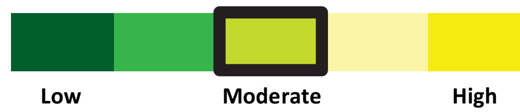
Mesic & Wet Forest Habitats

Climate Change Adaptation Summary for Hawaiʻi

An Important Note About this Document: *This document represents an initial effort to identify adaptation actions for mesic and wet forest habitats on the island of Hawaiʻi based on stakeholder input and existing information. Specifically, the information presented below comprises stakeholder input,[1] peer-review comments and revisions, and relevant examples from the literature or other similar efforts. The aim of this document is to expand understanding of possible adaptation actions for Hawaiʻi mesic and wet forest habitats in response to climate change.*

Habitat Vulnerability



Mesic and wet habitats on the island of Hawaiʻi were evaluated within three groups: mesic forests, montane wet forests, and lowland wet forests. Overall, mesic and wet forest habitats were evaluated as having moderate vulnerability to climate change due to moderate-high sensitivity to climate and non-climate stressors, moderate-high exposure to projected future climate changes, and moderate adaptive capacity, although individual rankings varied slightly between the forest types. Mesic and wet forest habitat types are primarily sensitive to factors that impact moisture gradients and water availability, including drought, changes in precipitation amount and timing, soil moisture, air temperature, and changes in wind and circulation patterns. Reduced water availability can alter species composition and forest distribution, potentially reducing habitat extent. Wildfire, tropical storms, disease, and volcanic activity can damage large areas of forest, resetting succession and increasing the risk of invasive species establishment. Invasive species (e.g., trees/shrubs, flammable grasses, ungulates, mammals, pathogens/parasites, social insects) are a major non-climate stressor for mesic and wet forest types, and these can alter ecosystem processes and directly compete with native species, contributing to species mortality, reduced recruitment and undermining the ecological integrity and persistence of native forests. Development, agriculture, and roads/highways reduce habitat extent and fragment and degrade remaining forest area. Although mesic and wet forests are relatively extensive on Hawaiʻi, lower-elevation forests are more fragmented and degraded due to human activity. Native species diversity and endemism is high; however, habitat fragmentation and invasive species have limited native mesic and wet forest regeneration following wildfire and other disturbances. Management and restoration efforts are not likely to alleviate the impacts of climate change, but mesic and wet forests have relatively high public value and societal support.

Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for Hawaiʻi mesic and wet forest habitats, and consists of stakeholder input during an adaptation workshop as well as additional options from the literature or other similar efforts. Stakeholders identified ways in which current management actions could be modified to reduce habitat vulnerabilities as well as future management actions that are not currently implemented but could be considered for future implementation.

Resilient management requires implementing a range of adaptation options within these different categories in order to achieve short-, mid-, and long-term resilience. These adaptation strategies and actions can generally be grouped according to one of five categories:

1. **Resistance**. These strategies can help to prevent the effects of climate change from reaching or affecting a resource.

[1] This information was gathered during a climate adaptation planning workshop in June 2017 (http://www.ecoadapt.org/workshops/hawaiiadaptationworkshop). Further information and citations can be found in the *Hawaiian Islands Climate Vulnerability and Adaptation Synthesis* and other products available online at www.bit.ly/HawaiiClimate.

2. **Resilience**. These strategies can help a resource withstand the impacts of climate change by avoiding the effects of or recovering from changes.
3. **Response**. These strategies intentionally accommodate change and/or enable resources to adaptively respond to changing and new conditions.
4. **Knowledge**. These strategies are aimed at gathering more information about climatic changes, impacts, or the effectiveness of management actions in addressing climate change.
5. **Collaboration**. These strategies may help coordinate efforts and/or capacity across landscapes and agencies.

Table 1. Summary of possible adaptation options for Hawaiʻi mesic and wet forest habitats. All strategies and actions were identified by Hawaiʻi workshop participants unless noted otherwise. Adaptation approaches are classified by implementation timeframes (*Near-term*: 0-5 years; *Mid-term*: 5-20 years; *Long-term*: >20 years).

Adaptation Approach	Adaptation Strategy	Specific Adaptation Actions
Resistance *Near-term approach*	Manage for invasive-resistant communities	• Expand fencing and ungulate removal in areas more resilient to invasion (e.g., aʻa lava flows, higher elevations) and Special Ecological Areas
	Increase biosecurity measures	• Support implementation of existing biosecurity plans
	Improve fire prevention and response	• Prevent off-road vehicle and pedestrian activity in high recharge areas, sensitive watersheds, and core native habitats through education and access limits[2] • Increase funding for support of fire response agencies and Community Wildland Protection Plans[2]
	Preserve, restore, and increase resilience of native ecosystems	• Protect and preserve remnant habitat, and include a diversity of sites[3]
Resilience *Near- to mid-term approach*	Maintain intact, native-dominated ecosystems	• Augment native habitat through outplanting and seeding of temperature- and drought-tolerant species in post-disturbance sites and buffer zones
	Create a self-sustaining forest that requires limited or no on-the-ground human management	• Change policy to allow the use of unmanned aerial systems to aid management efforts (e.g., invasive control, mapping/monitoring)
Response *Long-term approach*	Facilitate transition of species into new areas as climate regimes shift	• Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)[2] • Create test plots to determine where habitat may shift along ecotone boundaries and identify potential unintended consequences[2] • Erect fences across biome and habitat borders to allow for potential habitat and species range shifts[2]
Knowledge *Near- to long-term*	Increase development and implementation of new technology for invasive species	• Increase small-scale testing to determine ideal site conditions (e.g., treatment area size) • Look into community-based implementation options for

[2] Developed by Maui adaptation workshop participants in April 2017.
[3] Developed by Oʻahu adaptation workshop participants in April 2017.

Adaptation Approach	Adaptation Strategy	Specific Adaptation Actions
approach	control	new technology
	Increase education and outreach to increase public engagement and stewardship in conservation	• Increase awareness of biocultural and ecosystem services
Collaboration *Near- to long-term approach*	Increase education and outreach to increase public engagement and stewardship in conservation	• Promote native species in tourism and marketing • Support ecotourism • Increase cross-sectoral partnerships and promote understanding of diverse perspectives
	Increase biosecurity measures	• Determine individual agency roles in promoting biosecurity plans (e.g., decontamination stations, vehicle cleaning)

Table 2 identifies key Hawaiʻi mesic and wet forest habitat vulnerabilities that may be reduced and/or addressed by various adaptation actions. Linking vulnerabilities to adaptation options can help managers decide which actions to implement and aid prioritization based on multiple factors (e.g., habitat type, observed or projected changes, ecosystem service). However, when selecting adaptation actions for implementation, it is also important to consider secondary effects on other resources, both positive and negative. For example, fencing may benefit native forest ecosystems by limiting ungulate access and activity, but may increase ungulate stress on other habitats. For more information about mesic and wet forest habitat adaptation strategies and actions developed by workshop participants, including where and how to implement adaptation actions, implementation timeframe, collaboration and capacity required, and secondary effects on other resources (both positive and negative), please see the report *Hawaiian Islands Climate Vulnerability and Adaptation Synthesis*.

Table 2. Key vulnerabilities of Hawaiʻi mesic and wet forest habitats linked to specific adaptation actions and management activities (linkages are based on expert opinion); implementation of adaptation actions (central column) may help to directly reduce and/or address the impacts of identified climate and non-climate stressors and disturbance regimes (right columns). Actions highlighted in **red** represent adaptation strategies that enhance resistance, those highlighted in **orange** promote resilience, and those highlighted in **green** facilitate response. Adaptation actions aimed at increasing knowledge and collaboration are not included in this table as they address vulnerability indirectly. Adaptation actions listed in this table include those identified by stakeholders, in the scientific literature, and in other similar efforts.

Management Activity	Adaptation Actions	Climate Stressors			Disturbance Regimes		Non-Climate Stressors		
		↑ Drought; ↓ Soil moisture; Δ Precipitation (amount/timing)	↑ Air temperature	Δ Tropical storms/hurricanes	↑ Wildfire	Volcanic activity	Invasive species	Residential/commercial development; Roads/highways/trails	Agriculture
Habitat Management Activities	Expand fencing and ungulate removal in areas more resilient to invasion (e.g., aʻa lava flows, higher elevations) and Special Ecological Areas						✔		
	Support implementation of existing biosecurity plans						✔		
	Prevent off-road vehicle and pedestrian activity in high recharge areas, sensitive watersheds, and core native habitats through education and access limits				✔			✔	
	Augment native habitat through outplanting and seeding of temperature- and drought-tolerant species in post-disturbance sites and buffer zones	✔	✔		✔				
	Create test plots to determine where habitat may shift along ecotone boundaries and identify potential unintended consequences	✔	✔						
	Erect fences across biome and habitat borders to allow for potential habitat and species range shifts	✔	✔						
	Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)	✔	✔	✔	✔	✔	✔		
Policy & Planning Activities	Determine individual agency roles in promoting biosecurity plans (e.g., decontamination stations, vehicle cleaning)						✔		
	Increase funding for support of fire response agencies and Community Wildland Protection Plans				✔				
	Protect and preserve remnant habitat, and include a diversity of sites							✔	✔
	Change policy to allow the use of unmanned aerial systems to aid management efforts (e.g., invasive control, mapping/monitoring)	✔		✔	✔	✔	✔		

In addition to directly reducing vulnerabilities (Table 2), some adaptation actions may indirectly address vulnerabilities. For example, removing invasive ungulates is likely to reduce soil disturbances, which will minimize erosion during periods of heavy rainfall associated with storms.

Two other important considerations when selecting adaptation actions for implementation include feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability; Figure 1). An adaptation action with high feasibility has no obvious barriers and a high likelihood of implementation, whereas an action with low feasibility has obvious and/or significant barriers to implementation that may be difficult to overcome. An adaptation action with high effectiveness is very likely to reduce associated vulnerabilities (listed in Table 2) and may benefit additional management goals or resources, whereas an action with low effectiveness is unlikely to reduce vulnerability and may have negative impacts on other resources.

Feasibility of Implementing the Action

- *High*: There are no obvious barriers and it has a high likelihood of being implemented
- *Moderate*: It may be possible to implement the action, although there may be challenges or barriers
- *Low*: There are obvious and/or significant barriers to implementation that may be difficult to overcome

Action Effectiveness at Reducing Vulnerabilities

- *High*: Action is very likely to reduce vulnerability and may benefit additional goals or habitats
- *Moderate*: Action has moderate potential to reduce vulnerability, with some limits to effectiveness
- *Low*: Action is unlikely to reduce vulnerability

Figure 1. Description of action feasibility and effectiveness rankings.

Figure 2 plots adaptation actions listed in Table 1 according to feasibility and effectiveness (rankings described in Figure 1). Figure 2 can help managers prioritize actions for implementation (e.g., actions with high feasibility and high effectiveness), better target management efforts toward specific challenges (e.g., actions with low or moderate feasibility but high effectiveness), and/or evaluate whether to proceed with implementation (e.g., actions with high feasibility but low effectiveness). For the latter two purposes, managers may consider the following questions:

- **Low or Moderate Feasibility/High Effectiveness Actions**: What steps can be taken to increase the likelihood of this action being implemented in the future?
    - *Example*: Would improving public outreach and education or enhancing public/private collaboration facilitate increased management access and activity on private lands (e.g., to remove invasive species)?
- **High Feasibility/Low or Moderate Effectiveness Actions**: Does this action still make sense given projected climate changes and impacts?
    - *Example*: If conditions are projected to become drier, should groundwater pumping still continue to support lowland wetland hydrology?

Alternatively, there may be some actions that do not reduce vulnerability directly but could provide important information, tools, or support to address vulnerability down the line. For example, actions aimed at increasing knowledge through monitoring or modeling could provide key information for future restoration activities (e.g., creating detailed species genetic profiles to select genetically and ecologically suitable plant species for future conditions). Managers may want to weigh the costs and benefits of implementing actions with the timeframe required to reduce vulnerability directly. Additionally, actions focused on coordination and collaboration may not directly address vulnerabilities, but these remain important steps toward better planning and management.

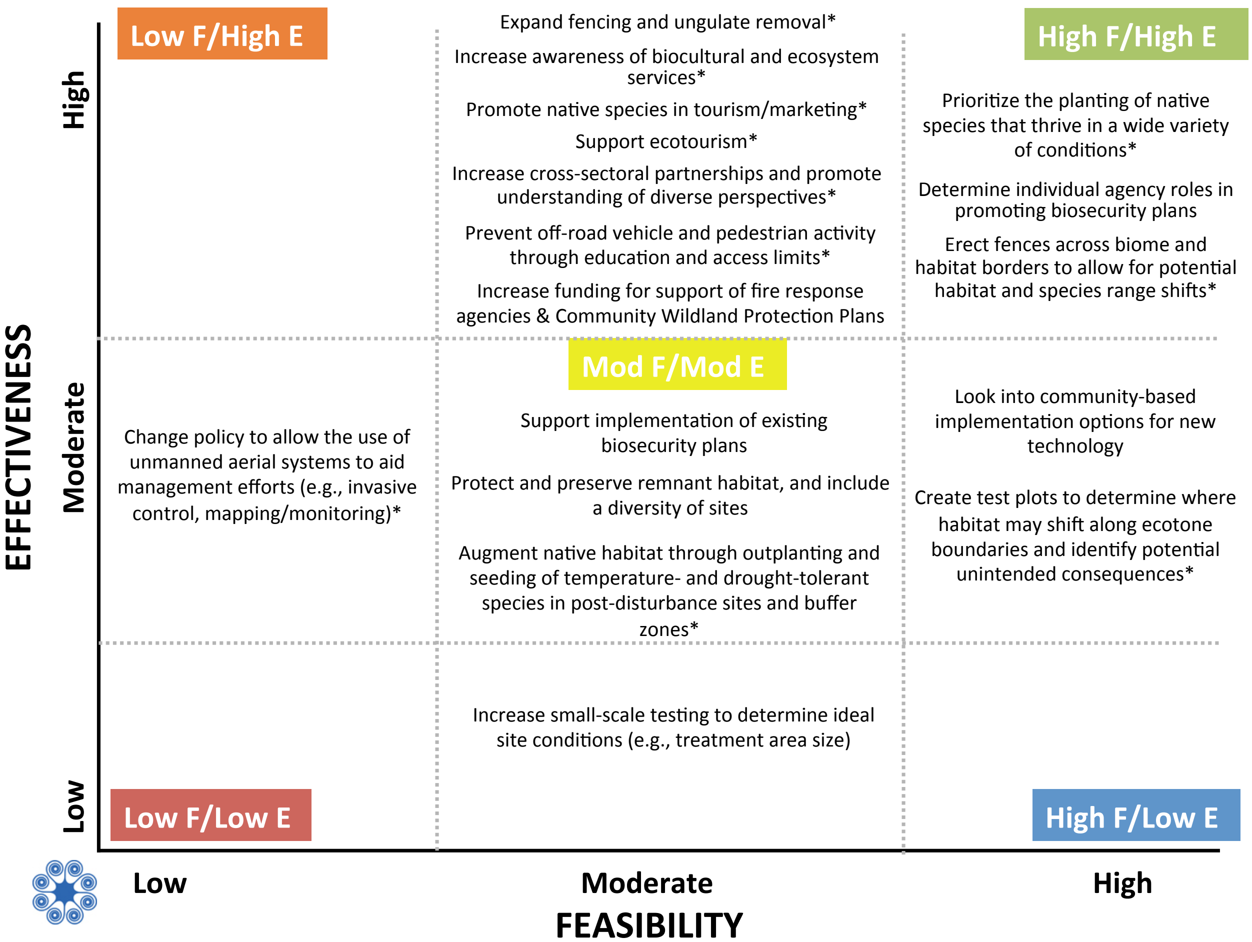


Figure 2. Hawaiʻi mesic and wet forest habitat adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner and those actions having low feasibility and effectiveness appear in the bottom left corner. An asterisk (*) denotes adaptation actions evaluated for feasibility and effectiveness by workshop participants. All other adaptation action evaluations are based on expert opinion.

Lastly, it is important to consider long-term consequences of implementing adaptation actions. One way to evaluate this is to consider how easy it would be to reverse a management action once it has been implemented in case of unintended consequences. When considering action reversibility, managers should consider cost, personnel time, overall time required to reverse an action, and other relevant factors. For example, it would likely be easy to reverse an action focused on altered outplanting timing; outplanting timing could simply be changed to a more favorable time. Alternatively, it would likely be hard to reverse the successful introduction of a new biocontrol agent, requiring significant personnel time and funding. Generally, actions involving infrastructure installation, policy or legislative change, or new species introductions may be moderately difficult or hard to reverse.

Table 3 lists adaptation actions identified in Table 1 according to ease of reversibility, as well as feasibility and effectiveness. This table can help managers evaluate whether to proceed with implementation (e.g., easily reversible actions) and/or identify actions that may need more research, small-scale testing, careful planning and implementation, and/or heightened adaptive management (e.g., moderately difficult or hard to reverse actions).

Table 3. Hawaiʻi mesic and wet forest habitat adaptation actions listed according to ease of reversibility, as well as feasibility and effectiveness. Actions that have high feasibility/effectiveness and are easy to reverse appear at the top of the list, and actions that have low feasibility/effectiveness and are hard to reverse appear at the bottom of the list. All adaptation action evaluations are based on workshop participant and expert opinion.

Adaptation Action	Feasibility	Effectiveness	Reversibility
Determine individual agency roles in promoting biosecurity plans (e.g., decontamination stations, vehicle cleaning, better maintain roadside eradication)	High	High	Moderate
Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)	High	Moderate-High	Easy
Erect fences across biome and habitat borders to allow for potential habitat and species range shifts	High	Moderate-High	Easy to Hard[4]
Look into community-based implementation options for new technology	High	Moderate	Easy
Create test plots to determine where habitat may shift along ecotone boundaries and identify potential unintended consequences	High	Moderate	Easy
Promote native species in tourism and marketing	Moderate	High	Easy
Support ecotourism	Moderate	High	Easy
Increase cross-sectoral partnerships and promote understanding of diverse perspectives	Moderate	High	Easy
Expand fencing and ungulate removal in areas more resilient to invasion (e.g., aʻa lava flows, higher elevations) and Special Ecological Areas	Moderate	High	Moderate
Support implementation of existing biosecurity plans	Moderate	Moderate	Moderate
Change policy to allow the use of unmanned aerial systems to aid management efforts (e.g., invasive control, mapping/monitoring)	Low-Moderate	Moderate-High	Easy
Augment native habitat through outplanting and seeding of temperature- and drought-tolerant species in post-disturbance sites and buffer zones	Moderate	Low-Moderate	Easy to Hard[5]
Increase small-scale testing to determine ideal site conditions (e.g., treatment area size)	Moderate	Low	Moderate

This document presents a range of adaptation options available for Hawaiʻi mesic and wet forest habitats. When applying adaptation principles in existing management frameworks, general best practices include:

- ✓ Utilizing a range of adaptation categories to promote short-, mid-, and long-term resilience.
- ✓ Thinking critically about which climate vulnerabilities an action can directly address versus those it may address indirectly.
- ✓ Identifying where opportunities overlap (e.g., actions that address multiple vulnerabilities or benefit multiple resources), and being cognizant of actions that could create detriments to other resources.

[4] Participants noted that the reversibility of this action ranges from easy (stop fence maintenance and allow for damage) to hard (expensive and logistically challenging to remove fences once in place).
[5] Participants noted that the reversibility of this action is dependent on scale.

- ✓ Prioritizing actions for implementation based on 1) how effective an action will be in reducing identified vulnerabilities; 2) how feasible implementing the action will be, and; 3) how easy it would be to reverse an action in case of unintended consequences.

Recommended Citation

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