Shoreline Habitats

Climate Change Adaptation Summary for Kaua'i

An Important Note About this Document: *This document represents an initial effort to identify adaptation actions for shoreline habitats on Kaua'i 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 Kaua'i shoreline habitats in response to climate change.*

Habitat Vulnerability

Shoreline habitats on Kaua'i were evaluated in five sub-groups: sandy beaches, sand dunes, rocky shorelines, cliffs, and caves. Overall, shoreline habitats on Kaua'i were evaluated as having high vulnerability to climate change due to high sensitivity to climate and non-climate stressors, high exposure to projected future climate changes, and low adaptive capacity. Climatic factors including tropical storms, sea level rise, and trade winds significantly affect sediment delivery patterns and shoreline vulnerability to erosion and inundation, potentially reducing overall habitat availability. Extreme precipitation events, streamflow, and riverine flooding also impact sediment delivery, erosion, and inundation risk, but to a lesser degree. Shoreline habitats are also sensitive to precipitation changes and drought, which affect vegetation communities and habitat conditions (e.g., cave humidity). Non-climate stressors such as pollution, invasive pathogens and parasites, recreation, and invasive vegetation can further alter shoreline vegetative and faunal composition by disturbing, outcompeting, or causing mortality of native species. Additionally, development and shoreline armoring eliminate shoreline habitat, prevent landward migration in response to sea level rise, and often increase erosion. The adaptive capacity of shoreline habitats is negatively affected by current habitat degradation and alteration as a result of human activities. Shoreline species are typically adapted to variable conditions, but human impacts undermine the natural ability of these habitats to cope with changing conditions. Additionally, shoreline habitats host many endangered, threatened, and climatically vulnerable species, reducing overall resilience. Some shoreline habitats are protected and managed, and shoreline habitats are highly valued by the public and provide many ecosystem services, which may increase overall management opportunities. However, managers lack funding and face challenges with private land ownership. Additionally, shoreline habitats face continued use conflicts with development and military activities.

Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for Kaua'i shoreline 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] This information was gathered during a climate adaptation planning workshop in June 2017 (http://www.ecoadapt.org/workshops/kauaiadaptationworkshop). 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.

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.
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 Kaua'i shoreline habitats. All strategies and actions were identified by Kaua'i 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	• Control invasive predators (cats, rats, snakes, mongooses) • Remove hau and mangroves • Increase biosecurity
	Prepare for sea level rise impacts	• Prioritize coastal areas for protection
	Reduce non-climate stressors	• Reduce litter and marine debris[2] • Remove existing debris from coastal habitats[2]
Resilience *Near- to mid-term approach*	Prepare for sea level rise impacts	• Redesign development guidelines to account for sea level rise and other climate change impacts
	Restore coastal habitats	• Restore dune and coastal strand habitats[3] • Nourish beaches in areas where habitat retreat is not an option[4] • Use exclusion fencing and restoration in upland habitats to enhance coastal erosion control[3]
	Practice climate-informed habitat restoration	• Maintain and/or increase coastal habitat restoration efforts that incorporate climate information[5]
	Implement climate-informed coastal zoning protections	• Incorporate climate change into Special Management Area siting and permitting[3] • Revise setback requirements to account for projected sea level rise[3]
Response *Long-term approach*	Prepare for sea level rise impacts	• Plant salt- and flood-tolerant vegetation
	Anticipate and facilitate habitat migration	• Implement living shorelines and green infrastructure • Facilitate managed retreat of infrastructure and human

[2] Score, A., editor. 2017. Rapid Vulnerability Assessment and Adaptation Strategies for the National Marine Sanctuary and Territory of American Samoa. EcoAdapt, Bainbridge Island, WA.
[3] Developed by Maui adaptation workshop participants in April 2017.
[4] Developed by O'ahu adaptation workshop participants in April 2017.
[5] EcoAdapt. 2017. Climate Adaptation Strategies and Actions. Bainbridge Island, WA.

Adaptation Approach	Adaptation Strategy	Specific Adaptation Actions
		communities • Plan for and facilitate inland/upland habitat migration • Limit development in inland/upland areas where coastal habitats may migrate • Investigate the utility of maintaining mangroves if they can effectively buffer sea level rise and flooding impacts • Acquire property with high future ecosystem value (e.g., less developed, less exposed/vulnerable sites)[4]
Knowledge *Near- to long-term approach*	Prepare for sea level rise impacts	• Map sea level rise impacts and future shoreline position
Collaboration *Near- to long-term approach*	Reduce human pressure on native ecosystems and species	• Improve land-use planning and increase outreach on conservation-informed land uses • Increase and create different education and outreach campaigns based on target audiences (resident vs. tourist, older vs. younger)

Table 2 identifies key Kaua'i shoreline 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 shoreline 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*.

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Table 2. Key vulnerabilities of Kaua'i shoreline 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				
		↑ Tropical storms/hurricanes; Δ Extreme precipitation events	Sea level rise	Δ Precipitation (amount/timing)	↑ Drought	Increasingly variable riverine flooding; ↓ Stream baseflows	Δ Wind & circulation	Residential & commercial development	Recreation	Invasive species	Seawalls	Pollution & poisons
Habitat Management Activities	Control invasive predators (cats, rats, snakes, mongooses)									✔		
	Remove hau and mangroves									✔		
	Increase biosecurity									✔		
	Prioritize coastal areas for protection	✔	✔					✔	✔			
	Reduce litter and marine debris											✔
	Remove existing debris from coastal habitats											✔
	Restore dune and coastal strand habitats	✔	✔		✔					✔		
	Nourish beaches in areas where habitat retreat is not an option	✔	✔				✔	✔				
	Use exclusion fencing and restoration in upland habitats to enhance coastal erosion control									✔		
	Maintain and/or increase coastal habitat restoration efforts that incorporate climate information	✔	✔	✔	✔	✔	✔					
	Incorporate climate change into Special Management Area siting and permitting	✔	✔					✔			✔	
	Revise setback requirements to account for projected sea level rise	✔	✔					✔			✔	
	Redesign development guidelines to account for sea level rise and other climate change impacts		✔					✔			✔	
	Plant salt- and flood-tolerant vegetation	✔	✔			✔						
	Implement living shorelines and green infrastructure	✔	✔			✔		✔			✔	
	Facilitate managed retreat of infrastructure and human communities		✔					✔			✔	
	Plan for and facilitate inland/upland habitat migration		✔					✔				
	Acquire property with high future ecosystem value (i.e. less developed, less exposed/vulnerable sites)	✔	✔				✔	✔	✔			
	Limit development in inland/upland areas where coastal habitats may migrate		✔					✔				
	Investigate the utility of maintaining mangroves if they can effectively buffer sea level rise and flooding impacts	✔	✔			✔						

In addition to directly reducing vulnerabilities (Table 2), some adaptation actions may indirectly address vulnerabilities. For example, planting salt-tolerant native vegetation may help combat and reduce the prevalence of invasive species.

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.

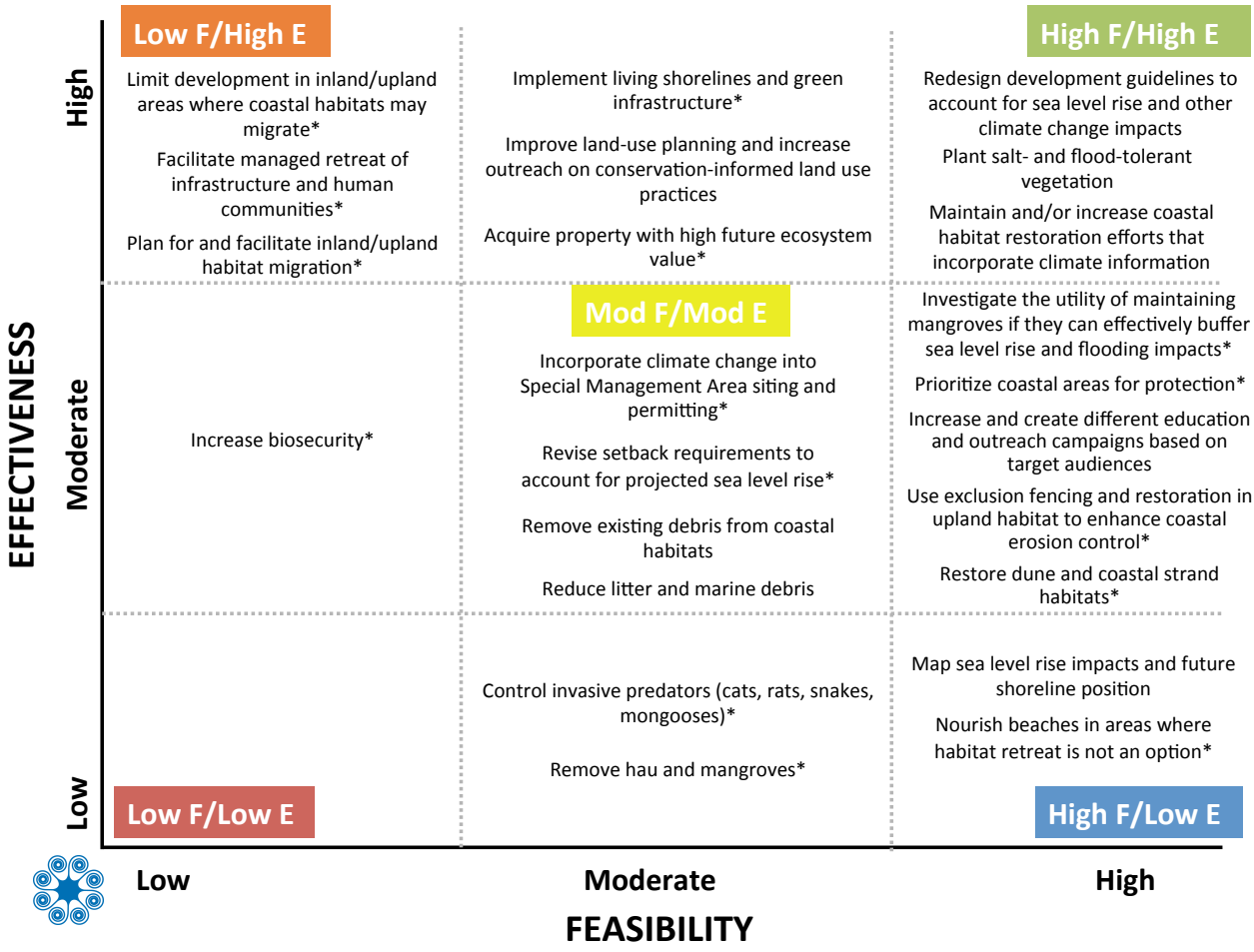

Figure 2. Kaua'i shoreline habitat adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner and those actions having 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. Kaua'i shoreline 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
Maintain and/or increase coastal habitat restoration efforts that incorporate climate information	High	High	Moderate
Redesign development guidelines to account for sea level rise and other climate change impacts	High	High	Easy
Plant salt- and flood-tolerant vegetation	High	High	Hard[6]
Prioritize coastal areas for protection	High	Moderate	Easy
Investigate the utility of maintaining mangroves if they can effectively buffer sea level rise and flooding impacts	High	Moderate	Easy
Restore dune and coastal strand habitats	High	Moderate	Easy
Use exclusion fencing and restoration in upland habitats to enhance coastal erosion control	High	Moderate	Easy
Increase and create different education and outreach campaigns based on target audiences (e.g., older vs. younger, tourists vs. residents)	High	Moderate	Moderate
Acquire property with high future ecosystem value (i.e. less developed, less exposed/vulnerable sites)	Moderate	High	Moderate
Implement living shorelines and green infrastructure	Moderate[7]	High	Moderate
Improve land-use planning and increase outreach on conservation-informed land use practices	Moderate	High	Moderate
Reduce litter and marine debris	Moderate	Moderate	Easy
Remove existing debris from coastal habitats	Moderate	Moderate	Hard
Incorporate climate change into Special Management Area siting and permitting	Moderate	Moderate	Moderate
Revise setback requirements to account for projected sea level rise	Moderate	Moderate	Moderate
Nourish beaches in areas where habitat retreat is not an option	Moderate-High	Low	Easy
Map sea level rise impacts and future shoreline position	High	Low	Hard
Limit development in inland/upland areas where coastal habitats may migrate	Low	High	Moderate

[6] Participants noted that the action may be hard to reverse once plants have successfully established.
[7] Participants noted that action feasibility depends on political will.

Facilitate managed retreat of infrastructure and human communities	Low	High	Hard
Plan for and facilitate inland/upland habitat migration	Low	High	Hard
Control invasive predators (cats, rats, snakes, mongooses)	Moderate	Low	Hard
Remove hau and mangroves	Moderate	Low	Hard
Increase biosecurity	Low	Moderate	Easy

This document presents a range of adaptation options available for Kaua'i shoreline 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.

Recommended Citation

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