

Climate Adaptation for Tropical Island Land Stewardship

Adapting a Workshop Planning Process to Hawai'i

Ryan J. Longman, Courtney L. Peterson, Madeline Baroli, Abby G. Frazier, Zachary Cook, Elliott W. Parsons, Maude Dinan, Katie L. Kamelamela, Caitriana Steele, Reanna Burnett, Chris Swanston, and Christian P. Giardina

Adaptation Planning and Practices for Hawai'i Forests and Native Ecosystems

What: More than 40 participants, representing federal and state government agencies, non-governmental organizations, academia, and private landholders met remotely to receive practical training in considering climate change information and identifying adaptation actions for natural resources management professionals working in forests and native Hawaiian ecosystems.

When: 26 January–16 March 2021

Where: Virtual, hosted by the Northern Institute of Applied Climate Science

KEYWORDS: Ecology; Tropics; Climate variability; Adaptation

<https://doi.org/10.1175/BAMS-D-21-0163.1>

Corresponding author: Ryan Longman, rlongman@hawaii.edu

In final form 3 August 2021

©2022 American Meteorological Society

For information regarding reuse of this content and general copyright information, consult the [AMS Copyright Policy](#).

AFFILIATIONS: Longman—East-West Center, Honolulu, Hawaii; Peterson—Forest and Rangeland Stewardship Department, Colorado State University, Fort Collins, Colorado, and Northern Institute of Applied Climate Science, Michigan Technological University, Houghton, Michigan; Baroli—Northern Institute of Applied Climate Science, Michigan Technological University, Houghton, Michigan; Frazier—Graduate School of Geography, Clark University, Worcester, Massachusetts; Cook—Institute of Pacific Islands Forestry, USDA Forest Service/Kupu AmeriCorps, Hilo, Hawaii; Parsons—Hawai'i Division of Forestry and Wildlife, Hilo, Hawaii; Dinan, Steele, and Burnett—USDA Southwest Climate Hub, Las Cruces, New Mexico; Kamelamela—Akaka Foundation for Tropical Forests, Hilo, Hawaii; Swanston*—Northern Institute of Applied Climate Science, Northern Research Station, USDA Forest Service, Houghton, Michigan; Giardina—Institute of Pacific Islands Forestry, Pacific Southwest Research Station, USDA Forest Service, Hilo, Hawaii

***CURRENT AFFILIATION:** Office of Sustainability and Climate, USDA Forest Service, Washington, D.C.

Tropical island ecosystems are highly vulnerable to the multiple threats of climate change (Nurse et al. 2014; Bonan 2008). In response, agencies and organizations are tasked with developing land-management strategies to help ecosystems adapt to changing environmental conditions (Swanston et al. 2016). Research has shown that proactive planning can reduce climate change impacts by facilitating more efficient and rapid responses (Bierbaum et al. 2013). Complex socio-ecological conditions, environmental change related stressors (e.g., wildfire, pests, disease, and drought), a lack of resources, and shifting public policy and agency mandates (Nagel et al. 2017) can all hinder response effectiveness (Crausbay et al. 2020). Despite these challenges, considerable progress has been made in assessing climate vulnerabilities of forest ecosystems and in developing adaptation options for land managers (Swanston and Janowiak 2012; Janowiak et al. 2014; Swanston et al. 2016; Halofsky et al. 2018; Schmitt et al. 2021). Adaptation planning in response to significant anticipated changes is becoming increasingly sophisticated, especially with respect to anticipated changes in forest wildfire regimes, species invasion, species composition, ecosystem health, and hydrological functioning due to climate change. Here we describe our conversion of a highly successful adaptation workshop process (Schmitt et al. 2021) to a virtual environment in response to COVID-19. We effectively delivered content to managers and created an experiential learning environment in which they developed adaptation tactics for their management projects, integrating Indigenous science and knowledge into the workshop format and content. This workshop was additionally novel because it used an adaptation process (Janowiak et al. 2014) that has been applied many times in the continental United States within primarily temperate and sub-boreal systems (<https://forestadaptation.org/>), and applied it for the first time to a tropical island system.

Climate Change Response Framework

The Northern Institute of Applied Climate Science (NIACS; www.niacs.org) has been collaboratively working with land managers since 2009 to conduct climate change vulnerability assessments and develop adaptation strategies and approaches through a Climate Change Response Framework (CCRF; <https://forestadaptation.org/>; Swanston et al. 2016). This framework uses the Adaptation Workbook and “menus” of discipline- or ecosystem-specific adaptation strategies to help natural resources professionals devise adaptation actions to meet their ecosystem management objectives. The CCRF then shares these real-world examples to

describe how climate change information can be integrated into management planning and implementation (Janowiak et al. 2014; <https://forestadaptation.org/adapt/demonstration-projects>).

Workshop format

Beginning in January 2021, NIACS, in collaboration with the USDA Southwest Climate Hub (www.climatehubs.usda.gov/hubs/southwest), the Pacific Drought Knowledge Exchange, and the Pacific Islands Climate Adaptation Science Center (PI-CASC; <https://pi-casc.soest.hawaii.edu/>) collaboratively led an “Adaptation Planning and Practices (APP)” Training for Hawai‘i-based stewardship professionals. Participants attended a series of eight weekly workshops, with each week focused on advancing climate adaptation planning and implementation including on-the-ground adaptation tactics. Designing this APP Training required overcoming COVID-19 related challenges and tailoring this adaptation workshop to a tropical island environment. The APP Training was designed for natural resource professionals working in forests, watersheds, and native ecosystems in Hawai‘i, as well as community-based land managers. Over eight weeks participants attended weekly 1.5-h web meetings (lectures and large and small group discussions), convened site-specific ad hoc meetings to discuss individual sites, and delivered presentations at the end of the program. Lectures were given by organizers as well as invited experts. Weekly Adaptation Workbook assignments were crafted to guide participants through adaptation planning materials and keep them actively engaged with organizers as they designed their projects. Interactions with APP instructors included one-on-one discussions to ensure that projects were robust, informed by the best information, and feasible. The typical APP project introduced participants to climate adaptation planning techniques appropriate for 20–50,000-ha parcels, and discussion with adaptation experts helped them with real-world planning considerations (Schmitt et al. 2021).

Climate portfolios

In preparation for the APP Training, each participant was provided a Climate Change, Climate Variability, and Drought (CCVD) portfolio (CCVD example, www.eastwestcenter.org/sites/default/files/filemanager/Research_pdfs/Hawaii%20and%20the%20US%20Affiliated%20Pacific%20Islands/Hawaii%20Volcanoes%20National%20Park_CCVD_Portfolio_V2_Workingin.pdf) that contained site-specific climate and drought information for each participant’s area of interest. These CCVD portfolios were developed by the Pacific Drought Knowledge Exchange to support the climate planning needs of stewards in Hawai‘i. The Pacific Drought Knowledge Exchange was formed to increase collaboration between scientists and managers, and support manager needs for a wide range of actions to prepare for and cope with drought (Frazier et al. 2019). Another goal of the Pacific Drought Knowledge Exchange is to facilitate exchange of knowledge and enable collaborative relationships among drought affected partners in Hawai‘i and the U.S.-affiliated Pacific islands.

The portfolios distill available gridded climate data products in Hawai‘i into a meaningful spatial resolution for land stewards and provide simplified analyses and descriptions of observed patterns and trends. The CCVD portfolio includes mean estimates of rainfall and other climate variables (Giambelluca et al. 2013, 2014), a 100-year time series analysis of rainfall and drought (Frazier et al. 2016; Lucas et al. 2020), and estimates of future changes in rainfall and temperature from downscaled projections for both mid- and end-century changes under high (RCP 8.5) and low (RCP 4.5) emissions scenarios (Elison Timm et al. 2015; Elison Timm 2017; Zhang et al. 2016; Xue et al. 2020).

Workshop results

In total, 42 individuals representing 19 organizations participated in the APP training, including two federal agencies (DOI Hawaii Volcanoes National Park and Haleakalā National Park),

Adaptation Workbook

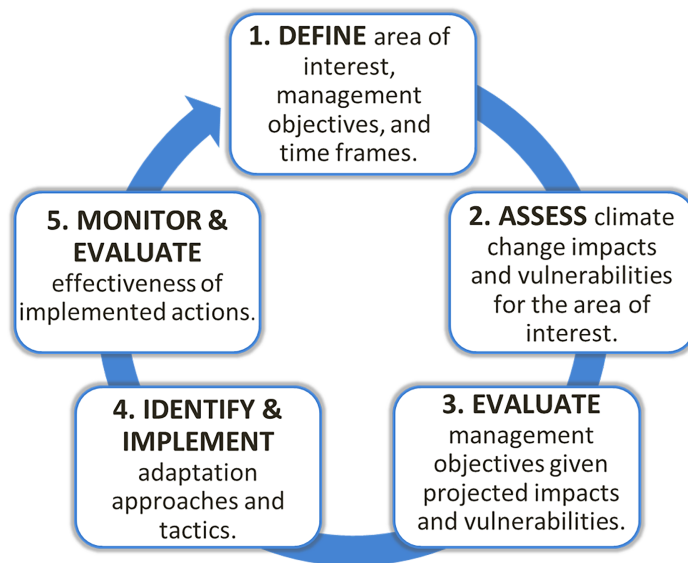


Fig. 1. Adaptation workbook process (Swanston et al. 2016; www.adaptationworkbook.org).

ten state or county organizations (Kaho‘olawe Island Reserve Commission, Three Mountain Alliance, O‘ahu Invasive Species Committee, Hawai‘i Division of Forestry and Wildlife, Department of Hawaiian Home Lands, Nāpu‘u Natural Resource Management, University of Hawai‘i at Mānoa, Wai‘anae Mountains Watershed Partnership, Division of Fish and Wildlife Kaua‘i, Leeward Haleakalā Watershed Restoration Partnership,), and seven NGOs (The Nature Conservancy, Kamehameha Schools, Gill Ewa Lands LLC, Protect Kaho‘olawe ‘Ohana, Pu‘uwa‘awa‘a Community Based Subsistence Forest Area, Akaka Foundation For Tropical Forests, PBR HI). Participants worked through five sequential steps of the Adaptation Workbook (Fig. 1), together spanning a diverse array of projects located across five islands (Hawai‘i, Kaho‘olawe, Kaua‘i, Maui, and O‘ahu). Small group discussions provided opportunities to engage in peer-to-peer learning, brainstorming, and sharing project information and proposed tactics. At the end of the eight-week course, each team had completed their own custom Adaptation Workbook analysis, with six of the teams giving a short presentation on their projects.

Climate vulnerabilities and adaptation priorities identified by land managers

To assess the overall vulnerability of their site and identify potential adaptation actions, participants first identified site-specific climate impacts, pulling information from regional vulnerability assessments, scientific literature, and the climate portfolios described above. Participants selected these regional climate change impacts as having the greatest influence on their management goals and objectives:

- altered precipitation patterns/seasonality,
- increases in non-native plant species,
- increasing drought conditions,
- increasing wildfire risk, and
- warmer temperatures at both high and low elevations.

Each team then identified a variety of adaptation approaches to guide their management actions. These approaches were selected from NIACS Menus of Adaptation Strategies and Approaches or developed by the team members (Table 1). Adaptation menus provide topical lists of adaptation actions that connect broad ideas to specific actions, and express the

Table 1. Climate adaptation themes, management goals, and management actions chosen in the APP training.

Themes	Management goals	Adaptation actions
Ecosystem Restoration	Restore native biodiversity, including endangered species recovery	Collect and propagate site appropriate plants Create or identify populations for protection Promote use of ecologically and culturally important species
	Reduce negative land use impacts and coastal erosion	Identify areas for active silvicultural trials and implementation Erosion fencing for ungulates and invasive plant control Climate-smart land use practices, native ground covers
	Reduce negative impacts of grazing	Use soil amendments to restore soil quality Remove ungulates to restore drylands
Wildfire	Manage increased wildfire risk and reduce threats to water quality	Collect, store and propagate fire tolerant/resistant species Maintain or establish fuel breaks incorporating native plants
Invasive Species	Reduce harmful effects of invasive species	Increase monitoring for early detection of invasive species Control and eradication of targeted invasive species
Drought	Manage for growing drought risk and build drought-resilient communities	Identify and restore drylands with drought-tolerant species Enhance water distribution systems Anticipate and mitigate drought
Cultural Stewardship	Center Indigenous values in community engagement and stewardship actions	Integrate Hawaiian practice of Kilo (to observe) to inform adaptation practice and stewardship of ‘āina (land) Conduct seasonal planting ceremonies
	Cultivate high-quality recreational opportunities	Lead culturally based observational moments Focus restoration on biocultural foundational keystone species serving ecological, sociocultural and subsistence functions, including non-timber forest products

adaptation intent of those actions. The menus provide adaptation strategies and approaches are informed by a combination of literature syntheses and widespread input from managers.

Cultural stewardship

Indigenous science and knowledge were integrated into the workshop through intentional program planning within an Indigenous framework. Prior to initiation of the program, Indigenous collaborators provided formal clarification of objectives and expectations, including potential benefits to Indigenous groups. Throughout the workshop NIACS facilitators created safe spaces for cultural stewardship dialogue by integrating recommendations from Hawai‘i-based team members, by confirming a land acknowledgment would be appropriate, then by supporting the writing and delivery of that land acknowledgment at the workshop orientation. A land acknowledgment statement (find and acknowledge Indigenous Lands here: <https://native-land.ca/>), is shared with the Indigenous community by a visiting member of the workshop to recognize historical injustices of Indigenous Peoples rooted in sovereignty, which impacts climate readiness.

The inclusion of Hawai‘i-based Indigenous organizers and a land acknowledgment statement at the beginning of the workshop, as well as individual invitations to participate in the APP Training based on personal connections, created an inclusive ethic, fostering opportunities for meaningful engagement throughout the workshop. Intentional recruitment of diverse participants and their subsequent involvement in the APP Training provided for a rich exchange between facilitators, researchers, and participants. These thoughtful actions can contribute to empowerment of Indigenous agency and collaborative land management (Winter et al. 2021). One such approach has already been defined by the Tribal Climate Adaptation Menu Team (2019) who developed an adaptation menu to serve tribes and tribal partners in the Great Lakes region. This Adaptation Menu (Dibaginjigaadeg Anishinaabe Ezhitwaad)

arose from the partnership between Tribal members, the Great Lakes Indian Fish and Wildlife Commission, and NIACS. The forefront of this approach is about developing “Culturally Appropriate Climate Adaptation Actions.” This approach can be replicated in Hawai‘i to make the Adaptation Workbook even more successful and appropriate for Indigenous perspectives in the Pacific Islands.

Mālama ‘Āina

Conservation and restoration work in Hawai‘i is often shaped by the concept of Mālama ‘Āina, which in Hawaiian means to care for the land, with the availability of resources and community wellbeing as a direct result of stewardship practices. For those working and living in Hawai‘i, it is important to recognize that conservation and land management groups highly value both the cultural and ecological connections they have to the land. Work to conserve an ecosystem or a species involves kincentric motivations, and a kuleana (responsibility) to care for the ‘āina (land) because Native Hawaiians are genealogically connected to the land, which is a beloved family member (Winter et al. 2021); this extends land management beyond the valuation of ecological functions, benefits, and services. This profound connection to place emphasizes reciprocal relationships and is captured by an often spoken phrase in Hawaiian restoration: “I ola ‘oe, I ola mākou nei,” meaning “My life is dependent on yours, your life is dependent on mine.”

Workshop best practices

Several key factors contributed to the success of the workshop. Leading up to the APP Training, organizers from NIACS, the Pacific Drought Knowledge Exchange, PI-CASC, and the Southwest Climate Hub met regularly to plan all aspects of the Training. Organizers hosted informational meetings with potential participants prior to the Training to answer questions, ensure preparedness, and adjust the workshop where necessary. Registered participants were asked to complete preliminary site assessment work using the adaptation framework. During the APP Training, participants received regular communications and opportunities for one-on-one support with assignments. The site-specific CCVD portfolios, in particular, were important to participant buy-in. The attention that APP Training instructors put into tailoring the presentations and resources to Hawai‘i, and the thoughtful adaptation of the in-person format to a virtual approach that included entirely online interactions, tools, and resources ensured the success of the Training. During whole-group discussions, all participants synthesized and shared ideas by adding annotations to a virtual board. Critically, there were enough instructors to facilitate up to six small break-out group discussions at one time. The efficiency in which instructors were able to execute both whole-group and break-out group participation was instrumental to fostering meaningful engagement.

Conclusions

The Adaptation Workbook and menus do not provide specific recommendations but are instead resources for brainstorming relevant adaptation actions to be used in adaptation planning. The APP Training is designed to help participants move from perceiving climate change as an impossible task (too large to address), to understanding how to break it into manageable steps that can be integrated into planning (Schmitt et al. 2021). The APP Training draws on the expertise of participants and complements existing processes for developing management plans and designing projects. Essentially, the APP Training and associated tools provide step-by-step instructions for land managers to translate the adaptation strategies and approaches they identified and turn them into on-the-ground management tactics. It also helps managers to consider how these forest management actions can be implemented over long time periods to maintain desired ecosystem functions and benefits across a range of plausible future climates

(Janowiak et al. 2014). Participants in the Hawai‘i APP Training brought a broad diversity of knowledge regarding potential future impacts of climate change and desired management goals and objectives. They found the process outlined in the Adaptation Workbook intuitive and straightforward, but they also discovered that to address each step thoroughly takes more time than they originally thought. Adaptation strategies that work for one location may not necessarily work for another. This not only depends on the environmental differences but also the perspectives and values of the communities. Some participants generously shared their projects online, which accelerates adaptation learning even as it demonstrates that many differing values and approaches can equally lead to conservation. The Hawai‘i APP Training helped to foster ideas, build confidence, and improve capacity of the many organizations and individuals dedicated to building resilience and addressing the threat of future changes to the climate, and the associated impacts to natural resources.

Acknowledgments. We thank Emile Elias for encouraging the Hawai‘i APP Training, and the USDA Southwest Climate Hub, the USDA Forest Service Institute of Pacific Islands Forestry, and the Pacific Islands Climate Adaptation Science Center for funding. This project would not be possible without the support of participants from across Hawai‘i, USNPS, USDA Forest Service, HI DLNR-DOFAW, The Nature Conservancy, Leeward Haleakalā Watershed Restoration Partnership, Three Mountain Alliance, O‘ahu Invasive Species Committee, Protect Kaho‘olawe ‘Ohana, Kaho‘olawe Island Reserve Commission, Dept. of Hawaiian Home Lands, Nāpu‘u Natural Resource Management, University of Hawai‘i at Mānoa, Wai‘anae Mountains Watershed Partnership, Kamehameha Schools, Gill Ewa Lands LLC, and PBR Hawaii and Associates PBR HI.). We also thank the NOAA National Integrated Drought Information System (NIDIS), for supporting the preparation of this meeting summary.

References

- Bierbaum, R., and Coauthors, 2013: A comprehensive review of climate adaptation in the United States: More than before, but less than needed. *Mitigation Adapt. Strategies Global Change*, **18**, 361–406, <https://doi.org/10.1007/s11027-012-9423-1>.
- Bonan, G. B., 2008: Forests and climate change: Forcings, feedbacks, and the climate benefits of forests. *Science*, **320**, 1444–1449, <https://doi.org/10.1126/science.1155121>.
- Crausbay, S. D., and Coauthors, 2020: Unfamiliar territory: Emerging themes for ecological drought research and management. *One Earth*, **3**, 337–353, <https://doi.org/10.1016/j.oneear.2020.08.019>.
- Elison Timm, O., 2017: Future warming rates over the Hawaiian Islands based on elevation-dependent scaling factors. *Int. J. Climatol.*, **37**, 1093–1104, <https://doi.org/10.1002/joc.5065>.
- , T. W. Giambelluca, and H. F. Diaz, 2015: Statistical downscaling of rainfall changes in Hawai'i based on the CMIP5 global model projections. *J. Geophys. Res. Atmos.*, **120**, 92–112, <https://doi.org/10.1002/2014JD022059>.
- Frazier, A. G., T. W. Giambelluca, H. F. Diaz, and H. L. Needham, 2016: Comparison of geostatistical approaches to spatially interpolate month-year rainfall for the Hawaiian Islands. *Int. J. Climatol.*, **36**, 1459–1470, <https://doi.org/10.1002/joc.4437>.
- , and Coauthors, 2019: Managing effects of drought in Hawai'i and U.S.-affiliated Pacific islands. *Effects of drought on forests and rangelands in the United States: Translating science into management responses*, J. M. Vose et al., Eds., Gen. Tech. Rep. WO-98, USDA Forest Service, 95–121, www.fs.usda.gov/treearch/pubs/59164.
- Giambelluca, T. W., Q. Chen, A. G. Frazier, J. P. Price, Y. L. Chen, P. S. Chu, J. K. Eischeid, and D. M. Delparte, 2013: Online rainfall atlas of Hawai'i. *Bull. Amer. Meteor. Soc.*, **94**, 313–316, <https://doi.org/10.1175/BAMS-D-11-00228.1>.
- , and Coauthors, 2014: Evapotranspiration of Hawai'i Final Report. *U.S. Army Corps of Engineers*, 168 pp.
- Halofsky, J. S., D. C. Donato, J. F. Franklin, J. E. Halofsky, D. L. Peterson, and B. J. Harvey, 2018: The nature of the beast: Examining climate adaptation options in forests with stand-replacing fire regimes. *Ecosphere*, **9**, e02140, <https://doi.org/10.1002/ecs2.2140>.
- Janowiak, M. K., and Coauthors, 2014: A practical approach for translating climate change adaptation principles into forest management actions. *J. For.*, **112**, 424–433, <https://doi.org/10.5849/jof.13-094>.
- Lucas, M. P., C. Trauernicht, A. G. Frazier, and T. Miura, 2020: Long-term, gridded standardized precipitation index for Hawai'i. *Data*, **5**, 109, <https://doi.org/10.3390/data5040109>.
- Nagel, L. M., and Coauthors, 2017: Adaptive silviculture for climate change: A national experiment in manager-scientist partnerships to apply an adaptation framework. *J. For.*, **115**, 167–178, <https://doi.org/10.5849/jof.16-039>.
- Nurse, L. A., and Coauthors, 2014: Small islands. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*, Cambridge University Press, 1613–1654.
- Schmitt, K. M., and Coauthors, 2021: Beyond planning tools: Experiential learning in climate adaptation planning and practices. *Climate*, **9**, 76, <https://doi.org/10.3390/cli9050076>.
- Swanston, C. W., and M. Janowiak, 2012: Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers. *Gen. Tech. Rep. NRS-87*, USDA Forest Service Northern Research Station, 121 pp., <https://doi.org/10.2737/NRS-GTR-87>.
- , and Coauthors, 2016: Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers. 2nd ed. *Gen. Tech. Rep. NRS-GTR-87-2*, USDA Forest Service Northern Research Station, 161 pp., www.fs.usda.gov/treearch/pubs/52760.
- Tribal Climate Adaptation Menu Team, 2019: Dibaginjigaadeg Anishinaabe Ezhitwaad: A Tribal Climate Adaptation Menu. Great Lakes Indian Fish and Wildlife Commission, 54 pp., <https://glifwc.org/ClimateChange/TribalAdaptationMenuV1.pdf>.
- Winter, K. B., and Coauthors, 2021: Empowering Indigenous agency through community-driven collaborative management to achieve effective conservation: Hawai'i as an example. *Pac. Conserv. Biol.*, **27**, 337–344, <https://doi.org/10.1071/PC20009>.
- Xue, L., and Coauthors, 2020: How will rainfall change over Hawai'i in the future? High-resolution regional climate simulation of the Hawaiian Islands. *Bull. Atmos. Sci. Technol.*, **1**, 459–490, <https://doi.org/10.1007/s42865-020-00022-5>.
- Zhang, C., Y. Wang, K. Hamilton, and A. Lauer, 2016: Dynamical downscaling of the climate for the Hawaiian Islands. Part II: Projection for the late twenty-first century. *J. Climate*, **29**, 8333–8354, <https://doi.org/10.1175/JCLI-D-16-0038.1>.