Recreation and Tourism

Climate Change Adaptation Summary for Maui, Lāna'i, and Kaho'olawe

An Important Note About this Document: *This document represents an initial effort to identify adaptation actions for recreation and tourism on Maui Nui[1] based on stakeholder input and existing information. Specifically, the information presented below comprises stakeholder input,[2] 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 Maui Nui recreation and tourism in response to climate change.*

Ecosystem Service Vulnerability

Recreation and tourism ecosystem services on Maui Nui were evaluated as having moderate-high vulnerability to climate change due to moderate-high sensitivity to climate and non-climate stressors, high exposure to projected future climate changes, and moderate-high adaptive capacity. Recreation and tourism are sensitive to climatic factors that reduce the integrity or naturalness of native systems or affect the health and behavioral patterns of wildlife, including drought, low streamflow, sea surface temperature changes, and increasing air temperatures. Recreation and tourism are also sensitive to factors such as sea level rise, flooding, tropical storms, extreme precipitation events, and wildfire that contribute to loss of recreation and tourism opportunities (e.g., physical loss of beaches, loss of access in burned or flooded areas). Insects and disease also degrade tourism and recreation experiences by negatively impacting Hawaiian landscapes and wildlife, and posing as a health hazard to visitors. A variety of non-climate stressors threaten recreation and tourism by affecting natural landscape integrity and access and degrading water quality via elevated runoff. Land use changes (e.g., urban development, agriculture, roads/highways/trails, water diversions, energy development) eliminate natural areas and alter ecosystem processes, impacting valued wildlife and native plant species characteristic of Hawai'i and exacerbating some impacts of climate change (e.g., flooding, erosion). Similarly, invasive species (e.g., ungulates, flammable grasses, trees, reptiles/amphibians, parasites/pathogens, social insects) displace native species and alter regional forest and watershed processes, affecting tourism and recreation access, quality, and safety. As a main component of Maui Nui's economy, recreation and tourism are highly valued and management for these ecosystem services has moderate-high societal support. However, management can be challenging because recreation and tourism can potentially degrade other ecosystem services (e.g., fresh water, food production, aesthetic values, cultural services), though it can benefit some services as well (e.g., provides support for biodiversity and conservation).

Adaptation Strategies and Actions

Table 1 presents a summary of possible adaptation strategies and actions for Maui Nui recreation and tourism ecosystem services, 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

[1] The vulnerability assessment workshop approach was not applied to Moloka'i as the PICCC funded Ka Honua Momona between 2014-2016 to host a workshop series to identify climate-related risks and vulnerabilities, and brainstorm potential solutions and partnerships. EcoAdapt and the PICCC were invited to participate in a one-day workshop with the Moloka'i Climate Change Network in April 2017 to discuss adaptation options. Members of the network are continuing to meet to discuss potential next steps, including developing an implementation and funding plan.

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

actions could be modified to reduce ecosystem service 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.
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 Maui Nui recreation and tourism ecosystem services. All strategies and actions were identified by Maui Nui 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*	Improve fire prevention and response	• Enhance public awareness of the risks and consequences of wildfire to native plant ecosystems • Increase funding for support of fire response agencies and Community Wildland Protection Plans
	Improve water conservation efforts	• Increase public and private water system conservation (i.e. alter rate structure, use low-flow fixtures, detect and fix leaks) • Increase agricultural water conservation (i.e. promote soil moisture management, capture rain water)
	Reduce non-climate stressors	• Increase public education to minimize disturbance and/or degradation of vulnerable habitats or species[3]
	Manage invasive species	• Prevent introduction of new diseases and pathogens by increasing biosecurity controls (e.g., quarantines, interisland policies, optional vs. mandatory restrictions)[4]
	Maintain/improve water quality and quantity	• Investigate and reduce non-point source pollution[5]
Resilience *Near- to mid-term approach*	Ensure no new development occurs in areas that will likely be inundated in the future	• Change permitting rules to limit development along the shoreline and floodplain to higher elevations above the 100-year sea level rise projections
	Provide sustainable recreation	• Adjust the timing of actions (e.g. open/close dates, road

[3] EcoAdapt. 2017. Climate Adaptation Strategies and Actions. Bainbridge Island, WA.
[4] Developed by Kaua'i adaptation workshop participants in June 2017.
[5] Developed by Hawai'i adaptation workshop participants in June 2017.

Adaptation Approach	Adaptation Strategy	Specific Adaptation Actions
	opportunities in response to changing supply and demand	or trail closures, food storage orders, special use permits) to accommodate changing climate conditions[6]
	Enhance habitat and species resilience	• Identify and protect refugia (e.g., temperature-tolerant coral areas)[3]
	Manage recreation sites to mitigate risks to public safety and infrastructure and to continue to provide recreation opportunities	• Modify existing infrastructure to better withstand future climate conditions[6] • Adjust infrastructure maintenance schedule as needed to accommodate changing climate conditions[6] • Relocate at-risk infrastructure[6]
Response *Long-term approach*	Implement climate-informed coastal zoning protections	• Revise setback requirements to account for projected sea level rise • Modify the formula for erosion control to incorporate data on climate change • Limit development in most vulnerable sites
	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)
Knowledge *Near- to long-term approach*	Monitor pollutants to protect water quality	• Monitor point- and non-point source pollutants associated with agriculture and development (e.g., fertilizers, insecticides, agricultural byproducts)
Collaboration *Near- to long-term approach*	Increase direct community restoration	• Conduct place-based community education, organizing, management, and action focused on habitat restoration, cultural practices, and climate change impacts

Table 2 identifies key Maui Nui recreation and tourism ecosystem service 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 Maui Nui adaptation strategies and actions developed by workshop participants, many of which are relevant to resilient management of recreation and tourism ecosystem services, 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*.

[6] EcoAdapt. 2016. Decision Support Tools for Natural Resource Managers: Vulnerability-Adaptation Tables. http://ecoadapt.org/programs/adaptation-consultations/decsuptools

Table 2. Key vulnerabilities of Maui Nui recreation and tourism ecosystem services 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								
		Sea level rise; ↑ Shoreline change; ↑ Coastal flooding	Δ Precipitation (amount/timing); ↑ Drought; ↓ Stream baseflows	↑ Tropical storms/hurricanes; Δ Extreme precipitation events	↑ Sea surface temperature	↑ Air temperature	Δ Wind & circulation	↑ Wildfire	Increasingly variable riverine flooding	↑ Disease & insects	Residential & commercial development	Agriculture & aquaculture	Pollution & poisons	Energy production	Roads, highways & trails	Groundwater development	Water diversions	Recreation	Invasive species
Habitat Management Activities	Enhance public awareness of the risks and consequences of wildfire to native plant ecosystems							✔											✔
	Increase public education to minimize disturbance and/or degradation of vulnerable habitats or species							✔										✔	✔
	Prevent introduction of new diseases and pathogens by increasing biosecurity controls (e.g., quarantines, intraisland policies, optional vs. mandatory restrictions)								✔										✔
	Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)	✔	✔	✔		✔	✔	✔	✔	✔									✔
	Identify and protect refugia (e.g., temperature-tolerant coral areas)	✔	✔	✔	✔	✔	✔	✔	✔	✔									
Land Use Planning Activities	Increase funding for support of fire response agencies and Community Wildland Protection Plans							✔											
	Change permitting rules to limit development along the shoreline and floodplain to higher elevations above the 100-year sea level rise projections	✔							✔		✔								
	Revise setback requirements to account for projected sea level rise	✔		✔							✔								
	Modify the formula for erosion control to incorporate data on climate change	✔		✔					✔										
	Limit development in most vulnerable sites	✔									✔								

Table 2 (continued)

Management Activity	Adaptation Actions	Climate Stressors					Disturbance Regimes				Non-Climate Stressors								
		Sea level rise; ↑ Shoreline change;	↑ Coastal flooding	Δ Precipitation (amount/timing);	↑ Drought; ↓ Stream baseflows	↑ Tropical storms/hurricanes; Δ Extreme precipitation events	↑ Sea surface temperature	↑ Air temperature	Δ Wind & circulation	↑ Wildfire	Increasingly variable riverine flooding	↑ Disease & insects	Residential & commercial development	Agriculture & aquaculture	Pollution & poisons	Energy production	Roads, highways & trails	Groundwater development	Water diversions	Recreation	Invasive species
Water Resources Management Activities	Increase public and private water system conservation (i.e. alter rate structure, use low-flow fixtures, detect and fix leaks)		✔								✔					✔				
	Increase agricultural water conservation (i.e. promote soil moisture management, capture rain water)		✔									✔					✔			
	Investigate and reduce non-point source pollution												✔							
Recreation Management Activities	Adjust the timing of actions (e.g. open/close dates, road or trail closures, food storage orders, special use permits) to accommodate changing climate conditions			✔				✔											✔	
	Modify existing infrastructure to better withstand future climate conditions	✔		✔					✔							✔			✔	
	Adjust infrastructure maintenance schedule as needed to accommodate changing climate conditions	✔		✔					✔							✔			✔	
	Relocate at-risk infrastructure	✔						✔	✔							✔			✔	

In addition to directly reducing vulnerabilities (Table 2), some adaptation actions may indirectly address vulnerabilities. For example, increasing funding for support of fire response agencies may help increase or accelerate reforestation efforts post-fire, which could help reduce risk of downstream sedimentation and flood events that could impact recreation and tourism.

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.

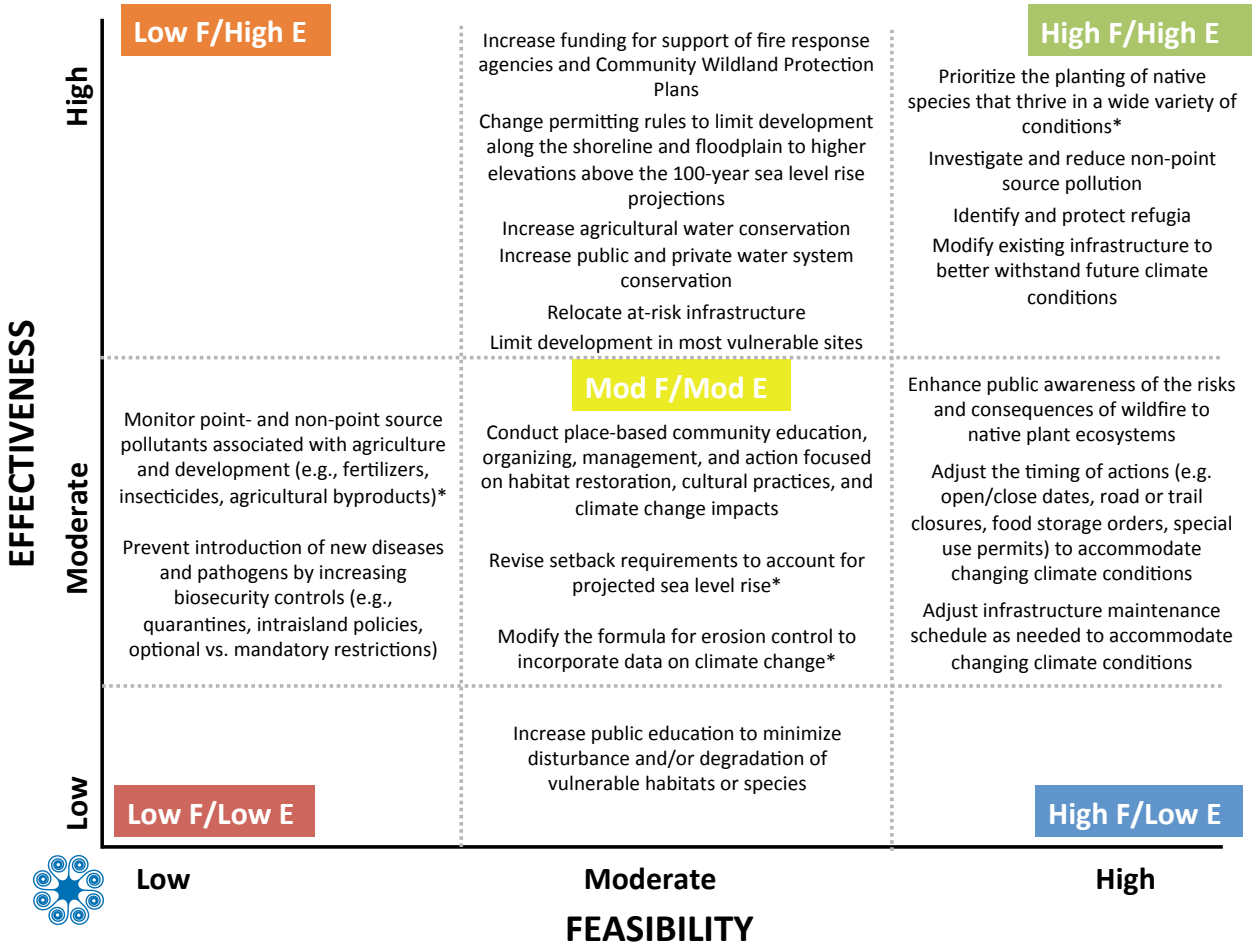

Figure 2. Maui Nui recreation and tourism ecosystem service adaptation actions plotted according to implementation feasibility (action capable of being implemented) and effectiveness (action reduces vulnerability). Those actions having high feasibility and effectiveness appear in the upper right corner 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. Maui Nui recreation and tourism ecosystem service 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
Prioritize the planting of native species that thrive in a wide variety of conditions (e.g., generalists, resilient native/endemic species)	High	High	Easy
Investigate and reduce non-point source pollution	High	High	Easy
Identify and protect refugia (e.g., temperature-tolerant coral areas)	High	High	Moderate
Modify existing infrastructure to better withstand future climate conditions	High	High	Hard
Adjust the timing of actions (e.g. open/close dates, road or trail closures, food storage orders, special use permits) to accommodate changing climate conditions	High	Moderate	Easy
Adjust infrastructure maintenance schedule as needed to accommodate changing climate conditions	High	Moderate	Easy
Enhance public awareness of the risks and consequences of wildfire to native plant ecosystems	High	Moderate	Moderate
Revise setback requirements to account for projected sea level rise	Moderate-High	Low-Moderate	Hard
Modify the formula for erosion control to incorporate data on climate change	Moderate-High	Low-Moderate	Moderate
Increase funding for support of fire response agencies and Community Wildland Protection Plans	Moderate	High	Moderate
Increase agricultural water conservation (i.e. promote soil moisture management, capture rain water)	Moderate	High	Moderate
Relocate at-risk infrastructure	Moderate	High	Hard
Limit development in most vulnerable sites	Moderate	High	Moderate
Change permitting rules to limit development along the shoreline and floodplain to higher elevations above the 100-year sea level rise projections	Moderate	High	Moderate
Increase public and private water system conservation (i.e. alter rate structure, use low-flow fixtures, detect and fix leaks)	Moderate	High	Moderate
Conduct place-based community education, organizing, management, and action focused on habitat restoration, cultural practices, and climate change impacts	Moderate	Moderate	Moderate
Increase public education to minimize disturbance and/or degradation of vulnerable habitats or species	Moderate	Low	Moderate
Monitor point- and non-point source pollutants associated with agriculture and development (e.g., fertilizers, insecticides, agricultural byproducts)	Low	Moderate	Easy
Prevent introduction of new diseases and pathogens by increasing biosecurity controls (e.g., quarantines, intraisland policies, optional vs. mandatory restrictions)	Low	Moderate	Easy

This document presents a range of adaptation options available for Maui Nui recreation and tourism ecosystem services. 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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