Hawai'i Conservation Alliance

Leaders in Environmental Management, Research and Education

CLIMATE CHANGE IN THE HAWAIIAN ISLANDS

I. Overview of Climate Change in the Hawaiian Islands

In Hawai'i, the seasonal and geographic distribution of rainfall and temperature has combined with steep, mountainous terrain to produce a wide array of island-scale climate regimes. These varying regimes in turn have supported the diversification of Hawai'i native plants and animals. Increasing amounts of anthropogenic greenhouse gases will likely alter the archipelago's terrestrial and marine environments by raising air and sea surface temperatures, changing the amount and distribution of precipitation, raising sea level, increasing ocean acidification, and exacerbating severe weather events.

Conservation managers need information on how climate change will affect Hawaiian natural resources so that they may better plan future management actions. This may include:

- How will the climate of small-scale island landscapes change over time?
- How will land plants and animals respond to changes in temperature and precipitation?
- How will natural coastal and atoll communities respond to changes in sea level?
- How will marine plants, animals, and reef structures respond to ocean acidification and warmer water?

Conservation managers also need to engage other decision makers and stakeholders because of the interconnections between human and natural communities. Increasing demands on freshwater resources will impact freshwater and near-shore aquatic species. Rising sea levels will displace households and communities to upland areas that may be important habitat for Hawai'i's native plants and animals. Warmer, more acidic oceans will impact coral reefs, fisheries, and tourism, with potential competition between sectors for shrinking resources. Identifying potential conflicts now will enable us to develop collaborative and innovative solutions as we all move forward in adapting to Hawai'i's changing climate.

II. How Climate Change is Altering Hawai'i's Climate

Hawaiian climate has two main seasons: *Kau wela*, the high sun season from May through October with warm, steady trade winds; and *Ho'oilo*, the cooler season from November through April with weaker, less frequent trade winds and storms that bring rain across the islands. The atmospheric processes of these seasons are (1) the Hadley Cell climate that drives the trade winds and trade wind inversion, and (2) non-Hadley Cell climate that drives winter weather events such as Kona storms, the southern tails of mid-latitude cyclonic storms, and upper level atmospheric troughs. Other important climate features that affect Hawai'i include El Niño drought events, hurricanes, and other lesser weather processes.

Effects of Climate Change on Average Temperature in Hawai'i

The average ambient temperature (at sea level) is projected to increase by about 4.1 (2.7 to 6.7) ^{o}F by 2100 (IPCC, 2007). These changes would increase the monthly average temperature to between 77 ^{o}F to 86 ^{o}F. Historically, temperature has been rising over the last 100 years with the greatest increase after 1975 (Giambelluca *et al.*, 2008). The rate of increase at low elevation (0.16 ^{o}F per decade) is below the observed global temperature rise of 0.32 ^{o}F per decade (IPCC, 2007). However, at high elevations, the rate of increase (0.48 ^{o}F per decade) greatly exceeds the global rate. Overall, the daily temperature range in Hawai'i is decreasing, resulting in a warmer environment, especially at higher elevations and at night.

Effects of Climate Change on Precipitation in Hawai'i

In the oceans around Hawai'i, the average annual

rainfall at sea level is about 25 inches. The orographic (mountain) features of the islands increase this annual average to about 70 inches but can exceed 240 inches in the wettest mountain areas. Rainfall is distributed unevenly across each high island, and rainfall gradients are extreme (approximately 25 inches per mile), creating very dry and wet areas. Global climate modeling predicts that net precipitation at sea level near the Hawaiian Islands will decrease in winter by about 4-6%, with no significant change during summer (IPCC AR4, 2007). Data on precipitation in Hawai'i, which includes sea level precipitation and the added orographic effects, shows a steady and significant decline of about 15% over the last 15 to 20 years (Diaz et al.; Chu and Chen 2005). These data are also supported by a steady decline in stream flow beginning in the early 1940s (Oki, 2004).

Effects of Climate Change on Sea Level

Melting of grounded ice and thermal expansion of the oceans are expected to continue for many hundreds of years with a predicted rise of two to three feet this century (IPCC, 2007). Low-lying coastal areas will be periodically or permanently inundated by seawater, and saltwater intrusion will permanently alter low coastal wetlands and low-lying freshwater resources (Fetcher and Marrifield 2009). Sea level rise also is directly implicated in increasing frequency and severity of high wave inundation and accelerate beach erosion (Fetcher and Marrifield 2009), which will impact coastal habitats (e.g., nesting areas), ports, and coastal infrastructure (*e.g*., roads, sewers, communities).

Effects of Climate Change on Ocean Temperature

By 2100 the monthly average sea surface temperature in Hawaiian waters may increase from 73 ^{o}F to between 75 ^{o}F and 79 ^{o}F (Vecchi and Soden, 2007). Bleaching of coral can be induced by long-term exposure (i.e. several weeks) to temperature increases of 1.8 ^{o}F to 3.6 ^{o}F. Localized and large-scale coral bleaching have been observed in Hawai'i (1986 -1988, 1996, 2002) during periods of high sea surface temperatures (Jokiel and Coles 1990; Jokiel and Brown 2004). A continuation of the warming trend in Hawaii would lead to mass bleaching similar to those observed recently in other geographic locations.

Ocean Acidity and the Effects of Increased Carbon Dioxide

Anthropogenic carbon dioxide that causes global warming also dissolves into the oceans and acidifies the surface waters. Models of ocean acidification predict that by 2070, conditions around Hawai'i will be marginal for corals, with even less favorable conditions in equatorial and western Pacific areas (Kleypas *et al*. 1999; Guinotte *et al*. 2003; Raven *et al*. 2005; Caldeira, 2007; Hoegh-Guldberg *et al*. 2007). Acidification has been observed to have a profound impact on Hawaiian coral and crustose coralline algae, reducing growth and calcification by as much as 20% (Jokiel *et al*. 2008). Acidification will inhibit, and eventually end, the growth of biota that rely on calcium carbonate structures (e.g., coral reefs, plankton, and mollusks) and so disrupt the marine food web.

Ecosystem Resilience & Adaptation

A variety of natural mechanisms may mitigate and facilitate ecosystem adaptation to climate change. However, Hawai'i's ecosystems already are functioning below their natural capacity due to multiple stressors. To preserve the genetic diversity of endemic Hawaiian species and promote their resilience to climate change, HCA recommends at a minimum:

- Ensuring wildlife and stream corridors are established to enable wildlife to migrate if necessary;
- Protecting healthy coral reefs from land-based and marine stressors, and restoring degraded reef systems;
- Preserving and restoring coastal wetlands that can minimize damage to coastal communities; and
- Protecting and restoring forests that can reduce soil erosion brought on by changing weather patterns and severe weather events.

III. Recommendations

There are four basic actions that we can take to reduce the negative impacts of a changing climate on Hawai'i:

- Be well informed of potential climate change impacts,
- Maintain the resilience of environmental and societal systems by minimizing non-climate change stressors,
- Engage stakeholders in creating culturally appropriate adaptation and mitigation management options, and
- Actively plan for a changing climate so that today's short-term decisions do not make future actions more difficult.

To help set the stage for Hawai'i's response to climate change, we suggest the following, more specific actions:

1) *Establish a Hawai'i Climate Change Coordinating Council.* This council should provide an umbrella function to ensure complimentary efforts by subordinate working groups addressing societal and environmental issues like biodiversity protection, infrastructure adaptation, carbon sequestration, and economic viability.

2) *Improve our understanding of how Hawai'i's climate may change.* It is especially important that we develop a good understanding of:

a. How temperature, precipitation, severe weather, sea-level rise, and ocean acidification will change throughout the Hawaiian archipelago.

b. How past climate changes have affected Hawai'i.

3) *Assess the likely impacts of climate change on important Hawaiian resources*:

a. Native terrestrial and marine plants and animals;

b. Terrestrial and marine ecosystem processes (*e.g.* nutrient cycling, carbon sequestration);

c. Terrestrial and marine ecosystem services (*e.g.* clean drinking water, fishing, recreation, protection from coastal erosion);

d. Cultural resources and practices; and

e. Coastal areas, especially beaches, reefs, wetlands, and societal infrastructure.

4) *Develop a plan for how Hawai'i will adapt to a changing climate.* This should include how we will deal with a rising sea level, warmer temperatures, and reduced freshwater availability. There will likely be significant impacts to not only our unique Hawaiian plants and animals, but also to our transportation systems (highways, seaports, and airports), food production, and land use patterns. Key components of a Hawai'i plan should address:

- Hawai'i's quality of life;
- Cultural heritage;
- Ecosystem and native species conservation;
- Economic viability;
- Tourism;
- Agriculture and food security;
- Energy independence and security;
- Changes to land use and zoning;
- Climate change refugees from other Pacific Islands;
- Infrastructure;
- Drinking water;
- Coastal erosion and loss of beaches; and
- Public health.

Stakeholder Engagement

Residents and visitors to Hawaii must be a part of the climate change solution. To this end, Hawaii's leadership must:

- Engage local communities in management and restoration work;
- Engage the public on land and water use and the effects of climate change; and
- Create culturally appropriate management strategies, *e.g.*, consider ahupua'a approaches to promote healthy function of terrestrial and marine systems in unison.

V. HCA Will Continue Addressing Climate Change Impacts in Hawai'i

To succeed in its goal of preserving Hawai'i's rich and unique biological diversity, the HCA must lead by example in minimizing our carbon footprint and promoting sustainable operational practices. We must take responsibility for understanding how climate change will impact Hawai'i and take appropriate steps to protect Hawai'i's natural treasures. Many of the resources managed by HCA member organizations support the highest ecologically functioning terrestrial and marine communities and provide us with our best opportunity of establishing environmental baselines to track change in the face of global climate change.

A high degree of collaboration and cooperation among HCA agencies and partners will be required to acquire needed scientific information, protect resources, and effectively mitigate the variety of impacts caused by global climate change. Collaboration with communities, private partners, and state, local and federal agencies will be a key element to successful mitigation and adaptation measures.

Significant research to predict climate change impacts in Hawai'i is underway. A concerted effort to share this information with the public in a proactive manner is now required. HCA has committed to developing a clearly articulated message and educational materials that communicate the complexities of climate change and the actions that may mitigate likely impacts.

HCA Commitment

HCA and its member organizations will:

- Provide critical research on climate change;
- Develop, implement, and share best management practices;
- Develop policy recommendations;
- Promote education and outreach around climate change at the annual Hawai'i Conservation Conference, forums, leadership summits;
- Coordinate and collaborate between its members; and
- Direct adaptation and mitigation funding to minimize negative effects of climate change in Hawai'i.

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For more information on HCA climate change activities, please visit our web site:
www.hawaiiconservation.org