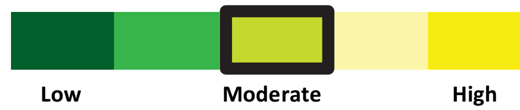
Upland Wetland Habitats

Climate Change Adaptation Summary for O'ahu

An Important Note About this Document: *This document represents an initial effort to identify adaptation actions for upland wetland habitats on O'ahu 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 O'ahu upland wetland habitats in response to climate change.*

Habitat Vulnerability



Upland wetland habitats on O'ahu 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. Climatic factors including precipitation, soil moisture, condensation levels, and drought affect water availability in upland wetlands, which along with air temperature, affects vegetation survival, composition, and peat formation. Tropical storms, wildfire, and disease may also affect water delivery to upland wetlands by affecting the condition of the broader water catchment; wildfire and tropical storms also affect wetland sediment input via erosion. Non-climate stressors such as invasive species (i.e., ungulates, flammable grasses, trees, and shrubs) can further alter upland wetland vegetative composition by displacing native species. Invasive vegetation also alters ecological processes, such as fire. Upland wetlands occupy only a small area on O'ahu and are structurally degraded by invasive species. Upland wetlands have limited room to migrate in response to climate change due to their location at high elevations, and the restricted range of component specialist and endemic species undermines overall habitat adaptive capacity. Vegetation appears to be somewhat resistant to invasives in the absence of disturbance, and able to recover from prior disturbance once disturbances (e.g., pigs) are removed. Additionally, vegetation seems somewhat adapted to seasonal variations in water availability, although large shifts in precipitation would likely lead to community composition changes. Management potential in the face of climate change is bolstered by high societal value, regulatory protection, and location of one wetland area within Natural Area Reserve boundaries.

Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for O'ahu upland wetland 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.
2. **Resilience**. These strategies can help a resource withstand the impacts of climate change by avoiding the effects of or recovering from changes.

---

[1] This information was gathered during a climate adaptation planning workshop in April 2017 (http://www.ecoadapt.org/workshops/oahuadaptationworkshop). 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.

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 Oʻahu upland wetland habitats. All strategies and actions were identified by Oʻahu 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 invasive species	• Increase invasive species eradication efforts through manual removal and/or biocontrol of ungulates, predators, and plants with a high rate of spread • Fence priority areas to exclude invasive species within intact forest
Resilience *Near- to mid-term approach*	Restore native habitat	• Restore habitat with resilient common species, as well as rare species
Response *Long-term approach*	Facilitate transition of species into new areas as climate regimes shift	• Identify and protect possible refugia based on precipitation modeling • Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)
Knowledge *Near- to long-term approach*	Increase restoration capacity	• Increase in-state capacity to conduct research on pests and pathogens • Increase knowledge of how to propagate common and rare species
Collaboration *Near- to long-term approach*	Increase outreach and education to support habitat restoration and management	• Increase education of the legislature, as well as public engagement with natural resource decisions made by the legislature
	Create new partnerships to increase capacity	• Increase state leadership, coordination, and engagement with organizations and stakeholders (e.g., watershed partnerships) • Collaborate with universities to conduct research on invasive species management • Improve data sharing within and between agencies

Table 2 identifies key Oʻahu upland wetland 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 upland wetland 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 Oʻahu upland wetland 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: Δ Precipitation (amount/timing); ↓ Soil moisture; ↑ Drought; Δ Condensation level	Climate Stressors: Δ Tropical storms/hurricanes	Climate Stressors: ↑ Air temperature	Disturbance Regimes: ↑ Wildfire	Disturbance Regimes: ↑ Disease	Non-Climate Stressors: Invasive species
Habitat Management Activities	Increase invasive species eradication efforts through manual removal and/or biocontrol of ungulates, predators, and plants with a high rate of spread						✔
	Fence priority areas to exclude invasive species within intact forest						✔
	Restore habitat with resilient common species, as well as rare species	✔	✔	✔	✔	✔	✔
	Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)	✔	✔	✔		✔	
	Identify and protect possible refugia based on precipitation modeling	✔					

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	Action Effectiveness at Reducing Vulnerabilities
• *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	• *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.

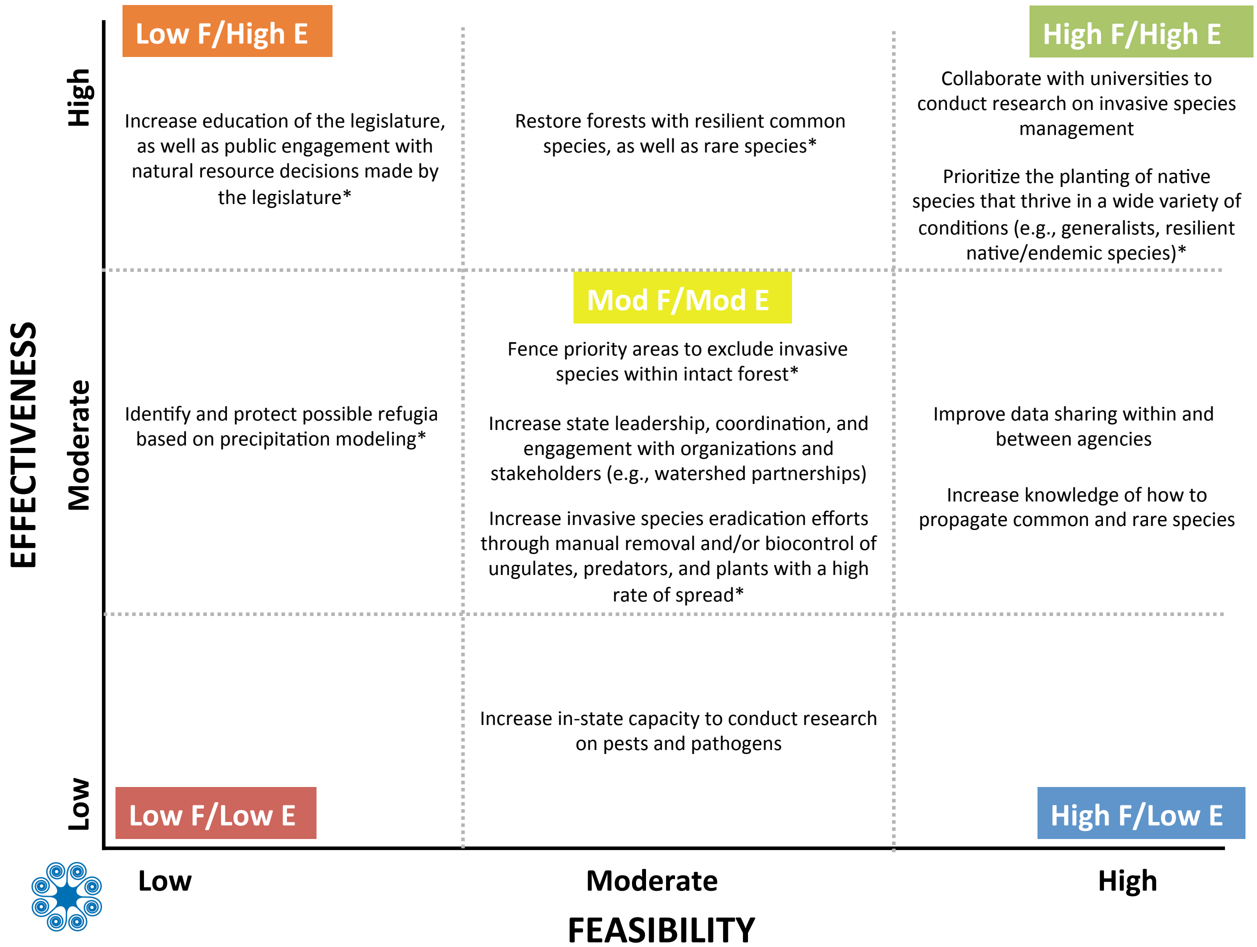


Figure 2. O'ahu upland wetland habitat adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner and those actions 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. Oʻahu upland wetland 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
Restore habitat with resilient common species, as well as rare species	Low-Moderate	Moderate to High[2]	Easy
Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)	High	High	Easy
Collaborate with universities to conduct research on invasive species management	High	High	Moderate
Improve data sharing within and between agencies	High	Moderate	Moderate
Increase knowledge of how to propagate common and rare species	High	Moderate	Moderate
Increase in-state capacity to conduct research on pests and pathogens	Moderate	Low	Moderate
Identify and protect possible refugia based on precipitation modeling	Low	Moderate	Moderate to Hard[3]
Fence priority areas to exclude invasive species within intact forest	Moderate	Moderate to High[4]	Moderate
Increase invasive species eradication efforts through manual removal and/or biocontrol of ungulates, predators, and plants with a high rate of spread	Moderate	Moderate to Unknown[5]	Moderate[5]
Increase state leadership, coordination, and engagement with organizations and stakeholders (e.g., watershed partnerships)	Moderate	Moderate	Moderate
Increase education of the legislature, as well as public engagement with natural resource decisions made by the legislature	Low	High	Moderate

This document presents a range of adaptation options available for Oʻahu upland wetland 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.
- ✓ 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.

---

[2] Participants noted that the effectiveness of this action when paired with fencing and invasive removal is high; when not paired, effectiveness is moderate.

[3] Participants noted that the reversibility of this action at a small scale is moderate; at a large scale, it is hard to reverse.

[4] Participants noted that the effectiveness of this action depends upon the type of upland forest present; for mesic forests, effectiveness is moderate and for wet forests, effectiveness is high.

[5] Participants noticed that the effectiveness of invasive species removal was moderate and reversibility was easy; for biocontrol, effectiveness is unknown and reversibility is hard.

Recommended Citation

Hilberg LE, Reynier WA, Kershner JM, Gregg RM. 2018. Upland Wetland Habitats: A Habitat Climate Change Adaptation Summary for Oʻahu. EcoAdapt, Bainbridge Island, WA.

Produced in cooperation with the Pacific Islands Climate Change Cooperative, with funding from the U.S. Fish and Wildlife Service.