Ecological Drought in the Hawaiian Islands

Unique tropical systems are vulnerable to drought

Pacific Islands Climate Science Center Workshop
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The Department of the Interior Climate Science Centers (CSCs) and their managing organization, the National Climate Change and Wildlife Science Center at the U.S. Geological Survey, have chosen the emerging climate science field of Ecological Drought as a research focus area. This workshop is part of a series of meetings at each of the nation's eight CSCs aimed at collating our existing knowledge of the ecological impacts, resistance, and recovery from drought. The eight CSCs provide a fantastic opportunity to compare the ecological effects of drought, related research activities, and management options at different regions, spatial scales, and biomes.

Unique tropical systems are vulnerable to drought

The Hawaiian Islands are among the most isolated and recently inhabited places on Earth. Discovered by Polynesian voyagers some 1000 years ago, people arrived to find unique wildlife and plants arrayed across a remarkable range of ecosystems. Polynesian settlers relied on traditional methods to cultivate canoe crops (plants carried in voyaging canoes) across the wide range of climate and soils. Early Hawaiian societies adapted to regular climate variations, including periods of extreme drought. Today, as drought events become more severe, contemporary communities must also learn to adapt.

Topography and prevailing wind patterns create dramatic gradients

Hawai'i is a state of dramatic landscapes, seascapes, and ecosystems. High mountainous topography, extreme soil age gradients, and seasonal weather patterns create diverse climates and ecosystems, each with a distinct response to drought. For windward areas, strong prevailing winds move moisture-laden air masses up steep slopes, resulting in rain clouds that nourish lush tropical forests that can receive hundreds of inches of rain a year. For most leeward areas, high mountains block prevailing wind moisture resulting in much drier conditions, including desert landscapes that receive less than 9 inches of rain per year. Climate variability drives wide-spread droughts, affecting highly diverse ecosystems and the people who depend on them, particularly in these drier leeward landscapes.

U.S. FWS / CC-BY

Hawai'i has remarkable biological diversity and a rich cultural heritage

90% of Hawai'i's plants and animals are unique to Hawai'i – they are found nowhere else on Earth. This rich biodiversity is a global treasure, and is integral to native Hawaiian cultural practices and plays a central role in maintaining quality of life for all communities. However, hundreds of Hawaiian species are now at risk of extinction as a result of drought, invasive fire-prone plants, and the fires they support. To save these species, we need to improve our understanding of how drought, invasive species, and fire interact on Hawaiian Islands in order to develop innovative strategies to ensure their survival.

Michael Janke / CC BY-NC-ND

Ridge to reef (Ahupua'a) land management is a holistic, multigenerational approach

Drought exerts impacts from ridge to reef, on upland forests, agricultural systems, human communities, and coastal nearshore areas. The small size of Hawai'i's watersheds and the tradition of collaboration resulted in stakeholders relying on a progressive framework and holistic approaches for managing water and land. The paucity of scientific information on drought limits the ability of managers to respond to severe drought events. Through retrospective climate analyses, and engaging traditional knowledge and agency managers, there is an opportunity to better understand how droughts have changed over the past centuries, as well as how people have managed resources during severe droughts.

Kamala Anthony, University of Hawai'i Hilo

Characterizing the impacts of drought on the Hawaiian Islands

Island ecosystems provide a diversity of freshwater benefits and services, including support of stream diversity, native Hawaiian cultural practices, nearshore ecosystems, and a public water supply for agriculture, recreation, and tourism. These island landscapes and ecosystem services are uniquely susceptible to changing climate.

Acceleration of the drying trends

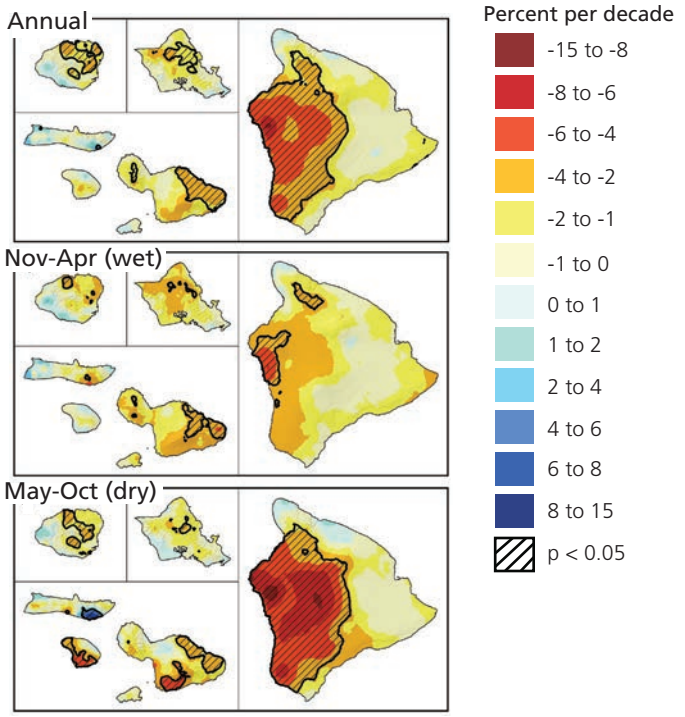
During the past 93 years, the average annual rainfall has decreased by 1.78% per decade, totaling almost one foot less rainfall today than a century ago. When trends are analyzed seasonally and spatially, much larger dry season declines are found, particularly on the leeward side of Hawai'i island, up to a 10% decline per decade. Streamflow and base flow have also declined by 22% statewide over this time, with impacts to groundwater storage–which supplies 99% of Hawai'i's drinking water. These trends highlight the urgent need to protect upland forests from fire and invasion, as these ecosystems stabilize the watersheds essential to life in Hawai'i. They also highlight the need for expanded research into biophysical and social aspects of drought, so that natural resource managers can more effectively prepare for and develop innovative management practices to cope with climate variability and changing rainfall patterns.

Drought reduces streamflow and increases the likelihood of wildfires

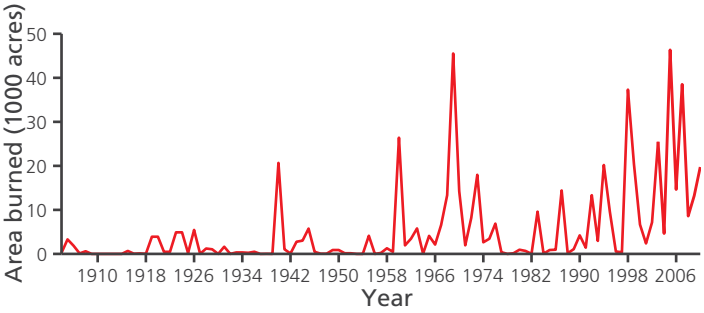
Over the last century, rainfall and streamflow have declined while wildfire area burned has increased. Drought and resulting dryness increase the likelihood of wildfire, which kills native plants while spreading fire-adapted, often fire-promoting, invasive grasses and shrubs. Wildfire can also elevate potential for severe erosion, delivering sediment into streams and nearshore areas. Droughts are often associated with El Niño events, which produce wetter than average summers then drier winters. This pattern increases fuel loads and the potential for wildfire occurrence and spread. Adaptive management measures are needed to maintain watershed health during drought. These measures include efficient water delivery systems, metering and monitoring, conservation practices, wildfire prevention through education and outreach, fuel breaks and vegetation management, and enhanced initial response.

Iconic imperiled species are on the brink

Invasive species, land use change, and disease confine many iconic Hawaiian species to high elevation habitats. These forest habitats are being degraded by warming and drought through increased tree mortality and accelerated grass invasion, which together can reduce the cover of high quality forest. These changes also increase the risk of wildfire. Following wildfires, native forest habitat can become converted to open, non-native grasslands that provide marginal habitat for other native plants and animals. Managers actively seek to maintain enough native habitat to support viable self-sustaining populations of Hawai'i's iconic native species.



Rainfall trends in the Hawaiian Islands from 1920-2012. Adapted from Frazier and Giambelluca 2017.

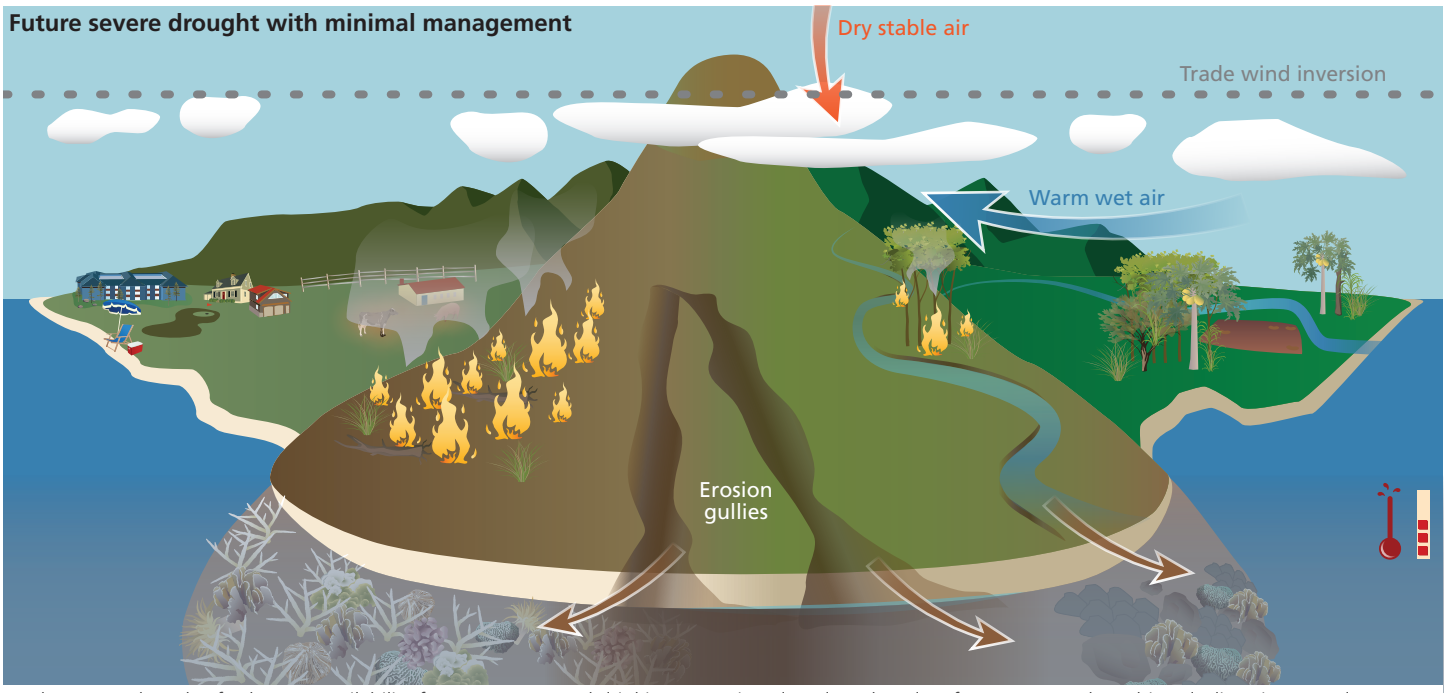


Annual area burned in Hawai'i 1904-2012. Trauernicht et al. 2015 Pacific Science.

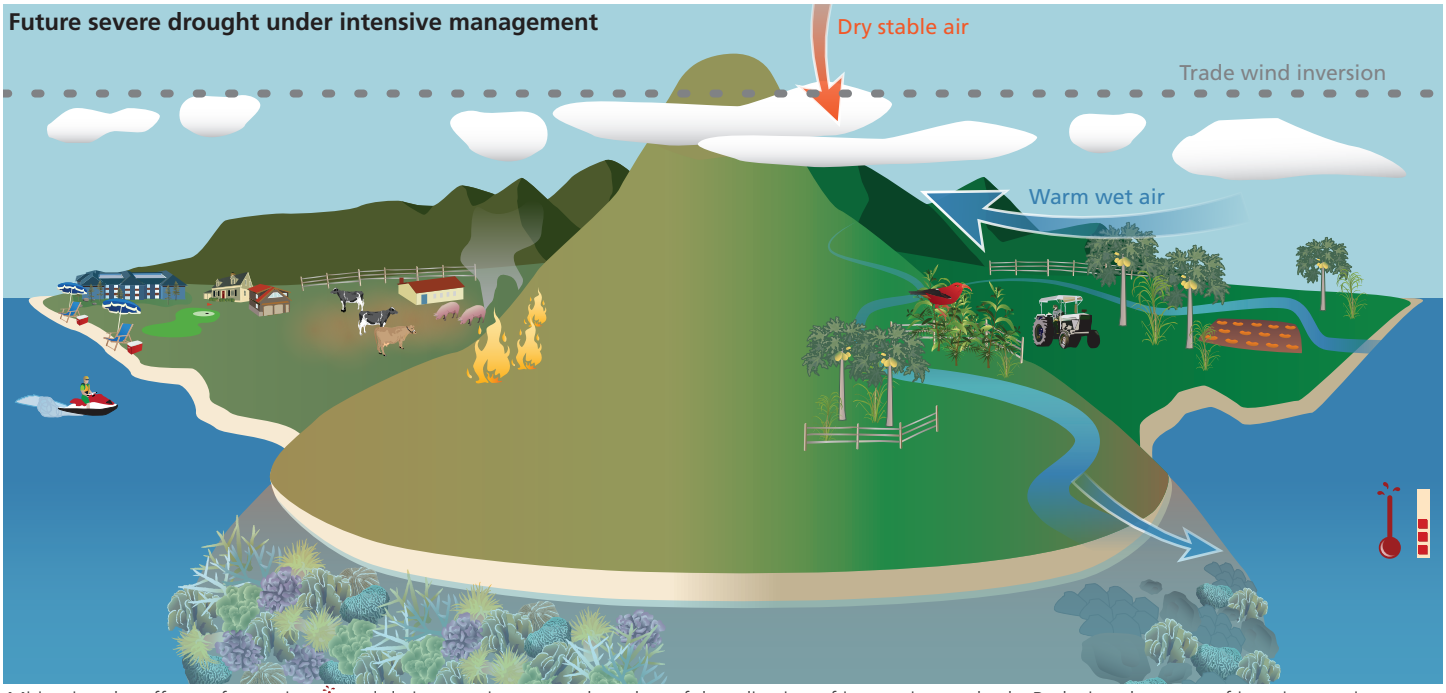
The Wiliwili tree (Erythrina sandwicensis) is drought tolerant, however, invasive pests, invasive grasses, and fire have threatened remnant dry forest populations. Photo by Rosa Say / CC BY-NC-ND.

Managing for drought on an island landscape

Changes in climate leading to increased frequency and severity of droughts are magnifying the importance of management across Hawai'i's landscape. Effective management can limit the impacts of drought, reduce wildfire risk, protect native species, and sustain delivery of goods and services that support ecosystems and society.



Under severe drought, freshwater availability for ecosystems and drinking water is reduced. Reduced surface water, and resulting declines in groundwater recharge also negatively impacts agriculture and ranching. Warmer and drier conditions often favor invasive plant species which typically use more water, and in leeward areas, increase the risk of wildfire. Expanding invasive species cover increases areas where native species regeneration is prevented by competing invaders. These degraded native forests are less able to support the rich flora and fauna that depend on intact forests systems. Increased fire danger and the expansion of wildland-urban inferfaces, typically in leeward areas, reduces the attractiveness of these areas for residences or as destinations for tourists. Even wet, windward areas become susceptible to wildfire without effective management, education, and outreach. Drought and wildfire increase erosion and sediment delivery to streams and nearshore areas. For nearshore reefs, erosion and sedimentation exacerabate other coral reef stressors including warming, which can cause coral bleaching and ocean acidification.



Mitigating the effects of warming and drying requires research and careful application of innovative methods. Reducing the cover of invasive species through physical, chemical, and biological methods enhances resiliency by reducing competition, allowing native species to regenerate and thrive. This practice can also indirectly work to prevent and reduce the spread of wildfires. There is a strong link between drought and El Niño events which provides some advanced warning for managers and researchers to prepare and perform outreach activities. Intensive wildfire management can help protect infrastructure and reduce erosion and sediment delivery to nearshore areas, and proactive water resource management can help increased surface water availability for agriculture and ranching.

Aloha,

In our islands, people and the land are deeply woven together, and fresh water is a precious resource. We are grateful to our panel of experts, who showed how drought has the potential to affect us all in many ways, reducing quality of life and impacting agriculture and native ecosystems. Through the workshop, we identified ways in which drought might be planned for, but also gaps that need further study, shared here as an agenda for drought planning in the main Hawaiian Islands.

Research on drought tolerance of native species will support new restoration efforts that seek to stabilize Hawai'i's dry and wet ecosystems, while research on the human dimensions of drought will support new efforts to prevent fires while providing information on how resource managers recently, and in the distant past, enhanced the resilience of the systems that sustained biodiversity and society.

Landsat 7/SOEST HMRG

Satellite image of the Hawaiian Islands.

-Dave Helweg, Director, Pacific Islands Climate Science Center & Christian Giardina, Pacific Southwest Research Station

Main Hawaiian Islands Drought Planning Agenda

Research

- Restore adequate monitoring infrastructure.
- Improve understanding of drought processes and relationships with other factors.
- Need more studies on the ecosystem services that could be lost and their socioeconomic and cultural impacts.

Management

- Manage stressors that interact with climate change.
- Include drought in landscape conservation design.
- Decision support tools.
- Support land management partnerships.
- Promote resilience, fire management, confront invasives, re-establish rare species habitats, insurance (breeding) populations.

Education

- Increase public awareness – residents and visitors (especially about fire and water issues).
- Increase awareness of elected officials.
- Sustainability agenda.

Participants at the Pacific Islands Climate Science Center workshop held in Honolulu, Hawai'i in March, 2017.

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For more information regarding ongoing research and activities at the Pacific Islands Climate Science Center, visit pi-csc.soest.hawaii.edu

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