspiration resulting in even less groundwater and stream discharge. At the same time, the rate of sea level rise is increasing (over one inch of rise per decade in Hawaii) and groundwater discharge to coastal environments is often impaired due to human withdrawal upslope. Treasured resources such as unique near-shore anchialine pools in Hawaii and wells on Guam may experience rising salinity as these hydrologic trends continue.

Perennial freshwater streams are rare on Pacific islands. Many still support unique native creatures that will be threatened if rainfall continues to decrease and water quality changes. The National Park Service annually monitors groundwater, water quality, and freshwater animals, and tracks changes to provide managers the information they need to safeguard these waters and the native shrimp, fish, and snails that inhabit them.

Coral Reef Communities

Oceans may absorb up to 90% of atmospheric CO₂ over the next 1000 years, providing Earth with a huge buffering capacity against even more rapid climate change. However, this is already resulting in changes to the oceans, namely ocean acidification. Coral reef ecosystems and the great diversity of creatures that depend on them are especially threatened by more acidic waters. Coral organisms are also very sensitive to heat stress and expel their colorful symbiotic algae (bleaching) when the water warms. Disease, reduced growth, and death often follow. In the next 50 years, temperature and CO₂ levels are predicted to increase beyond levels that coral reefs have experienced for the past half-million years.

Data from marine fish and coral reef monitoring detect not only changes in fish populations, but also changes in coral, invertebrates, and algae. The reefs of Kaloko-Honokōhau NHP, Kalaupapa NHP, NP of American Samoa, and War in the Pacific NHP are surveyed annually. These ecosystems are among the most immediate and effective indicators of climate change in the region.

Weather and Climate

A warming climate increases the frequency and intensity of tropical storms and droughts. Projections of future climate depend on developing models that use existing weather data. Weather information is routinely recorded at stations in and near all PACN parks. Plus, the addition of 10 new park weather stations in 2012 will allow near real-time tracking of weather conditions as well as provide climate modelers with more data to better predict the future climate.



NPS Climate Change Response Strategy

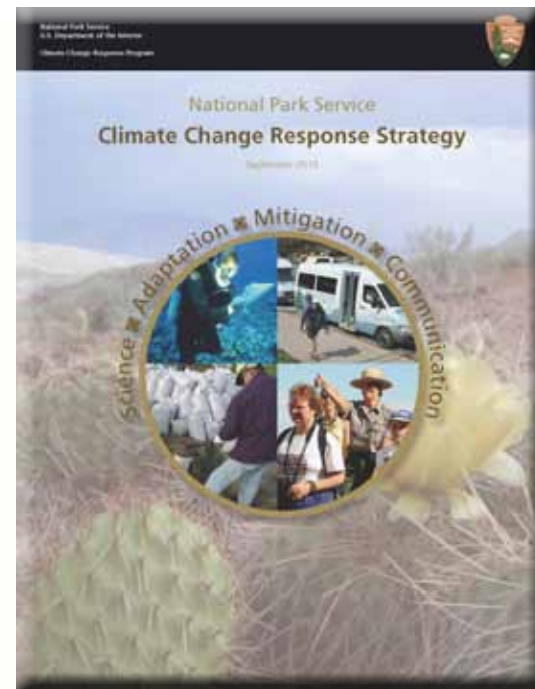
The NPS is moving rapidly beyond the question of whether Earth is warming and is focused on what to do about it. This crisis is daunting, but national parks can provide redemption. For one of the most precious values of the national parks remains their ability to teach us about ourselves and how we relate to the natural world. How we move forward in the era of climate change is up to each of us, at all levels of the NPS, and as citizens of the United States. The NPS Climate Change Response Strategy provides direction to our agency and employees to address the impacts of climate change. It describes goals and objectives to guide our actions under four integrated components:

Mitigation: Reduce the carbon footprint of the NPS. Promote energy efficient practices such as alternative transportation. Enhance carbon sequestration as one of many ecosystem services. Integrate mitigation into all business practices, planning, and the NPS culture.

Adaptation: Develop the adaptive capacity for managing natural and cultural resources and infrastructure under a changing climate. Inventory resources at risk and conduct vulnerability assessments. Prioritize and implement actions, and monitor the results. Explore scenarios, associated risks, and possible management options. Integrate climate change impacts into facilities management.

Communication: Provide effective communication about climate change and impacts to the public. Train park staff and managers in the science of climate change and decision tools for coping with change. Lead by example.

Science: Conduct scientific research and vulnerability assessments necessary to support NPS adaptation, mitigation, and communication efforts. Collaborate with scientific agencies and institutions to meet the specific needs of management as it confronts the challenges of climate change. Learn from and apply the best available climate change science.



http://www.nps.gov/climatechange/docs/NPS_CCRS.pdf



<http://www.nps.gov/climatefriendlyparks/>



Follow the link below for climate change studies in national parks.

<http://www.nature.nps.gov/parkscience/index.cfm?IssueID=28>

PICCC Science Priorities for 2012

Composed of the NPS and 28 other Federal, state, and non-governmental resources management organizations, the Pacific Islands Climate Change Cooperative (PICCC) assists in adapting these organizations to climate change for the benefit of the people of the Pacific islands. PICCC recently surveyed the members of the Cooperative about climate change priorities.

Key results from the survey (79% response rate)

Focus areas for science to aid members with goals and planning :

- Maintain or improve ecosystem function
- Maintain or improve status of at-risk species
- Preserve key cultural and natural resources and their uses

Climate factors which most concern members :

- Precipitation change and storm frequency/intensity
- Sea level rise
- Ocean chemistry and sea surface temperature

Greatest informational needs of members :

- Projected changes in climate
- Information on potential ecological and social responses
- Methods and models to evaluate climate change responses
- Tools to visualize or compare potential future states of resources

The survey process was an informal, but crucial first step in identifying the overall needs and immediate concerns of the varied member organizations in the Cooperative. The observations and recommendations from this survey help to drive research funding and cooperative projects through the coming year and beyond.

<http://piccc.net/>

Vulnerability Assessments Soon

The Pacific Islands Climate Change Cooperative will complete vulnerability assessments of Hawaiian plants and forest birds by 2013. These assessments will provide vital information when choosing the focus of future research and mitigation efforts throughout Hawaii. They will also provide a baseline for our understanding of vulnerability.

Phase 1: Landscape/Bioclimate Vulnerability Assessment:
Based on recorded locations of plants and forest birds

Phase 2: Trait-based Vulnerability Assessment:
Based on traits of plants and birds

Phase 3: Integration of Phases 1 and 2: Expert opinion assessment

The results of these assessments will be shared with resource managers to aid in adjusting management practices and adaptive planning.

PACIFIC ISLANDS CLIMATE SCIENCE CENTER, A REALITY

Joining seven other climate centers across the country, the Pacific Islands Climate Science Center will be hosted by the University of Hawaii - Mānoa in Honolulu, with the University of Hawaii-Hilo, and the University of Guam as consortium partners.

"The Pacific Islands Climate Science Center is an important science partnership that will greatly increase the ability of Hawaii and other Pacific islands to understand how future climate conditions may change and to help us prepare for those changes. The Center will work very closely with the U.S. Department of Interior's Pacific Islands Climate Change Cooperative, natural and cultural resource agencies, and other research organizations."

–Interim Center Director, Loyal Mehrhoff, of the U.S. Fish & Wildlife Service

<http://www.doi.gov/csc/pacific/index.cfm>

Pacific Island Parks Embrace the Climate Friendly Parks Program

Do we mitigate or do we adapt? This is a fundamental question whenever any organization reaches the point in the climate change discussion where they consider what can be done to make a difference. The National Park Service has launched several initiatives to address climate change. The [Climate Friendly Parks Program](#) is the most notable program for large-scale mitigation. In a nutshell, this program requires that each park apply for "climate friendly" recognition by going through an application process and a greenhouse gas (GHG) assessment; followed by a concrete vision and action plan to reach a targeted goal for reduced emissions.

According to the Climate Friendly Parks website list of participating parks (http://www.nps.gov/climatefriendlyparks/parks/applicant_parks.html), four Pacific Island Network national park units have achieved Climate Friendly Park status and two more (Pu'uhonua o Hōnaunau NHP and Haleakalā NP) have started the process.

Kalaupapa National Historical Park

WWII Valor in the Pacific National Monument

Hawai'i Volcanoes National Park

Pu'ukoholā Heiau National Historic Site

Pacific Island Network Climate Friendly Parks

Park Goal: Reduce GHG emissions to 5% below 2008 levels by 2016

Highlights: Emphasis on reduction and reuse

Park Goal: Reduce GHG emissions to 20% below 2008 levels by 2016

Highlights: Skylights and natural ventilation

Park Goal: Reduce GHG emissions to 12.5% below 2006 levels by 2012

Highlights: Green building and green buses

Park Goal: Generally reduce GHG emissions

Highlights: Solar energy and limited water use

The Psychology of Climate Change Communication

1. Know your audience
2. Get your audience's attention
3. Translate scientific data into concrete experience
4. Beware the overuse of emotional appeals
5. Address scientific and climate uncertainties
6. Tap into social identities and affiliations
7. Encourage group participation
8. Make behavior change easier



Center for Research on Environmental Decisions. (2009). *The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public*. New York. <http://cred.columbia.edu/guide/>

How to Bust Common Climate Change Myths

Have you ever heard, "It's just a solar flare," or "Scientists don't agree," or perhaps "It's natural so Earth can cope"? There are still climate change skeptics out there. The National Park Service Climate Change Response Program assembled a collection of climate change myths, and the facts to debunk them.

For the facts, visit: <http://www.nps.gov/climatechange/myths.cfm>