



# PACIFIC BIRDS

HABITAT JOINT VENTURE



T. Wolf

## Strategic Plan for Hawai'i Wetlands

## 2024



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### In Collaboration with Conservation Partners in Hawai‘i

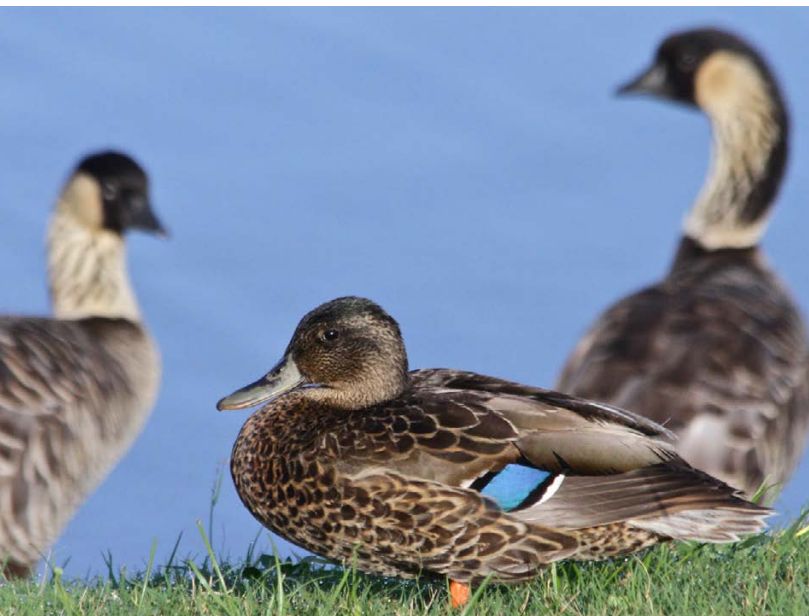
#### *Federal Government Agencies*

U.S. Fish and Wildlife Service,  
U.S. Geological Survey, National Park Service.

#### *State of Hawai‘i*

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Department of Hawaiian Homelands.

#### *Non-governmental Organizations and Private Landowners*



Left: Nēnē with koloa maoli. *H. Osterlund*

Right: 'Alae 'ula with chick. *H. Osterlund*

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# 1 | Introduction

## About Pacific Birds Habitat Joint Venture

Migratory Bird Habitat Joint Ventures are cooperative, regional partnerships located in the United States, Canada, and Mexico. [Pacific Birds Habitat Joint Venture](#) (Pacific Birds) includes the Hawaiian and other Pacific Islands, Alaska, and the coastal regions of the Pacific Northwestern USA and British Columbia, Canada.

Joint Ventures work through partnerships to improve habitats for birds and people. To do so, they assist partners to secure funding; help identify, prioritize, and implement shared conservation actions; raise awareness about birds and conservation through communications work; and foster on-the-ground habitat conservation. Since 1987, Migratory Bird Habitat Joint Ventures have protected a network of 33 million acres of key habitat, thanks to the power of partners working together.

Pacific Birds is primarily funded through the U.S. Fish and Wildlife Service (USFWS) Migratory Bird Program and led by an International Management Board. Pacific Birds has two fiscal sponsors, Ducks Unlimited and Oregon Wildlife Foundation. Pacific Birds operates independently from these two organizations, with a mission to “create the ideal environment for bird habitat conservation.” Pacific Birds’ work in Hawai‘i is guided by the leadership of the board and two key committees; the Pacific Birds U.S. Steering Committee, comprised of U.S.- based board members, and the Hawai‘i Wetlands Committee, comprised of U.S.- based board members, Pacific Birds staff, and Hawai‘i partners.

**In Hawai‘i, Pacific Birds is focused on advancing the conservation and restoration of wetlands for the benefit of birds, native wildlife, ecosystem services, people, and climate security.**



Pacific Birds staff, board members, and partners at Stillaguamish River Delta, WA. A. Summers





## Goals of Pacific Birds in Hawai‘i

Pacific Birds' goals in Hawai‘i are to restore and conserve healthy and climate-resilient wetland habitats across the Hawaiian Islands by:

- ▶ Building and maintaining effective partnerships.
- ▶ Supporting partners through networking, communications, and sourcing funding to achieve collective conservation goals for wetlands.
- ▶ Increasing the resilience of coastal wetlands in the face of climate change by ensuring that conservation planning accounts for expected climate impacts<sup>1</sup> and by increasing opportunities to include wetlands as nature-based solutions<sup>2</sup> for climate change impacts.



Top: Moloka‘i Wetland Partnership. *Ka Ipu Makani*

Bottom: DOFAW and Pacific Birds at Kawainui Marsh. *H. Raine*

<sup>1</sup> Climate impacts considered include sea level rise, marine and groundwater inundation, passive flooding, annual high wave flooding, and coastal erosion.

<sup>2</sup> Nature Based Solutions (NBS) refer to the sustainable management and use of natural features (e.g. wetlands) and processes to tackle socio-environmental issues (IUCN, 2023)



# Geography

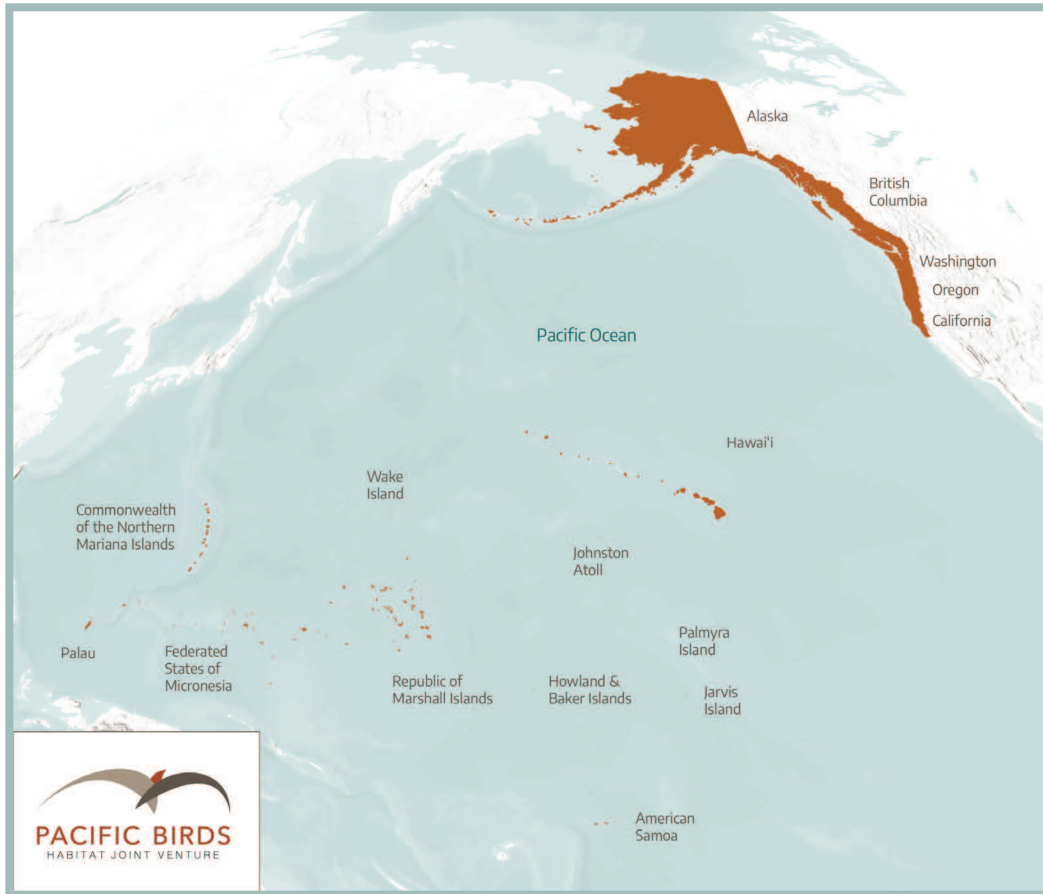


Figure 1. Pacific Birds' geographic service area includes the Pacific Northwest and much of the Pacific.



The geographic focus of this plan includes seven of the Main Hawaiian Islands (MHI) — Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, Kaho'olawe and Hawai'i Island.

Figure 2. This plan focuses on wetlands in the Main Hawaiian Islands.



# Background, Goals and Objectives of the Plan

## Background

The Strategic Plan for Hawai'i Wetlands prioritizes wetland sites and conservation actions to improve habitats for waterbirds and people, based on current and future conditions.

The plan builds upon the 2006 [Strategic Plan for Hawaiian Wetlands](#) that describes the planning and regulatory framework for wetland conservation and provides information on “core,<sup>3</sup> supporting, and other” sites identified in the USFWS Recovery Plan for Hawaiian Waterbirds (2011).

The Strategic Plan aligns with and draws from existing and in-development planning efforts, while analyzing new data to prioritize sites. Key planning documents for wetlands and waterbirds in Hawai'i include the U.S. Fish and Wildlife Service Recovery Plan for Hawaiian Waterbirds (2011) and the Hawai'i Department of Land and Natural Resources (DLNR) Hawai'i State Wildlife Action Plan (2015).

DLNR Divisions of Forestry and Wildlife (DOFAW) and Aquatic Resources (DAR) are also developing ‘Protection and Restoration Strategies’ for two priority wetland ecotypes, anchialine pools and marshes ([Table 1](#)), with estuaries expected to be added in future. Pacific Birds, DLNR, and other partners have collaborated closely throughout the planning process, and the DLNR prioritization included many criteria identified through the Pacific Birds’ work.

## Goal of the Plan

To guide the effective protection, restoration and management of wetlands for the benefit of Threatened and Endangered (T&E) waterbirds, migratory shorebirds and waterfowl, human communities, ecosystems, and climate resilience in Hawai'i.

## Objectives of the Plan

- Objective 1:** Prioritize wetlands for restoration across the state.
- Objective 2:** Secure and direct funding and resources to protect, restore, and manage wetlands.
- Objective 3:** Identify strategies and site-based actions to advance wetland conservation.
- Objective 4:** Incorporate Indigenous priorities for wetland restoration into planning and implementation work, including Indigenous agroecology.

The Wetland Plan has a ten-year horizon (2024–2034) but is intended as a living document that will be reviewed and updated as needed.

Table 1. A comparison of the DLNR (DAR/DOFAW) Plan and Pacific Birds Plan.

DLNR Plan	Pacific Birds Plan
Includes 1) marshes and 2) anchialine pools only	Includes all habitat in <a href="#">Table 2</a>
Includes state owned/managed sites or sites with DLNR partnerships	Includes multiple land ownership types
Emphasis on promoting habitat for native species with a focus on endemic and T&E species (all taxa)	Emphasis on recovery of T&E waterbirds, migratory shorebirds and waterfowl

<sup>3</sup> Core wetlands are defined by USFWS as “necessary for nesting”. Most core wetlands are managed by USFWS NWRs or the State and are intended to be managed in perpetuity. Supporting wetlands are “the stepping stones between core wetlands for foraging, loafing, etc., as well as potential nesting sites (depending on management).” (C. Harrington, pers. comm. 2023)



# 3

## Wetland Habitats



Keahuolū (Lili'uokalani Trust). H. Raine

This plan considers sites with wetland habitats defined by the **revised coastal wetland classifications** outlined in Drexler et al. (2023), based on Erickson and Puttock (2006) (Figure 3), and additional habitats and flooded lands used by waterbirds in Hawai'i<sup>4</sup> (Table 2).

Indigenous agriculture (Table 3) is included in the plan as these practices can provide habitat for waterbirds which is comparable to managed wetlands, provided that the needs of birds are considered (Bremer et al., 2018; Gee, 2007; Greer, 2005; Harmon et al., 2022; Möhlenkamp, 2018; Opie, 2022; USDA, 2009; USFWS, 2020a, 2020b; Webber, 2022; Winter et al., 2020).

Riverine wetlands and aquatic habitats within a stream or river channel are not included as a separate classification unless they occur adjacent to palustrine or estuarine wetlands.<sup>5</sup> Upland wetland bogs are not included.

Table 2. Habitats and land uses considered in the plan.

Habitats and Land Uses in Plan
Mudflats
Lowland swamps
Coastal shrub wetlands
Coastal fens
Herbaceous marshes
Estuarine and intertidal wetlands
Lakes
Reservoirs
Indigenous agroecology (Table 3)
Flooded aquaculture (e.g. shrimp or lotus farms)

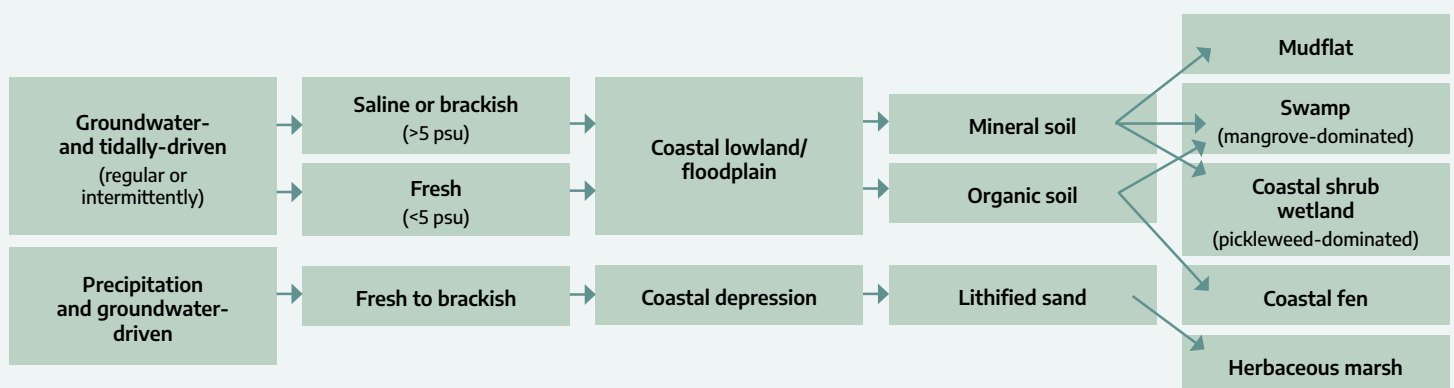


Figure 3. A classification system for coastal wetlands (Drexler et al., 2023).

<sup>4</sup> There are likely other wetland types throughout the Hawaiian Islands that are yet to be classified (Drexler, pers. comm. 2023).

<sup>5</sup> Stream and riverine habitats are likely important, particularly for 'ālae 'ula. Van Rees et al. (2018a) found that they likely facilitate movement of the species between wetlands. The lack of clear ownership and absence of mapping and other key data on this habitat prevented its inclusion in this edition of the plan, but it could be considered for future iterations.





Top: Hanalei National Wildlife Refuge (USFWS). *H. Raine*  
 Center: Alakoko Fishpond (Mālama Hulē'ia). *H. Raine*  
 Bottom: J. Drexler in Moloka'i during USGS and Pacific Islands Climate Change Adaptation Science Center fieldwork. *B. Haase*

Table 3. Indigenous agroecology considered in the plan, that can provide habitat for waterbirds (Keala et al., 2007. Lima, pers. comm.).

Type	Water	Description
Taro		
Lo'i kalo	Freshwater	Taro pondfield
Lo'i pūnāwai	Freshwater	Spring-fed taro pond / pondfield
Lo'i loko i'a	Freshwater	Taro pondfield adjacent to or within fishpond
Fishponds		
Loko pu'uone	Brackish	Connected to the sea by stream or ditch
Loko ku'apa	Brackish	Coastal fishpond with a wall, usually built over reef flat
Loko i'a kalo	Freshwater	Taro and fishpond
Loko wai	Freshwater	Natural ponds excavated by hand and irrigated through an 'auwai (channel)
Salt Ponds		
Lo'i pa'akai	Brackish	Salt pond and adjacent ponds



Nēnē. *H. Osterlund*





Top: Kōlea. *H. Osterlund*  
 Middle: Ae'o chick. *L. Beaugard USFWS*.  
 Bottom: Ūlilī. *H. Osterlund*

Species associated with wetland habitats identified by Pacific Birds and partners as conservation priorities for this planning process include the following:

## Priority species

### Threatened and Endangered Waterbirds and Waterfowl<sup>6</sup>

- ▶ Ae'o or Hawaiian Stilt (*Himantopus mexicanus knudseni*)
- ▶ 'Alae ke'oke'o or Hawaiian Coot (*Fulica alai*)
- ▶ 'Alae 'ula or Hawaiian Common Gallinule (*Gallinula galeata sandvicensis*)
- ▶ Koloa maoli or Hawaiian Duck (*Anas wyvilliana*)
- ▶ Nēnē or Hawaiian Goose (*Branta sandvicensis*)

## Focal species

### Migratory Waterfowl<sup>7</sup>

- ▶ Koloa mōhā or Northern Shoveler (*Spatula clypeata*)
- ▶ Koloa māpu or Northern Pintail (*Anas acuta*)
- ▶ American Wigeon (*Mareca americana*)
- ▶ Lesser Scaup (*Aythya affinis*)

### Migratory Shorebirds<sup>8</sup>

- ▶ Kōlea or Pacific Golden-Plover (*Pluvialis fulva*)
- ▶ Kioea or Bristle-thighed Curlew (*Numenius tahitiensis*)
- ▶ 'Ūlilī or Wandering Tattler (*Tringa incana*)
- ▶ 'Akekeke or Ruddy Turnstone (*Arenaria interpres*)
- ▶ Hunakai or Sanderling (*Calidris alba*)

For a table showing the status, range, and requirements of all endemic waterbirds and waterfowl, as well as migratory waterfowl and shorebirds in Hawai'i, see [Appendix 4](#).

<sup>6</sup> Identified in the Recovery Plan for Hawaiian Waterbirds (USFWS 2011). Plan also identifies recovery targets.

<sup>7</sup> Identified as top priorities in Conserving Hawai'i's Wetlands and Waterbirds (Pacific Birds Habitat Joint Venture, 2017) and Species of Greatest Conservation Need in Hawai'i State Wildlife Action Plan (Hawai'i Department of Land and Natural Resources, 2015).

<sup>8</sup> Identified in U.S. Pacific Islands Regional Shorebird Conservation Plan (Engilis and Naughton, 2004) and Species of Greatest Conservation Need in Hawai'i State Wildlife Action Plan (Hawai'i Department of Land and Natural Resources, 2015).



## Background

Wetlands in Hawai‘i are unusual ecosystems worldwide due to their hydrology, often characterized by groundwater discharge, intermittently heavy precipitation, porous volcanic soil, and steep terrain (Ward, 2015). The Hawaiian Islands have lost at least 15% of their original wetland acreage; in coastal areas the loss reaches up to 44%, with 65% on O‘ahu (van Rees and Reed, 2014; Henry, 2006). The current extent of coastal plain wetlands in the Main Hawaiian Islands is approximately 15,474 acres<sup>9</sup> (USFWS, 2021).

The causes of wetland declines include agricultural drainage, development, invasive species expansion, and human population growth leading to higher demand for water (USFWS, 2021). Climate change will exacerbate this trend; freshwater wetland habitat losses will occur through sea level rise (SLR), marine and groundwater inundation, passive flooding, annual high wave flooding, coastal erosion, saltwater intrusion, storm surges, declining water tables, and drought as the climate crisis continues (Harmon et al., 2021; Kane et al., 2015; NOAA, 2014; van Rees and Reed, 2018b).

In addition, dramatic changes to upland areas have reduced the ability of forests to absorb heavy rain. Intense periods of rainfall are not new for the Hawaiian Islands; there are more than 200 words for rain in the Hawaiian language (Akana and Gonzalez, 2016) and the forests have evolved to capture this water. In an ‘ua lani pili’ (sudden downpour) the forest acts like a giant sponge. However, due to the loss of native trees, establishment of invasive species like albizia (*Falcateria falcata*), and vegetation loss caused by invasive ungulates, this natural flood control system has begun to break down.

The roots of invasive species do not hold soil and water as well as native plants do. This causes large amounts of sediment and harmful pollutants to wash down the ahupua‘a (watershed) in storm events, negatively impacting adjacent reefs. Due to poor flushing rates in Hawai‘i, fine sediments can be trapped for decades, reducing reef productivity and health (TNC and EMWP, 2019). Large-scale flooding also occurs during major rain events as streams flash flood, and large rivers like the Hanalei in Kaua‘i or the Waimea in O‘ahu burst their banks. Since much of the natural floodplain has been developed, human communities and infrastructure are at high risk of more frequent and destructive flooding.



Makauwahi Cave Reserve. A. Raine

9 Excluding reservoirs, irrigation and flood control ditches, golf course water features, streams, ephemeral springs and basins, or sewer treatment ponds (USFWS, 2021).



## Wetlands mitigate climate change impacts

**Wetlands are the final line of defense to capture sediment, nutrients, and pollutants, and absorb flood events and coastal surges** (NOAA, 2014, Hovis et al, 2021).

A relatively small wetland might hold millions of gallons of flood water and slow its release (Foster et al., 2011). It is therefore critically important to stem losses of this habitat (NOAA, 2014), not only for wildlife or cultural values, but also for the ecosystem services that they provide.

## Wetlands provide community benefits

Communities in Hawai'i are vulnerable to the effects of climate change. Towns are commonly connected to essential services by single roads, which often run along the coast. Flash flooding, severe weather, and extreme storm surges cause catastrophic impacts to community access and safety. Additionally, in a state where up to 90% of food is imported, impacts to roads have significant consequences for food security. Damage to reefs also impacts food supply; in 2017, Hawai'i's aquatic resources supplied more than 7 million local meals, and the non-commercial value of catch was estimated between 7-12 million USD (Grafeld et al., 2017). Sedimentation adversely affects coral and reduces overall reef productivity (Tenever et al., 2016).

The people of Hawai'i have a long tradition of managing and maintaining wetlands for food and ecosystem services, in addition to adapting to localized changes. With the right support, communities can draw on this history to use wetland restoration as a nature-based solution. Community benefits of protecting wetlands include:

- ▶ Climate resilient infrastructure; e.g., roads better protected from catastrophic mudslides, homes protected from flooding.
- ▶ Nearshore ocean water quality improvements and ecosystem recovery through sediment capture.
- ▶ Improved reef resilience leading to protection of shorelines vulnerable to flooding; higher subsistence fishing yields.
- ▶ Improved surface water and groundwater supply to mitigate drought; restoration of multiple springs.
- ▶ Restoration of sustainable, culturally-important crops to reduce dependence on imported food.
- ▶ Opportunity to train the next generation to manage sustainable Hawaiian systems.
- ▶ Recovery of Threatened and Endangered waterbirds and migratory birds with cultural and ecosystem importance, as well as endemic fish, shrimp and invertebrates, and plants.
- ▶ Recreational opportunities.
- ▶ Natural beauty.







Kanaha Pond, He'eia NERR and Moloka'i mudflats. H. Raine

## Wetlands support endangered and migratory birds

Four endangered birds with extremely small global populations are wetland dependent:

- ▶ 'Alae 'ula or Hawaiian Common Gallinule (*Gallinula galeata sandvicensis*), world population ~1000
- ▶ 'Alae ke'oke'o or Hawaiian Coot (*Fulica alai*), world population ~2000
- ▶ Ae'o or Hawaiian Stilt (*Himantopus mexicanus knudseni*), world population ~2000
- ▶ Koloa maoli or Hawaiian Duck (*Anas wyvilliana*), world population ~1000

A threatened goose, the nēnē (*Branta sandvicensis*), world population ~ 3159, uses wetlands extensively (Paxton et al., 2022).

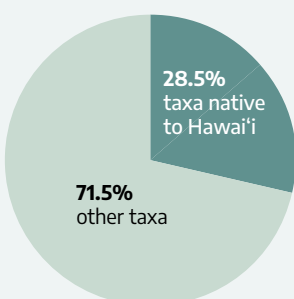
Kaua'i is home to the majority of the koloa maoli population (and those under least threat from hybridization with feral Mallards), as well as the majority of nēnē. Only Kaua'i and O'ahu support 'alae 'ula, with the bird extirpated from all other islands (van Rees and Reed, 2018b).

Thirty species of migratory waterfowl and more than thirty species of migratory shorebirds rely on wetland habitats in the Hawaiian Islands (Ducks Unlimited, 2023). One of the most notable is the kioea or Bristle-thighed Curlew (*Numenius tahitiensis*), which is IUCN vulnerable and listed as a Species of Greatest Concern in the U.S. Shorebird Conservation Plan (2004).

In total, it is estimated that wetlands in Hawai'i support 222 taxa of plants and animals listed under the U.S. Endangered Species Act (ESA), most of which are endemic to the islands (van Rees and Reed, 2014).

**Endemism is high in Hawai'i, and the remaining wetlands provide critically important habitat for native and endemic plant and animal species.**

ESA-listed taxa in the US  
1,476 species total

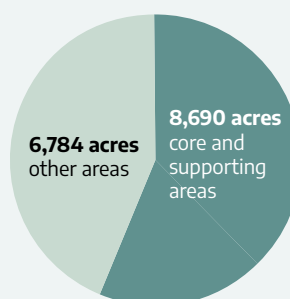


ESA-listed taxa native to Hawai'i account for 28.5% of the 1,476 species listed in the U.S.

Of these, 53% occupy wetlands in at least part of their range.

(van Rees and Reed, 2014).

Coastal plain wetlands  
15,474 acres overall



Of the coastal plain wetlands, roughly half (8,690 acres) are identified as core (5,820 acres) or supporting areas (2,869 acres) important for the recovery of waterbirds.

Core areas	5,820 acres
Supporting areas	2,870 acres

(USFWS, 2011)



## Wetland habitat includes culturally important Indigenous agriculture

Irrigated wetlands date back to 600 CE on Kaua'i and 1200–1400 CE on O'ahu and Moloka'i (Greer, 2005). By the time of European contact, nearly all lowlands with perennial streams contained irrigation systems, creating large areas of managed agricultural wetlands for the subsistence crop kalo (taro, *Colocasia esculenta*) (Kirch, 1982). Lo'i kalo (wetland taro patches) and loko i'a (fishponds) created a mosaic of wetland habitat along the coast (Burney et al., 2001; Harmon et al., 2021, Drexler et al., 2023) which was highly suitable for waterbirds and provided more wetland habitat than was available before Polynesians arrived (Engilis and Pratt, 1993, Olson and James, 1982). Naturalist Munro (1960) noted the presence of the birds in 'swampy taro patches' in 1891 (Greer, 2005).

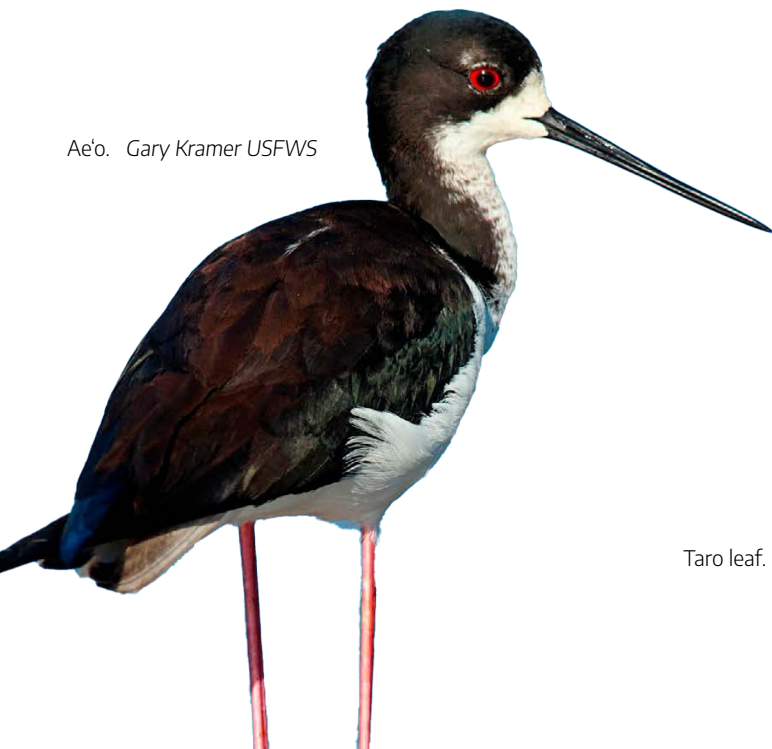
This mosaic of habitat continues to this day, albeit in only a tiny fraction compared to past accounts of the former range. Cultivation of kalo, lotus, watercress, shrimp, ogo, sea asparagus, and other crops can provide habitat similar to natural wetlands for waterbirds while producing sustainable food for local communities and, in some cases, providing an important source of economic revenue.

In addition, more than 350 fishponds have been identified, mainly within coastal lowlands and shorelines on the main islands (Wyban and Wyban, 1989), ranging from 0.5–500 acres, some with varied areas of open water and vegetated marshlands, which also provide important habitat. Most of these are in need of restoration, with only 14 still in production statewide (McCoy et al., 2017).



Top: Ae'o in a lo'i kalo. T. Wolf  
Bottom: 'Ūlili in a loko i'a. T. Wolf

Ae'o. Gary Kramer USFWS



Taro leaf. H. Raine





# 6

## Planning Framework

This planning effort prioritizes wetland sites for restoration across the state. It was created using a collaborative approach with partners as follows:

- ▶ Site managers and owners provided site-based data and information which was collected in a scoring matrix
- ▶ With partners, threats to wetlands, waterbirds and migratory birds were identified
- ▶ A climate sensitivity analysis was carried out

(See [Appendix 3](#) for methods)

This approach allowed identification of priority sites ([Table 5](#)) and site-specific conservation actions shown in the site narratives ([Appendix 5](#)). Strategies to address conservation challenges were also identified ([Section 8](#)).

After identifying the top 20 ranking priority sites, supplemental prioritizations for the sites not in the top 20 were also created, based on:

- ▶ High climate resilience at 2100
- ▶ Fewest roadblocks ('easy wins')
- ▶ Importance for Indigenous agroecology
- ▶ Prioritization by island

A detailed site narrative was created for each site in the plan ([Appendix 5](#)).

This planning process did not include an in-depth community outreach project or elicit Traditional Ecological Knowledge. This is a recognized gap and an important next step to ensure that communities are fully engaged in site-level implementation and statewide planning.



J. Jacobi surveying wetlands in Moloka'i. B. Haase



# 7

## Threats to Wetlands, T&E Waterbirds and Migratory Birds in Hawai'i

To effectively restore and manage wetlands and recover waterbird populations, it is vital to identify and better understand the threats they face. During the planning process, site managers, land owners, and other experts identified key threats to wetlands, waterbirds, and migratory waterfowl and shorebirds birds in Hawai'i (see [Appendix 3](#) for methods). The top threats identified were climate change impacts, predators, water quality and roads / car strikes (see [Table 4](#) for full list).

### Climate change related threats

Climate impacts were considered separately from other threats because the plan seeks to guide future investment in wetland management. The timescale and extent of site loss is, therefore, particularly important.



Floods in Hanalei. J. Guy

### Climate analysis

A climate sensitivity analysis was used to determine the threat of climate impacts to each wetland site in the prioritization using sea-level rise (SLR) projections from Anderson et al. (2018). The impacts of marine and groundwater inundation were considered separately for impacts by 2050 (1.1 ft SLR) and by 2100 (3.2 ft SLR). **Projections of SLR for the islands of Kaua'i, O'ahu and Maui accounted for passive flooding, annual high wave flooding, and coastal erosion.** For the islands of Lāna'i, Moloka'i, and Hawai'i, SLR projections only accounted for passive flooding due to the lack of historical shoreline data (methodology in [Appendix 3](#)).

Sites were assigned to categories as follows: (1) >75% of wetland inundated; (2) 50-75% of wetland inundated; (3) 25-50% of wetland inundated; (4) 5-25% of wetland inundated; (5) <5% of wetland inundated. It was assumed that inundation by groundwater or marine water would decrease available waterbird nesting habitat and thus, would have negative impacts on waterbird populations.

A limitation of the model is that it is based principally on elevation and cannot fully account for the particular topographical features at some sites that might affect the site's response to climate impacts. It is, however, one of the most widely used and robust climate models for the Hawaiian Islands at this time.

The analysis predicts that:

- ▶ By 2050, 23% of sites assessed in the prioritization process will be > 75% inundated, based on cumulative impacts of both marine and groundwater (8% marine, 15% groundwater); a further 18% will be 50-75% inundated (12% marine, 6% groundwater inundation).
- ▶ By 2100, 44% of sites assessed in the prioritization process will be > 75% inundated, based on cumulative impacts of both marine and groundwater (24% marine, 20% groundwater); a further 14% will be 50-75% inundated (6% marine, 8% groundwater inundation).
- ▶ 31% of sites either had no space to retreat or little space to retreat.



## Other threats

Participants identified other threats to wetlands and waterbirds (methods in [Appendix 3](#)).

Table 4. Threats to wetlands identified by participants, listed in order of cumulative frequency.\*

Threat	Includes	Frequency Score
Predators	Cat, rat, mongoose, dog, pig, Barn Owl, bullfrog, Cattle Egret	37
Water quality	Cesspools, fertilizer, herbicide, pesticide, agricultural runoff, residential runoff, heavy metals from dumps, pollution from machinery, coliform bacteria, leptospirosis, superfund site contamination, oil spills	25
Roads / Car strike	Department of Transport or private roads that are contributing to T&E waterbird fatalities	24
Human disturbance	Residential or homeless encampments	16
Hydrology challenges	Changes to hydrology (waterflow, diversions, water abundance, rainfall, flooding etc.)	13
Trash		13
Powerlines		13
Botulism		11
Ungulates	Pigs, deer, goats	9
Erosion / sedimentation		7
Development	Residential and other land development	6
Invasive plants and trees		5
Commercial infrastructure / Operations	Waste Water Treatment Plant infrastructure, hydroelectric plants, golf balls, golf carts	5
Military / Aviation	Unexploded ordnance, helicopters, planes, hang-gliders	4
Degraded or damaged conservation infrastructure	Fencing, deliberate damage to fencing, water control structures	3
Agricultural operations	Lo'i harvesting, aquaculture infrastructure, cattle trampling	3
Invasive fish		3
Fire		2
Presence of domestic ducks		1
Noise pollution		1

\* Frequency equates to number of sites where landowners / managers expressed concern about each threat.



Top: Cat stalking a koloa maoli. K. Uyehara

Bottom: Mangrove propagules. F. Starr



Key strategies to address specific threats and challenges to Hawai'i's wetlands were identified through discussions with partners and the Hawai'i Wetland Committee. The strategies were refined and ranked during two partner workshops. Strategies appear in order of rank.

## Predator management

- ▶ Promote and advance installation of predator proof fencing for waterbird recovery.
- ▶ Facilitate more extensive and effective predator control outside of fences (e.g., control grids, targeting entry points, trapping training, development of new techniques).

## Support partners

- ▶ Build capacity.
- ▶ Create and support wetland partnerships locally and regionally.
- ▶ Identify opportunities to secure and direct funds needed for priority actions.
- ▶ Connect partners with technical assistance, e.g., hydrological or avian expertise.
- ▶ Support partners through acquisitions and easement process.

## Control of invasive plants

- ▶ Strategic planning, removal and maintenance of invasive mangrove and other invasive species.

The scope and scale of conservation actions needed requires implementation of strategies across the state by a diverse collaboration of partners.



Nēnē join a blessing for the Mōli at Kilauea NWR. H. Raine

## Transfer science and knowledge

- ▶ Incorporate Traditional Ecological Knowledge (TEK<sup>10</sup>) and the work of cultural practitioners into wetland planning and implementation work.
- ▶ Advance conservation community knowledge on wetland management techniques; identify and fill research gaps.
- ▶ Develop Beneficial Management Practice Guides for key management challenges.
- ▶ Increase banding and tracking of birds to improve understanding of movement patterns, population dynamics and habitat use etc.

<sup>10</sup> Pacific Birds uses the phrase "Traditional Ecological Knowledge", but recognizes that a variety of terms, including Indigenous Knowledge, Traditional Knowledge, Indigenous Traditional Knowledge, Native Science, and related formulations are preferred by different Indigenous Peoples.



## Climate resilience planning and implementation

- ▶ Develop a statewide climate change adaptation strategy for wetlands.
- ▶ Identify and protect future habitat from development.

## Outreach

- ▶ Disseminate information on the benefits of wetlands for people and communities.
- ▶ Disseminate information on the cultural and ecological value of waterbirds and wetlands.
- ▶ Support appropriate community access to wetlands.
- ▶ Share information through workshops with conservation and farming communities.

## Cooperate

- ▶ Support equipment sharing (e.g., Marsh Masters) or cooperative purchases.
- ▶ Work at an ahupua'a level to connect wetland restoration activities with upland watershed restoration or entire hydrological systems.

## Indigenous agroecology

- ▶ Support locally led efforts to restore Indigenous agroecology to benefit people and birds.
- ▶ With farmers and biologists, develop updated bird-friendly Beneficial Management Practices for lo'i kalo farming and other Indigenous agroecology - additional research may be required.
- ▶ Build trust and develop networks with private landowners and lo'i farmers in conservation planning and implementation.
- ▶ Ensure that Indigenous agroecology plays a prominent role in the provision of high quality waterbird habitat, recognized by the best available science and knowledge, including Traditional Ecological Knowledge.
- ▶ Develop a statewide program that provides predator control resources to lo'i kalo farmers.
- ▶ Encourage funding programs to include Indigenous agroecology in waterbird conservation activities.

## Simplify permitting and planning

- ▶ Identify permitting challenges for landowner conservation efforts and facilitate efforts to address these challenges.<sup>11</sup>



Left: Makauwahi Cave Reserve. H. Raine

Right: Lo'i pūnāwai in Moloka'i. H. Raine

11 The Moloka'i Wetland Partnership has a summary of these challenges [here](#).



# 9

## Measures of Success



The following measures of success were identified in the two workshops held with partners across the state:

An increase in:

- ▶ Abundance of T&E birds by site
- ▶ Species richness by site
- ▶ Number of sites with T&E breeding birds
- ▶ Statewide population estimates for T&E birds

Top: Kawai'ele Wildlife Sanctuary. *H. Raine*

Bottom: 'Alae 'ula nest. *H. Raine*



A key objective of the plan is to prioritize wetlands sites across the state, providing a guide for the most effective way for decision makers, funders and managers to invest time and resources.<sup>12</sup> Through consultation with partners and a review of existing plans, 73 wetland sites were identified for inclusion in the plan.<sup>13</sup> For each site, data were collected on a series of criteria in a matrix ([Appendix 3](#) for methods and data sources). The criteria ([Table 14, Appendix 3](#)) were selected to rank the importance of each wetland site for waterbird recovery and other values, and were based on both current conditions, and likely future conditions after restoration and considering climate change impacts. The maximum possible score was 390. [Appendix 2](#) shows the location of each site on a map, island by island.

Given the small amount of wetland acreage statewide, and the dependence of T&E waterbirds on these sites, all wetland habitat should be considered valuable; and conservation investments at any of the wetland sites assessed in this plan would produce beneficial outcomes.

To capture as broad an overview as possible of the importance of sites based on diverse criteria, several scoring and ranking processes were carried out using data collected.

The rankings include:

1. The [top 20 ranking sites](#) with the highest overall scores statewide, indicating their broad-scale importance in supporting durable wetland conservation and waterbird recovery.

After removing the top 20 sites from the list, the remaining sites were assessed on thematic topics including:

2. Sites with [highest expected climate resilience](#) maintained in 2100.
3. Sites with the [fewest roadblocks](#) to conservation action implementation.
4. Sites where investments benefit [Indigenous agroecology](#) and waterbird conservation.
5. [Island based](#) ranking.



Top: Waiale'e wetland. H. Raine  
Bottom: Hakipu'u wetlands. H. Raine

<sup>12</sup> This approach to site prioritization was piloted in Moloka'i (Drexler et al., 2023) before being rolled out to the rest of the state.

<sup>13</sup> During the data gathering process, some sites were eliminated for reasons including an inability to contact a land manager / owner, or other factors which indicated that the site was not ready for restoration planning and implementation. Others were added at the request of partners.



Table 5: The highest scoring wetlands sites statewide (including ties - n = 23 sites).

Rank	Wetland	Score	Island	Est. restoration cost
1	Hanalei National Wildlife Refuge (incl. lo'i kalo)	353	Kaua'i	\$2-5+ million
2	Hökūala Resort	347	Kaua'i	n/a - HCP
3	Hulē'ia National Wildlife Refuge	334	Kaua'i	\$1-2 million
4	James Campbell National Wildlife Refuge (all subunits)	333	O'ahu	\$2-5+ million
5	Kawai'ele Waterbird Sanctuary <sup>14</sup>	326	Kaua'i	\$250-500k
6	Nu'u Pond	319	Maui	\$250-500k
7	Pearl Harbor National Wildlife Refuge (Honouliuli and Waiawa Units)	318	O'ahu	\$2-5+ million
8	Makauwahi Cave Reserve and Waiopili Stream, Maha'ulepu	316	Kaua'i	\$1-2 million
9	He'eia National Estuarine Research Reserve (NERR)	308	O'ahu	\$2-5+ million
10	Kanahā Pond Wildlife Sanctuary	305	Maui	\$2-5+ million
11	Lokowaka Pond	301	Hawai'i	\$2-5+ million
12	Kawainui State Waterbird Sanctuary	298	O'ahu	\$2-5+ million
12	Ka'elepulu Mitigation Pond (Enchanted Lake)	298	O'ahu	\$1-2 million
13	Alakoko Fishpond and Hulē'ia River	294	Kaua'i	\$2-5+ million
14	Waihe'e Coastal Dunes and Wetlands (& Kapoho Loko i'a)	293	Maui	\$2-5+ million
15	Turtle Bay, Golf Course Ponds	292	O'ahu	< \$250k
16	Punaho'olapa Marsh	288	O'ahu	\$1-2 million
16	Pouhala Marsh State Waterbird Sanctuary	288	O'ahu	\$2-5+ million
17	Hakipu'u Wetlands (Kualoa Ranch)	286	O'ahu	< \$250k
18	Hāmākua Marsh State Waterbird Sanctuary	283	O'ahu	\$1-2 million
18	Kea'au Pond (Ke'anae Pond)	283	Hawai'i	\$2-5+ million
19	Lumaha'i Valley	279	Kaua'i	no data
20	Mānā Plain Wetland Restoration Project (DOFAW) <sup>14</sup>	271	Kaua'i	\$500k-1 million

14 Kawai'ele and the Mānā Plain Wetland Restoration Project are technically Forest Reserves.



## Top twenty ranking: Discussion

The Priority Sites and Actions identified in [Section 10](#) provide a guide to decision makers and funders, statewide and nationally, on the most effective way to direct funding and other resources for wetland conservation in Hawai'i. Top ranking sites are those that provide the most important wetland habitat for waterbirds now and in the future, and require priority investment both to maintain their current condition, and to improve. This information will drive the restoration and management of key sites for T&E waterbirds and migratory birds (waterfowl and shorebirds).

Nine of the top twenty rankings (23 sites in total due to ties) are National Wildlife Refuges (4) or State Sanctuaries (5). A privately owned resort, the Hōkūala Resort ranks number two. Hōkūala is subject to a Habitat Conservation Plan due to the potential for Resort operations to adversely affect T&E waterbirds. This high score is likely because as an HCP participant, the resort is legally required to implement high quality predator control and other management on an ongoing basis and has provided adequate funding and expertise to do so. This suggests that a high level of sustained investment in key management actions pays high dividends for waterbird recovery.

Nonprofits manage eight of the top twenty rankings (Nu'u - HILT; Makauwahi Cave Reserve - MCR; He'eia - NERR partnership; Lokowaka Pond - 'Āina Ho'ōla Initiative; Waihe'e - HILT; Alakoko Fishpond - Mālama Hulē'ia; Punaho'olapa Marsh - North Shore Community Land Trust for Turtle Bay Resort; and Lumaha'i Valley - Kamehameha Schools). Their dedication to high quality management is reflected in these rankings. It is also encouraging that several privately owned sites and businesses appeared in the top twenty ranking, highlighting the important role of private landowners in wetland conservation and underlining the great efforts that many are making to manage their wetlands and protect native birds, including Kea'au Pond, and Hakipu'u Wetlands at Kualoa Ranch.

There is an ongoing need for conservationists to coordinate around these problems across the State and to continue to educate funders and decision makers at the national level on the unique problems faced by wetlands in Hawai'i, especially with regards to the need for management of invasive species in perpetuity.

The priority rankings indicate the importance of Kaua'i and O'ahu for wetlands. Out of 23 sites in the top 20 ranking (due to ties), 18 are on those two islands.



*Ae'o. Shairhem Dullaga, Chiefess Kamakahahei Middle School*

### Many of the required actions identified by land owners and managers appeared repeatedly throughout the top twenty ranking sites:

- ▶ Predator control
- ▶ The removal of invasive plant species / outplanting of natives
- ▶ Fencing
- ▶ Addressing hydrological challenges
- ▶ Staff capacity challenges
- ▶ Funding and training challenges
- ▶ Increasing outreach



*Koloa maoli. Gary Kramer USFWS*



Thematic prioritizations identify sites that did not feature in the “top twenty” ranking but are important for key criteria. For example, a small site, under restoration, that currently has few T&E waterbirds present, is unlikely to rank in the top twenty, but may have important characteristics that merit additional support, such as high climate resilience at 2100, fewest roadblocks (‘easy wins/low cost’), or importance for Indigenous agroecology. With appropriate support and investments these sites have the potential to host additional wetland birds and provide ecosystem services in the future.

Sites which were already included in the top twenty rankings were removed from this analysis.

## 11.1. High climate impact resilience at 2100

The following sites scored highly ( $\geq 4$  out of 5) for minimal marine and groundwater inundation at 2100.

*Table 6. Ranking of wetlands expected to be minimally affected by coastal climate impacts at 2100 (excluding top twenty ranked sites), in order.*

Site	Island
Wai'oli Valley Taro Fields	Kaua'i
Waiale'e (Kalou Fishpond and Marsh)	O'ahu
Waialua Lotus Fields - Na Mea Kupono Lo'i Kalo	O'ahu
Kaho'olawe (all sites)	Kaho'olawe
Pahuauiwai - Aquaculture Site	Moloka'i
Kealakehe (Kona) Sewage Treatment Plant	Hawai'i
Wailua Reservoir (Sloggett Reservoir)	Kaua'i
Kualapu'u Reservoir	Moloka'i
Paikō Lagoon Wildlife Sanctuary	O'ahu
Ke'anae Point	Maui
Paukukalo Wetland/Ka'ehu Bay	Maui
Kaupapalo'i o Ka'amola	Moloka'i
Hakalau National Wildlife Refuge	Hawai'i
Honu'apo Upland Wetland	Hawai'i

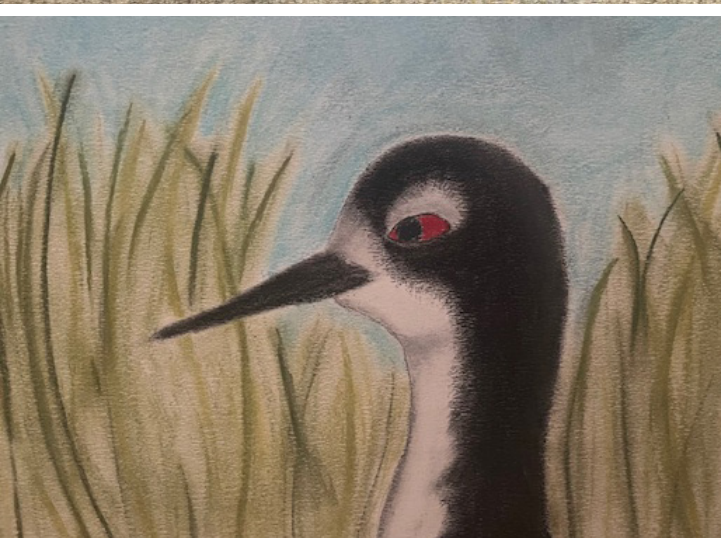
## Climate impacts: Discussion

[Table 6](#) identifies the sites expected to be minimally affected by the coastal climate impacts into 2100 (excluding top twenty rankings). While it is imperative to protect existing sites, even those that may be less resilient to climate change, so that T&E waterbirds and migratory birds have suitable habitat available in the short term, it is also important to consider protecting and restoring sites predicted to remain robust at 2100. This includes three reservoirs that provide habitat expected to increase in value as coastal wetlands are lost. Kaho'olawe wetlands are also robust at 2100, underscoring the importance of the wetland restoration work currently underway by the Kaho'olawe Island Reserve Commission.

Five of the top sites for climate resilience also support Indigenous agroecology or aquaculture, or have historical Indigenous sites that could be restored (Wai'oli Valley Taro Fields, Waiale'e, Waialua Lotus Fields, Pahuauiwai aquaculture site, and Ke'anae Point). Harmon et. al. (2021) found that the restoration of lo'i would more than compensate for loss of wetland habitat due to climate impacts, provided that lo'i offer “similar or equivalent habitat value to Hawaiian waterbirds as conventionally managed wetlands.” Harmon et. al. also noted that Indigenous agroecology has potential to substantially contribute toward the recovery of endangered waterbirds. Increased close collaboration with farmers will be important in ensuring that lo'i and other agricultural operations are able to provide a sustainable local food source, while also providing high quality habitat for native waterbirds.







## Fewest roadblocks to conservation action

The following sites scored highly ( $\geq 4$  out of 5) for having few roadblocks and low estimated cost of restoration.

*Table 7. Ranking of wetlands where few barriers to the implementation of conservation actions are expected, and restoration estimates are low (excluding top twenty ranked sites), in order.*

Site	Island
Wai'oli Valley Taro Fields	Kaua'i
Loko Ea Fishpond	O'ahu
Kānewai Fishpond	O'ahu
Paikō Lagoon Wildlife Sanctuary	O'ahu
Hakalau National Wildlife Refuge	Hawai'i
Honu'apo Upland Wetland	Hawai'i
Kalauha'īha'i Fishpond	O'ahu
Honokea Loko i'a	Hawai'i

## Fewest roadblocks to conservation action: Discussion

[Table 7](#) identifies sites that had few roadblocks ('easy wins') with modest restoration costs, that might provide opportunities for large gains with less investment (excluding top twenty sites). Indigenous agroecology sites feature highly, with four fishponds and a lo'i in the top eight sites (Wai'oli Valley Taro Fields, Loko Ea Fishpond, Kānewai Fishpond, Kalauha'īha'i Fishpond, Honokea Loko i'a). There is also one Wildlife Sanctuary (Paikō Lagoon) and one National Wildlife Refuge (Hakalau), as well as Honu'apo Upland Wetland.

Ae'o. Sofia Esposito, Chiefess Kamakahahei Middle School

'Alae 'ula. Sophia Benton, Chiefess Kamakahahei Middle School

'Alae ke'oke'o. Aiana Lagundino, Chiefess Kamakahahei Middle School

Ae'o. Carmela Ruiz, Chiefess Kamakahahei Middle School





## Indigenous agroecology

The following sites scored highly for Indigenous agriculture that was suitable for waterbirds, but did not score in the top twenty ranking.

*Table 8. Ranking of wetlands with Indigenous agroecology (excluding top twenty sites), in order.*

Site	Island
Kaloko-Honokōhau, National Historic Park, 'Aimakapā and Kaloko Ponds	Hawai'i
Wai'oli Valley Taro Fields	Kaua'i
Loko Ea Fishpond	O'ahu
Waimea Valley and Estuary	O'ahu
Keawāwa	O'ahu
Waiale'e (Kalou Fishpond and Marsh)	O'ahu
Waialua Lotus Fields - Na Mea Kupono Lo'i Kalo	O'ahu
Loko Waiāhole/Kapalaho	Hawai'i



## Indigenous agroecology: Discussion

[Table 8](#) identifies sites that scored highly, with Indigenous agriculture present, that are suitable for T&E waterbirds (excluding top twenty sites) or where historical structures exist for Indigenous agroecology that could be restored in the future. Lo'i kalo and loko i'a have great cultural importance and generate enthusiasm for wetland restoration in the community. The expansion of Indigenous agroecology is an opportunity to support wetland restoration with multiple benefits including the recovery of waterbirds at sites where the community is likely to be deeply committed.



Nēnē. Jade Sakamoto, Chiefess Kamakahelei Middle School

Nēnē and chick. Navaeh Smith, Chiefess Kamakahelei Middle School

Ae'o. Asa Bailey, Chiefess Kamakahelei Middle School





## 12.1. Kauaʻi

Table 9. Priority ranking of wetlands in Kauaʻi.

Rank	Wetland
1	Hanalei National Wildlife Refuge
2	Hökūala Resort
3	Hulēʻia National Wildlife Refuge
4	Kawaiʻele Waterbird Sanctuary
5	Makauwahi Cave Reserve and Waiopili Stream, Mahaʻulepu
6	Alakoko Fishpond and Hulēʻia River
7	Lumahaʻi Valley
8	Mānā Plain Wetland Restoration Project (DOFAW)
9	Waiʻoli Valley Taro Fields
10	Hanapēpē Salt Ponds and Coastal Ponds
11	Wainiha Valley River and Taro Fields
12	Wailua Reservoir (Sloggett Reservoir)
13	Smith's Tropical Paradise
14	Mānā Plain (Open Floodable Space)
15	Wailua River (DSP parcels)
16	Ōpaekaʻa Marsh (Wailua River)

Top: Makauwahi Cave Reserve. H. Raine

Bottom: Removing invasive species. H. Raine





## 12.2. O‘ahu

Table 10. Priority ranking of wetlands in O‘ahu.

Rank	Wetland
1	James Campbell National Wildlife Refuge (all subunits)
2	Pearl Harbor National Wildlife Refuge (Honouliuli and Waiawa Units)
3	He‘eia NERR
4	Kawainui State Waterbird Sanctuary
4	Ka‘elepulu Mitigation Pond (Enchanted Lake)
5	Turtle Bay, Golf Course Ponds
6	Punaho‘olapa Marsh
6	Pouhala Marsh State Waterbird Sanctuary
7	Hakipu‘u Wetlands (Kualoa Ranch)
8	Hāmākua Marsh State Waterbird Sanctuary
9	Kapapapuhi Point Park Wetland
10	Loko Ea Fishpond
11	Waimea Valley and Estuary
12	Keawāwa Wetland
13	Waiale‘e (Kalou Fishpond and Marsh)
14	Nā Mea Kūpono Learning Center (Waialua Lotus Fields)
15	Kānewai Fishpond
16	Pu‘ewai Wetland, Bellows Air Force Station
17	‘Uko‘a Marsh
18	Paikō Lagoon Wildlife Sanctuary
19	Kahana Valley
20	Kalauha‘iha‘i Fishpond
21	Ka‘a‘awa Wetland (Kualoa Ranch)

Top: Waiale‘e wetlands. *H. Raine*

Bottom: James Campbell NWR. *H. Raine*





Punalau Pond from the air. *B Haase*

## 12.3. Molokaʻi

Table 11. Priority ranking of wetlands in Molokaʻi.<sup>15</sup>

Rank	Wetland
1	Punalau Pond
2	ʻŌhiʻapilo Pond
3	Pahuauiwai Aquaculture Site
3	Kākāhaiʻa National Wildlife Refuge
4	Kualapuʻu Reservoir
4	Kamahuʻehuʻe Pond
5	Kaupapaloʻi o Kaʻamola
6	Moku Pond
7	Puʻu One Pond (Dunbar)
8	Pohoʻele Pond, Palaʻau State Wildlife Sanctuary



Keālia Pond National Wildlife Refuge. *H. Raine*

## 12.4. Maui

Table 12. Priority ranking of wetlands in Maui.

Rank	Wetland
1	Nuʻu Pond
2	Kanahā Pond Wildlife Sanctuary
3	Waiheʻe Coastal Dunes and Wetlands (and Kapoho Loko iʻa)
4	Keālia Pond National Wildlife Refuge
5	Piʻikea Wetlands (formerly Azeka Ponds 1&2)
6	Ukumehame Firing Range
7	Keʻanae Point
8	Paukukalo Wetland/Kaʻehu Bay
9	Papaʻula, Wailuku

<sup>15</sup> It is notable that the rankings in Molokaʻi are different from those in the prioritization process carried out by Drexler et. al. (2023). That is principally a function of the weighting applied to criteria. Drexler applied a weighting of three to climate change and community engagement only. In the workshops for the Strategic Plan, the wetland conservation experts consulted opted to apply weightings more broadly across a range of criteria (see [Table 14](#)).





Kaloko-Honokōhau, National Historic Park, 'Aimakapā and Kaloko Ponds. H. Raine

# 12.5. Hawai‘i Island

Table 13. Priority ranking of wetlands in Hawai‘i Island.

Rank	Wetland
1	Lokowaka Pond
2	Kea‘au Pond (Ke‘anae Pond)
3	Kaloko-Honokōhau National Historic Park, 'Aimakapā and Kaloko Ponds
4	Loko Waiāhole/Kapalaho
5	Honu‘apo Estuary (Coastal Area)
6	Kealakehe (Kona) Sewage Treatment Plant
7	Kapo‘ikai (‘Ōpae‘ula Pond)
8	Kaunani Loko Wai
9	Hakalau National Wildlife Refuge
10	Honu‘apo Upland Wetland
11	Honokea Loko i‘a
12	Ka‘ū Preserve

For Kaho‘olawe and Lāna‘i, see Section 13.

## Ni‘ihau

The island of Ni‘ihau was not included in this plan because access is not allowed, so restoration planning and implementation is not possible at this time. However, the island is known to have vitally important wetland sites used by T&E waterbirds and migratory birds.



Kōlea. H. Osterlund



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List of Wetland Sites included in the Wetland Plan, by Island, in alphabetical order.<sup>16</sup> Click on each site name to go to the site narrative.

## Kauaʻi

- ▶ [Alakoko Fishpond and Hulēʻia River](#)
- ▶ [Hanalei National Wildlife Refuge](#)
- ▶ [Hanapēpē Salt Ponds and Coastal Ponds](#)
- ▶ [Hōkūala Resort](#)
- ▶ [Hulēʻia National Wildlife Refuge](#)
- ▶ [Kawaiʻele Waterbird Sanctuary](#)
- ▶ [Lumahaʻi Valley](#)
- ▶ [Makauwahi Cave Reserve and Waiopili Stream, Mahaʻulepu](#)
- ▶ [Mānā Plain \(Open Floodable Space\)](#)
- ▶ [Mānā Plain Wetland Restoration Project \(DOFAW\)](#)
- ▶ [Ōpaekaʻa Marsh \(Wailua River\)](#)
- ▶ [Smith’s Tropical Paradise](#)
- ▶ [Waiʻoli Valley Taro Fields](#)
- ▶ [Wailua Reservoir \(Sloggett Reservoir\)](#)
- ▶ [Wailua River \(DSP parcels\)](#)
- ▶ [Wainiha Valley River and Taro Fields](#)

## Oʻahu

- ▶ [Hakipuʻu Wetlands \(Kualoa Ranch\)](#)
- ▶ [Hāmākua Marsh State Waterbird Sanctuary](#)
- ▶ [Heʻeia NERR](#)
- ▶ [James Campbell National Wildlife Refuge \(all subunits\)](#)
- ▶ [Kaʻaʻawa Wetland \(Kualoa Ranch\)](#)
- ▶ [Kaʻelepulu Mitigation Pond \(Enchanted Lake\)](#)
- ▶ [Kahana Valley](#)
- ▶ [Kalauihaʻi Fishpond](#)
- ▶ [Kānewai Fishpond](#)
- ▶ [Kapapahu Point Park Wetland](#)
- ▶ [Kawainui State Waterbird Sanctuary](#)
- ▶ [Keawāwa Wetland](#)
- ▶ [Loko Ea Fishpond](#)
- ▶ [Nā Mea Kūpono Learning Center \(Waialua Lotus Fields\)](#)
- ▶ [Paikō Lagoon Wildlife Sanctuary](#)
- ▶ [Pearl Harbor National Wildlife Refuge - Honouliuli Unit and Waiawa Unit](#)
- ▶ [Pouhala Marsh State Waterbird Sanctuary](#)
- ▶ [Puʻewai wetland, Bellows Air Force Station](#)
- ▶ [Punahoʻolapa Marsh](#)
- ▶ [Turtle Bay, Golf Course Ponds](#)
- ▶ [ʻUkoʻa Marsh](#)
- ▶ [Waialeʻe \(Kalou Fishpond and Marsh\)](#)
- ▶ [Waimea Valley and Estuary](#)



## Molokaʻi

- ▶ [Kākahaiʻa National Wildlife Refuge](#)
- ▶ [Kamahuʻehuʻe Pond](#)
- ▶ [Kaupapaloʻi o Kaʻamola](#)
- ▶ [Kualapuʻu Reservoir](#)
- ▶ [Moku Pond](#)
- ▶ [ʻŌhiʻapilo Pond](#)
- ▶ [Pahuauwai Aquaculture Site](#)
- ▶ [Pohoʻele Pond, Palaʻau State Wildlife Sanctuary](#)
- ▶ [Punalau Pond](#)
- ▶ [Puʻu One Pond \(Dunbar\)](#)

## Maui

- ▶ [Kanhā Pond Wildlife Sanctuary](#)
- ▶ [Keʻanae Point](#)
- ▶ [Keālia Pond National Wildlife Refuge](#)
- ▶ [Nuʻu Pond](#)
- ▶ [Papaʻula, Wailuku](#)
- ▶ [Paukukalo Wetland/Kaʻehu Bay](#)
- ▶ [Piʻikea Wetlands \(formerly Azeka Ponds 1 & 2\)](#)
- ▶ [Ukumehame Firing Range](#)
- ▶ [Waiheʻe Coastal Dunes and Wetlands \(and Kapoho Loko iʻa\)](#)

## Kahoʻolawe

- ▶ [Kahoʻolawe](#)

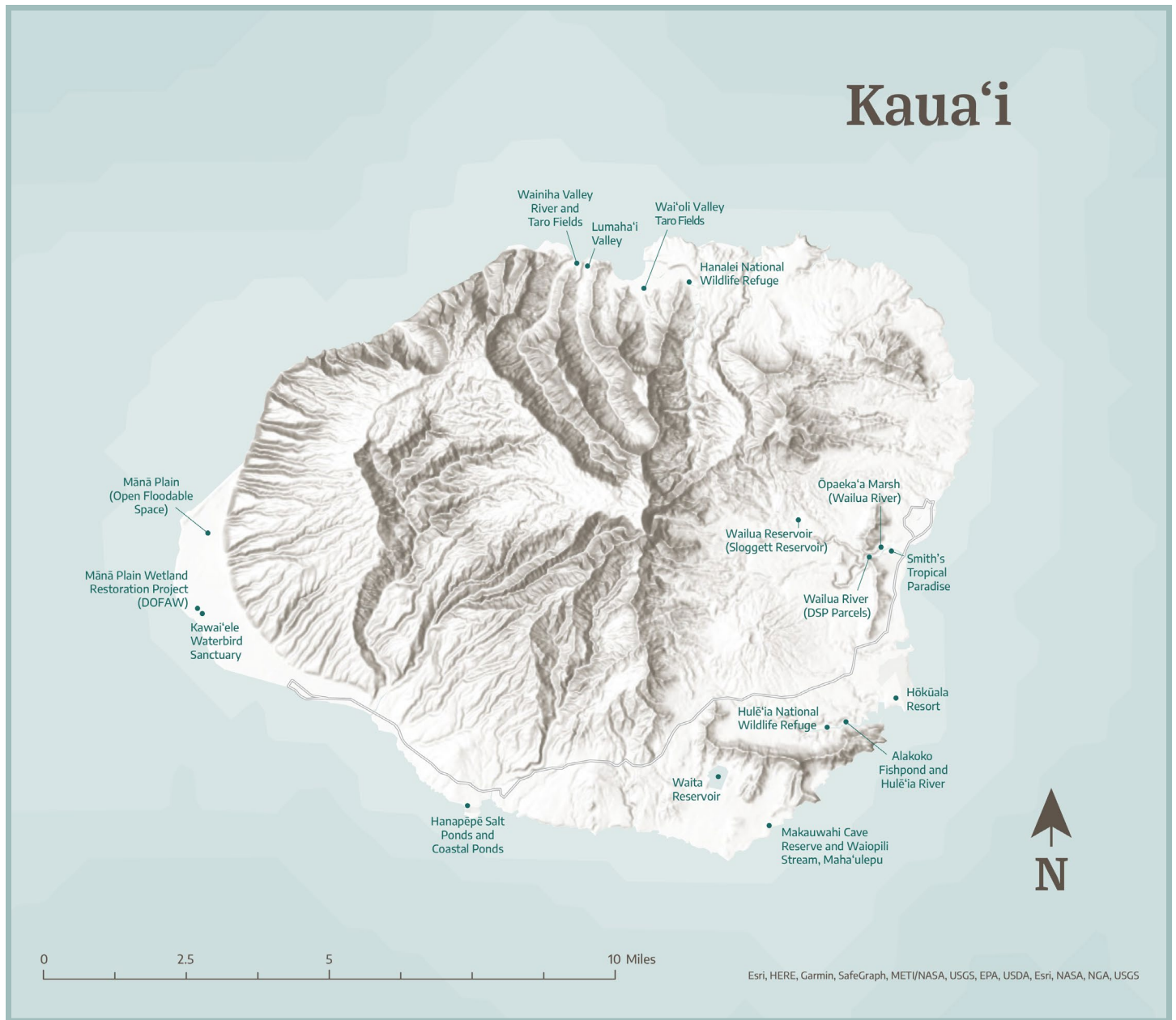
## Lānaʻi

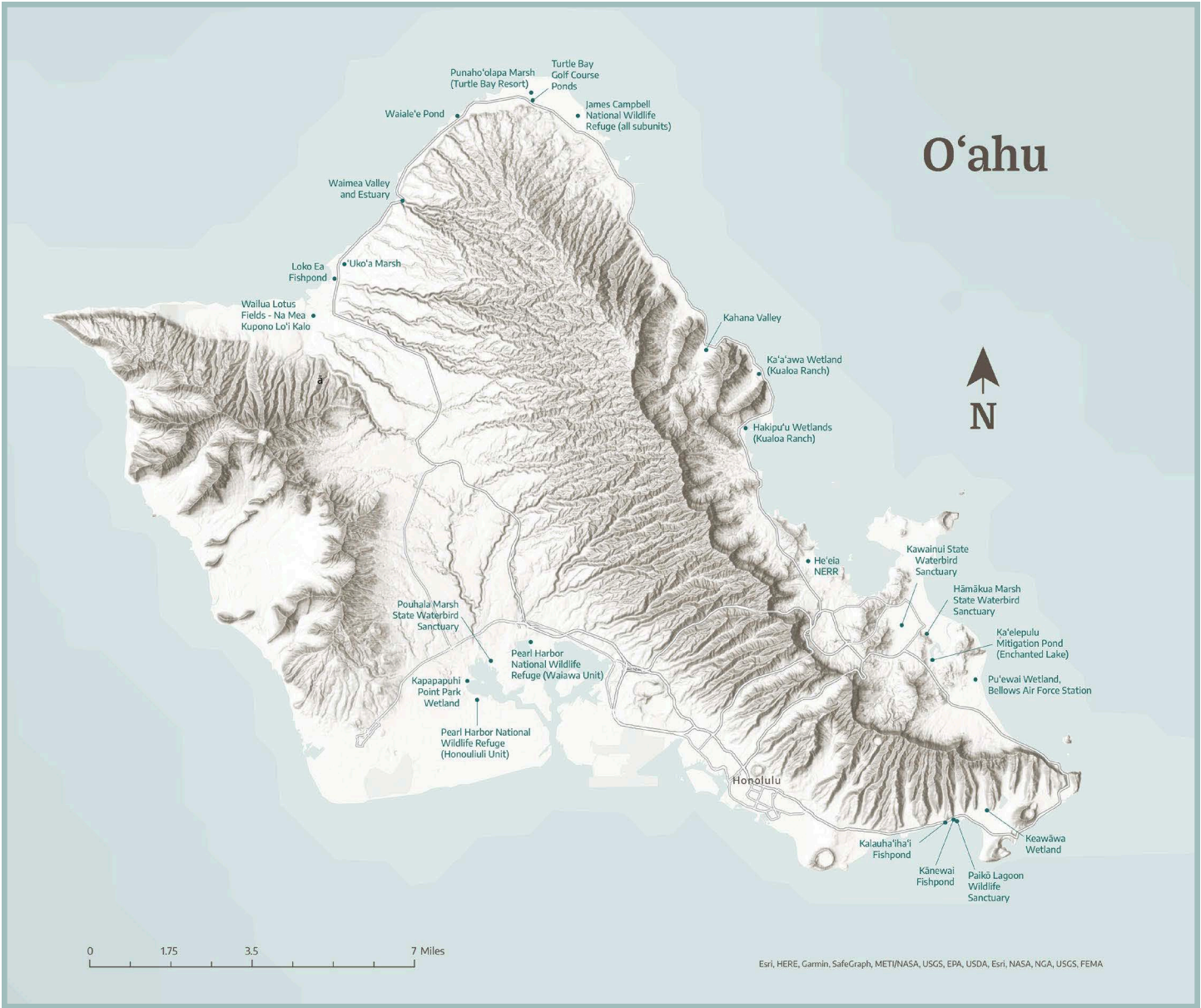
- ▶ [Lānaʻi](#)

## Hawaiʻi Island

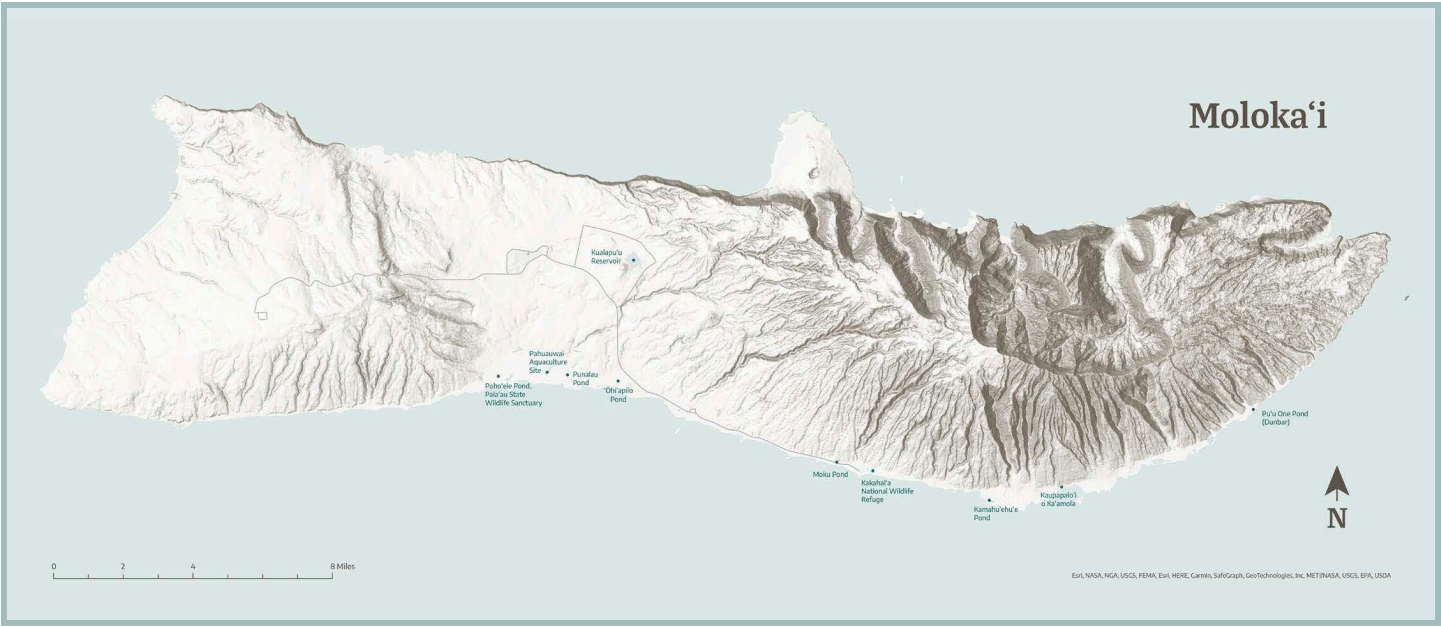
- ▶ [ʻAimakapā Fishpond and Kaloko Fishpond \(Kaloko-Honokōhau National Historical Park NHP\)](#)
- ▶ [Hakalau National Wildlife Refuge](#)
- ▶ [Honokea Loko iʻa](#)
- ▶ [Honuʻapo Estuary \(Coastal Area\)](#)
- ▶ [Honuʻapo Upland Wetland](#)
- ▶ [Kaʻū Preserve](#)
- ▶ [Kapoʻikai \(ʻŌpaeʻula Pond\)](#)
- ▶ [Kaumau Loko Wai](#)
- ▶ [Keaʻau Pond \(Keʻanae Pond\)](#)
- ▶ [Kealakehe \(Kona\) Sewage Treatment Plant](#)
- ▶ [Loko Waiāhole/Kapalaho](#)
- ▶ [Lokowaka Pond](#)

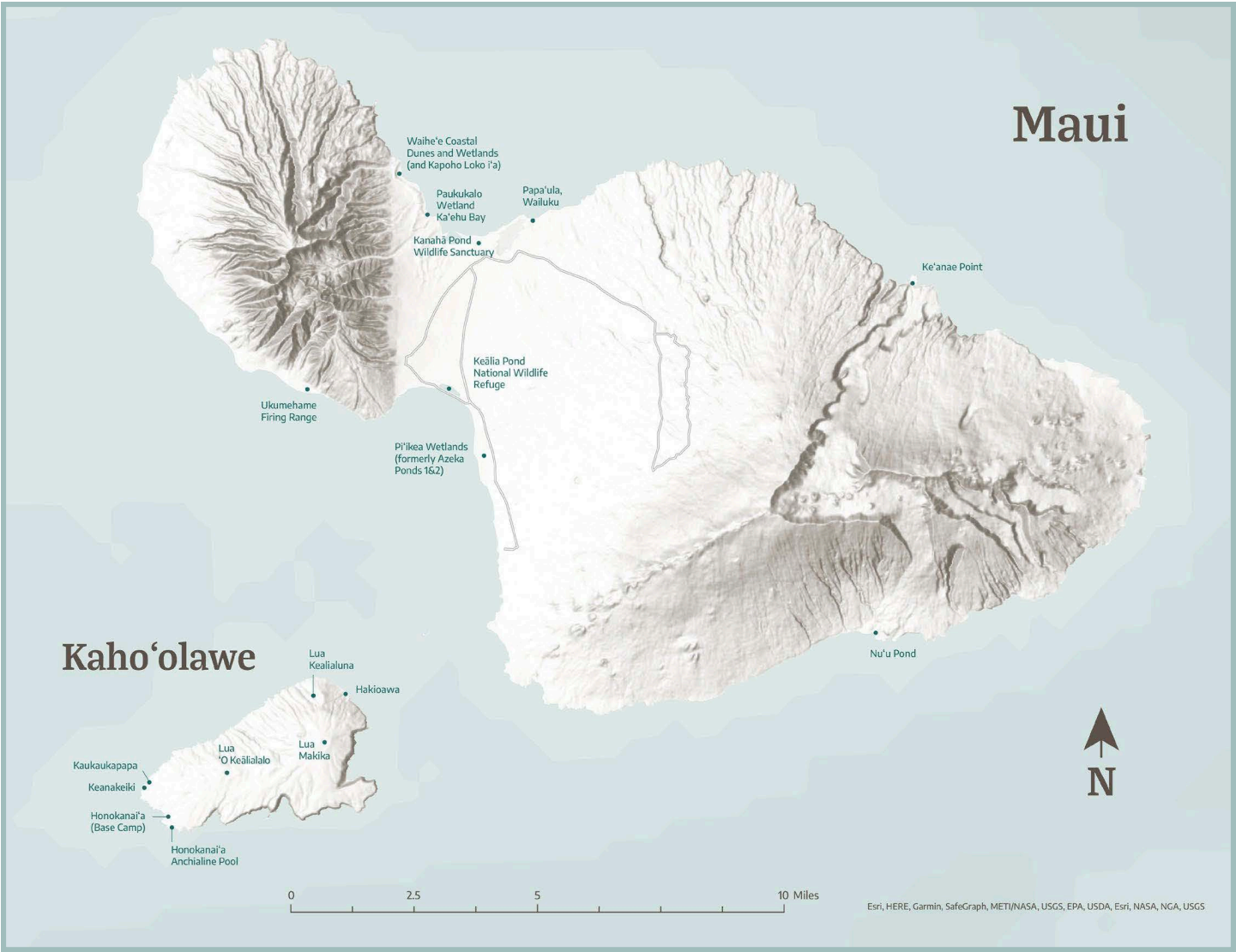






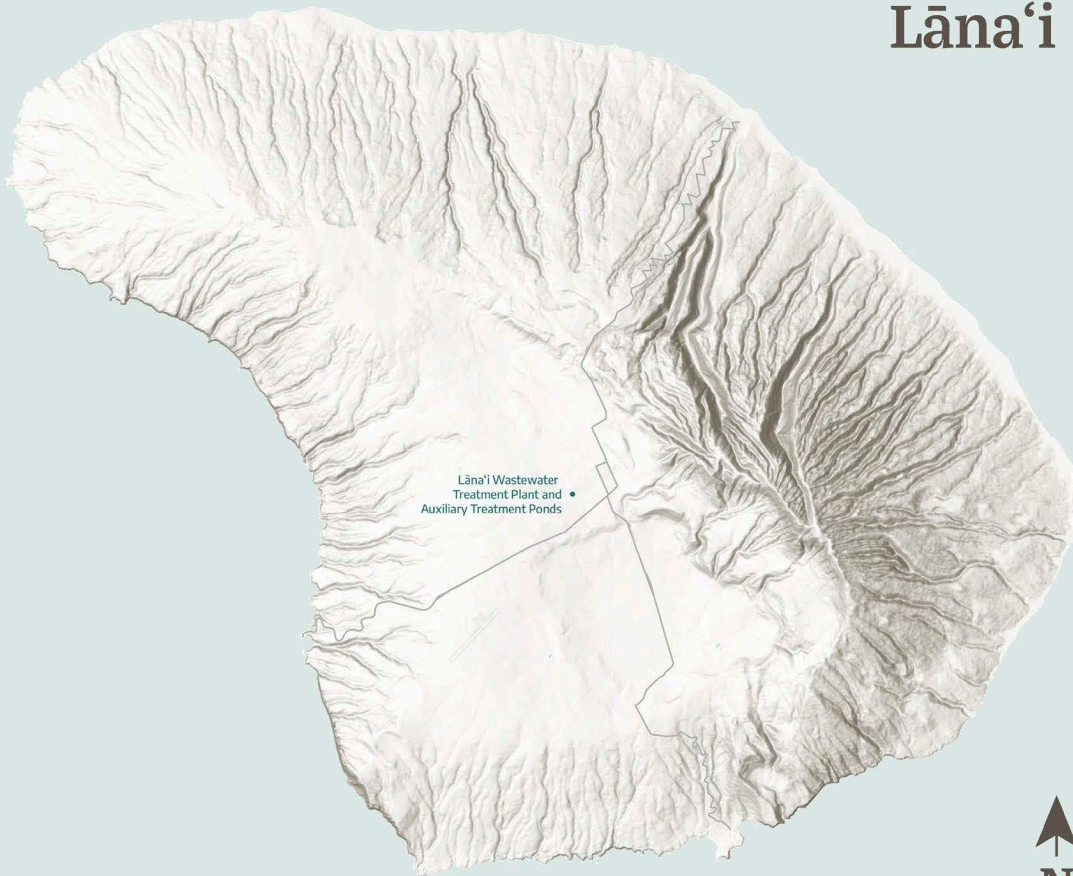




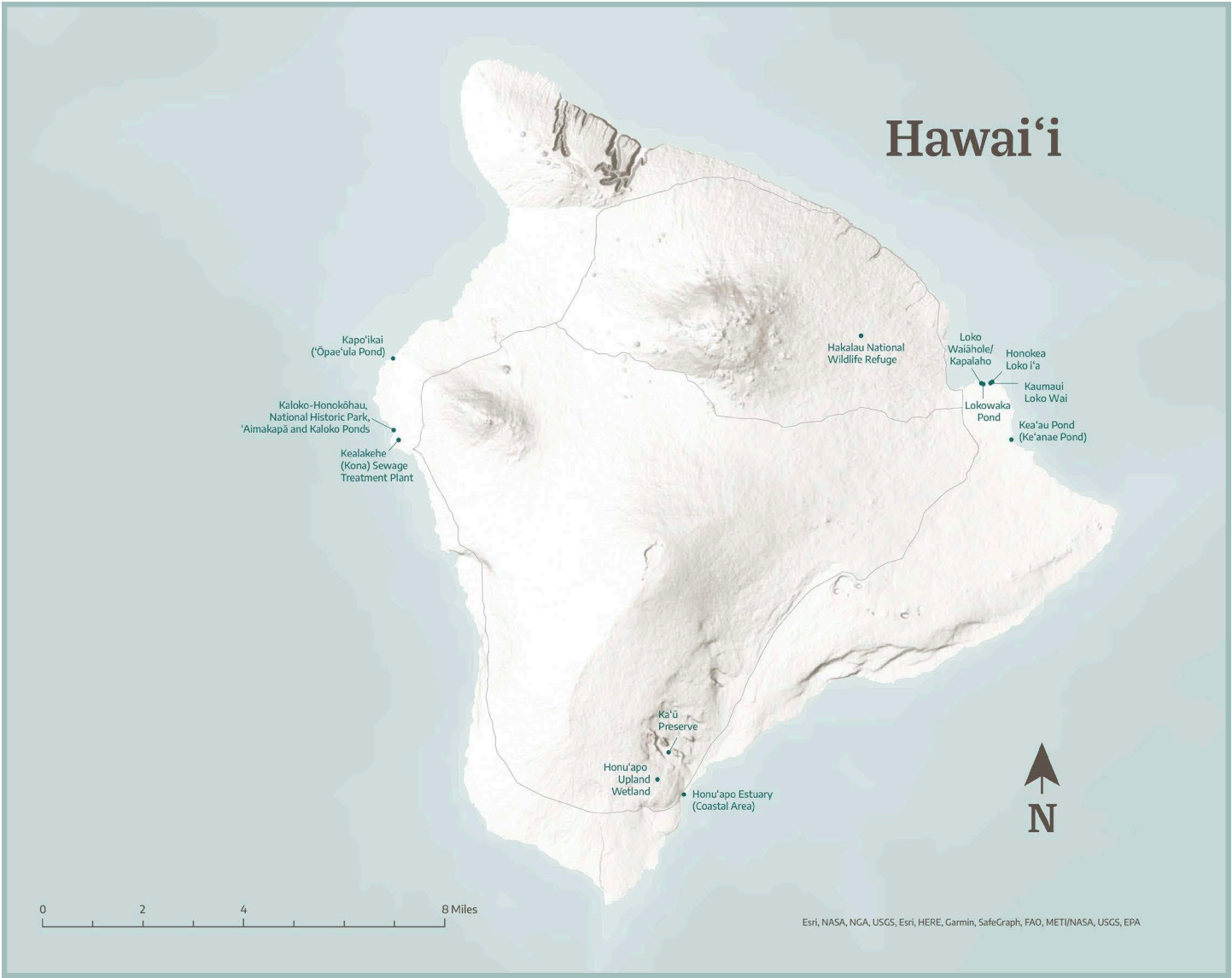




# Lānaʻi



Esri, NASA, NOAA, USGS, FEMA, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, USDA





# Appendix 3 | Methods

## 1) Planning framework

The Strategic Plan for Hawai'i Wetlands was developed using the following methods:

1. A list of potential wetland sites for inclusion in the plan, arranged by island, was created for the prioritization process using existing plans noted in Section 2 (Background, Goals and Objectives of the Plan).
2. Pacific Birds elicited feedback on the list of sites from the wetland conservation community and landowners. Experts were asked to identify any sites that ought to be removed from the list, and to explain why. Experts were also asked to add any important wetlands that had been missed.
3. A matrix was created to facilitate the prioritization process (based on a pilot Pacific Islands Climate Change Adaptation Science Center - PI-CASC project on Moloka'i (Drexler et al., 2023). The matrix collected narrative data and scored wetlands on key criteria (size, hydrological data, climate sensitivity particularly with regards to climate impacts at 2050 and 2100, space to retreat, land management and ownership, community support, spatial connectivity, threats, current restoration status, and roadblocks to future restoration). Sites were also scored on the presence, breeding and abundance of T&E birds, species richness, and suitability for T&E waterbirds and migratory shorebirds and waterfowl. [Table 14](#) shows the full list of scored criteria.

The matrix was populated by Pacific Birds staff and the team from the Hawaiian Islands Conservation Collective (HICO) using existing information (including the plans outlined in Section 2, and site management plans or similar where available). Expert opinion was sought from conservation staff and land managers familiar with each site to compile and score the matrix, and to identify and rank key actions and estimate their likely cost bracket.

Two workshops were held in October 2023 to seek feedback from site managers, owners and decision makers on whether any of the criteria should be weighted to account for their relative importance in relation to the likely success of restoration efforts. Multipliers were applied to the criteria listed in [Table 14](#).

Table 14. Wetland Prioritization Criteria, and their weighting in final analysis.

Scored Criteria	Multiplier
Freshwater availability future	3
T&E breeding	3
Land Management Security	2
Presence / Security of funding	2
Community support	2
Freshwater availability now	2
Threats	2
Predator control	2
Human disturbance control	2
Invasive plant control	2
Restoration feasibility	2
Roadblocks to restoration	2
T&E presence	2
Average T&E bird count	2
Species richness	2
Suitability now or after restoration for T&E / migratory birds	2
Marine inundation	2
Space to retreat / expand	2
Acreage	1
Indigenous agroecology / aquaculture / salt production	1
Botulism control	1
Restoration status	1
Groundwater inundation	1

4. Sites were ranked according to their final scores. The top twenty rankings are shown in [Table 5](#).
5. Sites were sorted into cost benefit categories for wetland restoration using the following criteria:
  - ▶ High Climate Impact Resiliency at 2100 - Section 11.1, [Table 6](#).
  - ▶ Fewest Roadblocks (Easy Wins - Low Cost) - Section 11.2, [Table 7](#).
  - ▶ Indigenous Agriculture present (or potential) - Section 11.3, [Table 8](#).
6. Lastly, sites were ranked by Island ([Kaua'i - Table 9](#); [O'ahu - Table 10](#); [Moloka'i - Table 11](#); [Maui - Table 12](#); [Hawai'i Island - Table 13](#)).

## 2. Wetland spatial data

Spatial delineations for each wetland were created in ArcGIS Pro 2.3.3 using a combination of spatial data from the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory, the Hawai'i Department of Land and Natural Resources, and Google Maps. Sites were ranked according to their acreage by removing outlier sites, then binning sites using quartiles, maximum, and greater than maximum as follows, (1) 0-7; (2) 7.01-28; (3) 28.01-76; (4) 76.01-418; (5) >418.

## 3. Climate sensitivity

A climate sensitivity analysis was carried out to determine the threat of climate impacts to each wetland in the prioritization. We assessed the impact of marine and groundwater inundation by 2050 (1.1 ft SLR) and by 2100 (3.2 ft SLR).

We used SLR projections produced by Anderson et al. (2018), which are the most robust for the state of Hawai'i. The Pacific Islands Ocean Observing System (PacIOOS 2019) provided the shapefiles for SLR inundation for the islands of Kaua'i, O'ahu, Maui, Lāna'i, Moloka'i, and Hawai'i. Anderson et al. (2018) mapped groundwater and marine inundation at 98 cm of global mean SLR, corresponding to the upper limit of the likely range (83rd percentile) as set forth in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), Representative Concentration Pathway 8.5 (RCP 8.5).

Projections of SLR for the islands of Kaua'i, O'ahu and Maui accounted for passive flooding, annual high wave flooding, and coastal erosion. For the islands of Lāna'i, Moloka'i, and Hawai'i, SLR projections only accounted for passive flooding due to the lack of historical shoreline data needed to model annual high wave flooding and coastal erosion (Anderson et al. 2018).

The models assume inundation of marine water in areas that have a connection to the ocean and assume groundwater inundation in areas without a connection to the ocean. The models are unable to identify sources of groundwater inundation (e.g., sewage, water table).

Working in ArcGIS Pro 2.3.3, we used the SLR projections in combination with the wetland spatial data to determine the degree of threat from SLR. Sites were assigned to categories as follows: (1) >75% of wetland inundated; (2) 50-75% of wetland inundated; (3) 25-50% of wetland inundated; (4) 5-25% of wetland inundated; (5) <5% of wetland inundated.

We also used the SLR layers to estimate the earliest projected timescale of wetland inundation by either marine or groundwater. Sites were assigned to categories as follows: (1) impacts seen by 2050; (3) impacts seen by 2100; (5) impacts not projected to occur by the end of the century. It was assumed that inundation by groundwater or marine water would decrease available waterbird nesting habitat and thus, would have negative impacts on waterbird populations.

## 4. Space to retreat

Spatial analyses were conducted in ArcGIS Pro 2.3.3 to evaluate the potential for expansion of each wetland in the matrix. We obtained shapefiles of state land use districts from the Hawai'i GIS program. The data was created by the State Land Use Commission and includes land districts in the categories of 'agricultural', 'conservation', 'rural', and 'urban'.

- ▶ Lands zoned as 'agricultural' include lands that are currently being used for the cultivation of crops, aquaculture, raising of livestock, wind energy production, timber cultivation, as well as lands that have significant potential for agricultural use.
- ▶ Lands zoned as 'conservation' primarily comprise existing forest and water reserve zones and include areas necessary for protecting watersheds, water sources, scenic and historic areas, recreational areas, and habitats of endemic species.
- ▶ Lands zoned as 'rural' include small farms intermixed with small, low-density residential lots.
- ▶ Lands zoned as 'urban' include lands with concentrations of people, structures, and services, as well as vacant areas for future development.



Additionally, we obtained a shapefile of current land cover classifications from the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP), which provides land cover data for coastal areas of the United States (Office for Coastal Management 2022).

The potential for each wetland to expand was based on the current land cover and state land use districts of the immediate surrounding area. In addition, site managers and owners were asked to verify the data and include any topographic restrictions that might not be obvious in a GIS analysis (for example, a cliff wall or other physical feature behind the site that would impede movement, or any other reason that would prevent retreat). Scores were amended based on this additional information.

Wetlands were categorized as follows:

1. Not possible to expand: immediate surrounding land is already developed;
2. Low potential to expand: immediate surrounding land is not currently developed but zoned for urban development;
3. Potential to expand: immediate surrounding land is not currently developed and is zoned for agriculture or rural;
4. High potential to expand: immediate surrounding land is not currently developed and is zoned for conservation;
5. Immediate surrounding area is already wetland habitat.

## 5. Spatial connectivity

Within ArcGIS, for each site, we calculated the distance to the nearest managed wetland, as well as the nearest wetland regardless of management. Sites were grouped based on their proximity to the near wetland type as follows: (1)  $\geq 9.0\text{km}$ ; (2) 7.0-8.9km; (3) 5.0-6.9km; (4) 3.0-4.9km; (5) 0-2.9km.

## 6. Threat analysis

Climate impacts (sea level rise, marine and groundwater inundation, passive flooding, annual high wave flooding and coastal erosion)<sup>16</sup> were considered separately from other threats because the plan seeks to guide future investment in wetland management and the timescale to, and extent of, site loss is therefore particularly important. It was assumed that inundation by groundwater or marine water would decrease available waterbird nesting habitat and thus, would have negative impacts on waterbird populations.

For all other threats, site managers were asked to identify the most important threats (hazards) at their site. Threats were then ranked on their cumulative score across the state.

## 7. Waterbird counts

Waterbird count data was obtained from the State of Hawai'i Biannual Waterbird Survey database and was used to calculate the average number of T&E waterbirds observed at each site over a 10 year period (2010 to 2020), as well as the number of different species (i.e., species richness) of waterbirds and migratory shorebirds or waterfowl observed at each site over the ten year period. The range of average count and species richness values were then split into 5 bins, each containing an equal number of sites, for scoring.

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17 For the islands of Lāna'i, Moloka'i, and Hawai'i, SLR projections only accounted for passive flooding due to the lack of historical shoreline data.

# Appendix 4

## Status, Range and Requirements of all Endemic Waterbirds, Waterfowl, Migratory Waterfowl, and Migratory Shorebirds in Hawai‘i

Table 15. Status, Range and Requirements of all Endemic Waterbirds, Waterfowl, Migratory Waterfowl and Migratory Shorebirds in Hawai‘i.

Common Name	Scientific Name	IUCN Status	USFWS Status	DLNR Species of Greatest Conservation Concern	US Shorebird Species of Conservation Concern	Range
<b>Waterbirds</b>						
‘Alae ‘ula, Hawaiian Common Gallinule	<i>Gallinula galeata sandvicensis</i>	n/a	EN	x		Kaua‘i, O‘ahu only, extirpated elsewhere
‘Alae ke‘oke‘o, Hawaiian Coot	<i>Fulica alai</i>	VU	EN	x		all MHI*
Ae‘o, Hawaiian Stilt	<i>Himantopus mexicanus knudseni</i>	n/a	EN	x		all MHI*
White-faced Ibis	<i>Plegadis chihi</i>	LC				all MHI*
<b>Waterfowl</b>						
Nēnē, Hawaiian Goose	<i>Branta sandvicensis</i>	VU	EN	x		Kaua‘i, Moloka‘i, Maui, & Hawai‘i Island
Koloa maoli, Hawaiian Duck	<i>Anas wyvilliana</i>	EN	EN	x		purebred on Kaua‘i only; hybrids other islands
Auku‘u, Black-crowned Night-Heron	<i>Nycticorax nycticorax hoactli</i>	LC		x		all MHI*
<b>Migratory Waterfowl</b>						
Snow Goose, Cackling Goose, American Wigeon, Eurasian Wigeon, Ring-necked Duck, Mallard, koloa moha or Northern Shoveler,** koloa mapu or Northern Pintail,** Green-winged Teal, Blue-winged Teal, Lesser Scaup	<i>Chen caerulescens</i> , <i>Branta hutchinsii</i> , <i>Anas Americana</i> , <i>Anas Penelope</i> , <i>Aythya collaris</i> , <i>Anas platyrhynchos</i> , <i>Anas clypeata</i> ,** <i>Anas acuta</i> ,** <i>Anas crecca</i> , <i>Spatula discors</i> , <i>Aythya affinis</i>	LC		x		varies annually
<b>Migratory Shorebirds</b>						
Kolea, Pacific Golden-Plover	<i>Pluvialis fulva</i>	LC	n/a	x	High Concern	all MHI*
Kioea, Bristle-thighed Curlew	<i>Numenius tahitiensis</i>	VU		x	<b>Greatest Concern</b>	all MHI*
Black-bellied Plover, Semipalmated Plover, Lesser Yellowlegs, Sharp-tailed Sandpiper, Pectoral Sandpiper, Spotted Sandpiper, ‘ūlili or Wandering Tattler,** ‘akekeke or Ruddy Turnstone,** hunakai or Sanderling,** Least Sandpiper, Long-billed Dowitcher, Dunlin, Red Phalarope, Whimbrel	<i>Pluvialis squatarola</i> , <i>Charadrius semipalmatus</i> , <i>Tringa flavipes</i> , <i>Calidris acuminata</i> , <i>Calidris melanotos</i> , <i>Actitis macularius</i> , <i>Tringa incana</i> ,** <i>Arenaria interpres</i> ,** <i>Calidris alba</i> ,** <i>Calidris minutilla</i> , <i>Limnodromus scolopaceus</i> , <i>Calidris alpina</i> , <i>Phalaropus fulicarius</i> , <i>Numenius phaeopus</i>	LC		x	High Concern; Whimbrel, Ruddy, Turnstone, Dunlin, Pectoral Sandpiper, Lesser Yellowlegs	varies annually

\* Main Hawaiian Islands

\*\* Although the Hawai‘i populations are not important at a U.S. or Global population level, starred species are designated as being of "Conservation Concern" by DOFAW. The flyway for these species has been negatively affected by habitat change in Hawai‘i.



# Appendix 5 | All Site Narratives

## Wetland site narratives

Each wetland site included in the plan has a site narrative which captures the information shared by site managers and the analyses carried out by Pacific Birds. Site narratives are arranged by island.

- ▶ Kaua'i
- ▶ O'ahu
- ▶ Moloka'i
- ▶ Maui
- ▶ Kaho'olawe
- ▶ Lāna'i
- ▶ Hawai'i Island



*'Alae 'ula feeding in a lo'i. A Raine*

KAUA'I



ISLAND: KAUA'I

LOCATION: Alakoko Fishpond and Hulē'ia River

DESCRIPTION OF SITE: The Hulē'ia River is the major waterway of the Nawiliwili Bay Watershed. Alakoko Fishpond was built more than 600 years ago by constructing a wall that cut off a bend in the Hulē'ia River. It is bounded to the south by the eight-mile-long spine of the Hā'upu Range. The site is a complex mosaic of loko i'a (fishpond with open water), mudflats, lo'i kalo, riverine habitat, and estuarine intertidal habitat. The site was almost completely lost to red mangrove invasion and is now part way through a major ecological and cultural restoration project by landowners Mālama Hulē'ia.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	40*	102	Lo'i kalo, loko i'a	Mālama Hulē'ia	Mālama Hulē'ia	\$2–5 + million	Restoration underway

\*Note: Pond itself is 40 acres. Mangrove removal area is 26 acres, with 5 acres to be restored in 2023 (new section upriver in addition to the 17 acres on refuge land, currently funded by National Coastal Wetlands Conservation Grant).

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Other	Yes
Breeding	x		x	x			

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service (Refuges and Fish Habitat Partnership Program), Hawai'i Division of Fish and Wildlife, Hawai'i Division of Boating and Ocean Recreation, National Coastal Wetlands Conservation Grant, Kamehameha Schools, community volunteers, Archipelago Research and Conservation, Hallux Ecosystem Restoration.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants are found throughout the restored parts of the site. The site contains habitat for the endangered 'ōpe'ape'a (Hawaiian hoary bat). At least four of the five species of 'o'opu (endemic Hawaiian freshwater gobies and sleeper goby) and 'ōpae'ula (Hawaiian red shrimp) have been observed in the waters in and around the fishpond.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: 6 springs, one of which has been fully restored
- Inputs: Hulē'ia Stream; Hulē'ia Estuary (tidal influence)
- Outflows: Hulē'ia Stream and estuary
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
None scored 3 or less	

- **Threats**

- Access to restoration sites within the ecological system
- Introduced predators
- Potential water quality impairments (nonpoint source runoff, anoxic conditions from mangrove debris, lack of flow and circulation)
- Trash from adjacent road
- Erosion

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
> 75% of wetland inundated	< 5% of wetland inundated	> 75% of wetland inundated	< 5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Understanding the waterbird life cycle on site, avian use of kalo lo'i and other habitat, and how to optimize the site for waterbird recovery.



- Considering restoration at a watershed level and as a hydrological whole, Mālama Hulēʻia wants to identify how to expand restoration work onto neighboring properties, particularly the USFWS NWR, but also private riverine lands with mangrove, as this provides an ongoing source of propagules.
- **Challenges**
  - The Hawaiʻi State Historic Preservation Division needs to increase capacity as they are currently unable to respond within the statutory time period, which causes major delays for conservation projects, potentially putting funding in jeopardy.
  - Property boundaries/land ownership and management; restoring hydrologic function is dependent on adjacent landowner agreements. Some freshwater inputs (springs and streams) that feed into the fishpond and wetland complex are on USFWS Hulēʻia Refuge land, requiring an ecosystem level approach to management.
  - Funding for ongoing management.
- **5–10 Year Conservation Priority Actions Needed**
  - Seek ongoing funding from diverse sources.
  - Create management agreements with USFWS.
  - Engage with neighboring USFWS NWR to assist with invasive species removal on their land and restoration of habitat suitable for T&E waterbirds.
  - Complete permitting process for restoration work.
  - Complete repairs to the fishpond wall to allow water levels to rise and facilitate the return of fishpond functionality while managing water depths along the edge for the benefit of waterbirds.
  - Restore historic springs and loʻi (kalo, iʻa and iʻa-kalo) to produce sustainable community food sources, while providing habitat for life cycle needs of T&E waterbirds.
  - Restore and maintain springs to ensure ongoing freshwater supply.
  - Maintain the restored area free from mangrove reinvasion and other invasive species, and expand the mangrove removal zone upstream and to the other side of the river to reduce propagule load.
  - Fence out pigs and dogs.
  - Assess subsites for predator-proof fencing and, if appropriate, seek funding for a predator proof fence.
  - Expand and maintain predator control long term (including training of staff).
  - Continue removal of invasive plants mauka of the site, and plant native plants or fruit trees which are compatible with waterbird recovery.
  - Continue and enhance waterbird monitoring and management (including training of staff).
- **Benefits to T&E birds / MBTA birds**

- The removal of mangrove has created high-quality waterbird habitat in an area that was previously choked with invasive species.
- Ongoing predator control will contribute to T&E waterbird fledging success and waterbird / migratory bird survival (additional monitoring is needed).
- The creation of lo'i kalo and restoration of springs is expanding the additional habitat suitable for waterbirds.

- **Benefits to People**

**Ecosystem Services:** Mangrove removal will improve water quality, and the restoration of the fishpond will provide sediment and flood control as well as serving as a critically important nursery ground for native fish.

**Education:** The Alakoko Fishpond hosts hundreds of school children and volunteer groups annually.

**Sustainable food:** The long-term aim is for the site to be a hub of sustainable food including fish from the fishpond, kalo from the lo'i, canoe plants, fruit trees (e.g. mango and banana) and fishing access.

**Fishing:** Fishing is possible on the river.

**Recreation:** Volunteer work days are arranged monthly. The mangrove removal is also keeping the river navigable for the canoe club and other water enthusiasts.

**Cultural:** Kaua'i archaeologist Bill Kikuchi described the fishpond as "one of the finest examples in the entire archipelago of prehistoric stonework and fishpond construction." Traditional Hawaiian beliefs and practices are at the heart of restoration work here, and the team regularly share their knowledge with other site managers from across the state.

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ISLAND: KAUAI

LOCATION: Hanalei National Wildlife Refuge (NWR)

DESCRIPTION OF SITE: The Refuge was established to aid in the recovery of five Endangered Species Act (ESA) listed waterbirds and is located in a relatively flat river valley containing abundant fresh water and surrounded by steep, wooded hillsides up to 1,600 ft high. A portion of the Hanalei River, which is a designated American Heritage River, runs through the Refuge. At the southeastern end, the Hanalei River is diverted into irrigation ditches which feed the managed wetlands and lo'i kalo. Lowland areas of the refuge are managed as a mosaic of wetland habitats, including rotational, moist-soil wetland management units and kalo farms. Waterbird use of this area is extensive. There has been wetland agriculture in the Hanalei Valley for several hundred years. Traditional kalo farming practices help maintain waterbird feeding and nesting areas in conjunction with service-managed wetlands. Kalo farming on the refuge provides approximately 40% of Hawai'i's total kalo production; it is managed through a special use permit. The refuge is mostly closed to the public for general access; however, there are a few sites that are open to the public, including the new Hanalei Viewpoint site, with ample parking and interpretive signage.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
10	275*	917	160*	USFWS	USFWS	\$2-5 million	Restored

\*115 acres of managed wetland units and associated dikes and ditches, 160 acres of lo'i kalo and associated dikes and ditches

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Core	No
Breeding	x	x	x	x	x		

SUPPORTING PARTNERS: Friends of Kauai Wildlife Refuges, permitted kalo farmers, Natural Resource Conservation Service, American Bird Conservancy, U.S. Geological Survey, Oregon State University, Kauai Invasive Species Council, Department of Land and Natural Resources, Save Our Shearwaters, Americorps, Kupu, Huliauapa'a, Hamline University, Conservation Dogs of Hawai'i, Hanalei Watershed Hui.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

3.1 miles of river running through the refuge provide habitat for 'o'opu (Hawaiian diadromous gobies and sleeper goby), native invertebrates including pinao 'ula (Hawaiian damselflies), and 'ōpae 'oeha'a (Hawai'i river prawn). The refuge also contains habitat for the endangered 'ōpe'ape'a (Hawaiian hoary bat), and the wetlands provide habitat for migratory waterfowl and shorebirds.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Kuna Spring (flow rate close to evaporative rates; others along toe slope of cliff along eastern boundary of NWR.
  - Inputs: Annual rainfall 75" +; Hanalei River; groundwater.
  - Outflow: Runoff, Hanalei River, percolation.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Human disturbance control	3
Botulism control	1
Predator control	2
Invasive plant control	2

- **Threats**

- Invasive plants
- Water quality
- Avian botulism
- Entry road and main highway (multiple mortality incidents of T&E waterbirds due to vehicle strikes)
- Major flooding several times a year.
- Invasive predators – pigs, feral cats, rats, mice, barn owls, egrets, bullfrogs.
- Powerlines.
- Farming intensity in lo'i kalo (human disturbance, nutrient load, water level fluctuations).



- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
5-25% of wetland inundated	<5% of wetland inundated	5-25% of wetland inundated	<5-25% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Sufficient inventory, monitoring, and research to direct management

- **Challenges**

- Freshwater availability is threatened by river breaches which divert and prevent water from reaching the refuge irrigation intake during low water conditions.
- Confirming hybridization of koloa through accurate plumage identification key is needed so that removal of hybrid individuals can be performed. **This is threatening the genetic integrity of the koloa maoli in the only location which has large numbers of purebred birds.**
- Staffing and expertise — recruitment and retention difficult due to high cost of living.
- Lack of funding, especially given the high cost of some key projects and very old and vulnerable infrastructure.
- Flooding (frequent damage to critical assets and infrastructure, as well as impact to native species).
- Lack of staff resources to increase community involvement.
- Lack of capacity and infrastructure to support expanded outreach and education (we are continually working to improve this through guided hikes and programs and our new Viewpoint site).

- **5–10 Year Conservation Priority Actions Needed**

- **Increase capacity.**
  - Boost staffing capacity to conduct biological research needed to inform habitat management.
  - Support increased habitat management and maintenance.

- Increase capacity to observe permitting compliance and reduce human disturbance.
  - **Control invasive predators.**
    - Implement valley-wide predator control to increase survival of waterbirds.
    - Increase predator control capacity, esp. barn owls, feral cats (particularly at key ingress points) and feral pigs.
  - **Improve water control and quality.**
    - Carry out infrastructural repairs from flooding.
    - Secure water access for refuge into future by securing a site and strategy for secondary intake location along river (first seeking public review/comment).
    - Improve water quality — Hanalei River contributes the largest amount of pollutants to Hanalei Bay (inorganic nitrogen, phosphate, fecal bacteria) (USEPA et al. 2004).
  - **Manage kalo for waterbirds.**
    - Continue to update and exchange information with kalo farmers on best management techniques for endangered waterbirds.
  - **Explore opportunities of neighboring parcels for wetland expansion.**
  - **Update hybrid ID Standard Operating Procedures.**
  - **Remove feral Mallards and Mallard x koloa maoli hybrids.**
  - **Restore /enhance additional 3–18 acres of wetland habitats for waterbirds.**
  - **Improve riverine habitat of 3.1 miles of Hanalei River for native fish, wildlife and humans.**
  - **Enhance / manage 14–24 acres of riparian grassland habitat for nēnē.**
  - **Enhance / manage 21 acres of upland habitat for nesting koloa maoli.**
- **Benefits to T&E birds / MBTA birds**

Management at Hanalei NWR is focused on the conservation of T&E waterbird species, with particular emphasis on the koloa maoli (Hawaiian Duck). Habitat is managed and available year-round to support all the life history needs of these waterbirds. The refuge is one of the only places where the threat of hybridization of koloa maoli with feral Mallards can be managed, and non-hybridized koloa maoli can thrive. Hanalei NWR is also one of the last strongholds of the ‘ālae ‘ūla. It has been documented that waterbirds move between the Hanalei Valley and other habitats on Kaua‘i and Ni‘ihau seasonally and during flooding events (Henry, 2006).

● **Benefits to People**

**Ecosystem Services:** The agroecological system provides a variety of societal benefits (ecological, cultural, aesthetic, and historical). Hanalei NWR is a critically important part of the flood control network that protects Hanalei town. The lower Hanalei River typically overflows onto its floodplain several times a year (most streams flood, on average, once every 2–3 years). The largest ever documented flood occurred in 2018 after rainfall of 50” in 24 hours.

- The refuge wetlands help to dissipate the energy of surface water flow during periods of heavy rainfall by temporarily retaining water, slowing downstream flows, and attenuating downstream flooding (USFWS, 2020b).



- Hanalei NWR acts as a ‘landscape filter’ to improve water quality of connected rivers and offshore waters (USFWS, 2020b).
- The plant communities and soil within Hanalei NWR serve as carbon sinks, helping to moderate global climate change.

**Education:** The Friends of Kaua’i National Wildlife Refuges provide education and outreach for all three NWRs on Kaua’i. More education and community programming will become available with the opening of our new 5-acre Viewpoint that is a safe distance from disturbance to waterbird species and farming operations.

**Sustainable food:** Hanalei NWR is an ideal place to farm traditional wet agriculture crops (kalo). Farming kalo provides food and supports the biological objective for managing shallow-water habitat to satisfy some of the life history requirements of threatened and endangered waterbirds.

**Cultural:** The site is important for kalo cultivation, producing more than 40% of the state’s crop yield. Infrastructure such as the China Ditch and the Kuna Ditch as well as other features, including many of the lo’i and terraced rock walls, have been issued a state site number for cultural importance. Haraguchi Rice Mill is on the National Register of Historic Places.

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ISLAND: KAUA'I

LOCATION: Hanapēpē Salt Ponds

DESCRIPTION OF SITE: Hanapēpē Salt Ponds has been a site of active salt production for centuries. This area consists of two basins separated by a decommissioned road. The western pond is used for the production of salt and is characterized by many small wells that connect to the sea. The eastern pond is a natural ephemeral wetland that fills during heavy rains. This site is listed in the State Inventory of Historic Places.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
1	12.49	50	Pa'akai, Hawaiian salt-making	State of Hawai'i	Hui Hana Pa'akai	\$500k–1 million	Preliminary planning

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Supporting	No
Breeding		x	x	x			

SUPPORTING PARTNERS: University of Hawai'i and County of Kaua'i in a hydrology study.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Native plants are present at the edges of the ponds, and the ponds themselves are habitat for native invertebrates. The presence of 'ōpae'ula (Hawaiian red shrimp) in wells indicates to the families that harvest salt from the ponds that the well is healthy.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Seawater seeps into many wells throughout the salt-making area.
- Inputs: 25+” annual rainfall, runoff coming from different sides, tidal overtopping over sand dunes occasionally during high wave events.



- Outflows: None, only evaporation. In the past, there used to be an outlet back to the ocean, but it's unclear where it was and was likely man made.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	1
Human disturbance control	3
Invasive plant control	3

- **Threats**

- Feral cats as predators and disease vectors
- Predators
- Human disturbance
- Trash
- Pollution

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	50-75% of wetland inundated	50-75% of wetland inundated	50-75% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0-2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Education on the native Hawaiian birds that the salt pan families coexist with is needed, including the needs of the birds during their different life cycle stages.
- **Challenges**

- Coastal erosion and sea level rise will result in waves overtopping into the salt pans. Hui Hana Paʻakai helped to stop vehicles driving on the beach which has partially improved the situation and allowed native plants to regrow, helping to stabilize the sand dune.
  - Runoff from surrounding properties carries pollution into the site. Polluted runoff comes from the adjacent airport and from an illegal cesspool (now removed), mauka from a cattle ranch, and the nearby beach park that is frequented by visitors and their vehicles.
  - Homeless encampments
  - This is a county camping site; people walk into the salt pans, impacting the cultural resource and birds. Pans are also occasionally used as a bathroom.
  - Trash — regular clean ups are needed.
  - Hard to navigate multiple landowners in the surrounding properties including Hawaiʻi Department of Land and Natural Resources, County of Kauaʻi, U.S. Coast Guard, Port Allen Airport, and private landowners mauka.
  - Mauka development above the state highway and development near Hanapēpē Heights will increase traffic to the beach.
  - Predators
  - Cat feces impacting salt and birds
- **5–10 Year Conservation Priority Actions Needed**
    - Understand and apply results of 2023 UH SeaGrant hydrology study on how coastal restoration efforts will mitigate wave overtopping and erosion. Initial results suggest that maintaining the beach area will help protect salt pans.
    - Expand advocacy efforts beyond the existing beach area into the mauka area when considering runoff from adjacent properties.
    - Continue discussions with DLNR regarding management of property adjacent to the helicopter business to create a buffer zone free from development and stabilize the area from runoff by planting native plants.
    - Remove the adjacent small airport that purely serves the business interests of two companies, followed by appropriate land management.
    - Build staff capacity so that future generations can carry out the practice of salt making, which also provides habitat for native waterbird foraging.
    - Build funding opportunities.
    - Relocate the camping area at the beach park away from the salt pans.
    - Build capacity to provide regular waterbird monitoring beyond the State Waterbird Count.
  - **Benefits to T&E birds / MBTA birds**
    - Hanapēpē Salt Ponds provide a continuum of available habitat for waterbirds along the southern coast of Kauaʻi from Līhuʻe to Mānā. The main salt pond and the eastern pond provide habitat for aeʻo (Hawaiian stilts) and other waterbirds (including native T&E species) and migratory birds during flooding events.



- **Benefits to People**

**Ecosystem Services:** Provisioning services, through salt production, and cultural services.

**Education:** The Hui Hana Paʻakai carry out extensive education work with local school children, cultural organizations, cultural practitioners, hula hālau, families visiting from around the world, scientists, etc. They receive requests throughout the year to share about the challenges they are faced with in the area but also the practice of making salt and the uses of it.

**Sustainable food:** Salt

**Fishing:** Fishing is available at the nearby coast but not in the ponds.

**Recreation:** The beach is an important recreation area for the local community.

**Cultural:** The Hanapēpē Salt Ponds area has been in use for centuries. Paʻakai (sea salt or 'solidify the sea') is produced using underground seawater from wells, then transferring the saltwater to waikū (shallow pools) lined with clay from the area. This is the only site still producing salt in this way in the Hawaiian Islands.

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ISLAND: KAUAI

LOCATION: Hōkūāla Resort

DESCRIPTION OF SITE: Hōkūāla Resort has a number of man-made ponds including a 32.4-acre pond system around the golf course and a number of small ponds totaling 7.82 acres within an older part of the golf course. The older area of the course has since been decommissioned and is now used as an organic farm with walking trails that are used for bird tours. This site has a Habitat Conservation Plan (HCP) in place until 2042 which includes predator control. These ponds are used by all five T&E waterbirds for foraging and breeding, as well as migratory shorebirds and waterbirds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
35	40.22	625	None	Tower Kauai Lagoons, LLC	AECOS, Inc.	N/A	Unrestored*

\*No obligation under the HCP for habitat restoration but landowner may consider it.

Bird Information							
T&E Bird Species Present							
	‘alaie ‘ula	‘alaie ke‘oke‘o	ae‘o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Other	No
Breeding	x	x	x	x	x		

SUPPORTING PARTNERS: None.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Pueo (Hawaiian Short-eared Owl), ‘ōpe‘ape‘a (Hawaiian hoary bat)

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: None



- Inputs: The water for the ponds is pumped from the Līhu‘e wastewater treatment plant, and is R2 classed water. Rainfall also contributes. There is no groundwater input.
- Outflows: There is no outflow, only evaporation.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
None scored 3 or less	

- **Threats**

- Predators, including cats, rats, cattle egrets and Barn Owls
- Vehicle collisions, on roads and in parking lots where chickens are being fed by the public.
- Golf ball strikes. Between July 1, 2021, and June 30, 2022, Hōkūala experienced the direct incidental take of 11 ‘ālae ke‘oke‘o, 5 ‘ālae ‘ula, and one ‘a‘o. 5 were killed by cars on paved roads; 1 was killed by a golf cart; 11 were killed by golf ball strikes. HCP is in place to mitigate for this take.

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- This site would benefit from habitat restoration (e.g. changing the landscaping regime around wetlands to outplant and maintain native plant species) around the ponds

where invasive vegetation encroaches. While this management is not required by the HCP, the landowner may welcome advice and support to carry out this work.

- **5–10 Year Conservation Priority Actions Needed**

- Continue habitat management actions / protocols for T&E waterbirds as agreed under HCP.
- Increase and maintain training to resort employees so that they can promote positive behavior and intervene in negative behavior of visitors.
- Increase and maintain education to golfers and visitors on how to behave around T&E birds, to reduce vehicle, golf cart and golf ball collisions.
- Install signage in parking lots and other key visitor locations advising people of the value of T&E birds and their legal protection, encouraging slow driving and no feeding of birds.
- Maintain predator control long term to increase avian survival and fledging success.
- Restore wetland habitat by removing invasive species around ponds and outplanting native species as part of landscaping operations to further improve waterbird survival and reproductive success.

- **Benefits to T&E birds / MBTA birds**

- This site is important for T&E species on Kauaʻi, with 26 nēnē nests , 17 ʻalaie ʻula nests, and 5 koloa maoli nests recorded in the 2021–2022 reporting year (Hōkūala HCP Annual Report 2022). During the prior two years, ʻalaie keʻokeʻo were also found nesting at the site.

- **Benefits to People**

**Ecosystem Services:** None.

**Education:** This property offers bird tours to guests.

**Sustainable food:** The decommissioned golf course has been converted to a 16.5 acre organic farm that produces food for the resort's restaurant.

**Fishing:** None.

**Recreation:** This property offers farm and birding tours to guests and is heavily used by local people for walking / biking.

**Cultural:** None.

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ISLAND: KAUA'I

LOCATION: Hulē'ia National Wildlife Refuge (NWR)

DESCRIPTION OF SITE: This approximately 241-acre site, established to aid in the recovery of five Endangered Species Act (ESA) listed waterbirds, is located along a tidally-influenced section of Hulē'ia River in a relatively flat valley and is bordered by a steep wooded hillside. Some of the lowland areas within the refuge were used for wetland agriculture including taro and rice in the past and have river bottom emergent wetlands. The habitat is managed to control invasive vegetation species through mowing, disking, rototilling, and water level manipulation, as needed, to set back wetland plant succession and provide suitable habitat structure and function for the benefit of T&E waterbirds. The refuge includes a significant portion of the land that is a part of and surrounding the Alakoko Fishpond (Mālama Hulē'ia), which is undergoing a major restoration project (including invasive mangrove removal, with native plant and wetland restoration) that spans from the fishpond to the upper reaches of the Refuge.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3	77*	241	No	USFWS	USFWS	\$1-2 million	Restoration underway

\*21 acres of wetland management units, with restoration potential for up to 56 more acres (~46 acres on the flats east of Papakolea ditch and ~10 acres west of unit H5)

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Core	No
Breeding	x		x	x			

SUPPORTING PARTNERS: Mālama Hulē'ia, Friends of Kaua'i National Wildlife Refuges.

Conducts site-based waterbird monitoring (not including SWBC): Yes

● **Other Wildlife of Note**

- Native plants are found in the site.
- Endangered 'ōpe'ape'a (Hawaiian hoary bat)
- Numerous species of migratory waterfowl and shorebirds

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes
- Inflows: Hulē'ia River, Papakolea Stream, rainwater runoff
- Outflows: Hulē'ia River and stream (pipes run from stream; open ditches into river with tide-gated water control structures)

- **Status of Key Management Actions (scored 3 or less, with 1 being most serious threat)**

Key Management Action	Score
Predator control	2
Botulism control	3
Invasive plant control	2

- **Threats**

- Invasive Plants
- Water Quality
- Salinity

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
5-25% of wetland inundated	<5% of wetland inundated	50-75% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Sufficient inventory, monitoring, and research to drive/direct management

- **Challenges**



- Outreach, education, and community involvement. The refuge is not currently open to the public. However, a proposal to allow guided access is being evaluated. Amongst the public there is currently little awareness of the site, but as the refuge works with partners including Mālama Hulē'ia on additional restoration, the refuge profile should increase.
  - A dedicated, full-time refuge staff member is needed to maintain current habitat and open up new units.
  - Confirming hybridization of koloa maoli through accurate plumage identification key is needed so that removal of individuals can be performed. This is threatening the genetic integrity of the koloa maoli.
  - Staffing and expertise; recruitment and retention are difficult due to high cost of living.
  - Funding and staffing capacity, limiting ability for predator control and habitat management.
- **5–10 Year Conservation Priority Actions Needed**
    - Improve water delivery so that wetland habitats are managed to provide maximum benefit for Hawaiian waterbirds.
    - Work with the Mālama Hulē'ia team to dovetail their restoration efforts with NWR efforts and maximize benefits to waterbirds, native plant habitat and ecosystem services.
    - Remove mangrove from Hulē'ia Stream to open up habitat for endangered Hawaiian waterbirds (planned in partnership with Mālama Hulē'ia through USFWS grants).
    - Within 5–10 years, enhance 5–18 acres of riparian grassland habitat for foraging and breeding nēnē.
    - Within 5–10 years, enhance and manage 8-28 acres of upland area for koloa nesting.
    - Remove California grass and other invasive species outside of currently managed units.
    - Expand the invasive predator trapping program.
    - Complete the ungulate fence around perimeter of refuge.
    - Improve water intake on some units.
    - Conduct additional waterbird monitoring.

- **Benefits to T&E birds / MBTA birds**

Management at Hulē'ia NWR is focused on the conservation of ESA waterbird species, with particular emphasis on the ae'o (Hawaiian stilt) and koloa maoli (Hawaiian Duck). Management actions include habitat restoration and creating or maintaining infrastructure, primarily for water management, to expand wetland functions throughout the Refuge to support the life history needs for endangered Hawaiian waterbirds. In addition, the refuge is one of the only places where the threat of hybridization of koloa maoli with feral Mallards can be managed, and non-hybridized koloa maoli can thrive. It is vitally important for waterbird recovery statewide.

- **Benefits to People**

**Ecosystem Services:** This site may contribute to improved water quality and provide flood control, but ecosystem service delivery is hampered by the presence of invasive plant species, particularly red mangrove. The plant communities and soil within the refuge serve as carbon sinks, helping to moderate global climate change.

**Education:** Yes, however, currently limited capacity due to remote access on a road that is not suitable for non-four wheel drive vehicles. Outreach currently possible a few times per year for small groups through staff-led opportunities. Additional opportunities will be evaluated in the future.

**Sustainable food:** No

**Fishing:** No, although this use would be evaluated in the future

**Recreation:** Kayaking and canoeing along navigable Hulē'ia River (refuge lands occur on both sides of the river).

**Cultural:** Portions of the Alakoko Fishpond are located on the Refuge which is rich with history. Archeological reports have identified several other cultural resources and features within Refuge boundaries.

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ISLAND: KAUA'I

LOCATION: Kawai'ele Waterbird Sanctuary

DESCRIPTION OF SITE: This site is a former sand mine, created to supply the concrete industry. It is located on the Mānā Plain, formerly one of the most extensive wetland areas in the Hawaiian Islands. There are six ponds of varying depths, designed to maximize value for T&E waterbirds. Invasive species have been removed, and there is extensive and successful outplanting with native plants. The site is permanently open to the public.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
9	30	32	None	Hawai'i Department of Land and Natural Resources (DLNR) — Division of Fish and Wildlife (DOFAW)	DOFAW	\$250-500k	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Core	Yes
Breeding	x	x	x	x	x		

SUPPORTING PARTNERS: Ducks Unlimited, Natural Resources Conservation Service, Pacific Birds, U.S. Fish and Wildlife Service.

- **Other Wildlife of Note**

Endangered and other native plants are found in the site, including outplanted 'ōhai (O'ahu riverhemp) and dwarf naupaka.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Hydrology**

Has there been a formal hydrological survey: No



- Springs: Not known
  - Inputs: Ponds are fed from groundwater and topped up with rain. The brackish nature of the water in the pits is thought to result from the percolation of marine water into groundwater through and under the narrow (< 1 mile) extension of land that separates the Kawai‘ele site and the beach (Tavares, 2009).
  - Outflows: There is no direct, superficial outflow of waters from the Kawai‘ele pits into drainage ditches, but there is subterranean outflow. The water level in the ponds is influenced by the drainage system through the regulation of groundwater saturation.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Botulism control (not prone but can't control water levels)	1

- **Threats**

- Trash
- Unfenced roads
- Powerlines
- Invasive fish
- Predators

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Staffing capacity

- **Challenges**

- Water temperature can be relatively variable, ranging from ~ 25.5°C in Dec. to 32°C in Sept.
- Salinity currently ranges from ~ 18–32 ppt across the year, with higher levels discouraging ‘alae ‘ula.
- There is no way to control water levels.
- Invasive, herbivorous tilapia have significantly reduced native aquatic vegetation such as *ruppia* (widgeon grass). Widgeon grass has started to become reestablished in the few ponds lacking tilapia.

- **5–10 Year Conservation Priority Actions Needed**

- Remove introduced fish (tilapia and western mosquitofish).
- Continue long-term monitoring of impacts of hydrologic alterations (i.e. groundwater pumping) on biological communities.
- Restore adjacent marginal agricultural lands to create a mosaic of coastal wetland habitats (project underway).
- Build a fence to prevent road deaths of waterbirds (preferably predator proof fence).
- Minimize collision risk of waterbirds with powerlines by installing diverters, growing a shield of trees, or undergrounding / rerouting the line.

- **Benefits to T&E birds / MBTA birds**

- Kawai‘ele is managed successfully for all five T&E waterbirds and also hosts migratory waterfowl and shorebirds.

- **Benefits to People**

**Ecosystem Services:** The site helps improve water quality in nearby ocean waters and provides flood control to nearby land.

**Education:** DOFAW hosts multiple school groups annually, as well as student projects and KUPU organization interns, and is planning an education center.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** This site is open to the public at all times and is used regularly for recreational birdwatching.

**Cultural:** None.

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ISLAND: KAUA'I

LOCATION: Lumaha'i Valley, Hanalei District

DESCRIPTION OF SITE: Lumaha'i Valley is a relatively undisturbed valley with a stream and floodplains providing habitat for waterbirds. The wetland transitions from fresh to brackish to fresh as it reaches the sea and there is an extensive beach area. Mauka (inland of the bridge), the estuary opens into a large pond which is fringed by a mix of wetland species including hau and other non-native plants. The floodplain behind supports lo'i kalo and there are large grassy mowed areas and a paddock. All five species of T&E waterbirds are seen here regularly. Further mauka, the wetland area is overgrown by hau bush (sea hibiscus) and other native and non-native plant species.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
River valley (5–600)	125	7,900	Lo'i kalo (approx. 30 acres)	Kamehameha Schools	Kamehameha Schools	\$500k-1 million	Preliminary planning (Kalo — partially restored, remainder unrestored)

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Core	Yes, partially
Breeding							

SUPPORTING PARTNERS: The Nature Conservancy.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

The upper reaches contain areas of high plant and stream diversity. The beach may be used for nesting by honu (green sea turtle) and for resting by 'ilio holo i ka uaua (Hawaiian monk seal).

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes
- Inputs: Lumaha'i Watershed, 85" + annual rainfall
- Outflows: Lumaha'i River
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control*	3
Invasive plant control	1

\*No known outbreaks

- **Threats**

- Unfenced roads
- Extreme weather events (e.g. tsunamis)
- Unleashed dogs
- Feral ungulates (e.g. pigs)
- Non-native predators (e.g. feral cats, rats, mongooses)
- Non-native vegetation
- Trespassing
- Trash

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
5-25% of wetland inundated	<5% of wetland inundated	25-50% of wetland inundated	<5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Permitting challenges

- Develop a restoration, monitoring, and management plan.
- Best Practices Management document needed to work with lo'i farmer so that site can be effectively managed for both kalo and birds.
- **Challenges**
  - Unmanaged non-native and/or polynesian introduced plants may be impacting water flow and/or quality.
  - Navigating mixed stakeholder and community needs.
  - Obtaining necessary permits and/or funding.
- **5–10 Year Conservation Priority Actions Needed**
  - Gather baseline information on native species and habitats present in the valley.
  - Conduct a spatial analysis to build a landscape plan.
  - Improve management through fencing, predator control, and invasive vegetation management.
  - Expand funding at the site.
  - Employ monitoring and management work.
- **Benefits to T&E birds / MBTA birds**
  - The valley has large tracts of relatively undisturbed habitat for endangered waterbirds, forest birds, and native plant species.
  - Estuary area above the bridge has an area of open water that is frequented by T&E waterbirds and migratory waterfowl.
  - The lo'i kalo support waterbirds and are well managed.
  - Nāmolo-kama upland bog in the mauka area is frequented by koloa maoli.
- **Benefits to People**

**Ecosystem Services:** The wetlands within the valley capture sediment and reduce runoff to the nearshore coastal ecosystem and offshore reefs. Management of invasive plants and the restoration of the site with native plants may increase native fish population, as indicated by early work in other wetland restoration projects, and will likely enhance the marsh's capacity to capture sediment.

**Education:** No organized educational opportunities are currently available although this may change in the future.

**Sustainable food:** Cultivation of lo'i kalo.

**Fishing:** Fishing in the river from land and/or via access to areas mauka of highway is not available to the public. Fishing from publicly accessible areas, like the shoreline, is regulated by applicable county, state, and federal regulations.

**Recreation:** Beach areas utilized by community and visitors for recreation.



**Cultural:** Lumaha'i and surrounding areas are important within numerous cultural mo'olelo and sayings. The valley has been in active kalo production since pre-contact times and once supported a large community. The plateau of Nāmolokama is a significant wahi pana referenced in mele, oli, and serves as one source of rain/water into Hanalei.

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ISLAND: KAUA'I

LOCATION: Makauwahi Cave Reserve (MCR) & Waiopili Stream, Maha'ulepu

DESCRIPTION OF SITE: This is a lowland forest restoration site with riparian and grassland habitat, four wetland ponds, and 15 lo'i kalo. The wetland restoration was designed to reduce heavy sediment loads detrimental to coral reefs along the southern coast of Kaua'i and to restore Kapunakea wetland which was lost in the 1950s. The restored wetlands, which provide breeding, foraging and loafing habitat for T&E waterbirds and nēnē, include a stream, whose surface water mixes with tidal inputs in an estuary. There is an extensive area of scrub, beach and dunes. The site contains important natural and cultural resources including the Makauwahi Cave, habitat for the endangered Kaua'i cave wolf spider and the Kaua'i cave amphipod. The cave is also an important geological feature where examination of sediment and fossil contents increased our understanding of the composition, dynamics, and human-induced changes of ecological communities dating back to pre-human settlement (Burney et al. 2001). The site is open to the public via walking trails, but the wetlands are well protected from disturbance.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
1–6	13	100	Lo'i kalo	Private	Leased to MCR	\$1–2 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Other	Yes
Breeding	x	x		x	x		

SUPPORTING PARTNERS: Pacific Birds, U.S. Fish and Wildlife Service Coastal Program, Grove Farm, Mālama Māhā'ulepū, Archipelago Research and Conservation.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

The Makauwahi Cave Reserve is designated as critical habitat for two endangered cave-dwelling invertebrates: the pe'e pe'e maka 'ole (Kaua'i cave wolf spider) and the 'uku noho ana (Kaua'i cave amphipod). Waiopili Stream is a key nursery habitat for native fish. The site also provides shorebird habitat as well as coastal beach habitat used by the 'Ilio holo i ka uaua (Hawaiian monk seal) and honu (green sea turtle).

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes
- Inputs: Tidal input, water distribution system piped from Waita Reservoir, groundwater (springs and seeps, including spring-fed ponds in cave), surface water / streams (ephemeral or perennial/ponding), and precipitation.
- Outflows: Waiopili Stream, which empties into ocean at the site; groundwater recharge / groundwater flows out below sea level along coast; evaporation; and tidal outflow.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Invasive plant control	3

- **Threats**

- Predators
- Single powerline

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 3.0-4.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Hydrology survey



- **Challenges**

- Funding
- Nonprofit structure via current Garden Island Resource, Conservation and Development (GIRCD)
- Staffing

- **5–10 Year Conservation Priority Actions Needed**

- Establish an Executive Director and build capacity.
- Maintain and expand effective predator control.
- Install predator-proof fence around the site.
- Maintain and expand invasive species removal.
- Monitor and manage waterbirds.
- Plan and implement site conservation development plans.
- Manage habitat by raising the water level of the ponds with islands to reduce the slope and increase edge habitat, ensuring that habitat is ideal for target species.
- Rejuvenate lo'i management through community groups.
- Minimize risk of collision with powerline by installing diverters, growing a shield of trees, or undergrounding / rerouting the line.

- **Benefits to T&E birds / MBTA birds**

- Brackish and freshwater wetlands provide important habitat for nesting and feeding by the five T&E waterbird species.
- The shoreline provides habitat for migratory shorebirds, including 'ūlili (Wandering Tattler) and 'akekeke (Ruddy Turnstone).

- **Benefits to People**

**Ecosystem Services:** Flood Control — the reserve wetlands are vitally important to control flow of sediment onto the reef.

**Education:** This site receives 70,000 + visitors, including multiple school groups, annually. MCR demonstrates that change is a fundamental part of nature, but that scientific evidence shows that we are entering a period of rapid change and uncertainty that will require all communities to adapt.

**Sustainable food:** Lo'i and fishing access

**Fishing:** This site provides deep drop-offs for ula (spiny lobsters), 'opihi, and large gamefish. Waiopili Stream has anadromous 'ama'ama (striped mullet) as well as introduced tilapia. Black rock crabs are found on the beach. Reefs and underwater caves are found just offshore, available for spearfishing, and sea cucumbers and sea urchins are found in the ample tide pools.

**Recreation:** Windsurfing, kayaking, canoeing, snorkeling, hiking, running, and swimming

**Cultural:** Native Hawaiians and Hawaiian interest groups have played a primary role in the development of the overall management philosophy, conservation techniques, and outreach

strategies at MCR. Many former residents and descendants of residents of the adjacent island of Ni'ihau live on Kaua'i. 48 Ni'ihau youth and adults worked as restoration trainees, learning skills in conservation, landscaping, agriculture, and tourism concessions while earning a decent stipend.

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ISLAND: KAUA'I

LOCATION: Mānā Plain Open Floodable Space

DESCRIPTION OF SITE: About 200 acres of open floodable space (OFS) will be created on around 400 acres of untillable agricultural land adjacent to the Pacific Missile Range Facility (PMRF), in an area that was formerly an expansive wetland before drainage for sugar cane cultivation. This natural infrastructure will reduce the amount and improve the quality of storm runoff being directly discharged from the agricultural drainage ditch system into the nearshore environment at PMRF, as well as sustaining agriculture on the plain in the face of ongoing sea level rise. The OFS will be enhanced by removing invasive species and outplanting native plants to stabilize soils and increase the ability of the land to retain water, capture sediment, and create optimal habitat for five species of T&E native Hawaiian waterbirds. A buffer of appropriate cover crops (e.g. kalo) will be planted to further enhance ecosystem services of this wetland. An ungulate proof fence is planned as a minimum but it is hoped that a cat proof fence could be built.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
Landward edge of plain < 10, dropping to -1m to 0.5 m MSL	200	400	Lo'i kalo (planned)	State of Hawai'i - Agribusiness Development Corporation (ADC)	Kekaha Agricultural Association (non profit)	\$5+ million	Planning

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x			Other	Yes
Breeding							

SUPPORTING PARTNERS: State of Hawai'i Agribusiness Development Corporation (ADC), Kekaha Agriculture Association (KAA), the U.S. Navy Pacific Missile Range Facility (PMRF), the State of Hawai'i Division of Forestry and Wildlife (DOFAW), the Kaua'i Island Utility Cooperative (KIUC), West Kaua'i Energy Project (WKEP), the University of Hawai'i Sea Grant Program, the County of Kaua'i.

Conducts site-based waterbird monitoring (not including SWBC): No, but monitoring is planned

- **Other Wildlife of Note**



None

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: None
- Inputs: 2 aquifers beneath plain, rainfall, storm runoff, the Kekaha Ditch and groundwater wells/shafts
- Outflows: An agricultural drainage system which supports agricultural production and ensures low-lying areas of Kekaha town and PMRF do not become waterlogged by maintaining the water table below the root zone and diverting storm runoff from the adjacent uplands away from fields

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Invasive plant control	3
Human disturbance control	3

- **Threats**

- Potential contaminants from runoff
- Predators

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	5-25% of wetland inundated	>75% of wetland inundated	5-25% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

None currently identified

- **Challenges**

- Planning, creating and maintaining a hydrologically functional, flood-tolerant domain where surface runoff will temporarily pond
- Ensuring wetland provides ecosystem services that will support and attract T&E Hawaiian waterbirds while improving water quality and reducing flooding and sedimentation onto PMRF lands and near-ocean waters
- Maintaining area free from invasive species and predators

- **5–10 Year Conservation Priority Actions Needed**

- Develop a restoration, monitoring, and management plan.
- Plan, implement and maintain effective predator control long term.
- Install an ungulate or cat proof fence around the site.
- Plan, implement, and maintain invasive plant removal.
- Complete outplanting with native species (and create an inhouse nursery).
- Initiate and maintain effective waterbird monitoring.
- Monitor success of ecosystem services delivery of the wetland.
- Monitor response of T&E waterbirds and adapt as necessary.

- **Benefits to T&E birds / MBTA birds**

- The Mānā Plain has been identified by state and federal agencies as a critically important location for wetland habitat restoration because it previously supported large populations of shorebirds and other migratory birds. The OFS has the potential to sustain a functioning coastal wetland ecosystem that will attract T&E Hawaiian waterbirds and migratory birds.
- Removal of invasive species and outplanting native plants will create optimal habitat for five species of T&E native Hawaiian waterbirds.
- Naturalizing this space will more than double the area of regenerated coastal wetland habitats on the Mānā Plain and could facilitate the removal of these birds from the base by providing more appealing habitat that meets all their life cycle requirements and is largely free of predators and invasive species.
- This site should reduce the Bird/wildlife Aircraft Strike Hazard at PMRF.
- 8 km of cat-proof fencing around ~ 200 acres of land will protect birds from predators.

- **Benefits to People**

**Ecosystem Services:** Land on the plain will become more vulnerable to event-based flooding as sea level continues to rise, because the ability of gravity flows to discharge storm runoff from the drainage ditch system will be constrained by tide and wave height. The increased flood risk

has implications for water quality and will severely impact the critical asset of PMRF (the nation's premier instrumented, multi-dimensional testing and training missile range). The natural infrastructure at this site will ameliorate these issues. In addition, agro forestry is planned mauka of the area, for ahupua'a level restoration.

**Education:** Research opportunities are being explored with UH. School trips might be possible in the future.

**Sustainable food:** Taro (or a similar aquatic crop) will be planted in the 200-acre buffer zone.

**Fishing:** None.

**Recreation:** KAA hopes to build recreational opportunities into the project and to include agro-tourism options.

**Cultural:** The site is part of an extensive former wetland, and this project restores the indigenous agricultural interest and natural history value. The project team intends to seek feedback from the community as the work progresses.

## References

Burt, R. J. (1979). *Availability of ground water for irrigation on the Kekaha-Mana coastal plain, Island of Kauai, Hawaii*. Report - Division of Water and Land Development, State of Hawaii, R53.

Gomez, B., personal communication, April, 2023.

Kekaha Agricultural Association. (2022). *Naturalizing Open Floodable Space on the Mānā Plain, Kaua'i*. National Fish and Wildlife Fund Grant Application.



ISLAND: KAUA'I

LOCATION: Mānā Plain Wetland Restoration Project - Department of Fish and Wildlife (DOFAW)

DESCRIPTION OF SITE: The Mānā Plain Wetland Restoration Project site is located on abandoned sugarcane fields dissected by two main drains and a series of field ditches. It is part of what was once an expansive wetland plain. 50 acres of agricultural fields are being restored to wetlands, and there are plans to expand to 100 acres with more funding. Previously, the restored area was dominated by invasive vegetation. The restoration site and low-lying surrounding lands are within feet of a shallow groundwater table and often flood during the wet season. Surrounding land uses include the Kawai'ele Waterbird Sanctuary, the Pacific Missile Range Facility, and agricultural lands. The shallow wetland restoration site will be able to mimic fluctuating seasonal water levels. The water delivery system is designed to prevent establishment of non-native fish populations and allow for management of invasive vegetation.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0-1; drainage ditch -1	47	100	None	DOFAW	DOFAW	\$500k -1 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Other	Yes
Breeding			x				

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service, Ducks Unlimited, Pacific Birds, Mānā Plains Wetland Partnership.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

There is patchy distribution of native plants at the site.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: None known to be present
  - Inputs: Pump moves water from nearby irrigation canal into the wetland; annual rainfall 21 inches per year; project area only experiences standing water during extreme Kona-type storms that can deliver up to 10 inches of rainfall in 24 hours.
  - Outflows: Evapotranspiration rates from irrigated lands are 83 inches per year. Water returns to the irrigation canal by gravity. The canal system effectively dewateres approximately 8 feet of the upper of naturally saturated soil and drains floodwaters within about a week.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Human disturbance control	2
Invasive plant control	2

- **Threats**

- Unfenced roads
- Powerlines
- Potential heavy metal contamination
- Potential herbicide contamination
- Trash
- Potential ingress of invasive fish

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	5-25% of wetland inundated	>75% of wetland inundated	5-25% of wetland inundate	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**

- Assessment for predator proof fence
- **Challenges**
  - Funding
  - Maintaining predator control
  - Hydrological management
  - DOFAW staffing
- **5–10 Year Conservation Priority Actions Needed**
  - Secure funding to manage the site and restore additional 50 acres.
  - Maintain predator control long term.
- **Benefits to T&E birds / MBTA birds**
  - Overall, this project will restore and enhance a total of 100 acres, of which approximately 90 acres are palustrine emergent wetlands. This represents a 45% percent increase in the area of wetland and aquatic habitats available to native wildlife in the immediate vicinity. The quality of restored managed wetlands will also be higher than existing aquatic habitats.
  - Shallow water will maximize habitat suitability for ae’o and koloa maoli.
- **Benefits to People**

**Ecosystem Services:** This site will reduce flooding to PMRF and improve water quality to nearshore ocean waters by capturing sediment.

**Education:** DOFAW already hosts multiple groups of students annually, and the long-term vision is to construct an education center at this site.

**Sustainable food:** None

**Fishing:** None

**Recreation:** The site will be open to the public and will likely be used for bird watching.

**Cultural:** The site is part of an extensive former wetland, and this project restores the wetland’s natural history value.

## References

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawai’i*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](https://www.pacificbirds.org/wp-content/uploads/2016/06/HWJVStrategicPlan-3.pdf).

Henry, A. R. (2010). *Mānā Plain Wetland Restoration. Phase II: Soil Sampling for the Hydrological Assessment Mānā Wetland Restoration Design*. A report for Ducks Unlimited.



Kamman, G. (2012). *Hydrologic Feasibility Assessment Report Mana Plain Restoration Project, Kauaʻi, Hawaiʻi*. Report for the Mānā Plain Wetland Restoration Partnership.

Vercelli, J., personal communication, June, 2023.

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ISLAND: KAUA'I

LOCATION: Ōpaeka'a Marsh, Division of State Parks parcels

DESCRIPTION OF SITE: Ōpaeka'a Marsh lies on Ōpaeka'a Stream, a tributary of the Wailua River. The banks of the river were once active lo'i kalo but are now filled in with sediment. Much of the riverbank is now thick with invasive plants, but the site is still used by T&E and migratory waterbirds and waterfowl.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
6-50	50	50	Lo'i kalo	Department of Land and Natural Resources	Division of State Parks	Unknown	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Supporting	Unknown
Breeding							

SUPPORTING PARTNERS: Unknown.

Conducts site-based waterbird monitoring (not including SWBC): Unknown

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: Unknown
- Inputs: Ōpaeka'a Stream
- Outflows: Wailua River

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Unknown	

- **Threats**

- Data missing

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Surveys are needed to establish the dynamics of the waterbird populations that utilize this site.

- **Challenges**

- Unknown

- **5–10 Year Conservation Priority Actions Needed**

- Establish ongoing waterbird surveys.
- Remove invasive plants to create high-quality waterbird habitat.
- Outplant native plants.
- Establish and maintain predator control to increase T&E waterbird fledging success and waterbird / migratory bird survival.

- **Benefits to T&E birds / MBTA birds**



- Unknown
- **Benefits to People**

**Ecosystem Services:** This site is invaded with invasive plants and has received no known restoration work though likely still has reduced ecosystem services of sediment capture and reducing runoff to the nearshore coastal ecosystem and offshore reefs.

**Education:** None.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** There are public viewing areas for Ōpaekaʻa Falls and the heiau that sits above the stream.

**Cultural:** Prior to European contact, the Wailua watershed was characterized by flooded bottomlands with abundant fresh water, fertile soil, plentiful fish, and a long sandy beach. Farming along the river and Ōpaekaʻa Stream supported a large human population, and this area was a center for aliʻi and kahuna (chiefs). Several heiau (temples) were built, the remnants of which are still present today in the archeological record. Ditches were constructed to divert water from the river to terraced taro fields. These ancient terraces are still present today, but they are concealed by the vast overgrowth of invasive plants.

## References

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaiʻi*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](http://www.pacificbirds.org/HWJVStrategicPlan-3.pdf).

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[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

ISLAND: KAUA'I

LOCATION: Smith's Tropical Paradise Ponds

DESCRIPTION OF SITE: The ponds on the Smith's Tropical Paradise property sit on the banks of the Wailua River and are utilized by a variety of native T&E waterbirds. This property is leased from the Department of State Parks and has been converted to a garden and artificial ponds that are used for lū'aus, weddings, and other gatherings. It is unclear if the lease agreement requires any management, such as predator control, to protect the native species that use this site.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	4.7	22.16	Unknown	Department of State Parks	Smith's Tropical Paradise	Unknown	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Supporting	No
Breeding							

SUPPORTING PARTNERS: Unknown.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: Unknown
- Inputs: Wailua River
- Outflows: Wailua River

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Unknown	

- **Threats**

- Introduced predators
- Potential water quality impairments
- Currently, bird feed is sold to tourists to feed the birds. This could be given to native birds and/or excess could feed rodents at the site.

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Identify if the lease agreement requires management for T&E birds that use the site.

- **Challenges**

- Predator control is needed to protect T&E native and migratory birds.

- **5–10 Year Conservation Priority Actions Needed**

- Develop and implement ongoing predator control at this site.
- Eliminate feeding of native birds.

- **Benefits to T&E birds / MBTA birds**

- **Benefits to People**

**Ecosystem Services:** None.

**Education:** There is an opportunity for Smith's Tropical Paradise visitors to be educated about the native T&E waterbirds that regularly use these ponds, though it is unknown if there are any signs or other outreach materials in place for guests.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** This site is regularly used by Smith's Tropical Paradise for lū'aus, weddings, and other events.

**Cultural:** Unknown.

## **References**

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawai'i. Pacific Coast Joint Venture: Honolulu, HI, USA.* [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](#).

U.S. Fish and Wildlife Service. (2011). *Recovery Plan for Hawaiian Waterbirds, Second Revision.*

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ISLAND: KAUA'I

LOCATION: Wai'oli Valley

DESCRIPTION OF SITE: Farmland in the historic Wai'oli Valley (Wai'oli translates to "joyful water"), in the Halele'a district on the North Shore of Kaua'i, is one of Hawai'i's most important taro-producing areas. Hawai'i Land Trust (HILT) acquired two conservation easements on 40 acres of wetland kalo (taro) which place permanent protections from future development and degradation on this important active farmland.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3-5	28	38	Lo'i kalo	Wilcox family	HILT conservation easement; leased to lo'i farmers	\$250k-500k, including southern edge of property	Restoration underway, almost complete

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Other	Yes
Breeding							

SUPPORTING PARTNERS: Lo'i kalo farmers.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Unknown
- Inputs: Waioli Stream/Watershed, 85" + annual rainfall.
- Outflows: Water runs into other adjacent lo'i, then into ditches to the ocean.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
None scored 3 or less	

- **Threats**

- Potential contamination from agricultural equipment.
- Potential for botulism outbreaks.
- Predators.

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- Funding

- **5–10 Year Conservation Priority Actions Needed**

- Secure funding.
- Restore the southern tip of the site (mauka side).

- **Benefits to T&E birds / MBTA birds**

- Lo'i kalo habitat provides life cycle needs for T&E waterbirds and contributes to a continuum of available habitat in the valley.

- **Benefits to People**

**Ecosystem Services:** This site provides flood and sediment control for makai areas.

**Education:** None.

**Sustainable food:** This site is a major producer of kalo/taro for the state.

**Fishing:** None.

**Recreation:** None.

**Cultural:** This valley has been in active kalo production since pre-contact times.

## **References**

Crowe, J., personal communication, May, 2023.

Hawai'i Land Trust. (2023). *Wilcox Conservation Easement, Wai'oli Valley*. Retrieved September 20, 2023, from <https://www.hilt.org/wilcox-conservation-easement-waioli-valley-i-1>.

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ISLAND: KAUAI

LOCATION: Wailua Reservoir

DESCRIPTION OF SITE: Wailua Reservoir was originally constructed to store water for large-scale sugarcane irrigation in the 1920s. Management of the reservoir, dam, and diversion was passed to Hawai'i Department of Land and Natural Resources (DLNR). This site includes grassy habitat suitable for waterbird foraging, roosting, and loafing as well as exposed shoreline where ae'o feed. The site is used by a number of T&E waterbirds, including koloa maoli and 'alae ke'oke'o that utilize the open water.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
143	49	49	None	DLNR	DLNR	< \$250k for habitat restoration, but see roadblocks	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Other	No
Breeding							

SUPPORTING PARTNERS: None.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: None
- Inputs: Natural streamflow from tributaries and water diverted from the North Fork Wailua River at the Wailua Ditch Intake



- Outflows: Spillway

- **Status of Key Management Actions (scored 3 or less, with 1 being most serious threat)**

Key Management Action	Score
Predator control	1
Botulism control	1
Invasive plant control	1
Human disturbance control	1

- **Threats**

- None

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

None

- **Challenges**

- The dam is classified as high hazard and poses a public safety risk to the population downstream of the reservoir in the case of an uncontrolled breach.
- Recent vandalism and trespassing have caused damage to the dam and spillway.
- The dam poses a significant financial burden, requires continuous maintenance, and is a liability for the DLNR.
- DLNR would like to decommission and drain the dam.

- Staffing and capacity for another agency to take over
- With the conversion of farmland to residential development in the surrounding areas, some North Wailua Ditch laterals have been removed or covered in place.
- Remaining ditches, laterals and tunnels have become overgrown and dilapidated throughout much of the system due to a lack of routine maintenance and a lack of flow through the system. The existing system is no longer viable without a substantial amount of maintenance and rehabilitation.
- **5–10 Year Conservation Priority Actions Needed**
  - Transfer management from DLNR Land Division to another of DLNR's divisions, or possibly to Kaua'i County Parks, to allow for conservation work to occur.
- **Benefits to T&E birds / MBTA birds**
  - The Wailua Reservoir provides feeding and roosting habitat for all T&E waterbirds on Kaua'i.
- **Benefits to People**

**Ecosystem Services:** Recreation (fishing).

**Education:** None.

**Sustainable food:** Water was used for adjacent lo'i until changes in the permitting process meant reapplying was no longer financially feasible for the cooperative involved.

**Fishing:** The reservoir contains smallmouth bass, largemouth bass, and bluegill and is one of two freshwater public fishing areas on Kaua'i.

**Recreation:** Public access is allowed for recreation and fishing.

**Cultural:** None.

## References

U.S. Fish and Wildlife Service. (2011). *Recovery Plan for Hawaiian Waterbirds, Second Revision*.

U.S. Fish and Wildlife Service, Portland, Oregon. xx + 233 pp.

[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

Vercelli, J., personal communication, June, 2023.

Wailua Reservoir Dam and Diversion, EISPN/EIS Public Scoping. (2023). *Home*. Retrieved June 24, 2023, from <https://www.wailuareservoir.com/>.

ISLAND: KAUAI

LOCATION: Wailua River, Division of State Parks Parcels

DESCRIPTION OF SITE: The Division of State Parks parcels along the Wailua River encompass both the north and south forks of the river. Much of the riverbank is now thick with invasive plants, but the site is still used by T&E and migratory waterbirds and waterfowl.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
6-27	50	145	Yes	Department of Land and Natural Resources	Division of State Parks	Unknown	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Supporting	Unknown
Breeding							

SUPPORTING PARTNERS: Unknown.

Conducts site-based waterbird monitoring (not including SWBC): Unknown

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: Unknown
- Inputs: Wailua watershed
- Outflows: Wailua River

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Unknown	

- **Threats**

- Unknown

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Surveys are needed to establish the dynamics of the waterbird populations that utilize this site and if any sub-regions within the site should receive particular attention.

- **Challenges**

- Wailua River is a large site and is heavily used by the public for recreational activities. Any restoration activities would need to allow for continued use of the river.

- **5–10 Year Conservation Priority Actions Needed**

- Establish ongoing waterbird surveys.
  - Remove mangrove to create high-quality waterbird and migratory bird habitat in an area that is currently choked with invasive species.
  - Outplant native plants.
  - Maintain predator control long term to increase T&E waterbird fledging success and waterbird / migratory bird survival.



- **Benefits to T&E birds / MBTA birds**

- This site is important for all T&E species as it is one of the largest wetlands on the eastern side of the island.

- **Benefits to People**

**Ecosystem Services:** Recreation (fishing).

**Education:** None.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** Public access is allowed for recreation including hiking, boating, stand-up paddle boarding, kayaking, and swimming.

**Cultural:** Prior to European contact, the Wailua River floodplain was characterized by flooded bottomlands with abundant fresh water, fertile soil, plentiful fish, and a long sandy beach.

Farming along the river supported a large human population, and this area was a center for ali'i and kahuna (chiefs). Several heiau were built, the remnants of which are still present today in the archeological record. Ditches were constructed to divert water from the river to terraced taro fields. These ancient terraces are still present today, though they are concealed by the vast overgrowth of invasive plants.

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ISLAND: KAUA'I

LOCATION: Wainiha Valley River and Taro fields

DESCRIPTION OF SITE: The Wainiha Valley on the North Shore of Kaua'i contains a diversity of wetland habitat types including estuarine marshes, palustrine marshes, and ephemeral flooded pastures with lo'i kalo. This valley is fed by the headwaters of the Alaka'i and was traditionally used extensively for lo'i. Today, a few families continue to farm kalo in the valley. The flow of water through the valley is impeded by invasive plants, and the 'auwai flow (water ditches that carry water to lo'i) is being affected by a patchwork of private landowners with differing interests.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
10–1,000	109	109	Lo'i kalo	501(c)(3) (multiple individual landowners )	Mālama Kua'āina (coastal and community advocate, point of contact for community)	\$2–5 million+	No restoration, other than a handful of lo'i kalo

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Other	Yes
Breeding							

SUPPORTING PARTNERS: The Nature Conservancy (in the upper valley), County of Kaua'i (flood mitigation grants).

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Native plants are found at higher elevation and deeper in the valley. 'O'opu (Hawaiian diadromous gobies and sleeper goby) are found in the river.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes, though water demands of invasive albizia trees impact traditional springs.
- Inputs: Water from the pali in the high mountains (watershed) into the site; Wainiha River flow and flooding; 91" + annual rainfall
- Outflows: Wainiha River to the ocean
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Invasive plant control	1
Human disturbance control	1

- **Threats**

- Invasive vegetation (albizia, overgrown hau, and invasive grasses) blocks flows into the 'auwai and floodplain
- Cesspool leaching from the built environment
- Hydroelectric power plant changes water flow
- Introduced predators, especially pigs and rats
- Land development along the river
- Impeded waterflow

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**

- The community has many new landowners that are missing local ecological and hydrological knowledge. Mālama Kuaʻāina is currently doing a Community Awareness Campaign to help educate residents and visitors of flood risks and vulnerability.
- **Challenges**
  - Land development is reducing available habitat in this area.
  - New owners that buy property often fell trees and put them on the bank. When the river floods, the trees get stuck at the bridge and cause flooding into other properties. Runoff from properties runs right into the river (gasoline/cesspools/trash). New owners are often unaware that their property is in the floodplain.
  - Individual ownership complicates efforts.
  - There is concern about land changing from subsistence to commodity properties, being bought and sold at the highest price, and pricing out local families.
- **5–10 Year Conservation Priority Actions Needed**
  - Develop a cooperative agreement with government agencies, NGOs, and multiple landowners that ensures stream flow is maintained in the valley and mimics the variability of the river's natural hydroperiod.
  - Initiate and maintain predator control long term.
  - Remove invasive tree species that impact stream and river flow.
  - Restore water flow including stream management at the ahupuaʻa level.
  - Acquire land to manage and restore hydrological processes and restore loʻi kalo.
  - Educate landowners; local ecological knowledge is missing for many newer landowners.
- **Benefits to T&E birds / MBTA birds**
  - Wainiha Valley is one of the largest valleys on Kauaʻi, and the river, riverbanks, and remaining loʻi kalo are used by native and migratory waterbirds and waterfowl. T&E waterbirds are present, but it is not known if they are breeding. Hydrological restoration and predator control would likely benefit the habitat and birds.
- **Benefits to People**

**Ecosystem Services:** The removal of invasive trees will improve water quality and flow as well as flood control, as large branches currently get trapped against the bridge during high river flows and cause flooding.

**Education:** The Wainiha Valley could serve as an educational model on riparian restoration.

**Sustainable food:** There is huge potential for sustainable loʻi farming, but most former loʻi are currently in disrepair. Restoration could provide food for the community.

**Fishing:** Fishing is not permitted in the river.



**Recreation:** The river is technically open to the public for recreation but access is difficult and limited to the area by the outflow to the ocean.

**Cultural:** Wainiha valley is a storied valley and was an active agricultural region. There are still remains of lo'i kalo, dry kalo agriculture, and stone terraces. There are also archeological records of habitations, burials, and two heiau. The valley is still culturally important in the community, and conservationists should partner with Kūpuna that have cultural and ancestral knowledge to restore and manage these significant natural and cultural resources.

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O'AHU

ISLAND: O'AHU

LOCATION: Hakipu'u Wetlands (Kualoa Ranch)

DESCRIPTION OF SITE: Located in the Hakipu'u ahupua'a along Kāne'ohe Bay on the northeast shore of O'ahu, this site covers wetlands and a historic fishpond that are actively used for agriculture, aquaculture, and education by Kualoa Ranch. The ponds are primarily managed for food production, including the production of kalo and shrimp (in earthen saline ponds and a nursery in above-ground tanks), learning opportunities, and tourism. The historic fishpond, Mōli'i, currently supports oyster production. The site supports native T&E and migratory waterbirds and waterfowl.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0-686	223	4000	Lo'i kalo, loko i'a	Kualoa Ranch	Kualoa Ranch	< \$250k	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Other	No
Breeding	x	x	x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service, Plant Extinction Prevention Program, Career and Technical Education program with Kalaheo High School.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

There are patches of native forest at higher elevation with hundreds of native plant species, and 'o'opu (native diadromous gobies and sleeper goby) are found in the streams. The wetlands have a number of native species, including kilo'o'opu (Manyspike flatsedge), 'ahu'awa (Javanese flatsedge), 'aka'akai (Bulrush, *Schoenoplectus tabernaemontani*), and kamole (Primrose willow).

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Several perennial springs in the valley
- Inputs: Hakipu'u stream and the many smaller streams that flow into it
- Outflows: Kāne'ohe Bay
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Human disturbance control	3

- **Threats**

- Unfenced roads / car strikes
- Predators
- Human disturbance
- Flooding

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 5.0–6.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - How much damage is caused by flooding
- **Challenges**
  - There is ongoing cat feeding, not sanctioned by Kualoa Ranch, in parts of the site, that needs to be eliminated.



- Education and communication to the public is needed to reduce human disturbance.
- Permitting process complicates restoration.
- The site has to manage multiple objectives with competing goals, e.g., agriculture and tourism.

- **5–10 Year Conservation Priority Actions Needed**

- Expand and maintain predator control long term, in particular to control cats and remove pigs from the landscape.
- Eliminate cat feeding within the site.
- Remove invasive plants that are filling in the marsh habitat, and outplant native species.
- Expand native plant restoration to the kalo and shrimp ponds, with waterbird habitat in mind.
- Reduce waterbird deaths due to vehicles through speed bumps, fencing along roads, or other means.
- Conduct hydrological survey.
- Monitor hydrological impact on the biological community.
- Increase bird banding capacity.

- **Benefits to T&E birds / MBTA birds**

- There are a range of wetland habitats within Hakipu'u ahupua'a including lo'i kalo, fishponds, streams, and marshes that provide a large amount of high quality habitat for waterbirds and waterfowl.

- **Benefits to People**

**Ecosystem Services:** Wetlands restoration would enhance the capacity to provide flood control and reduce sediment flow into the Kāne'ohe Bay.

**Education:** This site hosts educational tours for tourists and local school groups which include working in lo'i kalo, visiting the Mōli'i fishpond, and habitat restoration.

**Sustainable food:** There is a large agricultural presence in the site with over 60 different food crops grown and cattle and shrimp raised for meat production.

**Fishing:** Public fishing is prohibited, but the Mōli'i Fishpond supports oyster and fish farming.

**Recreation:** The site is open for tours to tourists and school groups. Tourism activities include UTV, bike, horseback riding, visiting movie locations, and farm tours.

**Cultural:** The cultural benefit to the community in Hakipu'u is linked to the cultural significance of the place and includes farming of agricultural crops like kalo, 'ulu, and other diversified agriculture. This ahupua'a contains important cultural sites, including Mōli'i fishpond, and was used as a pu'uhonua, or place of refuge, and during times of Makahiki opening and closing ceremonies. There are rich historical mentions of famed navigators and ali'i throughout the Pacific being in Hakipu'u, including La'amaikahiki, Kaha'i, Kahahana, Kā'eo, Kūali'i and others.

## References

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ISLAND: O'AHU

LOCATION: Hāmākua Marsh State Wildlife Sanctuary

DESCRIPTION OF SITE: Hāmākua Marsh is a rain-fed wetland that is connected to Kawainui Canal via a small channel, which in turn connects to the larger Ka'elepulu Stream. With the adjacent Kawainui Marsh, the site makes up the largest remaining wetland habitat in the State. The stream feeding Hāmākua Marsh's stream was diverted, and the marsh is now fully dependent upon rainfall from the hillside and runoff from Kailua town. This Division of Fish and Wildlife (DOFAW) State Wildlife Sanctuary is managed for T&E waterbirds and migratory species.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
4	23.3	91	None	DOFAW	DOFAW	\$1–2 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	ʻālae ʻula	ʻālae keʻokeʻo	aeʻo	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Core	No
Breeding	x	x	x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Healthy Climate Communities, Hawai'i Nature Center, University of Hawai'i at Mānoa, Hawai'i Pacific University (HPU).

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants, found throughout the restored parts of the site, include the endangered pu'uka'a (Sticky flatsedge). The 'ōpe'ape'a (Hawaiian hoary bat) is found at this site.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: None

- Inputs: Rainfall and runoff from Pu‘u O ‘Ehu hillside
- Outflows: Kawainui Canal
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Botulism control	3
Human disturbance control	3

- **Threats**

- Unfenced roads / car strikes
- Botulism
- Trash
- Changes to water flow

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
> 75% of wetland inundated	<5% of wetland inundated	> 75% of wetland inundated	<5% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- Site needs expanded staff.
- Assistance with homelessness in the area from the County and/or State is needed.
- Hydrological disruption due to diversion.



- **5–10 Year Conservation Priority Actions Needed**

- Expand and maintain predator control, especially for cats, long term.
- Remove invasive plants like pickleweed, and outplant native species to expand high-quality habitat.
- Reduce trash from businesses nearby.
- Expand pond habitat.

- **Benefits to T&E birds / MBTA birds**

- Hāmākua Marsh and the adjacent Kawainui Marsh are together the largest remaining wetland habitat in the state and have enormous potential to contribute to T&E waterbird recovery and to provide habitat for migratory birds.
- The site management includes active predator control, invasive plant removal, and native outplanting.

- **Benefits to People**

**Ecosystem Services:** Site contributes to improved water quality and provides flood control to the adjacent Kawainui Canal. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh's capacity to provide flood control.

**Education:** The site is publicly accessible on one side and has the potential to be used for native wetland and ecological education.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is accessible for bird watching.

**Cultural:** The region surrounding the marsh was settled by Hawaiians about 1,000 years ago and was extensively used for agriculture. The edges of the marsh were used for the cultivation of plants like taro, sweet potato, and bananas.

## **References**

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ISLAND: O'AHU

LOCATION: He'eia National Estuarine Research Reserve (NERR)

DESCRIPTION OF SITE: He'eia National Estuarine Research Reserve encompasses 1,385 acres of unique and diverse upland, wetland, stream, estuarine, coastal, and marine habitats within the He'eia ahupua'a. This includes He'eia State Park to the north, He'eia Fishpond in the center, the wetlands of Hoi to the west and south, Moku O Lo'e (Coconut Island) to the east, and a large expanse of marine waters with patch and fringing reefs. Four hundred of those acres are wetland, estuarine, and coastal habitat including lo'i and loko i'a. The reserve is a partnership between federal, state, and community organizations and has ongoing restoration, research, and education programs.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0-75	400	1385	Lo'i kalo, loko i'a	State of Hawai'i	Department of State Parks, Kāko'o 'Ōiwi, Paepae O He'eia, Hawai'i Institute of Marine Biology	\$2-5+ million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Supporting	Partially
Breeding	x		x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Hawai'i Institute of Marine Biology, Paepae o He'eia, Kāko'o 'Ōiwi, Ko'olaupoko Hawaiian Civic Club, Ko'olau Foundation, Office for Coastal Management (National Oceanic and Atmospheric Administration), Hawai'i Department of Land and Natural Resources, Hawai'i Community Development Authority.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Many native plants are found within restored areas of the site. The endangered 'ōpe'ape'a (Hawaiian hoary bat) is also present here.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes
- Inputs: He'eia Stream
- Outflows: Stream flows into fishpond and Kāne'ohe Bay.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Invasive plant control	2

- **Threats**

- Invasive plants
- Predators
- Erosion
- Sedimentation
- Pollution

- **Climate Change Threat**

Project Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 3.0–4.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Water availability issue - need to find ways to get more water into the lo'i system
- Continued research on benefit of Indigenous management to waterbirds

- **Challenges**

- The reserve is a mix of private and public land ownership, and there is limited public access on private lands.
- Erosion and pollutants reduce water quality.
- There is cat feeding in the area, including the State Park.
- Assistance is needed with homelessness from the County/State.
- Assistance is needed with overcoming water policy challenges.
- Army Corps jurisdiction – need a clear pathway for exemptions for sites with Indigenous management.

- **5–10 Year Conservation Priority Actions Needed**

- Continue removal of invasive plants like pickleweed and mangrove to expand high-quality waterbird and migratory bird habitat.
- Maintain predator control long term to contribute to T&E waterbird fledging success and waterbird / migratory bird survival.
- Maintain and expand indigenous agroecology to benefit people and wildlife.
- Continue to remove invasive grasses

- **Benefits to T&E birds / MBTA birds**

- Ae'o and 'alae 'ula are beginning to thrive again in He'eia due to the restoration work in the reserve by its community partners. High nesting success rates have been reported for both species (Opie, 2022).
- Lo'i kalo fed by the He'eia Stream provide habitat for waterbirds.

- **Benefits to People**

**Ecosystem Services:** Removal of invasive plants and the restoration of wetlands within the valley with native plants is enhancing the capacity to provide flood control and reduce sediment flow into Kahana Bay.

**Education:** He'eia NERR hosts education programs that reach over 6,000 students each year and coordinates professional development programs for teachers. The site also facilitates collaboration among partner organizations.

**Sustainable food:** The long-term aim is for the loko i'a and lo'i kalo within the site to be hubs of sustainable food for the community.



**Fishing:** Kāneʻohe Bay is used by the community for subsistence and recreational fishing.

**Recreation:** The reserve encompasses upland, coastal, and marine habitats and is utilized for a range of recreational activities including hiking, biking, bird watching, swimming, snorkeling, boating, and fishing.

**Cultural:** The Heʻeia ahupuaʻa historically supported a dense Hawaiian population and had a dense complex of agriculture and aquaculture with over 30 fishponds. There were also other culturally important areas including heiau, fishing shrines, and burial caves. Today, the approach of the Heʻeia NERR is biocultural restoration, or reviving the connections between biodiversity and humanity to sustain ecosystem services.

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ISLAND: O'AHU

LOCATION: James Campbell National Wildlife Refuge (JCNWR)

DESCRIPTION OF SITE: James Campbell National Wildlife Refuge is one of the largest protected wetlands in the State of Hawai'i and is critically important for the recovery of T&E waterbirds. The site has five core wetlands that differ in restoration status and the bird species that utilize them. The Refuge also hosts breeding seabirds, honu (threatened Hawaiian green turtle), 'ilio holo i ka uua (endangered Hawaiian monk seal), and endangered nalo meli maoli (yellow-faced bees).

#### *Punamanō Unit*

This site is located on the western side of the Refuge and consists of mostly natural ponds and wetlands. Management actions include predator control, invasive plant removal, and native plant outplanting.

#### *Ki'i Unit*

This site is located on the eastern side of the Refuge. The natural marsh here was converted into ponds for sugarcane processing. They are now intensively managed for T&E waterbirds and migratory waterbirds. Management actions include predator control, invasive plant removal, native plant outplanting, and control of water levels through wells and a system of pumps.

#### *Kahuku Aquaculture Farms and Wetlands (Kahuku Farms)*

This site has been owned by the USFWS since the expansion of the Refuge in 2005. The existing lease for the shrimp ponds ended in October 2023, when the ponds came under Refuge management. Trapped has been implemented. Funding is required to restore to T&E and migratory waterbird habitat.

#### *Salty Flats & Pueo Flats*

Ephemeral wetlands that provide foraging habitat for T&E and migratory waterbirds. Limited nesting occurs. Management actions include predator control and invasive plant removal.

Site Information				
Site	Elevation in m (from msl)	Wetland ac.	Est. \$ for restoration	Restoration status
Punamanō Unit	2	133	\$2–5 million	Restoration planning underway
Ki'i Unit	1-2	126	\$2–5 million	Restoration underway
Kahuku Farms	3	193	\$5 million+	Restoration planning underway
Salty Flats	3	5.6	\$250k–500k	Unknown
Pueo Flats	3	9.2	\$500k–1 million	Unknown

JCNWR Bird Information								
T&E Bird Species Present								
		‘alae ‘ula	‘alae ke‘oke‘o	ae‘o	koloa maoli*	nēn ē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Punamanō Unit	Present	x	x	x	x		Core	Yes
	Breeding	x	x	x	x			
Ki‘i Unit	Present	x	x	x	x		Core	Yes
	Breeding	x	x	x	x			
Kahuku Farms	Present	x	x	x	x		Supporting	Yes
	Breeding							
Salty Flats	Present	x	x	x	x		Other	Yes
	Breeding	x						
Pueo Flats	Present	x	x	x	x		Other	Yes
	Breeding	x						

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: KUPU Hawai‘i, Friends of O‘ahu NWRs

Conducts site-based waterbird monitoring (not including SWBC): Yes

#### ● Other Wildlife of Note

Native plants include ‘ōhai, pu‘uka‘a, ‘aki‘aki, naupaka, and ‘ilima. Native seabirds include mōlī (Laysan Albatross), ka‘upu (Black-footed Albatross), nunulu (Bonin Petrel), ‘akihi‘e‘hi‘ale (Tristram’s Storm-petrel), and ‘ua‘u kani (Wedge-tailed Shearwater). Native invertebrates found at the Refuge include endangered nalo meli maoli (yellow-faced bees) and ‘ōpae‘ula (Hawaiian red shrimp).

#### ● Hydrology (for sites that have information)

Has there been a formal hydrological survey: Yes (at Punamanō and Ki‘i Units)

##### *Punamanō Unit*

- Springs: Yes, at least two
- Inputs: The spring and streamflow is directed to the wetland by ditches. Overflow from Ki‘i Unit can also flow into Punamanō Unit via ditches when the water level is high.
- Outflows: There is an outlet ditch that leads to the ocean.

##### *Ki‘i Unit*

- Springs: None

- Inputs: Artesian wells and ditches bring water into the site, and water also flows from Punamanō Unit through a ditch.
- Outflows: There is an outlet ditch and pump system that leads to the ocean.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Site	Key Management Actions	Score
Punamanō Unit	Predator control	2
	Invasive plant control	2
Ki'i Unit	None	
Kahuku Farms	Predator control	3
	Invasive plant control	2
Salty Flats	Invasive plant control	3
Pueo Flats	Invasive plant control	3

- **Threats**

- Roads
- Botulism
- Predators

- **Climate Change Threat**

Projected Climate Change Impacts (all sites)				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated*	25-50% of wetland inundated*	25-50% of wetland inundated*	25-50% of wetland inundated*	Definite: surrounding area is already wetland habitat (Kahuku Farms is the planned retreat habitat for Ki'i)*

\*The wetlands at this site are protected by healthy, native, high dunes that have seen little erosion over the last 30 years. A limitation of the model is that it is based principally on elevation and cannot fully account for the particular topographical features that might affect

the site's response to climate impacts. More site specific work is needed to fully understand future impacts at JCNWR.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Expand bird banding capacity.
  - Climate change modeling specific to the site.
- **Challenges**
  - Site needs expanded staff.
  - Site-specific long-term funding for Kahuku Aquaculture Farms, Salty Flats, Pueo Flats, Punamanō units
  - Cat feeding in the area
  - Feral mallards are problem because they hybridize with the native koloa maoli
- **5–10 Year Conservation Priority Actions Needed**
  - Expand and maintain predator control long term, particularly for cats, mongooses, Barn Owls, and bullfrogs.
  - Eliminate cat feeding in areas adjacent to the Refuge.
  - Remove invasive plants, especially bulrush, and outplant native plants to expand high-quality habitat.
  - Secure funding and staff to expand restoration and monitoring for Kahuku Aquaculture Farms/shrimp leases, Pueo Flats, Salty Flats, and Punamano.
  - Control yellow crazy ants.
  - Remove invasive fish.
  - Reduce light pollution in the surrounding area through outreach.
  - Increase education and outreach.
  - Hire a contractor to develop a restoration design for Kahuku Aquaculture Farms/shrimp leases to ensure these wetlands provide ecosystem services to benefit the community and wildlife including sediment control and water quality benefits for the reef and near-ocean habitats.
  - Update/improve the water control structures that pump from fresh and saltwater wells.
  - Purchase heavy equipment — excavator and Marsh Master — and hire heavy equipment technicians to help staff accomplish site reconfiguration.
  - Install a predator exclusion fence around the entire wetland and seabird area.
  - Expand research efforts.
- **Benefits to T&E birds / MBTA birds**



- James Campbell National Wildlife Refuge is vitally important statewide for T&E waterbird recovery and migratory birds.
- The site management includes active predator control, invasive plant removal, and native outplanting.

- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearshore coastal ecosystem and offshore reefs. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to capture sediment.

**Education:** The Refuge offers educational programs including field trips, service learning events, and educational talks. The Refuge also hosts individuals from the KUPU Conservation Leadership Development Program.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The Refuge is closed to the public, though guided bird tours are offered October through February.

**Cultural:** Drawn to the area by the rich ocean waters and fertile lands dotted with natural springs, Native Hawaiians settled in this area around 1100 CE. This region supported numerous Hawaiian villages which were surrounded by agriculture including lo'i kalo.

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ISLAND: O'AHU

LOCATION: Ka'a'awa Wetlands (Kualoa Ranch)

DESCRIPTION OF SITE: The Ka'a'awa ahupua'a, located on the North Shore of O'ahu on the north side of Kāne'ōhe bay, is owned by Kualoa Ranch, and much of the valley is actively used for agriculture, including the rearing of cattle, pigs, and sheep. There are a number of wetlands in various states of restoration, some of which are used by T&E waterbirds throughout their lifecycle. The ranch carries out their own monitoring and management program, including predator control and outreach.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0-270	21	4000	None	Kualoa Ranch	Kualoa Ranch	< \$250k	Preliminary planning

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x		x			Other	No
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service, Plant Extinction Prevention Program.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants including neke (swamp shield-fern), 'aka'akai (*Schoenoplectus tabernaemontani*), kilo'o'opu (manyspike flatsedge), 'ahu'awa (Javanese flatsedge), and kamole (Primrose willow) are found in the wetland areas, and 'o'opu (native diadromous gobies and sleeper goby) are found in the streams. Hundreds of native plant species are found in the montane areas.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: There are springs in the back of the valley.
- Inputs: Ka'a'awa Stream and groundwater

- Outflows: Ka'a'awa Stream to the ocean
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Human disturbance control	3
Invasive plant control	3

- **Threats**

- Unfenced roads / car strikes
- Powerlines
- Predators
- Human disturbance

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 5.0–6.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - The ponds are thought to be fed by groundwater, but salinity surveys of the wetlands would be helpful to confirm what proportion of water in the wetlands is from groundwater.
- **Challenges**
  - Education and communication to the public is needed to reduce human disturbance.
  - Permitting

- The site has to manage multiple objectives with competing goals, e.g. agriculture and tourism.
- **5–10 Year Conservation Priority Actions Needed**
  - Expand and maintain predator control long term, in particular to control cats and mongooses. Mongooses are a particular problem.
  - Create cattle-free areas in the agroforestry and wetland zones in the valley.
  - Remove invasive plants that are filling in marsh habitat and plant native plants.
  - Reduce take due to vehicles through speed bumps, fencing along roads, or other means.
  - Conduct bird surveys to determine waterbird presence in the site.
  - Conduct hydrological surveys.
  - Monitor hydrological impact on the biological community.
- **Benefits to T&E birds / MBTA birds**
  - There are a range of wetland habitats within Ka'a'awa ahupua'a including agricultural ponds, streams, and marshes that provide high-quality habitat for waterbirds and waterfowl.
- **Benefits to People**

**Ecosystem Services:** Wetlands restoration would enhance the capacity to provide flood control and reduce sediment flow into the ocean.

**Education:** Kualoa Ranch supports student groups from multiple schools in the area, from preschool to college, in restoration activities on the site.

**Sustainable food:** There is a large agricultural presence in the site with over 60 different food crops grown and cattle, pigs, and sheep raised for meat production.

**Fishing:** None.

**Recreation:** The site is open for tours to tourists and school groups. Tourism activities include UTV, bike, horseback riding, movie location, and farm tours.

**Cultural:** Ka'a'awa is the northern ahupua'a of Kualoa Ranch and is culturally significant through being the first ahupua'a in the larger division or moku of Ko'ola'ula.

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ISLAND: O'AHU

LOCATION: Ka'elepulu Mitigation Pond (Enchanted Lake)

DESCRIPTION OF SITE: Ka'elepulu is a privately-owned wetland area managed for waterbird habitat at the south end of the larger Ka'elepulu Pond. The site was formerly a tidal wetland, but the tidal input from Kawainui Stream was largely cut off with the installation of the Kawainui Dike, and the outflow to Kailua Bay has been stopped by a sand plug. This former mitigation site supports native T&E and migratory waterbirds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	16.61	13	None	Hugo de Vries and Cindy Turner de Vries	Hugo de Vries and Cindy Turner de Vries	\$1–2 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Supporting	No
Breeding	x	x	x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service, SWCA.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants are found throughout the restored parts of the site.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: None
- Inputs: Rainfall and storm water runoff is fed into the wetland through a culvert and storm drain system.



- Outflows: Stream that flows to Kailua Bay, though it's usually blocked by a sand spit/berm
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Invasive plant control	3

- **Threats**

- Predators
- Flooding
- Trash
- Changes to water flow
- Botulism

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - None
- **Challenges**
  - There are issues with access, land ownership, and jurisdiction relating to the land and streams that flow into the wetland.
  - The sand spit/berm that blocks water flow from the pond to Kailua Bay needs to be regularly dredged to maintain water quality.

- **5–10 Year Conservation Priority Actions Needed**

- Improve water flow to increase the marsh's water level, increase fish recruitment, reduce botulism outbreaks, and improve the marsh's capacity for flood control. This will be achieved either through redirecting water from Kawainui into Hāmākua (which would then flow into Ka'elepulu and raise the water level) or by dredging the spit/berm that is plugging the outflow from the pond to Kailua Bay.
- Expand and maintain predator control, especially for cats, long term.
- Remove introduced fish.

- **Benefits to T&E birds / MBTA birds**

- This site is 1.2 km away from Hāmākua and Kawainui Marshes, some of the largest remaining wetland habitat in the State, and is likely utilized by the large T&E waterbird populations that live there.
- The site management includes active predator control, invasive plant removal, and native outplanting.
- Much of the shoreline of Ka'elepulu Pond has been developed and is now residential property. This now rare wetland area likely has outsized importance to T&E waterbirds.

- **Benefits to People**

**Ecosystem Services:** Ka'elepulu Pond provides flood control to the surrounding urban area, but it is limited by the sand berm that partially blocks the outflow into Kailua Bay.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is accessible for bird watching.

**Cultural:** The region surrounding the marsh was settled by Hawaiians about 1,000 years ago and was extensively used for agriculture. The edges of the marsh were used for the cultivation of plants like taro, sweet potato, and bananas.

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ISLAND: O'AHU

LOCATION: Kahana Valley

DESCRIPTION OF SITE: The Kahana Valley ahupua'a is entirely owned by the State and includes the ahupua'a 'O Kahana State Park, Kahana Bay Beach Park, Huilua Fishpond, Kapa'ele'ele Trail, and Nakoa Trail that are currently managed by the Division of State Parks. This area presents a unique opportunity for restoration. The valley is used by waterbirds, supporting native T&E and migratory waterbirds, though surveys detailing their use across the valley are limited.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0-813	176	5225	Lo'i kalo, Loko i'a	State of Hawai'i	Division of State Parks	\$2-5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x			x		Supporting	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Commission on Water Resource Management (CWRM), Hawai'i Division of Fish and Wildlife (DOFAW), Kako'o 'Oiwī, O'ahu Invasive Species Committee (OISC), Board of Water Supply (BWA), Hō'ala 'Āina Kūpono, Nakamakai, The Nature Conservancy (TNC), Ko'olau Mountains Watershed Partnership (KMWP).

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

'Alae ke'oke'o and ae'o were found in the valley when native 'aka'akai (bulrush) was more abundant (Wyban 1995).

Many T&E native plants are found deeper in the valley with heavy encroachment by invasive species lower in the valley. Native plants include pōhuehue (beach morning glory), 'aka'akai (bulrush), naupaka kahakai (beach naupaka), and hala. Canoe plants include kukui (candlenut), 'ulu (breadfruit), niu (coconut palm), kī (ti), hau (sea hibiscus), milo (portia tree), and noni. Native fish, invertebrates, and seaweeds are found in the fishpond and estuary, including palani (eyestripe surgeonfish), manini (convict surgeonfish), 'o'opu hue (pufferfish), 'o'opu nākea, pāpio (trevallies), āholehole (flagtails), 'ama'ama (striped mullet), kākū (great barracuda), 'ōpae

(shrimp), 'opihi (limpets), pipipi (Hawaiian black nerite), blue-pincher swimming crab, Samoan crab, ghost crabs, rock crabs, barnacles, limu 'ele'ele, and limu kala.

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: Multiple
- Inputs: Rainfall; Kawa and Kahana Streams
- Outflows: Kahana Bay

- **Status of Key Management Actions (scored 3 or less, with 1 being most serious threat)**

Key Management Action	Score
Predator control	2
Botulism control	3
Invasive plant control	2

- **Threats**

- Flooding
- Landslides
- Back of valley is very hard to access
- Potential cesspool leaching
- Predators
- Invasive plants (albizia trees & others)
- Leptospirosis
- Crossfire from hunting
- Hunting dogs

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural



- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 5.0–6.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - There is a lack of knowledge about the species, number, and habitat usage of T&E waterbirds in the valley.
  - Increase wetland and wildlife outreach and education to the community.
- **Challenges**
  - In-kind lease agreement issues between leasing families and the State need to be addressed before any attempts at large-scale restoration.
  - This site needs expanded staff.
  - The watershed needs more funding for large-scale restoration projects.
  - The Division of State Parks doesn't have the expertise or capacity for natural resource management relating to the wetlands, forests, and fishpond within the ahupua'a. The DSP could work with DOFAW if the wetland sections were developed into a formal state wildlife sanctuary.
  - Feral cats and cat feeding in the valley
- **5–10 Year Conservation Priority Actions Needed**
  - Continue to address community issues relating to in-kind leases within the valley.
  - Increase expertise and staff capacity by collaborating with DOFAW and partners (KMWP, OISC) to manage existing resources.
  - Undertake waterbird surveys and establish regular waterbird monitoring.
  - Develop a management plan for the valley.
  - Expand and maintain predator control long term, especially for cats.
  - Remove invasive plants and outplant native plants.
- **Benefits to T&E birds / MBTA birds**
  - Kahana Valley has relatively little human presence, and restoration of the wetland habitats in Kahana Valley, including the lo'i kalo and the fishpond, would provide a large amount of high-quality habitat for waterbirds and waterfowl.
- **Benefits to People**

**Ecosystem Services:** Wetland restoration would enhance the capacity to provide flood control and reduce sediment flow into the Kahana Bay.

**Education:** The valley is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** Some small lo'i kalo are currently tended, and a former fishpond is actively being restored.

**Fishing:** Some within the State Park.

**Recreation:** The valley contains a number of State Park parcels that have hiking trails and campsites. The beach and fishpond are also accessible.

**Cultural:** Kahana Valley was a thriving fishing and farming community prior to Western contact, and the archaeological remnants include a heiau, ko'a (fishing shrine), fishpond, stone-walled enclosures, 'auwai, and agricultural terraces.

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ISLAND: O'AHU

LOCATION: Kalauha'iha'i Fishpond

DESCRIPTION OF SITE: Kalauha'iha'i Fishpond is an ancient spring-fed fishpond located in East Honolulu. Water flow into the pond was cut off in the 1990s during expansion of the highway which resulted in a decline of the pond and nearshore ecosystems. Maunalua Fishpond Heritage Center is currently working with the state to drill under the road and restore water flow to the pond. This site is currently visited by koloa maoli hybrids but has the potential to host more T&E native and migratory birds once the water flow and habitat is restored.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
2	0.1	0.1	Loko i'a	State of Hawai'i / Maunalua Fishpond Heritage Center (in process of signing lease with state)	Maunalua Fishpond Heritage Center	\$500k–1 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present				x		Other	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: National Oceanic and Atmospheric Administration, Hawai'i Senator Brian Schatz.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants are found at the site, and the freshwater snails hīhīwai and hapawai were formerly found here when waterflow was active.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, though the spring is currently being restored
- Inputs: Spring, rainfall, and runoff
- Outflows: Currently there are no outflows, as waterflow is so low. Once waterflow is restored, it will flow to the ocean.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	1

- **Threats**
  - Maintaining waterflow at the spring
  - Predators (rats, mongooses, cats)
  - Developers building at the water source
  - Runoff from nearby highway
  - Highway traffic
- **Climate Change Threat**
  - Site added after climate analysis
- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - A hydrology survey is needed at the site.
- **Challenges**
  - Water flow has been damaged by expansion of the highway.
  - Lack of funding
  - Difficult to safely access the site as it sits right along the highway
  - The City of Honolulu has restrictions on using large equipment.
  - Predators, especially cats, rats, and mongooses
- **5–10 Year Conservation Priority Actions Needed**
  - Complete current excavation/restoration of the spring.

- Determine if the site is eligible for funding through the Bipartisan Infrastructure Bill that designates funds for areas with legacy pollution from infrastructure development.
- Remove invasive plants and outplant natives.
- Initiate and maintain predator control, especially for cats, long term.
- **Benefits to T&E birds / MBTA birds**
  - This site is located in a largely urban area and protects some of the last remaining wetland habitat there, providing critical habitat for waterbirds.
- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs.

**Education:** The Maunalua Fishpond Heritage Center hosts a weekly education and cultural program at the site.

**Sustainable food:** None, though this was historically a fishpond.

**Fishing:** None.

**Recreation:** Bird watching at the site is possible by observing from the beach edge.

**Cultural:** The Kalauha'iha'i area was home to King Kamehameha and Queen Ka'ahumanu's royal kalo patch and their summer home, and the fishpond was historically used for farming, primarily of 'ama'ama (striped mullet).

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ISLAND: O'AHU

LOCATION: Kānewai Fishpond

DESCRIPTION OF SITE: Kānewai Fishpond is an ancient, spring-fed fishpond located in East Honolulu. The mixing of fresh and salt water between the spring and fishpond provides a fertile estuary habitat for rare freshwater limpets and brackish water mollusks (pīpīwai and hapawai). The site is connected to Paikō Lagoon State Wildlife Sanctuary by an 'auwai, and the two sites together offer varied habitat for T&E and migratory birds, particularly ae'o. Freshwater inflow from the spring is threatened by nearby development.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
2	3.5	3.5	Loko i'a	State of Hawai'i / Department of Transportation / Maunaloa Fishpond Heritage Center / private residential owners	Maunaloa Fishpond Heritage Center	\$500k–1 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alaie 'ula	'alaie ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Other	Yes
Breeding	x			x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: National Oceanic and Atmospheric Administration, Hawai'i Senator Brian Schatz.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants are found at this site, as well as nesting 'auku'u (Black-crowned Night-Heron), three species of 'o'opu (native diadromous gobies and sleeper goby), and the freshwater snails hīhīwai and hapawai.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Kānewai spring
- Inputs: The spring, rainfall, and tidal input
- Outflows: An 'āuwai connects the fishpond to Paikō Lagoon.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	1
Human disturbance control	3

- **Threats**

- Maintaining waterflow at the spring
- Predators
- Human disturbance
- Runoff from nearby highway
- Traffic accidents
- Powerlines

- **Climate Change Threat**

- Site added after climate analysis

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- A hydrological survey is needed at the site.

- **Challenges**

- Difficult to safely access the site as it sits right along the highway
- There are City of Honolulu restrictions on directly accessing the fishpond.
- Water flow has been damaged by nearby excavation for development that has lowered the water table.
- Predators, especially cats, rats, and mongooses

- **5–10 Year Conservation Priority Actions Needed**

- Determine if the site is eligible for funding through the Bipartisan Infrastructure Bill that designates funds for areas with legacy pollution from infrastructure development.
- Gain permission from the city to access the pond for more restoration activities.
- Remove invasive plants and outplant natives.
- Initiate and maintain predator control, especially for cats, long term.

- **Benefits to T&E birds / MBTA birds**

- This site is directly adjacent to the Paikō Lagoon State Wildlife Sanctuary, providing a range of habitats and prey in the area suitable for different waterbird species.

- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff into Paikō Lagoon and to the nearby coastal reefs.

**Education:** The site is publicly accessible (though access is a challenge) and has potential to be used for native wetland and ecological education.

**Sustainable food:** None, though this was historically a fishpond.

**Fishing:** None.

**Recreation:** The site has walking trails around the pond and has viewing areas for bird watching.

**Cultural:** The Kānewai Fishpond was historically used for farming, primarily of ‘ama‘ama (striped mullet), and was frequented by the monarchy. Kūpuna Uncle Henry Chang-Wo notes that the spring is where the mountain gives birth to the ocean (TPL, 2023).

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Maunalua Fishpond Heritage Center. (2022). *Home*. Retrieved September 27, 2023, from <https://maunaluafishpond.org/>.

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ISLAND: O'AHU

LOCATION: Kapapahu Point Park, West Loch, Pearl Harbor (Pu'uloa)

DESCRIPTION OF SITE: This 28-acre stretch of coastline is in the West Loch region of Pearl Harbor. It sits adjacent to the Honouliuli Unit of the Pearl Harbor National Wildlife Refuge and extends the stretch of restored habitat further along the coast. Hui O Ho'ohonua, with the help of community volunteers, is restoring the wetland through invasive plant removal, outplanting native plants, and predator control. This site supports T&E native and migratory bird species.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0-3	28	28	None	Honolulu City and County	Hui o Ho'ohonua	\$2-5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x			Other	No
Breeding	x	x	x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Wounded Warriors Project, 'Ewa Beach Boy Scouts, 'Ewa Beach Girl Scouts, 808 Cleanups, Hilton Grand Vacations, Hawai'i Bicycle League, O'ahu Waterkeepers, Hawai'i Medical Service Association Blue Zones, Kua'āina Ulu 'Auamo (KUA), Hui Mālama Loko I'a, Hawaiian Island Land Trust, Mālama Learning Center, Ulu A'e Learning Center.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

The endangered orangeblack Hawaiian damselfly occurs here, as well as the indigenous fish 'ama'ama (striped mullet), nehu (Hawaiian anchovy), awa (milkfish), barracuda (*Sphyræna spp.*), 'ulua (giant trevally), 'omilu (bluefin trevally), āholehole (reticulated flagtail and Hawaii flagtail), and 'ō 'iō (bonefish). The endemic fish 'o'opu nākea and 'o'opu 'akupa (Hawaiian sleeper goby) also occur here.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, many
- Inputs: Honouliuli Stream and Waikele Stream
- Outflows: Ocean
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	3
Invasive plant control	1

- **Threats**

- Predators
- Trash
- Heavy metals
- Potential for unexploded ordnance
- Pollution from septic tanks and landfill runoff

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	50-75% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated*	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

\*This does not represent an improvement in inundation, rather that the source of inundation is now marine, not groundwater.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**



- Research is needed on the effectiveness of restoration efforts at the site to inform future management strategies.
- **Challenges**
  - Difficulty navigating multiple landowners
  - Difficulty in fostering collaboration between landowners
  - Engaging the community in long-term stewardship is a work in progress.
  - Capacity, expertise, and funding issues across agencies involved in the site
  - Building respect for indigenous resource management
  - Red mangrove is the main invasive plant in the area, and if it is not removed from all of the Pu'uloa (Pearl Harbor) shoreline and offshore islets, maintenance of cleared areas will be a costly and significant challenge.
- **5–10 Year Conservation Priority Actions Needed**
  - Expand and maintain predator control, especially for cats, long term.
  - Remove invasive plants, especially red mangroves, and outplant native plants to expand high-quality habitat.
  - Initiate waterbird monitoring.
  - Identify new funding sources.
- **Benefits to T&E birds / MBTA birds**
  - This site is directly adjacent to the Pearl Harbor NWR Honouliuli Unit and extends the restored wetland. Together, these sites are located in a largely urban area and protect some of the last remaining wetland there, providing critical habitat for waterbirds.
  - The site management includes active predator control, invasive plant removal, and native outplanting.

- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh's capacity to capture sediment.

**Education:** The site is used for environmental education programs; many school and youth groups have participated in the restoration work.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** Kapapapuhi Point Park provides a walking path and benches for recreation.

**Cultural:** This area was historically dominated by loko i'a and lo'i kalo.

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Hui O Ho'ohonau. (n.d.). *Restoring Honouliuli to Abundance*. Retrieved August 24, 2023, from [www.malamapuuloa.org/honouliuli-restoration.html](http://www.malamapuuloa.org/honouliuli-restoration.html).

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[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

Ward, S., personal communication, August, 2023.

ISLAND: O'AHU

LOCATION: Kawainui Marsh State Wildlife Sanctuary

DESCRIPTION OF SITE: Kawainui Marsh State Wildlife Sanctuary is one of the largest remaining wetlands in the State of Hawai'i, located just east of Kāne'ohe. It is a Ramsar Wetland of International Importance. Historically this area contained a large fishpond. A flood control levee along the makai portion of the marsh has greatly altered the natural hydrology, promoting conditions that favor dense stands of emergent invasive vegetation. Under natural hydrologic conditions, the marsh went through cycles of fresh water and brackish water, but under current conditions, it remains fresh. DOFAW is focusing restoration on a number of key locations, although both managed and unmanaged areas provide habitat for T&E waterbirds and migratory species. Recently, lo'i have been restored on site by a local partner to provide habitat for waterbirds and sustainable food and to forge connections with the community.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
2	741.6	830	Lo'i kalo	DOFAW	DOFAW	\$5 million +	Restoration planning underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Core	No
Breeding	x	x	x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Hui o Ko'olaupoko, Le Jardin, Kauluakalana, University of Hawai'i Mānoa, Hawai'i Pacific University, U.S. Department of Agriculture APHIS Wildlife Services.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants are found throughout the restored parts of the site as well as 'ōpe'ape'a (Hawaiian hoary bat).

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: None
- Inputs: Rainfall and flooding / surface runoff from Maunawili Stream and Kahanaiki Stream
- Outflows: Kawainui Canal
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	3
Botulism control	3
Invasive plant control	1

- **Threats**
  - Botulism
  - Predators
  - Human disturbance
  - Runoff from surrounding developed properties
- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - None

- **Challenges**

- Site needs additional staff.
- Invasive plants
- Issues with water control and provision are leading to dry conditions in the marsh.
- Assistance with homelessness in the area from the county and/or state

- **5–10 Year Conservation Priority Actions Needed**

- Expand and maintain predator control, especially for cats, long term.
- Remove invasive plants, including mangroves, and outplant native plants.
- Improve water delivery throughout the marsh, and restore water flow to areas that were once flooded.

- **Benefits to T&E birds / MBTA birds**

- This site is among the largest wetlands in the state and has enormous potential to contribute to T&E waterbird recovery and to provide habitat for migratory birds. The site is an important site for waterbird research.
- The lo'i attracted waterbirds almost immediately after restoration.
- The site management includes active predator control, invasive plant removal, and native outplanting.

- **Benefits to People**

**Ecosystem Services:** Kawainui Marsh is an important site for flood control and sediment filtration in the Ko'olaupoko region's watershed and protects the nearby urban area of Kailua. The marsh also recharges groundwater and improves water quality in the Kailua Bay ecosystem.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** The non-profit organization Kauluakalana is working to restore part of the site to lo'i kalo and other agriculture.

**Fishing:** None.

**Recreation:** The marsh has a walking trail on the eastern border and has multiple viewing areas for bird watching.

**Cultural:** The region surrounding the marsh was settled by Hawaiians about 1,000 years ago and was extensively used for agriculture. Within the sanctuary is the Ulupō Heiau, which is O'ahu's largest and oldest agricultural heiau and is being restored by the non-profit organization Kauluakalana. The site also has plans to build the Kapa'a Cultural Center.

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Works, A., personal communication, July, 2023.

ISLAND: O'AHU

LOCATION: Keawāwa

DESCRIPTION OF SITE: Keawāwa wetland and the adjacent Hāwea heiau were once at the heart of an expansive wetland. Hawaiians used the area for fishing and farming until the marshland was dredged. The outflow at Maunalua was home to Keahupuaomaunalua, the largest fishpond in Polynesia. Keawāwa is a remnant of that time and provides key ecosystem services. Hawai'i Kai is one of the most built-out communities in Hawai'i; development, storm water, and fertilizer runoff has led to a nutrient overload in Maunalua Bay, causing widespread algal blooms. The wetland is also connected to Kuapa Pond (known as Hawai'i Kai Marina) and acts as a buffer during storms, preventing runoff by slowing inland water flow in heavy rains and flooding, trapping/filtering sediments and pollutants, stemming soil erosion, and retaining nutrients that would otherwise overflow into Kuapa Pond and the ocean. Managed by Livable Hawai'i Kai Hui, the spring-fed site is important to the community culturally and for the native flora and fauna present. Restoration work has included the removal of invasive species and outplanting of native plants around the wetland. The native dry forest habitat on the hillside above the wetland has also been expanded. This site is used by T&E native and migratory waterbirds and a number of other native species.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	3	7	Loko i'a	Kamehameha Schools / Livable Hawai'i Kai Hui	Livable Hawai'i Kai Hui	\$2–5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x		x	x		Other	Yes
Breeding	x		x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Trust for Public Land, City and County of Honolulu, Boy Scouts, Kaiser High School, Women's Correctional Facility, Chaminade University, O'ahu Club, Maunalua.net, Dr. van Rees, Conservation Council for Hawai'i, Pacific Birds, Fishpond Heritage Center, U.S. Fish and Wildlife Service, Natural Resources Conservation Service.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Native plants have been planted in the wetland, and 'ōpae'ula (Hawaiian red shrimp) and pinao (common green darner) are found at the pond.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes, but unknown how many
- Inputs: Spring water, including an upland underground stream, rainfall, and runoff feed this wetland. There is a traditional well uphill that was previously capped and needs to be opened. Salt water intrusion from the marina occurs as well.
- Outflows: None

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	3

- **Threats**

- Predators, including cats
- Potential for disease
- Car strikes
- Powerlines

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	25-50% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - A new hydrological survey is needed to assess recent drops in water level and develop projections and an action plan for the future.
  - Technical expertise and funding are needed for the removal of bulrush and conversion of the site's flora to native plants.
  - Waterbird monitoring is needed to understand current habitat use by birds and how expansion of the site may affect them.
  - Bird banding and banding expertise is needed at the site.
- **Challenges**
  - Funding
  - Staff capacity
- **5–10 Year Conservation Priority Actions Needed**
  - Identify site-specific funding.
  - Get assistance with grant writing.
  - Expand and maintain predator control, especially for cats and cattle egrets, long term.
  - Install a predator-proof fence.
  - Remove invasive plants, especially bulrush, and outplant native plants.
  - Conduct a hydrological assessment and develop projects for the future.
  - Conduct bird banding.
  - Develop a conservation plan with Kamehameha Schools for the portion of the wetland that is on their property.
  - Expand the wetland area at the site through dredging.
  - Remove ornamental trees that predators like cattle egrets roost in.
- **Benefits to T&E birds / MBTA birds**
  - Much of the coastline in the area of Keawāwa has been developed and is now residential properties. This wetland is one of the few wetlands in the area and may have an outsized importance to the waterbirds that use the area. Research suggests that the 'ālae 'ula here are a genetically important subpopulation, underlining the importance of these smaller, urban sites for the survival of the species (van Rees, et al. 2018).
  - The site management includes active predator control, invasive plant removal, and native outplanting.
- **Benefits to People**

**Ecosystem Services:** Keawāwa wetland provides flood control and other ecosystem services to the surrounding urban area and the reef.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education. The site regularly hosts volunteer work days for restoration.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is accessible for bird watching.

**Cultural:** Keawāwa wetland is the last remaining part of an ancient fishpond that once supported the local community. The site also had other agriculture and still has the remains of agricultural terraces. The Hāwea heiau and petroglyphs are also found on the site.

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ISLAND: O'AHU

LOCATION: Loko Ea Fishpond

DESCRIPTION OF SITE: This five-hundred-year-old fishpond is composed of three distinct features: a large pond, a smaller pond, and the Loko Ea stream area. It is connected to the unrestored 'Uko'a Marsh through the stream. In the last seven years, the site has been nearly completely restored as a functioning loko i'a and has seen an increase in the presence of waterbirds with a particularly large increase in breeding 'alae 'ula. The site supports native T&E and migratory waterbirds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
4	5.4	12	Loko i'a	Kamehameha Schools / Bishop Estate	Mālama Loko Ea Foundation	\$250k–500k	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Supporting	Maybe
Breeding	x						

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: O'ahu Resource Conservation and Development; 6,000 volunteers and learners (80–85 schools).

Conducts site-based waterbird monitoring (not including SWBC): Unknown

- **Other Wildlife of Note**

Native plants found at the pond include makaloa (smooth flatsedge), 'ākia, 'ōhai, and 'āweoweo. Multiple 'o'opu species are also found in the fishpond, including 'o'opu 'akupa, 'o'opu nākea, and 'o'opu naniha.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: There is a spring at 'Uko'a that used to flow into Loko Ea fishpond.

- Inputs: Loko Ea stream, previously fed by 'Uko'a spring, which was capped by Waialua Sugar Company in 1994.
- Outflows: Wailua Bay
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	3

- **Threats**
  - Predators, including the introduced Samoan crab
- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - A hydrological survey is needed.
- **Challenges**
  - None
- **5–10 Year Conservation Priority Actions Needed**
  - Expand and maintain predator control long term.
  - Eliminate cat feeding within the site.
  - Remove invasive plants that are filling in marsh habitat and plant native plants.
  - Conduct a hydrological survey.

- Implement agroforestry within the site.
  - Build a community center and gardens.
  - Develop a long-term conservation plan.
  - Expand training in waterbirds and waterbird habitat.
- **Benefits to T&E birds / MBTA birds**
    - As a near-fully-restored loko iʻa, this is an important site for many T&E native waterbirds, in particular for breeding ʻalaie ʻula, in the Haleʻiwa area of northwest Oʻahu.
    - The site management includes active predator control, invasive plant removal, and native outplanting.
  - **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearshore coastal ecosystem and offshore reefs. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh's capacity to capture sediment. The site also functions as a nursery habitat for juvenile nearshore fish.

**Education:** This site hosts cultural and educational tours for local school groups, which include loko iʻa maintenance and habitat restoration, cultural tours, and monthly volunteer days open to the public.

**Sustainable food:** The long-term aim is for the site to be a source of sustainable food, including fish from the fishpond and vegetables grown on the property.

**Fishing:** Public fishing is prohibited.

**Recreation:** The site is open for site visits and tours to tourists and school groups.

**Cultural:** Loko Ea fishpond is a place of significant importance to the people of Waialua. It is associated with deities and cultural practices and helped sustain the surrounding community with fish and seaweed (*Ahupuaʻa of Kawaihoa*, n.d.).

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ISLAND: O'AHU

LOCATION: Nā Mea Kūpono Learning Center (Waialua Lotus Fields)

DESCRIPTION OF SITE: Located on the northwestern coast of O'ahu in the Kamananui ahupua'a, the wetlands at the Nā Mea Kūpono Learning Center include six acres of lo'i kalo that are actively managed and regularly used for outreach and education in the community. The programs offered include ecotours and Hawaiian cultural education activities designed to connect the community with the land. Current management at the site, including the removal of invasive vegetation, benefits T&E waterbirds and migratory birds as well as native flora and fauna. It also protects a culturally important lo'i kalo.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	6	6	Lo'i kalo	Theodore J. P. Lopez Trust (Leased to Nā Mea Kūpono Learning Center)	Nā Mea Kūpono Learning Center	\$500k–1 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x		x		Supporting	Maybe
Breeding	x			x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Patagonia, Loko Ea, Jack Johnson Kōkua Hawai'i Foundation.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

The endemic goby 'o'opu nākea and the endemic sleeper goby 'o'opu 'akupa are found here.

- **Hydrology**

Has there been a formal hydrological survey: No



- Springs: Yes, in the form of an artesian well
- Inputs: Rainfall and water from the well
- Outflows: Ki'iki'i stream and Paukauila stream

• **Status of Key Management Actions (scored 3 or less, with 1 being most serious threat)**

Key Management Action	Score
Predator control	3
Human disturbance control	3
Invasive plant control	3

• **Threats**

- Predators
- Noise pollution
- Potential for water contamination from uphill industrial agriculture and military training activities at Schofield Barracks

• **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

• **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

• **Knowledge Gaps and Planning / Research Needs**

- A hydrological survey is needed to understand how changes uphill will impact the spring.
- Water quality surveys are needed to assess the impact of industrial agriculture and military activities mauka of the site.

• **Challenges**

- Predators
  - Site-specific long-term funding
  - Staffing — lack of capacity for both site management and waterbird monitoring
  - Maintaining equipment at the site
  - Homelessness in the area
- **5–10 Year Conservation Priority Actions Needed**
    - Expand and maintain predator control long term, particularly to control cats and mongooses.
    - Remove invasive plants, and plant native plants to improve habitat for waterbirds.
    - Conduct bird surveys to understand waterbird and waterfowl dynamics at the site.
    - Conduct hydrological surveys.
    - Spread awareness of the importance of wetlands, waterbirds, and lo'i kalo in the community.
    - Seek assistance from the county on homelessness in the area.
    - Develop a long-term conservation plan.
    - Partner with the DoD to assess water quality and improve it if required.
- **Benefits to T&E birds / MBTA birds**
    - Lo'i kalo habitat provides life cycle needs for T&E waterbirds and contributes to a continuum of available habitat in the region.

- **Benefits to People**

**Ecosystem Services:** Wetlands restoration would enhance the capacity to provide flood control and reduce sediment flow and pollutants into the ocean.

**Education:** Nā Mea Kūpono Learning Center offers a range of educational programs including ecotours for schools or other groups, family strengthening workshops, and educational land-based experiences. They also have an afterschool program for children in the neighborhood.

**Sustainable food:** Kalo is actively farmed at the site.

**Fishing:** None.

**Recreation:** This site hosts volunteers, and in-person and virtual tours are available.

**Cultural:** This region was historically an important agricultural area that included many lo'i as well as dryland crops like sweet potatoes.

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ISLAND: O'AHU

LOCATION: Paikō Lagoon State Wildlife Sanctuary

DESCRIPTION OF SITE: Paikō Lagoon State Wildlife Sanctuary, located in East Honolulu, is a tidal wetland that is surrounded by residential properties but is open to the ocean at its eastern edge. Tidal influence leaves exposed mudflats at low tide that are used by migratory and native T&E birds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
2	37	37	None	Hawai'i Division of Fish and Wildlife (DOFAW)	DOFAW	< \$250k	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x		x	x		Supporting	No
Breeding			x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Mālama Maunalua.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

'Ōpe'ape'a (Hawaiian hoary bats) are found at the site.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: None
- Inputs: Rainfall; Kānewai Fishpond; ocean
- Outflows: The lagoon opens into Maunalua Bay.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	1
Botulism control	3
Human disturbance control	3

- **Threats**

- Predators
- Human disturbance
- Runoff from surrounding developed properties

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
5-25% of wetland inundated	<5% of wetland inundated	5-25% of wetland inundated	<5% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- This is not a high priority area for DOFAW as the site is not very productive, and the community in the nearby condominiums does not support a high presence of birds in the area.

- **Challenges**

- Low community support
- Predators, especially cats
- Runoff from surrounding private properties

- **5–10 Year Conservation Priority Actions Needed**

- Initiate and maintain predator control, especially for cats, long term.
- Expand education and outreach to the community to improve support for waterbirds in the wetland.
- **Benefits to T&E birds / MBTA birds**
  - This site features large tidal mudflats that are an important habitat for ae'o.
  - This site is not heavily impacted by invasive plant species.
- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs.

**Education:** The site is publicly accessible and is used for native wetland and ecological education.

**Sustainable food:** None.

**Fishing:** None, fishing is prohibited in the State Wildlife Sanctuary.

**Recreation:** The site has walking trails around the lagoon and has multiple viewing areas for bird watching.

**Cultural:** The Kānewai Fishpond is on the northern edge of the Paikō Lagoon, and the fresh water in the pond flows into the lagoon.

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Works, A., personal communication, July, 2023.



ISLAND: O'AHU

LOCATION: Pearl Harbor National Wildlife Refuge (NWR)

DESCRIPTION OF SITE: The shoreline pattern of Pearl Harbor, characterized by its narrow entrance and varied lochs, is a system of eroded watercourses which developed when sea level was approximately 18 m (60 ft) lower than present levels (Ziegler 2002). The NWR contains two core wetlands that differ in restoration status and the bird species that utilize them.

#### *Honouliuli Unit*

The Honouliuli Unit is a constructed wetland on West Loch of Pearl Harbor that was built as mitigation for the construction of the Honolulu Airport reef runway and features a mammal exclusion fence. Given the widespread development across O'ahu, this small unit protects some of the last remaining wetland areas on the island and is vital to endangered wildlife and sensitive coastal habitats in O'ahu.

#### *Waiawa Unit*

Waiawa is a brackish, constructed wetland on Middle Loch of Pearl Harbor that was primarily created to protect ae'o. The site is unfenced, in comparison to the nearby Honouliuli Unit, and is being used to compare reproductive success of waterbirds (particularly ae'o) between sites with differing predator control management strategies. This small unit protects some of the last remaining wetland habitat in the area. Given the widespread development in this coastal area, it is vital for endangered wildlife and sensitive habitats. Water is pumped into the refuge from nearby springs and from Pearl Harbor itself.

Site Information								
Site	Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
Honouliuli Unit	0–10	36.6	36.6	None	US Navy	USFWS	\$1–2 million	Restoration complete
Waiawa Unit	0–10	27.5	27.5	None	USFWS	USFWS	\$1–2 million	Restoration underway

Bird Information								
T&E Bird Species Present								
		'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Honouliuli Unit	Present	x	x	x	x		Core	Yes
	Breeding	x	x	x	x			
Waiawa Unit	Present	x	x	x	x		Core	Yes
	Breeding	x	x	x	x			

\*presumed koloa maoli x mallard hybrid

## SUPPORTING PARTNERS:

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

### *Honouliuli Unit*

Native plants, including ko'oloa'ula, pu'uka'a, and 'ae'ae (water hyssop), are found at the site (Christensen, et al. 2020). Pueo (Hawaiian Short-Eared Owls) also frequent the site.

### *Waiawa Unit*

Pueo (Hawaiian Short-eared Owl) can be found here.

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: None
- Inputs:
  - Honouliuli Unit: A pump and pipe system transport water into the site.
  - Waiawa Unit: A pump and pipe system transport water into the site, and there is also some salt water intrusion.
- Outflows: Ocean

- **Status of Key Management Actions (scored 3 or less, with 1 being most serious threat)**

Site	Key Management Action	Score
Honouliuli Unit	Invasive plant control	3
Waiawa Unit	Invasive plant control	3

- **Threats**

- **Honouliuli Unit**

- Botulism
- Predators
- Sea level rise

- **Waiawa Unit**

- Contamination
- Botulism

- Predators
- Sea level rise

- **Climate Change Threat**

Projected Climate Change Impacts					
Site	Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
Honouliuli Unit	<5% of wetland inundated	>75% of wetland inundated	50-75% of wetland inundated	50-75% of wetland inundated*	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural
Waiawa Unit	<5% of wetland inundated	>75% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated*	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

\*This does not represent an improvement in inundation, rather that the source of inundation is now marine, not groundwater.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands (both sites)**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- **Honouliuli Unit**

- None

- **Waiawa Unit**

- A consistent source of freshwater needs to be identified for the site.

- **Challenges**

- **Honouliuli Unit**

- Expanded staff needed
- Site-specific long-term funding
- Simplifying regulatory processes

- Invasive plant species including pickleweed, cattails and mangrove.
- **Waiawa Unit**
  - Contamination from Pearl City Peninsula landfill
  - Site needs additional staff.
  - Site-specific long-term funding
  - Simplifying regulatory processes
  - Salt water intrusion
  - Invasive plant species incl. mangrove.
- **5–10 Year Conservation Priority Actions Needed**
  - Expand and maintain predator control long term.
  - Remove invasive plants and outplant native species to expand high-quality habitat.
  - Honouliuli Unit:
    - Maintain the existing mammal exclusion fence.
    - Remove invasive fish.
    - Create dynamic wet / dry cycle of wetland to aid in vegetation management, decrease invasive fish populations, enhance nutrient turnover, and increase invertebrate abundance.
  - Waiawa Unit:
    - Improve freshwater input to reduce salinity.
    - Remove invasive fish.
- **Benefits to T&E birds / MBTA birds**
  - The Honouliuli and Waiawa Units are located in a largely urban area and protect some of the last remaining wetland in the area, providing important habitat for waterbirds.
  - The site management includes active predator control, invasive plant removal, and native outplanting.
- **Benefits to People**

**Ecosystem Services:** These sites help capture sediment and reduce runoff to the nearby coastal reefs. Further removal of invasive plants and the restoration of the sites with native plants will likely enhance these wetlands' capacity to capture sediment.

**Education:**

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is closed to the public, but a public viewing platform is available outside the fence at Honouliuli.

**Cultural:** Unknown.

## References

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ISLAND: O'AHU

LOCATION: Pouhala Marsh State Wildlife Sanctuary

DESCRIPTION OF SITE: At 84 acres, Pouhala Marsh State Wildlife Sanctuary is the largest remaining estuarine wetland in the Pearl Harbor basin. The site has experienced a lot of habitat change in the last 200 years, going from a fishpond and lo'i to rice fields and then a planned landfill, but it is now undergoing habitat restoration and is partially predator-proof fenced. This site supports T&E waterbirds as well as migratory bird species, and there are plans to restore some of the filled-in ponds to provide additional habitat for waterbirds. A GIS StoryMap is available [here](#).

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0–5	30	84	None	Honolulu City and County, State of Hawai'i	Hawai'i Division of Fish and Wildlife	\$2–5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Core	Yes
Breeding	x	x	x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: U.S. Department of Agriculture APHIS Wildlife Services.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native plants include 'aka'akai (*Schoenoplectus tabernaemontani*) and makaloa (smooth flatsedge). 'Ōpe'ape'a (Hawaiian hoary bats) are also found at the site.

- **Hydrology**

Has there been a formal hydrological survey: Yes



- Springs: Unknown
- Inputs: Rainfall and tidal influence
- Outflows: Waikele Stream and Pearl Harbor
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	3
Botulism control	3
Human disturbance control	3
Invasive plant control	3

- **Threats**
  - Botulism
  - Predators
  - Fertilizer
  - Human disturbance
  - Runoff from surrounding developed properties
  - Cesspool leaching
  - Trash
- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
5-25% of wetland inundated	5-25% of wetland inundated	25-50% of wetland inundated	25-50% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - None

- **Challenges**

- This site needs increased staff.
- Site-specific long-term funding.
- Simplifying permitting.
- Assistance with homelessness in the area from the County and/or State.
- 35 acres of invasive red mangrove.

- **5–10 Year Conservation Priority Actions Needed**

- Expand and maintain long-term predator control, especially for cats and mongoose.
- Remove invasive plants, especially mangrove, and outplant native species to expand high-quality habitat.
- Reduce trash from nearby residential and commercial areas.
- Expand the partial predator-proof fence to enclose the entire site.
- Expand waterbird monitoring.
- Increase staff capacity.
- Acquire nearby coastal land to expand wetland habitat.

- **Benefits to T&E birds / MBTA birds**

- Pouhala Marsh is the largest remaining estuarine wetland habitat in the Pearl Harbor basin and supports an estimated 10% of the world ae’o population during the winter.
- The marsh has a partial predator-proof fence that helps protect nesting birds from mongoose and cats.
- The site management includes active predator control, invasive plant removal, and native outplanting.

- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh’s capacity to capture sediment.

**Education:** The site is closed to the public, but there is interest in using it for environmental education programs once restoration is closer to completion.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is closed to the public.

**Cultural:** Lo’i and loko i’a were once present here. It was also an important site for fishing, with an abundance of ‘ama’ama (mullet), ‘oama (goatfish), and crabs, and was used by the Royal Court prior to the 19th century. During the Great Māhele, the area was converted to rice and kalo fields, and following that period the site was filled in for use as a landfill.

## References

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Works, A., personal communication, June, 2023.

ISLAND: O'AHU

LOCATION: Pu'ewai wetland - Bellows Air Force Station

DESCRIPTION OF SITE: The Pu'ewai wetland on Bellows Air Force Station is a large wetland with ongoing restoration, fed by groundwater seepage and two nearby streams. The site is heavily influenced by the tides and level of Pūhā (Waimanalo) Stream. A sand plug occasionally forms at the mouth of the Inoa'ole stream which can lead to high salinity levels and complicate restoration efforts by creating harsh conditions for native plants. A major mangrove removal project has been carried out on site, and ongoing invasive plant removal and outplanting of native flora takes place on a regular basis along with pig control and other predator management. The wetland provides a range of habitats and supports endangered and migratory waterbirds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	76	486	None	DoD — Air Force (Bellows Air Force Station)	CSU CEMML	\$2–5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Supporting	Yes
Breeding				x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Sustainable Coastlines, Waimanalo Schools, Charter Schools (Mālama Nui), 25th Army Brigade, Boy Scouts, Mililani First Ward.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- Other Wildlife of Note**

'Ōpe'ape'a (Hawaiian hoary bat) is found on the site. An 'ua'u kani (Wedge-tailed Shearwater) colony is present in the restored sand dune, and 'ilio holo i ka uua (Hawaiian monk seals) use the beach for resting.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: None
- Inputs: Inoa'ole and Pūhā Streams, groundwater seepage, and the ocean
- Outflows: Outflow to the ocean via streams

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	2
Botulism control	1
Human disturbance control	2
Invasive plant control	2

- **Threats**

- Lead contamination.
- Car strikes of birds.
- Invasive plants, specifically ironwoods.
- Predators.
- Little fire ants are possibly at the site.
- A sand plug can form occasionally at Inoa'ole stream that leads to high salinity.
- Coconut rhinoceros beetle.

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- A hydrological survey is needed.
- A cooperative agreement is needed.

- **Challenges**

- Site needs additional staff.
- Site-specific long-term funding
- There are competing objectives for land use between making the property accessible to guests and a small number of active duty personnel stationed on site, and restoring habitat for native species.
- There is cat feeding in the area.
- Off-site water pollution flows into the wetland.

- **5–10 Year Conservation Priority Actions Needed**

- Identify additional funding sources.
- Identify the cause(s) of pollution, and work with state and federal partners to reduce/prevent it; also carry out actions to minimize the impacts in the short term (e.g. forested bioshield or other vegetation management to filter out contaminants).
- Increase staff capacity.
- Conduct a hydrological study and determine methods to prevent sand plug formation at Inoa'ole stream.
- Expand and maintain predator control, especially for cats and mongooses, in the long term.
- Install a predator-proof fence at the site.
- Remove invasive plants, especially ironwoods, and outplant native plants to expand high-quality habitat.
- Add speed bumps near the stream to reduce the risk of car strikes to waterbirds.
- Determine if little fire ants are at the site and implement control measures if so.
- Eliminate cat feeding in the area.
- Continue partnership with local cultural practitioners to allow access to the site for resource harvesting.
- Build trails and/or viewing stations for increased community access and recreation at the site.

- **Benefits to T&E birds / MBTA birds**

- The Pu'ewai wetland at Bellows Air Force Station provides a large amount of habitat for native T&E waterbirds as well as migrants.
- Site management includes predator control, invasive plant removal, and outplanting of native plants.



- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to capture sediment.

**Education:** Bellows Air Force Station is used by cultural practitioners for resource harvesting and encourages volunteers for clean up days for the beach and stream. There are current plans to establish a historical/cultural center on site.

**Sustainable food:** None.

**Fishing:** None within the wetland site.

**Recreation:** Bellows Air Force Station is open to members of the military, Department of Defense civilian retirees, and sponsored guests for beach access, ocean sports, and golf, among other activities. There is limited access to the wetland site via walking paths, though there are plans to build trails and/or viewing stations for increased access.

**Cultural:** There is an ongoing partnership with local cultural practitioners for collecting wood at the site for building hale. Bellows Air Force Station also contains historical burial sites.

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ISLAND: O'AHU

LOCATION: Punaho'olapa Marsh

DESCRIPTION OF SITE: Punaho'olapa Marsh consists of a spring-fed pond and a large marsh. A portion of this area was modified and converted into the Kuilima Golf Course during the early 1990s. The elevation of the golf course area was raised several feet, which continues to impact the site; much of its potential value to waterbirds has been lost. The remaining wetland provides a diversity of habitats ranging from permanently-flooded, open-water habitats to temporarily-flooded mudflats which are still used by T&E birds. The marsh is in a degraded state.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
2	100	100	None	Turtle Bay Resort	Turtle Bay Resort	\$1–2 million	Preliminary planning

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x	x	Supporting	No
Breeding	x	x	x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: North Shore Community Land Trust.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Mōlī (Laysan Albatross), 'ōhai, 'iliahi alo'e (coastal sandalwood), and dwarf naupaka are in the coastal site adjacent to the marsh.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes — number unknown
- Inputs: Agricultural drainage ditches and runoff from the surrounding golf course
- Outflows: None

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	3
Human disturbance control	3
Invasive plant control	1

- **Threats**

- Unexploded ordnance
- Herbicides
- Fertilizer
- Predators
- Golf carts

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	25-50% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0-2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- There is a lack of clarity about past restoration/mitigation agreements.
- Securing long-term funding

- Surveys needed to establish what native plants, fish, and invertebrates are present at the site
- **5–10 Year Conservation Priority Actions Needed**
  - Consider the feasibility of incorporating the site into the nearby James Campbell NWR.
  - Clarify if previous mitigation requirements have been met.
  - Secure long-term funding for the site.
  - Remove invasive plants that are filling in marsh habitat, and plant native plants.
  - Initiate and maintain long-term predator control.
  - Educate visitors and encourage them to keep dogs on leashes and not to feed outdoor cats.
  - Encourage landowners to consider waterbirds in golf course management, e.g. by reducing fertilizer and pesticide use around wetlands.
- **Benefits to T&E birds / MBTA birds**
  - The site is used by waterbirds and, with restoration and additional predator control, could be a highly productive area.
- **Benefits to People**

**Ecosystem Services:** Invasive plant removal and the restoration of the site with native plants will likely enhance the marsh's capacity to improve water quality.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is publicly accessible and can be used for bird watching.

**Cultural:** None.

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ISLAND: O'AHU

LOCATION: Turtle Bay Resort Golf Course Ponds

DESCRIPTION OF SITE: Turtle Bay Resort's golf course contains natural and man-made ponds that support waterbirds but currently have little native vegetation. Water from the Kuilima Wastewater Treatment Plant is recycled into the golf course ponds. These ponds support T&E native and migratory birds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	16.61	~ 500	None	Turtle Bay Resort	Turtle Bay Resort	< \$250k	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x	x		Other	No
Breeding	x	x	x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: North Shore Community Land Trust.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Mōlī (Laysan Albatross), 'ōhai, 'iliahi alo'e (coastal sandalwood), and dwarf naupaka are in the coastal site adjacent to the golf course.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes; number unknown
- Inputs: Kuilima Wastewater Treatment Plant discharge
- Outflows: None

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Predator control	2
Human disturbance control	3
Invasive plant control	3

- **Threats**

- Unexploded ordnance
- Herbicides
- Fertilizer
- Predators
- Golf carts
- Invasive plants species

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- There is a lack of clarity about past restoration / mitigation agreements.
- Securing long-term funding



- Surveys are needed to establish what native plants, fish, and invertebrates are present at the site.
- **5–10 Year Conservation Priority Actions Needed**
  - Clarify if previous mitigation requirements have been met and/or secure long-term funding for the site.
  - Remove invasive plants that are filling in marsh habitat, and plant native plants.
  - Expand and maintain predator control long term.
  - Reduce T&E waterbird strike from golf balls and golf carts.
  - Establish waterbird surveys to track species abundance and site utilization.
  - Encourage landowners to consider waterbirds in golf course management, e.g. by reducing fertilizer and pesticide use around wetlands etc.
- **Benefits to T&E birds / MBTA birds**
  - This site is important for T&E species on O‘ahu and is utilized by ‘alae ‘ula, ‘alae ke‘oke‘o, and ae‘o for breeding. Exact breeding figures are not known.
- **Benefits to People**

**Ecosystem Services:** Invasive plant removal and the restoration of the site with native plants will enhance the marsh’s capacity to improve water quality.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is publicly accessible and can be used for bird watching.

**Cultural:** None.

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ISLAND: O'AHU

LOCATION: 'Uko'a Marsh

DESCRIPTION OF SITE: 'Uko'a Marsh, near Hale'iwa in northwest O'ahu, is the site of an ancient fishpond that is connected to Loko Ea fishpond. 'Uko'a Marsh was detrimentally affected by dumping and filling at the former Kawaihoa Landfill (SWCA Environmental Consultants 2011). 'Uko'a Marsh is now managed under a Habitat Conservation Plan (HCP) in place until 2032 as mitigation for the impact of construction and operation of the Kawaihoa Wind Power project. Management includes predator control and invasive vegetation removal and the site is surrounded by an ungulate proof fence. The marsh is used by three T&E waterbirds for foraging and 'alae 'ula are known to breed there.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3	40	~93	Loko i'a	Kamehameha Schools / Bishop Estate	Kawaihoa Wind / Tetra Tech	N/A	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x	x			Supporting	Yes
Breeding	x						

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: None.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

11 native plant species, including 'ae'ae (Water hyssop), have been identified at the site in plant surveys (SWCA 2012). 'Ōpe'ape'a (Hawaiian hoary bat) are regularly detected at the site with acoustic monitoring.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes
- Inputs: 'Uko'a Marsh is spring fed, but some springs were capped by Waialua Sugar Company in 1994. Surface water runoff also feeds the marsh.
- Outflows: A channel to Loko Ea fishpond
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Unknown	

- **Threats**

- Predators
- Invasive plants

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	50-75% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Waterbird breeding has been low at the site and efforts should be made to determine if predators or invasive vegetation are reducing breeding attempts.
- **Challenges**
  - This site would benefit from habitat restoration (e.g. outplanting and maintaining native plant species) at the marsh in addition to invasive vegetation removal. While this management is not required by the HCP, the landowner may welcome advice and support to carry out this work.

- **5–10 Year Conservation Priority Actions Needed**

- Continue habitat management actions / protocols for T&E waterbirds as agreed under HCP.
- Maintain predator control long term to increase avian survival and fledging success.
- Continue removal of invasive plants that are filling in marsh habitat.
- Maintain ungulate fence around the site.
- Continue waterbird monitoring.
- Restore wetland habitat by removing invasive species at the marsh and outplanting native species to further improve waterbird survival and reproductive success.

- **Benefits to T&E birds / MBTA birds**

- This large wetland site is connected to Loko Ea fishpond which has management in place including ongoing predator control and invasive plant control. At present, 'Uko'a marsh is used by a small population of T&E native waterbirds. Although the site has predator control and limited invasive vegetation removal, waterbird site use remains low which initiated discussions regarding HCP adaptive management. Restoration of the site and the channel that connects to the neighboring Loko Ea could greatly expand suitable habitat for T&E and migratory waterbirds in northwest O'ahu.

- **Benefits to People**

**Ecosystem Services:** In its partially restored state, this site has a limited capacity for sediment capture and reducing runoff to the nearshore coastal ecosystem and offshore reefs. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh's capacity to capture sediment.

**Education:** None.

**Sustainable food:** None, though this site was once a fishpond.

**Fishing:** None.

**Recreation:** None.

**Cultural:** 'Uko'a Marsh is a former fishpond and, together with the connected Loko Ea fishpond, was a significant place of importance to the people of Waialua. It helped sustain the surrounding community with fish and seaweed (Bishop Museum, 2023).

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ISLAND: O'AHU

LOCATION: Waiale'e (Kalou Fishpond and Marsh)

DESCRIPTION OF SITE: This 30-acre site includes a freshwater emergent wetland and is managed through a community-based initiative (Waiale'e Lako Pono) led by North Shore Community Land Trust (NSCLT). Program activities include native ecosystem restoration, sustainable food production, k  naka   iwi (Native Hawaiian) ways of life, and education. The site is located on the coast in northwest O'ahu on University of Hawai'i land. Management work, including the removal of invasive vegetation, will protect a culturally important loko wai and benefit T&E waterbirds and migratory birds as well as native flora and fauna.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	20	30	Lo'i kalo, Loko i'a	University of Hawai'i	North Shore Community Land Trust	\$2–5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae ��ula	'alae ke'oke'o	ae'o	koloa maoli*	n��n��	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x		x		Other	Yes
Breeding	x						

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: University of Hawai'i (UH), UH Sea Grant, UH Faculty, Da Hui, Sunset Beach Community Association.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

The endemic goby   o'opu n  kea and the endemic sleeper goby   o'opu   akupa are found here.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, one known
- Inputs: Precipitation



- Outflows: There is natural groundwater discharge and two channels that would flow out to the coast, but they are clogged.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	3
Invasive plant control	2

- **Threats**

- Predators
- Invasive plants
- Human disturbance from people passing through site on foot and with ATVs
- Homeless encampment immediately adjacent

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Baseline waterbird monitoring, including nest surveys, is needed to understand waterbird population dynamics and how they utilize the site.
  - Improve ability to manage water levels.
- **Challenges**
  - Site-specific long-term funding

- Staffing — lack of capacity for both site management and waterbird monitoring
  - Support needed for multi-functional land management (conservation and indigenous agriculture)
  - Housing for conservation staff
  - Homeless encampment on the immediately adjacent beach
- **5–10 Year Conservation Priority Actions Needed**
    - Initiate and maintain predator control long term, particularly to control cats, mongooses, bullfrogs, and cattle egrets.
    - Remove invasive plants that are filling in marsh habitat, and plant native plants.
    - Restore indigenous agriculture at the site, as it will provide additional waterbird habitat.
    - Expand bird surveys to understand waterbird and waterfowl dynamics at the site.
    - Conduct hydrological surveys.
    - Assess how to manage water levels to reduce botulism risk.
    - Continue to conduct education and outreach to the community.
  - **Benefits to T&E birds / MBTA birds**
    - With appropriate management, the loʻi kalo and loko iʻa at Waialeʻe may provide varied habitat types suitable for the life cycle needs of T&E waterbirds and migratory bird species.
  - **Benefits to People**

**Ecosystem Services:** Wetlands restoration would enhance the capacity to provide flood control and reduce sediment flow into the ocean.

**Education:** Waialeʻe Lako Pono initiative intends to provide education.

**Sustainable food:** This site has former loʻi kalo, and continued restoration could provide additional food to the community.

**Fishing:** This site has former loko iʻa, and restoration could provide additional food to the community.

**Recreation:** Volunteer opportunities at the site provide recreation.

**Cultural:** This site was formerly a loko iʻa surrounded by loʻi kalo.

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ISLAND: O'AHU

LOCATION: Waimea Valley and Estuary

DESCRIPTION OF SITE: Waimea Valley is a large watershed of several thousand acres that funnels into a comparatively narrow opening of wetlands and estuary. This site also has an artificial pond with water that is diverted from the stream. The wetlands and pond are used by waterbirds for feeding, resting, and breeding.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5–550	45	1875	Dryland kalo	Hi'ipaka LLC	Hi'ipaka LLC	\$500k–1 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	x	x		x		Other	No
Breeding	x	x		x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Hawai'i Division of Forestry and Wildlife, O'ahu Army Natural Resource Program, University of Hawai'i Department of Natural Resources and Environmental Management, Mālama Pūpūkea-Waimea, Waimea Arboretum.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

All five species of 'o'opu (Hawaiian diadromous gobies and sleeper goby) are found in the stream, and the valley contains 63 endangered and 83 vulnerable plants (International Union for the Conservation of Nature listing).

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: Potentially, though currently undocumented
- Inputs: Waimea Stream, rainfall, and tidal input at the estuary
- Outflows: Waimea Stream

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Actions	Score
Human disturbance control	2
Invasive plant control	2

- **Threats**

- Botulism
- Unfenced road / car strikes
- Powerlines
- Human disturbance
- Pollution from machinery
- Coliform bacteria
- Predators
- Runoff from surrounding developed properties

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	<5% of wetland inundated	50-75% of wetland inundated	<5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 3–4.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- Need to keep businesses open during restoration

- There is ongoing cat feeding in the nearby beach park that needs to be eliminated.
  - There is shared access to the site between organizations that could complicate restoration efforts.
  - Parts of the site are inaccessible.
- **5–10 Year Conservation Priority Actions Needed**
    - Expand and maintain predator control long term to address bullfrogs, cattle egrets, and mammalian predators.
    - Eliminate cat feeding at the nearby beach park.
    - Remove invasive plants that are filling in marsh habitat, and plant native plants.
    - Reduce take due to vehicles through speed bumps or other means.
    - Reduce human disturbance.
    - Expand education and outreach, including signage.
    - Manipulate water levels to improve waterbird habitat.
  - **Benefits to T&E birds / MBTA birds**
    - A population of about 15 ‘alae ‘ula are present on site. Work is underway to maintain their habitat (particularly the estuary) and monitor the birds.
  - **Benefits to People**

**Ecosystem Services:** Invasive plant removal and restoration with native plants will enhance the marsh’s capacity to remove fertilizer-based nutrients from runoff.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** There is dryland kalo farmed in the valley, including over 60 varieties in the Hi‘ipaka LLC botanical garden collection, some of which are rare.

**Fishing:** None.

**Recreation:** The estuary and marsh are publicly accessible and can be used for bird watching. The beach is a popular recreation area, and the valley has a hiking trail and a botanical garden open to paying visitors.

**Cultural:** Waimea Valley contains many important cultural sites including the heiau Hale o Lono and Ku‘ula shrine, lo‘i terraces, building foundations, and burial temples and caves. The valley is the final resting place of the last high priest of O‘ahu, Hewahewa (Waimea Valley, 2022).

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MOLOKA'I

ISLAND: MOLOKA'I

LOCATION: Kākāhai'a National Wildlife Refuge (KNWR)

DESCRIPTION OF SITE: KNWR was established in 1976 to protect a permanent freshwater wetland on Moloka'i's southeastern coast. The remainder of the 44.6-acre property is comprised of two ponds separated by an access road — a seasonal wetland (New Pond, 5.5 ac) — and Old Pond (15 ac). Old Pond was engineered into the shape of the spokes of a wheel, which proved to be an unsuccessful management strategy. The entire property is surrounded by coastal dry forest and grassland. The site is a former loko pu'uone (inland fishpond). The refuge continues as a strip of coastal beach strand on the other side of the Kamehameha V Highway, managed by the County of Maui as a beach park. The goal of the site is to protect and manage breeding, nesting, and foraging habitat for 'alae ke'oke'o and ae'o. However, the habitat value has been lost due to a lack of management which has resulted in invasive species taking over, particularly California grass, kaluhā (California bulrush), fleabanes, and kiawe. Ungulates in the upper watershed have contributed to a high volume of eroded sediments settling in the refuge during rainfall events. In some places, the 4' high hog wire fence has less than a foot of height remaining until total burial by sediment. The USFWS is a member of the Moloka'i Wetland Partnership and is working with partners to find creative ways to restore and manage the site. Kākāhai'a ranked second in the 2023 PI-CASC suitability analysis (Drexler et al., 2023).

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
1.56	20.5	44.6	Potential	USFWS	USFWS	\$1–2 million	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x			Core	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Moloka'i Land Trust, Ka Ipu Makani (KIM), Pacific Birds Habitat Joint Venture, Arleone Dibben-Young, Moloka'i Wetland Partnership.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

‘Ōpe‘ape‘a (Hawaiian hoary bat)

- **Hydrology**

Has there been a formal hydrological survey: No, but one is planned for 2024.

- Springs: 2+ underground springs feed Old Pond.
- Inputs: Discharge of fresh groundwater (Old Pond); surface water (especially during flash floods); New Pond requires water inputs (e.g. pumping); several shallow dug wells
- Outflows: Groundwater discharge; surface water runoff from the springs flows to the sea via a canal on the east side to a drainage culvert under the highway; an old water control structure in Old Pond pumped water to New Pond, which then overflowed to the ocean via a culvert under the highway (note: both culverts on east side and west side are lower than the mean tide and quickly plug with sand)

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Botulism control	3
Human disturbance control	3

- **Threats**

- Beach erosion
- Sedimentation
- Highway (bird vehicle strikes)
- Powerlines

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	5-25% of wetland inundated	Not likely: site is bounded to the north by a cliff and development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0-2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Hydrological Survey
- **Challenges**
  - Inadequate funding
  - Serious lack of staff capacity
  - Permitting and compliance
  - Invasive species
  - Community concerns
  - Funding
  - Predator control
  - Botulism
- **5–10 Year Conservation Priority Actions Needed**
  - Continue with co-development of restoration design with the community (already underway with Ka Ipu Makani).
  - Remove invasive species.
  - Outplant native species.
  - Restore coastal strand and establish native bioshield border.
  - Continue ridge to reef work to reduce sedimentation.
  - Carry out hydrological and engineering surveys to understand how to reengineer topography and hydrology to create variable water depths with edge.
  - Repair existing fence in the short term, and install predator-proof fence in the medium term.
  - Develop and implement a restoration plan.
  - Installation of diverters on powerlines to reduce risk of waterbird collisions.
- **Benefits to T&E birds / MBTA birds**
  - Restoration will benefit a‘eo, ‘alae ke‘oke‘o, and migratory birds.
- **Benefits to People**

**Ecosystem Services:** A primary goal is restoration of the wetland to enable it to perform its full ecosystem services.

**Education:** MWP and KIM are undertaking outreach work as part of restoration efforts.

**Sustainable food:** Feasibility of traditional agroecology will be considered at the site.

**Fishing:** None.

**Recreation:** Volunteer opportunities will be available.

**Cultural:** The site was formerly a Kākāhai'a loko pu'uone (inland brackish fishpond fed by the ocean and freshwater streams or springs).

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ISLAND: MOLOKA'I

LOCATION: Kamahu'ehu'e

DESCRIPTION OF SITE: Kamahu'ehu'e Fishpond and wetland is on the western side of Kamalō Wharf. It is a loko kuapā (walled fishpond) spanning 37 acres with a 3,470 feet wall. Historically, this fishpond had two strategically placed mākāhā (entrances), one along the eastern shoreline and the other in the central area of the southwestern wall (Summers, 1971). According to Cobb's documentation (Cobb, 1902), Kamahu'ehu'e was actively utilized for commercial fish production purposes. However, as time passed, significant challenges emerged. By 1957, reports indicated that the pond had shrunk to just 25% of its original size due to siltation (Summers, 1971). The current pond area covers about 81 acres. Mangrove growth now obscures the eastern end of the pond, while the southern section has suffered deterioration from wave action (Sust'āinable Molokai, 2023). There are large expanses of open mudflats that inundate during high tide or following heavy rainfall. Ae'o, 'alae ke'oke'o, and migratory waterfowl and shorebirds use the site regularly. The entire ahupua'a belongs to Kamehameha Schools, which provides potential for landscape-level restoration.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
1	81	89	None	Kamehameha Schools	Kamehameha Schools	\$2-5 million+	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x			Other	Yes
Breeding			x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: .

Conducts site-based waterbird monitoring (not including SWBC): No

#### ● Other Wildlife of Note

Native plants makaloa, milo, and 'ākulikuli are found at the site, as well as migratory birds including 'akeke'e (Ruddy Turnstone), hunakai (Sanderling), kolea (Pacific Golden Plover), and Lesser Yellowlegs.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Unknown
- Inputs: Surface water, groundwater
- Outflows: Unknown

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	1
Human disturbance control	1

- **Threats**

- Proximity to unfenced highway is a threat to birds
- Extreme weather events (e.g. tsunamis)
- Unleashed dogs
- Feral ungulates (e.g. pigs, deer, etc.)
- Non-native predators (e.g. feral cats, rats, mongooses)
- Non-native vegetation
- Trespassing
- Trash

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
25-50% of wetland inundated	25-50% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated*	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

\*This does not represent an improvement in inundation, rather that the source of inundation is now marine, not groundwater.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**



- 3.0-4.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Better understanding of overall hydrology and erosion is needed.
  - Regular monitoring of wildlife/waterbirds to better understand demographics and survival.
  - Increased understanding of deer populations and impacts on site is needed.
- **Challenges**
  - Changes in hydrology (e.g. degradation of springs, sedimentation, drought) has increased salinity levels to hypersaline ranges in some locations.
  - Invasive plant species, for example, mangrove (cover approximately  $\geq 36\%$ ) and pickleweed (cover approximately  $\geq 26\%$ ).
  - Navigating mixed stakeholder and community needs.
  - Obtaining necessary permits and/or funding.
- **5–10 Year Conservation Priority Actions Needed**
  - Develop relationship between landowner and Moloka'i Wetland Partnership.
  - Community and stakeholder engagement.
  - Support efforts for ahupua'a-level restoration to decrease erosion and reduce sedimentation.
  - Develop restoration plan.
  - Secure funding to implement the plan.
- **Benefits to T&E birds / MBTA birds**
  - This site provides a key opportunity for mauka marsh migration as SLR intensifies, and will be increasingly important for both T&E and migratory birds as SLR increases.
- **Benefits to People**

**Ecosystem Services:** The size of the site and the continuity of landownership in the ahupua'a provides a rare and important opportunity to carry out landscape-level restoration that could reduce sedimentation onto the road and reef.

**Education:** No organized educational activities are currently provided on site although this may change in the future.

**Sustainable food:** No food production is currently occurring.

**Fishing:** None.

**Recreation:** No

**Cultural:** This site is a historic fishpond. The areas of Kamalō are revered in Hawaiian cultural history.

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ISLAND: MOLOKA'I

LOCATION: Kaupapalo'i o Ka'amola (KOK)

DESCRIPTION OF SITE: The site is a lo'i pūnawai (spring fed taro pondfield), emptying directly into Kāina'ohe, a 17.2-acre loko i'a (fishpond). Over the last decade, Ka Ipu Makani has worked in collaboration with the land owners, other land tenants, and community volunteers to restore the lo'i pūnawai. The loko i'a remains unrestored. Between the lo'i and the loko i'a, there is a groundwater-fed coastal freshwater marsh containing organic peat soil (a coastal fen). The site has the low salinity and shallow depths to groundwater characteristic of a freshwater ecosystem. Kaupapalo'i O Ka'amola is a vibrant community asset, providing educational and volunteer opportunities and showcasing successful restoration of a site from highly degraded mangrove invasion to a fully-functional indigenous agroecological system. This site ranked first in the 2023 PI-CASC suitability analysis ([Drexler et al., 2023](#)). Ae'o have recently been observed at the site, and migratory birds such as 'akekeke (Ruddy Turnstone) have also been seen using the fen area.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
1.2	0.12	2	Lo'i kalo, loko i'a	Private (lo'i) / Thacker Corporation (loko i'a)	Ka Ipu Makani	\$1-2 million	Lo'i — fully restored; Loko i'a — unrestored

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x			Other	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Moloka'i Wetland Partnership.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Native fish are present, including awa'aua (Hawaiian ladyfish). Widgeon grass is present in the outflow from the lo'i, which would provide food for waterbirds. There is a sporadic presence of migratory shorebirds at this site, particularly 'akekeke (Ruddy Turnstone).

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Mauka of KOK there are springs or seeps — a strong groundwater discharge is present on site.
- Inputs: Surface water and groundwater
- Outflows: Water flows out of the lo'i into the loko i'a.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Invasive plant control	1

- **Threats**

- Highway mauka of the site

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	5-25% of wetland inundated	<5% of wetland inundated	Not possible: site is backed by a small cliff and highway.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 7.0-8.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Monitoring of native birds as they return to the site

- **Challenges**

- Full restoration would include the loko i'a as an integral part of this indigenous system; that section of the site is owned by a private corporation.

- Invasion of California bulrush into the fen
- **5–10 Year Conservation Priority Actions Needed**
  - Restore and manage loko iʻa for sustainable food and wildlife.
  - Remove invasive California bulrush and outplant native plants in its place.
  - Investigate the feasibility of a native bioshield or food forest to protect the site from flooding and sedimentation.
  - Investigate options to expand the site to the east or west.
  - Initiate predator control to protect native birds
- **Benefits to T&E birds / MBTA birds**
  - Recently, aeʻo have been recorded on site for the first time, an exciting development that indicates the suitability of the habitat. Restoration of the loko iʻa could expand that.
- **Benefits to People**

**Ecosystem Services:** This site provides flood and sediment control to protect the fringing reef and nearshore water quality.

**Education:** Ka Ipu Makani carries out extensive education and outreach work for local students and the community.

**Sustainable food:** This site produces a significant amount of kalo.

**Fishing:** None.

**Recreation:** Educational volunteer opportunities exist at the site.

**Cultural:** This site holds significant cultural value as a model for the restoration of a highly-degraded site to a fully-functioning loʻi punawai.

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ISLAND: MOLOKA'I

LOCATION: Kualapu'u Reservoir

DESCRIPTION OF SITE: This state-owned reservoir in north-central Moloka'i was constructed in 1969 and holds up to 1.4 billion gallons of water. It has grassy slopes, a muddy shoreline and the south slope is paved in concrete to reduce wave action erosion. The site is surrounded by a fence, and public access is prohibited, making it relatively safe from human disturbance. The site is seasonally important for 'alae ke'oke'o and migratory waterfowl.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
250	95	95	None	State of Hawai'i, Dept. of Agriculture	State of Hawai'i DOA Agricultural Resource Management Division	\$250k	No restoration.

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x			Supporting	Yes
Breeding		x					

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS:

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: None.

- Inputs: Moloka'i Irrigation System (surface water diversion dams, groundwater interception, and wells; west portal tunnel flow from Waikolu Valley); rainfall.
- Outflows: Water is removed through the irrigation system and used by the consumers, and water is lost to evaporation.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	2
Human disturbance control	1

- **Threats**

- Reservoir infrastructure
- Highway
- Powerlines
- Predators

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundate	< 5% of wetland inundate	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural, with exception of HHL, where land is under long term ag homestead leases

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 7.0-8.9 km
- **Knowledge Gaps and Planning / Research Needs**



- **Challenges**

- This site is managed for the provision of water; T&E waterbirds are not prioritized there.
- Need to maintain high-quality predator control.
- Need to minimize likelihood of botulism outbreaks, ensure botulism monitoring occurs, and develop and implement an action plan for botulism events.

- **5–10 Year Conservation Priority Actions Needed**

- Establish ongoing predator control.
- Establish ongoing botulism monitoring and management.
- Enhance habitat for the benefit of waterbirds.
- Assess any potential mortality hazards as a result of reservoir function, complete a report on how to reduce them, and liaise with the land manager to implement the actions.

- **Benefits to T&E birds / MBTA birds**

- This site provides important open water habitat that attracts ‘alae ke‘oke‘o and migratory waterfowl in large numbers seasonally. This habitat is otherwise scarce on the island. Shorebirds roost on the cement revetment.

- **Benefits to People**

**Ecosystem Services:** Irrigation for farms

**Education:** None

**Sustainable food:** Indirectly, via irrigation

**Fishing:** None

**Recreation:** All recreation prohibited

**Cultural:** Sweet potatoes were grown on the south and west slopes of Kualapu'u hill, defined by rows of stones. According to Sophie J. Cooke, the former name of Kualapu'u was Ka 'Uala Pu'u, 'The Sweet Potato Hill'. (Summers, 1971).

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ISLAND: MOLOKA'I

LOCATION: Moku Pond

DESCRIPTION OF SITE: This diminutive site was likely a vernal pool or fen with some saltwater intrusion. Heavy sedimentation has buried any springs. It is usually unsaturated until the rainy season arrives (November to March). During that time, and particularly during high tides, the groundwater rises to fill the pond, which can then remain saturated for several months. The site is currently overgrown with invasive species, and the waterbird habitat has largely been lost, although ae'o have been observed attempting to nest there.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0.5	0.3	0.3	None	Kawela Plantation Homeowners Association (HOA) (private)	Kawela Plantation Homeowners Association (private)	\$500k – 1 million	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x			Other	Yes
Breeding			x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Moloka'i Wetland Partnership, Moloka'i Land Trust, Arleone Dibben-Young.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Springs or seeps have been noted at the upland edge but are at least partially buried under deposited materials (Drexler et al., 2023).
- Inputs: Groundwater, ocean water, and surface water.
- Outflows: Groundwater discharge and evapotranspiration.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	2
Botulism control	1
Human disturbance control	1

- **Threats**

- Beach erosion, which will lead to overtopping across the highway
- Highway
- Powerlines
- Dogs and feral cats

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Not possible: site is backed by a small cliff

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0-2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Develop relationship with Kawela Plantation HOA
- Hydrological survey
- Community scoping project

- **Challenges**

- Adjacent to residential homes

- Iwi kūpuna may have been moved in this area or surroundings.
- Adjacent to highway (need to leave screen of trees or replant with natives to reduce likelihood of bird collisions).
- **5–10 Year Conservation Priority Actions Needed**
  - Develop a relationship with HOA.
  - MWP to support Molokaʻi Land Trust to partner with HOA to enact long-term management and provide support (both financially and technically).
  - Plant a screen of native trees along the highway to prevent avian road deaths.
  - Installation of diverters on powerlines to reduce risk of waterbird collisions.
  - Remove kiawe and other aggressive nonnative species.
  - Develop and implement a restoration plan.
  - Install ungulate fencing.
  - Outplant native species.
- **Benefits to T&E birds / MBTA birds**
  - Restoration will benefit aeʻo and prevent the site from being a sink in the vicinity of Kākāhaiʻa NWR.

- **Benefits to People**

**Ecosystem Services:** A primary goal is restoration of the wetland to full ecosystem services.

**Education:** None

**Sustainable food:** None

**Fishing:** None

**Recreation:** None

**Cultural:** Likely used for indigenous agro-ecology in the past.

## References

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ISLAND: MOLOKA'I

LOCATION: 'Ōhi'apilo Pond

DESCRIPTION OF SITE: This Department of Hawaiian Homelands (DHHL) site provides important habitat for both T&E waterbirds and migrants and ranked first out of all sites on Moloka'i for its value to birds in the 2023 [Pacific Islands Climate Adaptation Science Center](#) (PI-CASC) research project. Habitat enhancement to create seasonally-flooded mudflats and semi-permanently flooded ponds and channels was completed in 1999 and provided nesting habitat for Ae'o (Hawaiian Stilt). A canal designed for the site and an 1898 molé (berm created for a railroad) are features of the site. Low salinities and shallow depths to groundwater demonstrate a high discharge of fresh groundwater, although hypersaline areas exist. Despite a lack of active invasive species management, the site still has a relatively high proportion of native to non-native wetland species, but there are high levels of depredation and much of the site is a monotypic pickleweed flat threatened with mangrove invasion. The 'partial predator control' fence is in poor condition due to the mangrove invasion and flooding, and needs urgent repair. The canal regularly overflows, marooning invasive fish on the site which leads to botulism outbreaks as the floods dry up. DHHL is working with the Moloka'i Wetland Partnership on restoration options and will be carrying out community engagement. The area outside the fence consists of swampy saltwater marshlands with mangrove and pickleweed. The closed Kalama'ula landfill is directly to the east.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0.26	94.2	119	None	DHHL	DHHL	\$1 million	Planning underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x			Core	Yes
Breeding		x	x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Moloka'i Wetland Partnership.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Two low-volume, slightly brackish springs.
- Inputs: Precipitation; surface water; groundwater to small pond and canal but not large pond.
- Outflows: Discharge to groundwater; evapotranspiration.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	2
Botulism control	1
Invasive plant control	2
Human disturbance control	3

- **Threats**

- Botulism; several times a year, high tides breach the sand berm and 1" to 2" of seawater enters the big pond, bringing in fish. When the floods recede and the fish die, botulism events are triggered.
- Water quality
- Sedimentation
- Invasive fish
- Trash
- Damage to fence
- Development
- Infrastructure

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated*	Possible: all or most of the surrounding land is undeveloped and is zoned for



				ag or rural
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\*This does not represent an improvement in inundation, but rather, that the source of inundation is now marine, not groundwater.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0-2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - A management plan exists, but concern has been expressed as to whether the plan will fully deal with the challenges of botulism — a review is underway.
- **Challenges**
  - DHHL has a mandate to support beneficiaries rather than carry out conservation work, so any restoration work needs to have a strong link to beneficiary benefits and co-management.
  - Some areas of the site are hypersaline due to sedimentation.
- **5–10 Year Conservation Priority Actions Needed**
  - Review management plan.
  - Involve beneficiaries of Hawaiian Homelands in the planning, stewardship, and restoration of the site.
  - Initiate culture-based education and involvement of cultural practitioners.
  - Remove mangrove which is pushing the fence over, and allowing propagules to float across ponds and establish new mangrove trees.
  - Reduce fish in canal, and initiate regular monitoring and removal to prevent botulism. An alternative option is to fill canal with clean filter rock and sand to same elevation of small pond, thereby inhibiting fish growth to size too small to trigger botulism outbreaks.
  - Regularly monitor and remove dead fish as the two ponds evaporate after inundations.
  - Remove pickleweed and other aggressive non native species to allow native seedbank to regenerate.
  - Outplant and/or broadcast the seeds of native species.
  - Repair and/or upgrade fence to predator proof.
  - Make infrastructural changes to address hydrological problems resulting in botulism.
- **Benefits to T&E birds / MBTA birds**
  - Under a previous intensive management regime, T&E waterbirds as well as migratory species thrived. Resuming management is critically important to maintain the current bird populations and encourage recovery.

- **Benefits to People**

**Ecosystem Services:** Yes, this wetland provides benefits to the reef and water quality.

**Education:** Yes, DHHL allows school trips, etc.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** None.

**Cultural:** DHHL owns this property and the closest neighbors are DHHL beneficiaries.

## **References**

Dibben-Young, A., personal communication, 2020-2023.

Drexler, J. Z., Raine, H., Jacobi, J. D., Haase, B., House, S., Lima, P., Dibben-Young, A., Wolfe, B. (2023). *A prioritization protocol for coastal wetland restoration on Molokaʻi, Hawaiʻi*. *Frontiers in Science*. <https://www.frontiersin.org/articles/10.3389/fenvs.2023.1212206/full>.

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Munekiyo and Arakawa Inc. (1997). *Final environmental assessment - ʻŌhiʻapilo Wetlands*. Report prepared for the County of Maui, Dept of Public Works and Waste Management.

U.S. Fish and Wildlife Service. (2011). *Recovery Plan for Hawaiian Waterbirds, Second Revision*. U.S. Fish and Wildlife Service, Portland, Oregon. xx + 233 pp.  
[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

ISLAND: MOLOKA'I

LOCATION: Pahuauiwai Aquaculture Site

DESCRIPTION OF SITE: A portion of this 157-acre site is an active shrimp farm, consisting of 22 earthen ponds and one lined pond and multiple effluent canals leading to the surrounding wetlands. The manager rotates pond filling and drawdowns for harvests and supports the protection of T&E waterbirds. Intermittent predator control occurs on site. The remainder of the site consists of unmanaged, storm-filled pickleweed flats to the east, west and south. There are two former loko i'a on site and a historic Hawaiian village within the wider property boundary.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3-15	110	157	None	Private	Private	\$1–2 million	No restoration, but T&E birds use the ponds already.

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x			Other	No
Breeding			x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Arleone Dibben-Young.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, number unknown.

- Inputs: Pumping of seawater for shrimp ponds; groundwater at the surface in the natural wetland areas.
- Outflows: Canal to the ocean.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	2
Botulism control	2

- **Threats**

- The degradation of springs from sedimentation and drought has caused salinity levels to climb into the hypersaline range (> 40 psu) in shoreline locations (Drexler et al., 2023) and as low as 4 at the previous spring, which since 1900 has been an open well utilized by waterbirds.

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	5-25% of wetland inundated	<5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 5.0-6.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Hydrological survey to guide restoration planning
  - Restoration and management planning.
- **Challenges**

- Invasive species, including pickleweed ( $\geq 26\%$ ) and mangrove, will need to be controlled and native species planted in order to regain some of the original plant diversity.
- **5–10 Year Conservation Priority Actions Needed**
  - Remove invasive species (pickleweed and mangrove).
  - Dredge accumulated sediment.
  - Recontour topography of pickleweed flats.
  - Carry out ongoing predator control.
  - Carry out ongoing botulism control.
  - Develop restoration and management plan, to include archaeological features on site.
- **Benefits to T&E birds / MBTA birds**
  - The site currently supports ae’o in the shrimp farm area. The extensive pickleweed flats beyond the shrimp farm infrastructure could provide exceptional waterbird habitat if restored. This site is part of the south shore complex of wetlands identified for restoration in the PI-CASC project and as such, has very high conservation value.
- **Benefits to People**

**Ecosystem Services:** The site represents a key opportunity for mauka marsh migration as sea level rise intensifies.

**Education:** None.

**Sustainable food:** Yes.

**Fishing:** None.

**Recreation:** None.

**Cultural:** There is a 20 acre former Hawaiian village within the TMK, in the lowland dry forest area.

## References

Dibben-Young, A., pers. comm., Jan 2022 - Dec 2023.

Drexler, J. Z., Raine, H., Jacobi, J. D., Haase, B., House, S., Lima, P., Dibben-Young, A., Wolfe, B. (2023). *A prioritization protocol for coastal wetland restoration on Moloka’i, Hawai’i*. *Frontiers in Science*. <https://www.frontiersin.org/articles/10.3389/fenvs.2023.1212206/full>.

Morgenstein, M. E and Kaschko, M. W. (1981) *Archaeological Survey And Testing Investigations Orca Sea Farms Inc. Property, Kahanui, Molokai*. Hawai’i Marine Research Inc Report.

ISLAND: MOLOKA'I

LOCATION: Poho'ele Pond, Pala'au State Wildlife Sanctuary

DESCRIPTION OF SITE: The largest fishpond on Moloka'i, this loko 'ume'iki contained 27 outward lanes, and its size is estimated to be up to 500 acres with a coral and basalt wall of 6,300 feet. It is now buried in sediment. The site has episodic seasonal ponds and streams during the winter caused by flash flooding. It is part of a larger parcel of state land, and the Division of Fish and Wildlife (DOFAW) intends to restore the entire ahupua'a. The site is relatively isolated and the most westerly of a series of wetland sites on the south shore of Moloka'i. The wetlands have been degraded primarily through rapid and extensive sediment accumulation caused by effects of feral ungulates and decades of agricultural practices (primarily pineapple production) on upslope areas, as well as the encroachment of non-native weedy plants, especially pickleweed, marsh fleabane, and red mangrove. Sedimentation has resulted in substantial depth to the water table, and during drought conditions the site becomes a hypersaline dust bowl. It also floods severely in heavy rainfall.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0.68	133	314	No	Department of Land and Natural Resources	DOFAW	\$2-5+ million	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present						Other	No
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS:

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Possible at the east end, but buried
- Inputs: Rainfall, surface water
- Outflows: Evapotranspiration
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	1
Human disturbance control	1

- Threats
  - Predators, especially dogs and feral cats
  - Sedimentation
  - Invasive species

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	50-75% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 7.0-8.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Hydrological survey needed.
- **Challenges**



- Management capacity
- Flash floods regularly cause trees to fall across the access road.
- Sedimentation — at three soil pits, the bottom was dry at 80 cm. Exposed fence-posts demonstrate that depths of sediment can currently exceed 4' of fill over most of the wetland.
- Monotypic cover of pickleweed was  $\geq 26\%$  of the site; invasive vegetation will need to be controlled and native species planted in order to regain some of the original plant diversity.

- **5–10 Year Conservation Priority Actions Needed**

- Proceed with DOFAW plans to develop a management/restoration plan. Initial actions identified are:
  - Survey the perimeter.
  - Conduct an environmental assessment.
  - Fence the delineated perimeter with an 8' tall (deer-proof) fence.
  - Restore a permanent open pond area by excavating the deep aggregation of sediment.
  - Restore permanent natural water ponding by constructing shallow impoundments/embankments (with use of some excavated sediment).
  - Consider options to control water levels, including installing a shallow groundwater pump.
  - Remove the mangroves and other non-native trees by cutting and chipping (note that mangroves may be in the Waters of the State). Replace non-native vegetation with native low-stature Hawaiian wetland plants necessary for foraging, nesting, loafing, and security of the T&E Hawaiian waterbirds.
  - Develop trails and non-obtrusive observation points (benches and blinds) in the complex to allow for both staff monitoring and management of predators, invasive weeds, and waterbird resources as well as to provide opportunities for wetland and wildlife education and recreation.

- **Benefits to T&E birds / MBTA birds**

- Waterfowl frequented this area following heavy rainfall when the ranch maintained the mauka portion along the road free of kiawe trees. No ducks have been observed since the early 1980s when the trees grew taller (Joey Joao pers comm. to ADY). In addition, no stilts have ever been observed on the mudflats (Dibben-Young pers.comm. 2023).

- **Benefits to People**

**Ecosystem Services:** Yes, this site captures sediment from upland erosion, protecting the reef and improving water quality.

**Education:** None.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** None.

**Cultural:** This site is a former fishpond. An 1897 map shows a portion of the stone wall which is no longer visible.

## **References**

Dibben-Young, A., personal communication, 2020-2023.

Drexler, J. Z., Raine, H., Jacobi, J. D., Haase, B., House, S., Lima, P., Dibben-Young, A., Wolfe, B. (2023). *A prioritization protocol for coastal wetland restoration on Moloka'i, Hawai'i*. *Frontiers in Science*. <https://www.frontiersin.org/articles/10.3389/fenvs.2023.1212206/full>.

Duvall, F. (2009). *Enhanced Resource Protection and Management – Ho'olehua (Pala'au) Wetlands Restoration and Management Proposed as a Wildlife Sanctuary*. Department of Land and Natural Resources - Division of Forestry and Wildlife. Report.

ISLAND: MOLOKA'I

LOCATION: Punalau Pond

DESCRIPTION OF SITE: This undeveloped site is part of an expansive coastal floodplain on Moloka'i's south shore which provides a mosaic of freshwater, brackish, and saltwater habitats. It has excellent restoration potential. Punalau consists of storm-filled mudflats in the center of monotypic pickleweed stands, interspersed with open depressions in mudflats that fill with rainwater and retain water for long periods due to hydric soils. Extensive mangrove invasion centers around the springs and their outflow. The site is a former fishpond, but the walls are mainly buried beneath the sediment. Soils are organic rather than mineral.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0.55	42	45	Potential	Acquisition in progress	Moloka'i Land Trust (MLT) (acquisition expected Jun 2024)	\$3 million	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x			Other	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Pacific Birds Habitat Joint Venture, Arleone Dibben-Young, Moloka'i Wetland Partnership.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- Other Wildlife of Note

Ōpe'ape'a (Hawaiian hoary bat) is found at Punalau Pond. The Orangeblack Hawaiian damselfly is found at two basal springs within this property, one of the few sites in Hawai'i where this species persists. This site also has potential for 'ōpae 'oeha'a (Hawai'i river prawn), 'o'opu 'akupa (Hawaiian sleeper goby), 'o'opu naniha, and 'o'opu nākea.

- **Hydrology**

Has there been a formal hydrological survey: No, but one is planned.

- Springs: Yes; number unknown, but site name means “many springs”.
- Inputs: Water varies; likely large watershed input; groundwater present; ephemeral streams emanate from springs.
- Outflows: Groundwater recharge; evapotranspiration.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	2
Human disturbance control	1

- **Threats**

- Invasive plant species, esp. mangrove
- Predators
- Pools for Orangeblack Hawaiian damselfly are not protected or managed at present

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	>50-75% of wetland inundated	Definite: surrounding area is already wetland habitat

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 5.0-6.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Hydrological Survey
- Community Scoping project
- Co-development of restoration design with community

- **Challenges**

- Invasive species: > 65% of the habitat on site is seriously affected by mangrove, while > 26% of the area's vegetation is comprised of pickleweed. Invasive vegetation will need to be controlled and native species planted in order to increase plant diversity.
- Permitting.
- Maintaining Orangeblack Hawaiian damselfly.

- **5–10 Year Conservation Priority Actions Needed**

- Focus restoration principally on the eradication of red mangrove, pickleweed, and kiawe.
- Develop and implement a restoration plan.
- Install a predator-proof fence.
- Outplant native species.
- Incorporate indigenous agriculture if appropriate with hydrological conditions.
- Establish a native bioshield and sedimentation ponds.
- Create grassland habitat for nēnē.

- **Benefits to T&E birds / MBTA birds**

- Acquisition and subsequent restoration would benefit ae'o and 'alae ke'oke'o.
- The site will potentially benefit 'alae 'ula by providing a reintroduction site to a 3rd island.
- Restoration would benefit migratory birds including 13 State of Hawai'i species of greatest conservation need & 30 species of migratory waterfowl & shorebirds (10 of which use the site already).
- Site hosts IUCN 'near threatened' kioea (Bristle-thighed Curlew) (listed as of 'greatest concern' in the US Shorebirds of Conservation Concern, 2016).

- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to capture sediment.

**Education:** MLT is planning education work as part of restoration efforts.

**Sustainable food:** This site will be considered for traditional agroecology.

**Fishing:** Fishing access onto the reef will be considered during restoration planning.

**Recreation:** Volunteer opportunities will be available.

**Cultural:** The site has deep cultural importance, due to a buried ~600-year-old loko 'ume'iki (shoreline-bound fishpond) known as Punalau Pond. An archaeological survey from 1981 found the walls of the pond buried under sediment in "excellent preservation." That survey concluded

that the pond was used to grow awa (milkfish) and that no mitigation procedures were required to preserve the site. In 1901, the site was still being used commercially. After 1922, it was filled completely by mangrove. While removal of sediment to restore the fishpond is likely to prove expensive, the presence of the original walls will help to protect the site from sea level rise, allowing the freshwater to retreat north. In the longer term, erosion may see this historic structure uncovered naturally, providing for possible restoration management into the future.

## References

Dibben-Young, A., personal communication, 2020-2023.

Drexler, J. Z., Raine, H., Jacobi, J.D., Haase, B., House, S., Lima, P., Dibben-Young, A., Wolfe, B. (2023). *A prioritization protocol for coastal wetland restoration on Moloka'i, Hawai'i*. Frontiers in Science. <https://www.frontiersin.org/articles/10.3389/fenvs.2023.1212206/full>

Raine, H., Dibben-Young, A., Haase, B. (2022). *Punalau Pond Acquisition Briefing Document and Supplementary Information*. Pacific Birds Habitat Joint Venture Report.

ISLAND: MOLOKA'I

LOCATION: Pu'u One Pond (Dunbar)

DESCRIPTION OF SITE: This site is an inland fishpond enclosed by a sand berm. It is fronted at the sea by the Ipuka'iole fishpond (a loko ku'apa). It is not known whether the inland pond was naturally created or not; neither historical nor recent data mentions its creation.\* Restoration of Ipuka'iole was carried out in 1991; while the walls are submerged, they are discernible from the air as well as the water. Pu'u One Pond was excavated and restored in 2012. The water table is at the ground surface, providing open water. Low salinities and shallow depths to groundwater demonstrate a high discharge of fresh groundwater.

\*Research and restoration has been carried out here by Dr. David Ziemann of OI Consultants, Inc. Makapu'u Point, Kepa Maly of Kumu Pono and Associates, and Dr. Russell Apple.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0.26	0.76	3.2	Loko i'a	Private	Private	\$120k	Preliminary planning

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present	Historically present. As a child, owner witnessed 'alae ke'oke'o and 'alae 'ula in Pu'u One.					Other	Yes
Breeding							

(no other data available)

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS:

Conducts site based waterbird monitoring (not including SWBC): No

● **Other Wildlife of Note**

Unknown



- **Hydrology**

Has there been a formal hydrological survey: Yes (by USFWS, Dr. Greg Koob)

- Springs: Very likely
- Inputs: Surface water, groundwater
- Outflows: Discharge to groundwater

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Invasive Plant control	3

- **Threats**

- Steep banks
- Invasive species
- Predators

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 9.0 km +

- **Knowledge Gaps, and Planning / Research Needs**

- Need to locate Koob report and establish the data available on hydrology

- **Challenges**

- Private land; cooperative owner with a history of established facts on the site
- **5-10 Year Conservation Priority Actions Needed**
  - Recontour steep banks to make them more suitable for waterbirds
  - Remove invasive plants and outplant native plants to expand high-quality habitat.
  - Initiate predator control and maintain it long term.
- **Benefits to T&E birds / MBTA birds**
  - This wetland site is secluded and could provide suitable habitat for waterbirds, if restored, on the east of the island.
- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs. Removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to capture sediment.

**Education:**

**Sustainable food:** N/A

**Fishing:** Unknown

**Recreation:** This is not a recreational site.

**Cultural:** This site has the Ipuka'iole fishpond which was formerly used for aquaculture.

## References

Dunbar, K., pers. comm., November, 2023.

MAUI

ISLAND: MAUI

LOCATION: Kanahā Pond Wildlife Sanctuary

DESCRIPTION OF SITE: Kanahā Pond Wildlife Sanctuary, located near Kahului Airport, is one of the largest wetlands in Maui as well as the first wildlife sanctuary established in Hawai'i. It has a partial predator-proof fence that is expected to be completed and enclose the site.

Management includes predator control and habitat restoration. It supports all native T&E waterbirds found on Maui and is particularly important for breeding ae'o and 'alae ke'oke'o. The sanctuary also supports many migrants, native plants, and native invertebrates, most notably the endangered Hawaiian hornworm sphinx moth. It is one of the few brackish-water wetlands remaining on Maui, important for resident and migratory waterbirds. Salinity at Kanahā Pond ranges from brackish to hypersaline. This area is culturally significant as it was the site of an ancient royal Hawaiian fishpond.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3–5	80	240	Loko i'a	Hawai'i Department of Transportation	Hawai'i Division of Forestry and Wildlife (DOFAW)	\$2–5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x	x	x	Core	Yes
Breeding		x	x	x	x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: National Tropical Botanical Garden.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Over 100 native plants including naupaka kahakai, 'ōhelo kai, makaloa, 'aki'aki, 'ākulikuli, and invertebrates including the endangered Hawaiian hornworm sphinx moth.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes, number unknown
  - Inputs: Freshwater from springs, surface water, and pumped groundwater
  - Outflows: There is an outlet that can be opened to release water to the ocean when the ponds are full or during flooding events.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Invasive plant control	3

- **Threats**

- Predators, particularly cats, rats, and mongooses
- Homeless encampments
- Changes in water abundance
- Development of adjacent lands
- Oil spills from adjacent area
- Trash
- Vehicle strikes
- People dropping off domestic ducks at the wetland

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	50–75% of wetland inundated	< 5% of wetland inundated	> 75% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- Staffing
- Nearby development
- Homelessness in the area
- Conflict of objectives with nearby airport
- Feral cat colony and feeding areas adjacent to the sanctuary

- **5–10 Year Conservation Priority Actions Needed**

- Initiate and maintain long-term predator control, especially for cats.
- Finish building predator-proof fence.
- Eliminate cat feeding in the area.
- Remove invasive plants, like pickleweed, and outplant native species to expand high-quality habitat.
- Restore small wetlands and ponds on the makai side of the road near the treatment plant (where 'ua'u kani also nest).
- Find assistance with homelessness in the area from the county and/or state.
- Increase education and outreach to the public with informational signs and school projects.
- Hire a site-specific manager and technician; currently there is only one waterbird biologist for all of Maui Nui.

- **Benefits to T&E birds / MBTA birds**

- This site is the largest wetland in the Kahului region and supports all T&E native waterbirds found on Maui as well as many migratory species.
- This site is located in a largely urban area and protects some of the last remaining wetland in the area, providing important habitat for waterbirds and many other native species.
- This site is partially predator-proof fenced, with plans to completely enclose the site.

- **Benefits to People**

**Ecosystem Services:** This site contributes to improved water quality and provides flood control. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to provide flood control.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is accessible for bird watching, hiking, and study of native plants and insects. It has trails and viewing platforms around the pond.

**Cultural:** This site was once a set of two royal fishponds known as the twin ponds of Kapi'ioho. It was constructed over 200 years ago by Kapi'ioho'okalani, King of Maui. Part of the twin ponds was filled in following construction of the nearby harbor and later altered when the area was under military control during World War II.

## References

Department of Land and Natural Resources. (n.d.) *Kanahā Pond Wildlife Sanctuary*. Retrieved August 24, 2023, from [www.dlnr.hawaii.gov/wildlife/sanctuaries/kanaha/](http://www.dlnr.hawaii.gov/wildlife/sanctuaries/kanaha/).

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaii*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](http://www.pacificbirds.org/HWJVStrategicPlan-3.pdf).

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U.S. Fish and Wildlife Service. (2011). *Recovery plan for Hawaiian waterbirds, second revision*. U.S. Fish and Wildlife Service, Portland, Oregon.  
[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).



ISLAND: MAUI

LOCATION: Ke‘anae Point (Kepler property)

DESCRIPTION OF SITE: The Hawai‘i Land Trust (HILT) is working with a private landowner on a conservation easement for a 6-acre property on Ke‘anae Point in the northeast of Maui. The remaining 90% of the point is predominantly cultivated for kalo by private farmers. The 6-acre property is an overgrown ephemeral marsh with some small active and inactive lo‘i kalo. The property owner is interested in restoration of the site but would need a restoration partner with the expertise to implement management.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	6.12	6.3	Lo‘i kalo	Hawai‘i Division of Fish and Wildlife	Dr. Bill Kepler / HILT in process of getting conservation easement	Unknown	No restoration

Bird Information							
T&E Bird Species Present							
	‘alae ‘ula	‘alae ke‘oke‘o	ae‘o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x		x	Supporting	No
Breeding							

\*presumed koloa maoli / mallard hybrid

SUPPORTING PARTNERS: Hawai‘i Land Trust.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Unknown
- Inputs: Pi'ina'au and Palauhulu Streams
- Outflows: None; water is lost to evaporation and porous substrate.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	3
Invasive plant control	1

- **Threats**
  - Predators
  - Potential for flooding
- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 9.0 km +
- **Knowledge Gaps and Planning / Research Needs**
  - Expertise
  - Partnerships
  - Funding
  - How the habitat will respond to climate change
  - Surveys needed to understand how waterbirds utilize the site
- **Challenges**

- There is interest in supporting conservation and restoration, but partnerships, funding, and expertise are lacking to do so independently.
- **5–10 Year Conservation Priority Actions Needed**
  - Complete the conservation easement (HILT).
  - Build partnerships with conservation organizations.
  - Find long-term funding.
  - Establish predator control, especially for cats.
  - Remove invasive plants and outplant native plants to expand high-quality habitat.
- **Benefits to T&E birds / MBTA birds**
  - This site is quite far from other wetlands on Maui and provides connectivity between sites further east and the many wetlands in the Kahului region.

- **Benefits to People**

**Ecosystem Services:** This site may contribute to improved water quality and provide flood control. Removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to provide flood control.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** There are some active lo'i kalo on the property.

**Fishing:** None.

**Recreation:** The marsh is accessible for bird watching.

**Cultural:** This site contains some active and inactive lo'i kalo and is surrounded by other lo'i on the point.

## References

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaii*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](https://www.pacificbirds.org/HWJVStrategicPlan-3.pdf).

Kepler, B., personal communication, July, 2023.

U.S. Fish and Wildlife Service. (2011). *Recovery Plan for Hawaiian Waterbirds, Second Revision*. U.S. Fish and Wildlife Service, Portland, Oregon. xx + 233 pp.

[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

ISLAND: MAUI

LOCATION: Keālia Pond National Wildlife Refuge

DESCRIPTION OF SITE: Along the south-central shore of Maui, this NWR contains open water, vegetated mudflats, and upland habitat that supports a very large number of breeding ae’o (80 fledglings produced in 2022) as well as ‘alae ke’oke’o, ‘auku’u, and migratory shorebirds and waterfowl. The area is known for its soil with a high salt content, which poses some management challenges. Keālia Pond was once an ancient fishpond and is the largest remaining lowland wetland on Maui.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0	418	704	Loko i’a	USFWS/ Alexander & Baldwin	USFWS	\$2–5 million +	Restoration underway

Bird Information							
T&E Bird Species Present							
	‘alae ‘ula	‘alae ke’oke’o	ae’o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x	x	x	Core	Yes
Breeding		x	x	x			

\*presumed koloa maoli / mallard hybrid

SUPPORTING PARTNERS: Friends of Keālia Pond, Maui Nui Seabird Recovery Project, Department of Land and Natural Resources, Maui Invasive Species Committee, Division of Aquatic Resources, Maui Nui Marine Resources Council, KUPU, Student Conservation Association (SCA), Maui Nui Botanical Garden, Maui Native Nursery.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Honu (green sea turtle), honu ‘ea (hawksbill sea turtle), ‘oka’i ‘aiea (Hawaiian hornworm sphinx moth), and ‘ilio holo i ka uaua (Hawaiian monk seal)

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: It is unclear; the whole pond may be at the level of the water table.
- Inputs: Pōhākea, Pale‘a‘ahu, and Waikapū Streams which, for the most part, only flow during storms; groundwater well, precipitation, and maybe some upwelling or seepage.
- Outflows: Ocean
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Human disturbance control	3
Invasive plant control	3

- **Threats**

- Human disturbance, including illegal entry, fence cutting, and car strikes to fence
- Invasive predators (cats, mongooses, rats, ungulates)
- Botulism
- Invasive plants, fish, and invertebrates
- Droughts
- Changes in surrounding lands
- Wildfire
- Cat feeding

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
50-75% of wetland inundated	5-25% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated*	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

\*This does not represent an improvement in inundation, rather that the source of inundation is now marine, not groundwater.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 3.0–4.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Investigate outplanting strategies for very saline environments.
- Tilapia control
- Develop a consistent monitoring plan for bird populations.
- Bird banding

- **Challenges**

- Staffing
- Funding
- Cat feeding
- Changes in water flow; ensuring sufficient fresh water supply
- Successfully outplanting native plants (due to high salt content in soil)
- Reducing the tilapia population
- Managing the cost of infrastructure

- **5–10 Year Conservation Priority Actions Needed**

- Reduce operating costs.
- Secure site-specific long-term funding.
- Increase staff capacity.
- Expand and maintain long-term predator control, especially for cats.
- Eradicate ungulates.
- Eliminate cat feeding in the area.
- Remove invasive plants and outplant native plants.
- Develop outplanting strategies for environments of high salinity.
- Improve or maintain the fence around the site.
- Create sustainable water control structures.
- Control tilapia.
- Increase bird banding capacity, and establish consistent population monitoring.

- **Benefits to T&E birds / MBTA birds**

- Keālia Pond is the largest wetland on Maui and is a significant breeding site for ‘alae ke’oke’o, ae’o, and ‘auku’u.
- Keālia Pond is an extremely important habitat for large numbers of overwintering and transiting migrant birds.

- **Benefits to People**

**Ecosystem Services:** This site provides flood control and helps capture sediment and reduce runoff to the nearshore coastal ecosystem including offshore reefs. Further removal of invasive

plants and the restoration of the site with native plants will enhance the marsh's capacity to capture sediment.

**Education:** There is a visitor center with interactive learning opportunities and self-guided interpretive displays. The site is open to the public and can be used for native wetland and ecological field education.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The Keālia Coastal Boardwalk and the Keālia Pond area near the visitor center have publicly accessible trails available for bird watching, wildlife observation, walking, and interpretation.

**Cultural:** Keālia Pond is a former fishpond that was constructed about 400 years ago by building ditches into the sand dune to allow seawater and coastal fish into the pond. A rock platform on the property is thought to have been the site of a heiau or fishing shrine (USFWS 2011a).

## References

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaii*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](#).

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Wolfe, B., personal communication, June, 2023.



ISLAND: MAUI

LOCATION: Nu'u Pond

DESCRIPTION OF SITE: Nu'u Pond is characterized as a coastal palustrine discharge wetland which is spring fed with about 7 acres of wetlands adjacent to dry forest. While the dry forest is invaded by kiawe, the wetlands are dominated by native plants and are some of the healthiest coastal wetlands in the Hawaiian Islands. The site is located on the south side of East Maui and is the closest wetland on Maui to Hawai'i Island, serving as an important stopover site for 'alae ke'oke'o and ae'o moving between the two islands. Recent studies on the palynological record are being used to inform restoration efforts.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
6	7	82	Loko i'a	Hawai'i Land Trust	Hawai'i Land Trust	\$250k–500k	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x	x	x	Other	Yes
Breeding		x	x	x	x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, National Fish and Wildlife Fund, North American Wetlands Conservation.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

There is a stable population of land snails at the site identified by malacologist Mike Severns (Fisher, 2023).

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, there are many throughout the site.
- Inputs: Freshwater from springs

- Outflows: None; water is lost to evaporation and porous substrate.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3

- **Threats**

- Predators
- Invasive vegetation, particularly in dry forest habitat
- Sea level rise
- Impact to shoreline from big storms
- Wetland adjacent to Pi'ilani Highway

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	25-50% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 9.0 km +
- **Knowledge Gaps and Planning / Research Needs**
  - None
- **Challenges**
  - Zoning as 'conservation' slows conservation work, as only one tree can be removed per month.
- **5–10 Year Conservation Priority Actions Needed**

- Expand and maintain long-term predator control, especially for cats.
  - Build a predator-proof fence at the site.
  - Remove invasive plants, especially kiawe, and outplant native dry forest plants to expand high quality habitat and mitigate storm impacts.
  - Conduct a hydrological survey.
- **Benefits to T&E birds / MBTA birds**
    - This site supports all T&E native waterbirds found on Maui as well as some migratory species.
    - This site is the closest wetland point to Hawai'i Island and serves as a stopover point for 'ālae ke'oke'o and ae'o moving between Hawai'i Island and Maui. As such, it is disproportionately important for its size, as it provides population connectivity between islands.
  - **Benefits to People**

**Ecosystem Services:** The site contributes to improved marine water quality and provides sediment capture and flood control. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to provide flood control.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education. Free guided tours are available through the 'Talk Story on the Land' environmental education series.

**Sustainable food:** None at the moment, but potential for sustainable aquaculture if the site is restored as a functioning fishpond.

**Fishing:** The site is open for access to the coast for fishing.

**Recreation:** The wetland is accessible for bird watching, hiking, and native plant and insect study. It is and has long been used as a recreational spot for local fishermen.

**Cultural:** This site preserves pre-contact archaeological sites and was used as a fishpond before a tsunami inundated the area.

## References

Fisher, S., personal communication, May, 2023.

Hawai'i Land Trust. (n.d.). *Nu'u Refuge*. Retrieved September 20, 2023, from <https://www.hilt.org/nuu>.

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ISLAND: MAUI

LOCATION: Papa'ula, Wailuku

DESCRIPTION OF SITE: This 20-acre shoreline site sits along the north coast of Maui, just north of the Kahului Airport, and is owned and managed by E Paepae Ka Puko'a Community Association and protected from future development by a Hawai'i Land Trust (HILT) conservation easement. The site is regularly used by the public for beach access and is a favorite location for windsurfing. The site includes native coastal habitat and a 1-acre freshwater pond that is likely spring fed and is frequented by ae'o and migratory shorebirds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
1	1	20	None	E Paepae Ka Puko'a Community Association	E Paepae Ka Puko'a Community Association in partnership with HILT (easement)	\$250k	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x			Other	No
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Hawai'i Land Trust.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Pōhuehue (beach morning glory), 'ākulikuli (sea purslane), and 'aki'aki (seashore dropseed).

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Possibly one
- Inputs: Freshwater from likely spring
- Outflows: None; water is lost to evaporation and porous substrate.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Human disturbance control	1
Invasive plant control	1

- **Threats**

- Human disturbance
- Trash

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	25-50% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 3.0–4.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - More palynological information on how the ecosystem responds to a changing climate
  - Baseline hydrological and waterbird site usage research
- **Challenges**
  - Lack of funding

- Homelessness in the area
- **5–10 Year Conservation Priority Actions Needed**
  - Initiate predator control, especially for cats, and maintain it long term.
  - Remove invasive plants and outplant native plants to expand high-quality habitat.
  - Find assistance with homelessness in the area from the county and / or state.
  - Initiate waterbird surveys.
  - Conduct a baseline hydrological study.
- **Benefits to T&E birds / MBTA birds**
  - This site provides habitat for ae’o and migratory shorebirds in a region that has little remaining coastal wetlands for these species.
- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh’s capacity to capture sediment.

**Education:** The site is publicly accessible and has the potential to be used for native wetland and ecological education.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is accessible for bird watching.

**Cultural:** The cultural history of the site is unknown.

## References

Fisher, S., personal communication, May, 2023.

Hawai’i Land Trust. (n.d.). *Spreckelsville*. Retrieved August 24, 2023, from <https://www.hilt.org/spreckelsville>.

ISLAND: MAUI

LOCATION: Paukukalo Wetland / Ka'ehu Bay

DESCRIPTION OF SITE: The Paukukalo Coastal Wetlands sit along the coast of Ka'ehu Bay, on the north coast of Maui, just west of Kahului. Paukukalo is fed by Wailuku River and Waiehu Stream and freshwater springs throughout the property. This area was once filled with lo'i kalo and productive fishponds. The wetland is currently overgrown with invasive vegetation but the non-profit Ka'ehu plans to restore the inland fishponds and lo'i kalo which will improve the habitat for native T&E waterbirds. There are over 40 important cultural sites on the property. The area also held a "sacred lauhala grove" and a sacred healing spring. The coastal area is used by many species of migratory shorebirds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
4	55	64	Lo'i kalo	County of Maui	County of Maui / Ka'ehu	\$2–5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present						Other	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: County of Maui, Kauahea Inc., Ku-A-Kanaka and EA Ecovercity, Nakoa Goo at Hawai'i Institute of Marine Biology, Andrea Kealoha at University of Hawai'i, Hawai'i Wildlife Fund, Sharkastics, Ocean Futures Society, Maui nui Marine Research Council, Natural Resources Conservation Service, Maui Invasive Species Committee, Maui Nui Seabird Recovery Project.

Conducts site based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

The nearshore habitat is an important area for spawning fish, 'ilio holo i ka uua (Hawaiian monk seal), and honu (Green sea turtle) and honu'ea (Hawksbill turtle). The beach is also used by 'ilio holo i ka uua for resting and by honu and honu'ea for nesting.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, 4 springs including 1 healing spring
- Inputs: Springs, and the nearby Iao and Waiehu streams
- Outflows: Channels to the ocean

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Invasive plant control	2

- **Threats**

- Feral and off-leash dogs
- Cats and mongooses

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Not possible: all or most of the surrounding land is already developed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0-2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Expertise in waterbirds and wetlands
- Expertise in predator control
- A hydrological study is needed

- **Challenges**



- The lease to the site is not yet in hand
  - Potential reduction of water flow from water diversion
  - Lack of expertise in predator control
  - Lack of expertise with waterbird monitoring and habitat needs
- **5–10 Year Conservation Priority Actions Needed**
    - Expand staff at the site including a site manager and crew for regular maintenance.
    - Expand and maintain long-term predator control, especially for cats.
    - Continue removing invasive plants, especially hau, and outplanting native plants.
    - Focus restoration efforts on the loko i‘a.
    - Seek assistance from the county on homelessness in the area.
    - Remove driftwood that can impede turtle nesting.
    - Conduct a hydrological study.
  - **Benefits to T&E birds / MBTA birds**
    - This area is regularly used by migratory birds and has a large former fishpond and wetland habitat that has the potential , with restoration, to be an important site for native T&E waterbirds.

- **Benefits to People**

**Ecosystem Services:** This site traditionally helped to capture sediment and reduce runoff to the nearshore coastal ecosystem including offshore reefs through the inland fishponds and ancient taro patches. The non-profit Ka‘ehu is working hard to restore both. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh’s capacity to capture sediment. This site is also an important nesting site for honu‘ea (Hawksbill turtle).

**Education:** Ka‘ehu hosts volunteer work days at the site, including beach cleanups and an environmental stewardship program where they teach traditional shoreline and land stewardship. In addition, Ka‘ehu uses the site for field trips for public and private schools, after-school programs, summer natural resource management and archeological programs for students, and monthly family workshops (Ka‘ehu, n.d.).

**Sustainable food:** This site could potentially be used for aquaculture given its history as a fishpond.

**Fishing:** There is access to the beach for nearshore fishing.

**Recreation:** There is public access to the beach for recreation.

**Cultural:** The site includes many significant cultural sites including healing springs, Makahiki grounds, and a sacred lauhala grove. It was a recreational site for ali‘i and was kapu. There were also productive fishponds and lo‘i kalo. The site and its resources are still used for cultural practices by the community (Ka‘ehu, n.d.).

## References

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaii*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](#).

Ka'ehu. (n.d.). *Home*. Retrieved November 3, 2023, from <https://www.kaehu.org/>.

Maunupau, K., personal communication, October, 2023.

ISLAND: MAUI

LOCATION: Pi'ikea Wetlands (formerly Azeka Ponds 1&2)

DESCRIPTION OF SITE: This site is composed of two artificial ponds fed by natural springs and the aquifer that were created as a mitigation site for filling in a nearby natural wetland during development of the Kihei area. The wetlands occur in a remnant floodplain, and are located on two different TMKs, both included in a development plan for affordable housing. The Army Corps of engineers cleared the area for development, but current restoration activities only include removing invasive plants and outplanting native ones.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
2	6.22	6.22	None	Krausz Companies LLC and Downtown Kihei South — Condo Master	'Ikenākea Development	Unknown	No restoration

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x	x	x	Other	No
Breeding		x	x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: None.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, unknown how many
- Inputs: Spring and aquifer
- Outflows: Groundwater
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	1
Human disturbance control	3
Invasive plant control	3

- **Threats**

- Unfenced roads / car strikes
- Predators
- Botulism
- Nearby development
- Powerlines
- Flooding
- Human disturbance
- Runoff from surrounding development

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 3.0–4.9 km
- **Knowledge Gaps and Planning / Research Needs**

- A hydrology study is needed at the site.
- Assess the impact of hydrology on the biological community.
- **Challenges**
  - Staffing
  - Limited expertise / knowledge gaps need to be filled
- **5–10 Year Conservation Priority Actions Needed**
  - Establish formal protection for the site, perhaps through a conservation easement or cooperative agreement.
  - Initiate and maintain long-term predator control, especially for cats.
  - Remove invasive plants and outplant native plants.
  - Create a management plan for the site.
  - Conduct regular monitoring at the site to assess wetland condition and use by waterbirds.
  - Conduct a hydrological study, and monitor the impact of hydrology on the biological community.
- **Benefits to T&E birds / MBTA birds**
  - The Piʻikea wetlands are the largest wetlands remaining in the Kīhei area which used to be a large coastal wetland plain. They are part of a patchwork of small wetlands in the area which make up an important site for all T&E waterbirds found on Maui and serve as breeding sites for aeʻo and ʻalae keʻokeʻo.
- **Benefits to People**

**Ecosystem Services:** This site sits in an urban landscape and, with the other small wetlands in the area, provides flood control and helps capture sediment and reduce runoff to the nearshore coastal ecosystem during storm events. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to provide flood control.

**Education:** This site is potentially valuable for field study of Hawaiian wetland ecology and biodiversity given its location right in the town of Kīhei and visibility from the sidewalk on Piʻikea Avenue.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** This site could be used as a casual local bird watching site given the visibility of the ponds from the road.

**Cultural:** The Kīhei area had extensive wetlands and coastal fishponds that supported a large Hawaiian population. Following deforestation of the uphill Kula highlands in the 1800s, flooding

and sedimentation reduced the productivity of the region, and much of the population moved to other areas (Save the Wetlands, n.d.).

## References

County of Maui, Department of Planning. (2022). *Amendment to the special management area (SMA) use permit for the proposed downtown Kihei, located on Piikea Avenue, Kihei, Island of Maui, Hawaii; TMK (2) 3-9-02:030, 076, 080 and 158 (SM120120006).*

Flaherty, K., personal communication, August, 2023.

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaii*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](#).

Save the Wetlands. (n.d.). *A brief history of wetlands in Kihei*. Retrieved September 27, 2023, from <https://savethewetlands.org/a-brief-history-of-wetlands-in-kihei/>.

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[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

ISLAND: MAUI

LOCATION: Ukumehame

DESCRIPTION OF SITE: Ukumehame belongs to several owners including the County, State, private owners, and the County-run Ukumehame Firing Range, where Nēnē are known to breed. The wetlands are ephemeral, drying up almost completely in the summer. They are heavily invaded with kiawe and other non native plant species although some native coastal plants can still be found there. The County and State wetlands are bisected by abandoned agricultural ditches from the sugar cane era, which still drain the land and include the Pāpalaua sediment retention basin. The wetlands are vitally important to capture sediment from the uplands, which is impacting the Olowalu reef. Several partners are working at an ahupua'a level towards protecting areas mauka of the wetlands from erosion. The major Department of Transportation Honoapi'ilani Highway Realignment Project is developing alternative routes to move the highway inland from the shoreline to reduce flooding of this vital transport link and allow the restoration of a more natural shoreline, wetland and reef system. TNC will be seeking community input on restoration options and may work with DOFAW to plan wetland restoration. This project provides a unique opportunity statewide to carry out road realignment and the restoration of the shoreline ecosystem.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
10	9	90	Lo'i kalo (former site)	County of Maui, State of Hawai'i	County of Maui, The Nature Conservancy, State of Hawai'i (DoD, DOFAW)	\$2–5 million +	Preliminary planning

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x		x	Other	Yes
Breeding					x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Division of Aquatic Resources (DAR), Division of Forestry and Wildlife (DOFAW), NOAA Kipuka Olowalu, Coral Reef Alliance, Department of Transportation, Maui Nui Marine Resource Council, The Nature Conservancy, Hawai'i and Palmyra, local community.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

The wetland is monitored by DOFAW Hawaii Invertebrate Protection Program for pinao (dragonflies and damselflies). There also may be 'o'opu (endemic Hawaiian freshwater gobies and sleeper goby) present in streams.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: No
- Inputs: Streams, groundwater
- Outflows: Ocean; abandoned agricultural ditches; old culverts.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	1
Human disturbance control	1
Invasive plant control	1

- **Threats**

- Invasive species
- Presence of homeless people
- Suspected presence of heavy metals from agricultural operations
- Car strikes of birds due to unfenced roads
- Wildfire
- Accidental shooting and disturbance of T&E species (Nēnē) at firing range
- Bird strike on highway
- Powerline strike
- Wetland contamination due to munitions constituents of concern (MCOC) from firing range

- **Climate Change Threat**



Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	50-75% of wetland inundated	<5% of wetland inundated	>75% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 7.0–8.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Confirm whether heavy metals are present in significant and ecologically relevant amounts.
  - Biological surveys to confirm which ‘o’opu species are present, and if the orangeblack Hawaiian damselfly, and any other T&E species are present.
  - Additional staff capacity, particularly at Firing Range, for wetland and waterbird work.
- **Challenges**
  - Funding and expertise are needed.
- **5–10 Year Conservation Priority Actions Needed**
  - Delineate wetland and ensure it is included in Maui County mapping project (currently missing from NWI).
  - Conduct a hydrological survey.
  - Collate historical information on the wetlands
  - Remove invasive plants and outplant native plants.
  - Expand and maintain predator control long term, especially for cats.
  - Evaluate a predator-proof fence for the site.
  - Perform biological surveys.
  - Conduct regular waterbird monitoring.
  - Install diverters on powerlines
- **Benefits to T&E birds / MBTA birds**

- This is an important site for ae‘o, ‘alae ke‘oke‘o, and nēnē in West Maui, and is used by nēnē for breeding. The wetland restoration project here could provide ideal habitat for waterbirds and the return of ae‘o to the site has been a positive sign of the impact of restoration.

- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearshore coastal ecosystem including offshore reefs. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh’s capacity to capture sediment.

**Education:** None.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The firing range is used for law enforcement agencies and the public.

**Cultural:** This site was formerly an inland fishpond with lo‘i kalo on the banks.

## References

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Maui County. (n.d.). *Ukumehame Firing Range*. Retrieved September 25, 2023, from <https://www.mauicounty.gov/Facilities/Facility/Details/Ukumehame-Firing-Range-411>.

Schmidt, C., personal communication, February 2024.

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ISLAND: MAUI

LOCATION: Waihe'e Coastal Dunes and Wetlands (and Kapoho Loko i'a)

DESCRIPTION OF SITE: The Waihe'e Coastal Dunes and Wetlands Refuge is located on the coast west of Kahului and includes 105 acres of sand dunes and 27 acres of wetland, including an ancient fishpond. It was once the site of two Hawaiian villages and still has many important cultural sites. Restoration efforts, including outplanting of native plants, have helped to restore native habitat for wildlife including endangered insects, T&E native waterbirds, and migratory birds. This is an important wetland site for connectivity between T&E waterbird populations that utilize the wetlands in Maui's central valley. Recent studies on the palynological record are being used to inform restoration efforts.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3-5	27	277	Loko i'a, lo'i kalo	Hawai'i Land Trust	Hawai'i Land Trust	\$2-5 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x	x		Supporting	No
Breeding		x	x	x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, National Fish & Wildlife Foundation, North American Wetlands Conservation Act.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Native plants including naupaka kahakai, 'ūlei, 'ākia, 'a'ali'i, pōhinahina (beach morning glory), ko'olua'ula, and loulou palms are located on the refuge. Additionally, Hawaiian medicinal plants 'uhaloa (sleepy morning) and noni are also found here. The site hosts two endangered insects, the Blackburn's Sphinx Moth and nalo meli maoli (Yellow-faced bee), as well as 'ilio holo i ka uaua (Hawaiian monk seal) and honu (green sea turtle).

- **Hydrology**

Has there been a formal hydrological survey: Partial (survey on inflow into the site)

- Springs: Yes, one currently flows into the wetlands. There are other springs nearby, but their flow was diverted away from the wetlands in the past.
- Inputs: Fresh water from the spring has been diverted towards the wetlands. The land also floods as the result of a high water table. Seawater occasionally floods into the wetland. There are plans to return the input from other nearby springs that were diverted away from the wetland.
- Outflows: No outlet, the substrate is porous.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Invasive plant control	3

- **Threats**

- Freshwater flowing into the site is potentially high in nutrients from agricultural pollutants.
- There is a potential for oil spills as the site sits along a shipping channel.

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
25-50% of wetland inundated	5-25% of wetland inundated	>75% of wetland inundated	<5% of wetland inundated*	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

\*This does not represent an improvement in inundation, rather that the source of inundation is now marine, not groundwater.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 5.0-6.9 km

- **Knowledge Gaps and Planning / Research Needs**

- More information on palynology
- How the ecosystem responds to a changing climate

- **Challenges**

- HILT wants to increase the amount of water that is input into the site, though there is difficulty in increasing the water available for conservation. Water from the nearby river is currently being diverted for domestic use at a dairy farm.
- Predator-proof fencing would be complicated by the close proximity of cultural sites around the wetland.

- **5–10 Year Conservation Priority Actions Needed**

- Continue predator control and maintain it long term.
- Remove invasive plants and outplant native plants to expand high-quality habitat.
- Increase water flow into the wetland.

- **Benefits to T&E birds / MBTA birds**

- This site is the largest wetland in the Kahului region and supports all T&E native waterbirds found on Maui as well as many migratory species.
- This site is located in a largely urban area and protects some of the last remaining wetland in the area, providing important habitat for waterbirds and many other native species.

- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearby coastal reefs. Further removal of invasive plants and the restoration of the site with native plants will likely enhance the marsh's capacity to capture sediment.

**Education:** The site hosts volunteer days for the public to assist in restoration and offers free guided tours.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The marsh is accessible for bird watching and hiking via trails that run through the site.

**Cultural:** This site was once populated with two Hawaiian villages, Kapoho and Kapokea, an inland fishpond, and several heiau. The dunes are also the site of Hawaiian burials.

## **References**

Hawai'i Land Trust. (n.d.). *Waihe'e Coastal Dunes and Wetlands Refuge*. Retrieved August 24, 2023, from [www.hilt.org/waihee](http://www.hilt.org/waihee).

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[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

KAHO'OLawe

ISLAND: KAHO'OLAWA

LOCATION: Kaho'olawe

DESCRIPTION OF SITE: Kaho'olawe Island is largely covered in dry forest habitat but also has ephemeral wetlands that differ in restoration status. These wetlands are used by migrating birds including kioea (Bristle-thighed Curlew), kōlea (Pacific Golden-Plover), 'akekeke (Ruddy Turnstone), hunakai (Sanderling), and 'ūlili (Wandering Tattler). Though there are few records of T&E waterbirds visiting the island, Kaho'olawe is a potentially important site in terms of connectivity between Maui Nui populations. With additional restoration, up to 11 of the ephemeral wetlands have potential to support T&E species as many of the hazards found on inhabited islands are absent, such as disturbance, trash, roads, and powerlines. In addition, dogs, mongoose, and pigs are absent. All habitat restoration and management is conducted by the Kaho'olawe Island Reserve Commission (KIRC). Kaho'olawe is important for breeding seabirds, honu (green sea turtles), and 'ilio holo i ka uua (Hawaiian monk seals).

#### *Honokanai'a (Base camp)*

Honokanai'a Wetland is found on the western coast of Kaho'olawe. This ephemeral scrub/shrub wetland is the closest wetland to the base camp and therefore is the most accessible and the easiest to manage. It is currently used by shorebirds and seasonal migrants.

#### *Honokanai'a anchialine pool*

Honokanai'a anchialine pool is an artificial crater on the western shoreline that was created from simulated atomic bomb exercises. The crater now provides aquatic habitats for 'ōpae'ula and other organisms. It is one of the closest wetlands to the base camp.

#### *Keanakeiki*

This seasonal wetland on the northwest coast is adjacent to wetlands in Kaukaukapapa. Habitat restoration in either site will provide ecosystem service benefits to the neighboring site including flood control during heavy rains, reduced runoff to the ocean, and improved groundwater penetration. This wetland is surrounded by native grasses and plants and hosts crustaceans that serve as food for migratory shorebirds and waterfowl.

#### *Kaukaukapapa*

This 10-acre ephemeral northwest coastal wetland is just southwest of Keanakeiki and supports several native species, including the plants 'ākulikuli (sea purslane) and ma'o (Hawaiian cotton) as well as the native crustaceans longtail tadpole shrimp and seed shrimp. 'Ōpe'ape'a (Hawaiian hoary bats) are regularly detected at the site. Adjacent to the wetland is a small coastal dune ecotype and 'aki'aki (seashore dropseed) coastal habitat.

#### *Lua 'O Keāliāloa*

This seasonal scrub/shrub wetland is unique on Kaho'olawe as one of the island's few upland wetlands. It provides habitat for native grasses and other plants as well as crustaceans that serve as food for native and migratory shorebirds and waterfowl. Pueo (Hawaiian Short-eared Owls) have also been documented roosting at this site.



### *Hakioawa*

This ephemeral coastal wetland sits at the base of the Hakioawa watershed on the eastern side of the island, in the vicinity of multiple upland dry forest restoration sites. This watershed historically supported the island's largest Hawaiian community and holds a number of historic sites. Restoration of this wetland will support many species of migratory shorebirds and waterfowl.

### *Lua Kealialuna*

This 15-acre seasonal wetland sits in a cinder cone depression. The habitat is similar to Lua 'O Kealialalo but is currently more degraded.

### *Lua Makika*

This 20-acre upland seasonal wetland sits in the volcanic crater at the summit. It is currently fully vegetated with alien grasses and scant native outplantings.

Site Information								
Site	Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
Honokanai'a (Base camp)	6	5	5	None	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Restoration underway
Honokanai'a anchialine pool	4	0.5	1	None	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Preliminary planning
Keanakeiki	5	3.5	3.5	None	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Restoration underway

Site Information								
Kaukaukapapa	5	10	10	None	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Restoration planning underway
Lua ‘O Keāliālalo		25	25	Lo‘i kalo	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Restoration underway
Hakioawa	9	17	17	Lo‘i kalo	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Restoration underway
Lua Kealialuna		15	15	Lo‘i kalo	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Preliminary planning
Lua Makika	429	20	20	Lo‘i kalo	State, held in trust for a future Native Hawaiian sovereign entity	KIRC	\$2–5 million	Preliminary planning

Bird Information								
T&E Bird Species Present								
Site		‘alae ‘ula	‘alae ke‘oke’o	ae‘o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Honokanai‘a (Base camp)	Present						Other	Partial
	Breeding							

Honokanai'a anchialine pool	Present				x		Other	Yes
	Breeding							
Keanakeiki	Present						Other	Yes
	Breeding							
Lua 'O Keāliālalo	Present						Other	Yes
	Breeding							
Hakioawa	Present						Other	Partial
	Breeding							
Kaukauapapa	Present						Other	Yes
	Breeding							
Lua Kealialuna	Present						Other	Yes
	Breeding							
Lua Makika	Present						Other	Yes
	Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Protect Kaho'olawe 'Ohana, Maui Invasive Species Committee, Trilogy, Maui Nui Seabird Recovery Project, Ka Ipu Kukui, Mālama Maui Nui.

Conducts site-based waterbird monitoring (not including SWBC): Yes

#### ● Other Wildlife of Note

'Ilio holo i ka uaua (Hawaiian monk seal) can be found at all coastal sites.

#### *Honokanai'a (Base camp)*

Though these species are not currently found here, this area has been determined by the USFWS to be essential for the conservation and recovery of coastal species kanaloa, 'ōhai, and O'ahu cowpea because it provides the primary elements necessary for the reestablishment of wild populations within their historical range.

#### *Honokanai'a anchialine pool*

'Ōpae'ula (Hawaiian red shrimp) are found in the pool, and 'ua'u kani (Wedge-tailed Shearwater) nests have been found along the edges.

#### *Kaukauapapa*

Native plants including 'ākulikuli (sea purslane) and ma'o (Hawaiian cotton), the native crustacean longtail tadpole shrimp, and 'ōpe'ape'a (Hawaiian hoary bat) are regularly detected at the site. Adjacent to the wetland is a small coastal dune ecotype and 'aki'aki (seashore dropseed) coastal habitat.

#### *Lua Makika*

‘Ōpe‘ape‘a (Hawaiian hoary bat) has been detected at the site.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Some are known from the historical record, but their current status is unknown.
- Inputs:
  - Honokanai‘a (Base camp): Rainfall, ~ 25 in annually, and coastal flooding
  - Honokanai‘a anchialine pool: Possibly cracked aquifer from bombing, as fresh water is seeping into pond
  - Keanakeiki: Rainfall, ~ 25 in annually, and coastal flooding
  - Lua ‘O Keāliālalo: Rainfall, ~ 25 in annually
  - Hakioawa: Rainfall, ~ 25 in annually
  - Kaukaukapapa: Seasonal stream
  - Lua Kealialuna: Rainfall, ~ 25 in annually
  - Lua Makika: Rainfall, ~ 25 in annually
- Outflows: Evapotranspiration: the wetlands dry out after rain events.
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Site	Key Management Action	Score
Honokanai‘a (Base camp), Hakioawa, Keanakeiki	Predator control	3
	Invasive plant control	3
Honokanai‘a anchialine pool	Predator control	3
Kaukaukapapa, Lua Makika, Lua Kealialuna	Predator control	3
	Invasive plant control	1
Lua ‘O Keāliālalo	Predator control	3
	Invasive plant control	2

- **Threats**

- Major potential for unexploded ordnance
- Hydrological changes
- Sedimentation

- **Climate Change Threat**

Projected Climate Change Impacts (all sites)				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	Definite: surrounding area is already wetland habitat

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 0–2.9 km, 3.0–4.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Additional staff and funding are needed for ongoing management.
- **Challenges**
  - Cats are a significant problem on the island but could be controlled with regular predator control or a predator-proof fence and even eradicated with adequate funding and staff. A cat removal plan has been developed.
  - Habitat restoration
  - Staffing and funding
- **5–10 Year Conservation Priority Actions Needed**
  - Seek continued funding.
  - Expand staff capacity.
  - Expand and maintain predator control long term, particularly for cats, Barn Owls, and rats.
  - Eradicate cats from the island.
  - Remove invasive plants and outplant native plants to expand high-quality habitat.
  - Install predator-proof fencing or partial fencing at sites
- **Benefits to T&E birds / MBTA birds**
  - The wetland sites on Kahoʻolawe have the potential to provide important wetland habitat and connectivity between the wetlands in Maui Nui. Banded T&E waterbird records from the neighboring islands, Molokaʻi, Lānaʻi, and Maui, have already shown that birds routinely move between these islands.
  - Apart from restoration efforts, Kahoʻolawe’s wetlands are free from human disturbance and associated hazards.

- Restored wetlands on Kaho‘olawe would provide wetland habitat at high elevation which would not be impacted by projected sea level rise due to climate change.

- **Benefits to People**

**Ecosystem Services:** Invasive plant removal and outplanting of native plants will improve water quality, and the restoration of the wetlands will provide sediment and flood control as well as potentially serving as important nursery grounds for native fish.

**Education:** The KIRC hosts monthly volunteer groups and employs early-career interns.

**Sustainable food:** None.

**Fishing:** The reserve is open for permitted trolling two weekends a month. Anyone can request and purchase a yearly permit from the KIRC office.

**Recreation:** None.

**Cultural:** Archeological records suggest Kaho‘olawe had been inhabited since AD 1000 and was an important site for astronomical and navigational training, tool making, fishing, and agriculture. Over 3,000 cultural sites and artifacts have been documented across the island. Settlements were found along the coast, and a number of ahupua‘a once supported larger agricultural communities, with the largest found in the Hakioawa Ahupua‘a on the northeast of the island.

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LĀNAʻI

ISLAND: LĀNA'I

LOCATION: Lāna'i

DESCRIPTION OF SITE: Lāna'i contains a number of artificial wetlands including the Lāna'i Wastewater Treatment Plant, managed by the County of Maui, and auxiliary treatment ponds, managed by Pūlama Lāna'i. These sites are utilized by native T&E waterbirds, but they are industrial facilities with the goal of minimizing impacts to and providing a safe place for waterbirds that are present without increasing habitat usage. There are also some ornamental hotel ponds. Pūlama Lāna'i has plans to create a small artificial habitat and native plant outplanting for the endangered orangeblack Hawaiian damselfly near a historic diked/impounded wetland that is currently dry. Though these small artificial ponds are being planned with the endangered damselfly in mind, they will likely provide some safe foraging habitat for the ae'o, and potentially 'alae ke'oke'o, that have been observed at the treatment ponds. Although the water table tends to be deeply buried on the island due to sedimentation, there are some gulches and coastal areas along the north and east shores that might have potential for future restoration.

Site Information								
Site	Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
Lāna'i Wastewater Treatment Plant	458	13.8	37	None	County of Maui	County of Maui	N/A	Unrestored
Auxiliary Treatment Ponds	458	5.9	11.5	None	Pūlama Lāna'i	Pūlama Lāna'i	N/A	Unrestored
Planned Damselfly Habitat	409	200–500 sq ft	3	None	Pūlama Lāna'i	Pūlama Lāna'i	Unknown	Restoration planning

Bird Information								
T&E Bird Species Present								
		'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Lāna'i Wastewater Treatment Plant	Present		x	x			Supporting	No
	Breeding		x	x				



Auxiliary Treatment Ponds	Present			x			Supporting	No
	Breeding			x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Hawai'i Division of Fish and Wildlife (DOFAW), U.S. Fish and Wildlife Service (USFWS), Department of Defense Readiness and Environmental Protection Integration program (DoD REPI).

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Unknown

- **Hydrology**

Has there been a formal hydrological survey: Unknown

- Springs: None
- Inputs:
  - Treatment ponds: Lāna'i City wastewater
  - Planned damselfly habitat: Water will be piped in.
- Outflows:
  - Treatment ponds: Unknown
  - Planned damselfly habitat: None
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Unknown	

- **Threats**

- Predators, particularly cats and rats
- Invasive plants

- **Climate Change Threat**

Projected Climate Change Impacts (for water treatment sites)				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 9.0 km +
- **Knowledge Gaps and Planning / Research Needs**
  - None
- **Challenges**
  - Invasive plants
  - Ungulates — the high numbers of chital (deer) result in a loss of vegetation, so any restoration projects would need to exclude deer and include extensive outplanting to stabilize soils.
  - Sedimentation — depth to water table
  - Extensive land use change and sedimentation has buried evidence of indigenous agroecology.
- **5–10 Year Conservation Priority Actions Needed**
  - Complete the creation of a small artificial habitat for the endangered orangeblack Hawaiian damselfly.
  - Consider expanding this site to include potential larger wetland creation and habitat for ae’o.
  - Continue ongoing waterbird surveys and coordinate surveys with state agencies to improve survey effectiveness.
  - Maintain predator control to increase T&E waterbird fledging success and waterbird / migratory bird survival.
  - Engage with the local community to understand their vision of wetland restoration, which may include lo’i and loko i’a restoration.
- **Benefits to T&E birds / MBTA birds**

- The planned artificial habitat creation for the endangered orangeblack Hawaiian damselfly will provide some small wetland habitat for ae'o (and potentially 'alae ke'oke'o) that currently utilize the treatment ponds on Lāna'i. This site could provide even more important wetland habitat in the future and support connectivity between Lāna'i and other wetlands in Maui Nui. Banded ae'o from the neighboring islands of Moloka'i and Maui have been resighted on Lāna'i (A. Dibben-Young, pers. comm.).
- Artificial or restored wetland habitat on Lāna'i would be at an elevation to avoid impacts from projected sea level rise due to climate change.
- Lāna'i has potential to be the site of a free-range breeding facility for koloa maoli.

- **Benefits to People**

**Ecosystem Services:** None.

**Education:** None.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** None.

**Cultural:** None.

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HAWAI'I

ISLAND: HAWAI'I

LOCATION: Hakalau Forest National Wildlife Refuge

DESCRIPTION OF SITE: Hakalau Forest National Wildlife Refuge is located on the windward slope of Mauna Kea. Encompassing 32,733 ac, this Refuge protects some of the best remaining stands of native rainforest in Hawai'i. This historical ranch is actively being restored predominantly for forest bird habitat. However, bogs and fern patches are common below 4,000 ft where rainfall exceeds 250 in. Spring-fed montane ponds and numerous streams that bisect the area provide potential habitat for koloa maoli. Further upslope, native forest merges into abandoned pasture dominated by introduced invasive vegetation as rainfall decreases to 100 in annually. Remnant stock ponds, bogs, and streams historically provided nēnē habitat. Long-term objectives for the Refuge include reforestation of all areas, except for those maintained as grassland for nēnē. Land above the Refuge is owned by the Department of Hawaiian Homelands (DHHL) and is currently managed for a variety of land uses including grazing and reforestation efforts.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
~ 790–1980	17242	32733	None; upper third of refuge was previously ranch land	USFWS	USFWS	\$500k–1 million	Preliminary planning

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present				x	x	Supporting	Yes
Breeding					x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: DHHL, Mauna Kea Watershed Alliance, Mauna Kea Forest Restoration Project, USGS, community volunteers.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Native forest birds including 'io (Hawaiian Hawk), pueo (Hawaiian Short-eared Owl), Hawai'i 'ākepa, 'akiapōlā'au, 'alawī (Hawai'i Creeper), 'i'iwi, 'apapane, Hawai'i 'amakihi, Hawai'i 'elepaio, and 'ōma'o, as well as 'ōpe'ape'a (Hawaiian Hoary Bat), are known to inhabit this refuge.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Unknown
- Inputs: Rainfall
- Outflows: Hakalau Stream and Wailuku Stream & their headwaters, Umauma Stream, Wa'awa'a Stream, Kolekole stream, Kawainui Stream, Kapue Stream, Honoli'i Stream, 'Awehi Stream, Kapehu Stream

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Invasive plant control	2

- **Threats**

- Invasive ungulates
- Invasive weeds

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 9.0 + km

- **Knowledge Gaps and Planning / Research Needs**

- Historical distribution and current habitat use of native waterbirds at high elevation.
- Research needed to understand whether clearing invasive plants from the wetland area will create more mosquito breeding habitat.
- Establish a plan for efforts to control mosquitoes.
- Hydrological survey.
- Genetic studies on koloa maoli.

- **Challenges**

- Concerns about potentially creating mosquito habitat in the process of clearing invasive vegetation from ponds
- Balancing priorities within the Refuge

- **5–10 Year Conservation Priority Actions Needed**

- Control predators.
- Remove invasive plants, namely mats of Kikuyu grass and *Juncus* covering the ponds.
- Install small, localized, predator-proof fences.
- Manage additional habitat for nēnē to expand their distribution.
- Enhance stream-fed montane ponds and abandoned stock ponds to provide high-quality habitat for koloa maoli. Enhancement activities must include measures that reduce the threat of increased mosquito populations that are disease vectors for native forest birds.
- Maintain exclusion of ungulates from Refuge lands.

- **Benefits to T&E birds / MBTA birds**

- Being mauka wetlands, this complex will not be affected by sea level rise, so it should provide long-term habitat for native or migrant waterbirds.
- The site may retain a number of koloa maoli that may appear to be ‘purebred’.
- Careful management of this wetland area to minimize mosquito breeding would benefit the surrounding population of threatened and endangered forest birds.
- This large tract of native forest was established as a National Wildlife Refuge in 1985. Nēnē were reintroduced to Refuge lands and have established localized migration routes around Mauna Kea and Mauna Loa between the Refuge and Hawai’i Volcanoes National Park.

- **Benefits to People**

**Ecosystem Services:** Wetland habitat in the site provides flood storage in heavy rainfall events.

**Education:** The Refuge holds regular education and volunteer days which could potentially be expanded to the wetland areas.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** The Pua Akala tract of the forest is a prime birding destination, accessible through guided tours, but the wetlands area in particular is not visited by the public.

**Cultural:** Place names within the Refuge are used as descriptors for land markings and boundaries. Two prime users of the Hakalau Forest were canoe makers and bird hunters. Trails were utilized by bird catchers, for instance to access Honohina (within the Refuge). Several archaeological sites have been identified within the Refuge. Present historical research indicates a high significance of two complexes: Nauhi cabin (established in 1924) and Pua Akala Ranch (built in late 1800s).

## Resources

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ISLAND: HAWAI'I

LOCATION: Honokea Loko i'a

DESCRIPTION OF SITE: This loko i'a kuapā (walled coastal fishpond) is located at a public beach park owned by the County of Hawai'i. The wall was later cemented but swells have created large holes, allowing the ingress of seawater through cracks and under the wall. The pond is connected to the ocean through the mākāhā (sluice gate that opens to the sea), although the high flow of freshwater from springs keeps the salinity in the pond low. The pond reaches up to 10 ft in depth. Limu and 'ōpae are harvested here and fish recruit naturally from the ocean. The site is used by nēnē as well as many migratory shorebirds.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
2	1	5	Loko i'a	County of Hawai'i	Hui Ho'oleimaluō, unofficial manager	\$250k–500k	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present					x	Other	No
Breeding					x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: County of Hawai'i.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

Native birds that use the site include 'ulili (Wandering Tattler), 'auku'u (Black-crowned Night-Heron), 'akekeke (Ruddy Turnstone), and kōlea (Pacific Golden-Plover).

The majority of the fish present are kanda / Australian mullet although there are some native 'ama'ama (striped mullet). There are hapawai, 'alamihi, and two species of 'ōpae (shrimp). Two species of 'o'opu ( 'o'opu 'akupa or Hawaiian sleeper goby and 'o'opu naniha) are found here. Occasionally there are pāpio (young trevallies) and puhi (moray eels).

In terms of aquatic vegetation, brown limu (seaweed) is present and green limu grows seasonally.

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes, there are many underground springs surrounding the pond.
- Inputs: Springs, rainfall, runoff, and tidal influence feed the pond.
- Outflows: 'Auwai connect the fishpond to the ocean.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	1
Human disturbance control	2
Invasive plant control	2

- **Threats**

- Powerlines along road present a strike risk to birds.
- Road immediately adjacent to site cause runoff and present a strike risk to birds
- Possibility of harmful bacteria in wastewater runoff from nearby neighborhood
- Area busy with pedestrians/tourists, resulting in disturbance and trash

- **Climate Change Threats**

- Site added after climate analysis was completed

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Conduct additional hydrological sureys, particularly on how the pond system would change if the cement wall were to break.
- Study primary productivity at different salinity levels.
- Regular waterbird monitoring.

- **Challenges**

- Permitting and agreement with the county needed for restoration actions.
  - Controlling predators at a site busy with people.
  - Influx of tourists and limited space to accommodate them.
- **5–10 Year Conservation Priority Actions Needed**
    - Get support with permitting authorities for restoration activities at the site.
    - Increase funding to provide a career path in wetland restoration.
    - Increase staff capacity so regular site management can be implemented.
    - Increase access to the site for restoration activities.
    - Initiate and maintain long-term predator control efforts.
    - Remove invasive plants and outplant native plants.
    - Conduct further hydrological studies.
    - Conduct regular waterbird monitoring.
    - Conduct a study on primary productivity across the varying salinity levels in the pond.
  - **Benefits to T&E birds / MBTA birds**
    - This site has suitable habitat for many migratory birds as well as nēnē. Nēnē attempted breeding at this site in 2022, but their nest failed, potentially due to disturbance. With additional management at this site, nēnē could potentially breed successfully here.
    - This site is one of five fishponds in close proximity to each other east of Hilo that provide a suitable habitat network for migratory and T&E waterbirds in the area.
  - **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearshore coastal ecosystem and offshore reefs. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh's capacity to capture sediment. The site also functions as a nursery habitat for juvenile nearshore fish.

**Education:** The organization Hui Ho'oleimaluō works with school groups at the pond, providing introductory information about loko i'a, the many types of fishponds, and performing general loko i'a maintenance with the students. Students learn how to care for the 'auwai and mākāhā and how to build fish shelters in the pond. Many community and family events and celebrations are also held here.

**Sustainable food:** This site currently supports the harvest of limu and 'ōpae and has the potential to provide fish for the community with further restoration.

**Fishing:** None.

**Recreation:** This area is frequented by tourists. Turtle watching is a common activity along the coast in this area.

**Cultural:** This site is a historic fishpond that supported the local community. Today it is still used regularly for community and family events and other celebrations. The translation of Honokea is “white bay” referring to the white sand that covered the bay at one time.

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ISLAND: HAWAI'I

LOCATION: Honu'apo Estuary (Coastal Area)

DESCRIPTION OF SITE: Located on the south shore of Hawai'i Island, Loko o Honu'apo (estuary) is fed by fresh water from Mauna Loa, mixing with ocean water in the wetland to create a brackish environment. This wetland is composed of subtidal and intertidal estuary areas and a palustrine area, in a former loko i'a. The estuary is frequented by honu (green sea turtles), T&E waterbirds, shorebirds, and 'ilio holo i ka uaua (Hawaiian monk seals). It also hosts native coastal plants. Invasive plants and non-native predators such as rats, cats, and mongooses are also present. Decades of neglect has altered the hydrology of the site due to sedimentation and invasion by non-native species (aquarium fish and plants). Numerous springs are situated along the inland margin of the wetland; many are negatively affected by California grass, kiawe, and seashore paspalum on the southern edge. The community group Ka 'Ohana O Honu'apo (KOOH) has been actively working to restore the estuary since March, 2021, focusing on rebuilding the kuapā rockwall and clearing out sediment and invasive vegetation from around the freshwater springs.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
0-5	12	226	Loko i'a, lo'i kalo, pa'akai	Department of Land and Natural Resources (DLNR) - DOFAW	Hawai'i County (Department of Parks and Recreation) / Ka 'Ohana O Honu'apo / DLNR-DOFAW	\$5 million +	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x		x	Other	Yes
Breeding			x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Hawai'i Wildlife Fund, Nā Mamo o Kawa, Hawaiian Civic Club, Historical Society of Ka'ū, Ala Kahakai Trails Association, Ho'omalū Ka'ū.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Plants found within and around the wetlands at this site include makaloa (smooth flatsedge), milo, ‘aka‘akai (known locally as nanakū), naupaka kahakai, ‘ilima, pa‘uohi‘iaka, pōhuehue, ‘ākulikuli, nehe, ‘ae‘ae, and kīpukai.

Wildlife found in the marine habitat here includes two species of snapping shrimp (*Alpheus rapax* and *Alpheus rapacida*) and the symbiotic Hawaiian shrimp goby. Honu also use perennial channels to access the estuary. ‘Īlio holo i ka uaua have been spotted in the estuary and lounging on the papā lava rocks along the tide pools.

Native birds that use the site include ‘auku‘u (Black-crowned Night-Heron), nēnē, and ae‘o and other visiting shorebirds and waterfowl.

Lamson (2010) counted 129 fish species using the shallow tide pools and marine waters of Honu‘apo. There is evidence of the nearshore/estuary habitat being an important area for fish recruitment and juvenile fish populations (especially in summer months).

The orangeblack Hawaiian damselfly has been confirmed ~ 6 miles away in Wai‘ōhinu and as well as the endemic, endangered yellow-faced *Hylaeus* bee. It has been proposed by Hawai‘i Wildlife Fund (HWF) to start planting loulou palms at the site; permitting is underway.

- **Hydrology**

Has there been a formal hydrological survey: Yes\*

- Springs: Yes, there are many springs and seeps along the margins and inside the estuary.\*
- Inputs: Rainfall, runoff, and tidal inflow
- Outflows: Tidal outflow

\*Sustainable Resources Group International Inc. did a comprehensive survey with their Honu‘apo Park plan (May 2011).

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	2
Botulism control	3
Human disturbance control	2
Invasive plant control	2

- **Threats**

- Predators
- Invasive plants

- Old chemicals from the adjacent sugar mill (and disposal of old cane haul waste down the Mill Ditch Road on the north side of the property).

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
> 75% of wetland inundated	< 5% of wetland inundated	> 75% of wetland inundated	< 5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation. However there is a rock face to the upland south side of the estuary which abuts the public-access road preventing retreat on that side.

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 5.0–6.9 km

- **Knowledge Gaps and Planning / Research Needs**

- Research to understand how restoration would impact the reef and estuary fish.
- Use eDNA to understand the biological community in the estuary.
- Take core samples for palynological study.
- Further hydrological surveys.

- **Challenges**

- Community education regarding predator fence benefits.
- Simplifying permitting.
- Staff capacity.
- Resource sharing between organizations.
- Concerns from community members about restricting movement of honu and restricted water flux with the installation of the kuapā (fishpond rock wall) gate.

- **5–10 Year Conservation Priority Actions Needed**

- Expand and maintain long-term predator control, especially for cats. Remove the feral cat colonies and prevent feral cat feeding behavior.

- Ongoing removal of invasive plants; outplanting native plants.
- Increase staff capacity.
- **Benefits to T&E birds / MBTA birds**
  - This wetland is southwest of Hilo and provides a continuum of available habitat for waterbirds along the southern coast of Hawai'i Island in an area that otherwise has few wetlands (Wai'ōhinu, Punalu'u, Kāwā).
- **Benefits to People**

**Ecosystem Services:** Invasive plant removal will improve water quality and expand habitat for waterbirds as well as improve sediment control to the nearshore habitat during high rainfall. The nearshore habitat adjacent to the estuary is an important site for fish, with 129 marine species recorded in the shallow tidepools and nearshore environment. There is evidence of the estuary and nearshore ocean being an important area for fish recruitment and juvenile fish populations, especially in the summer months.

**Education:** KOOH and HWF hosts regular community and school groups, and bimonthly community workdays.

**Sustainable food:** This site was historically used as a fishpond and potentially could be fully restored. There were at least 11 kuleana parcels, some of which were used for harvesting pa'akai (salt) and indigenous agriculture, with crops including *kalo* (taro), *'uala* (sweet potato), *mai'a* (banana), *niu* (coconut), *kō* (sugarcane), *wauke* (paper mulberry), *paka* (tobacco), and *hau* (true hibiscus).

**Fishing:** No fishing occurs in the estuary, but there are fishing opportunities from the shore.

**Recreation:** The beach next to the estuary is used for recreation, and bird watching is possible from the edge of the estuary.

**Cultural:** Honu'apo means 'caught turtle' or 'turtle with its head above water' in Hawaiian. The estuary was formerly used as a fishpond, and the land around the estuary was used for agriculture.

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ISLAND: HAWAI'I

LOCATION: Honu'apo upland wetland

DESCRIPTION OF SITE: The property is located between 400 and 730 m in elevation on the southeast flank of Mauna Loa, mauka of the Honu'apo Estuary, and has panoramic views of the Ka'ū coastline. The site habitat includes grassland and lowland wet 'ōhi'a forest which hosts multiple native forest bird and plant species. The wetland complex at this site is composed of small ponds that hold water most of the year. This site is visited by ae'o and nēnē as well as many other native species.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
400–730	0.5	877	Unknown; possibly historically used for indigenous agriculture	Ed Olsen (private ownership of mauka portion) / Hawaiian family group purchased makai portion / HILT Conservation Easement	None	250k–500k	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present			x		x	Other	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: TBC

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

'Io (Hawaiian Hawk), Hawai'i 'ākepa, 'akiapōlā'au, and 'ōpe'ape'a (Hawaiian hoary bat) are known to inhabit lands near this easement. Native plants including 'ōhi'a, uluhe, māmakī, kōpiko, hāpu'u pulu, and maile are found in the lowland wet forest habitat.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Uncertain, though some consistent water source feeds the ponds.
- Inputs: Unknown, though likely springs
- Outflows: No clear outflow
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Botulism control	1
Invasive plant control	1

- **Threats**

- Pigs
- Predators
- Invasive Plants

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 5.0–6.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - History / creation of ponds, and former use
  - Assess hydrology, including the presence of springs.

- **Challenges**

- Funding
- Capacity

- **5–10 Year Conservation Priority Actions Needed**

- Identify site-specific funding.
- Develop a conservation action plan
- Install predator-proof fence.
- Initiate and maintain long-term predator control efforts.
- Remove invasive plants and outplant native plants.
- Conduct hydrological survey.
- Conduct regular waterbird monitoring.

- **Benefits to T&E birds / MBTA birds**

- Being a mauka wetland, this site will not be affected by sea level rise, so it would remain a usable habitat for any native or migrant waterbirds.
- This site has great potential for increased use by nēnē with the grassland habitat that surrounds the wetland.

- **Benefits to People**

**Ecosystem Services:**

**Education:** None currently, but this site has the potential to be used for science education or graduate research.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** None.

**Cultural:** It is unclear if the ponds at this site are man-made and whether they have a history of use for ranching or perhaps older, more traditional uses.

**References**

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ISLAND: HAWAI'I

LOCATION: Ka'ū Preserve

DESCRIPTION OF SITE: The Ka'ū Preserve is the Nature Conservancy portion of the large Ka'ū Forest Reserve that covers the entire southeast flank of Mauna Loa. There is potential to restore around 100 acres of former sugarcane plantation, now grazed by cattle, as nēnē habitat. Much of the 100 acres was drained via sloughs for cane production though some portions are flooded throughout the year by about 2 feet of water. This area is currently being considered for lā'au lapa'au restoration (Hawaiian traditional medical practice using plants) with the dual objective of reducing fire risk. The wetlands here are characterized by springs and ephemeral streams.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
560	100	3548	None	The Nature Conservancy	The Nature Conservancy	2–5 million	Preliminary planning

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present					x	Other	Yes
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: DLNR (Natural Areas Partnership Program), Natural Resources Conservation Service, USFWS, private donors.

Conducts site-based waterbird monitoring (not including SWBC): No

#### ● Other Wildlife of Note

Many threatened and endangered plants occur upland, including nuku 'i'iwi. Native birds include 'io (Hawaiian Hawk), Hawai'i 'amakihi, 'apapane, and 'ōma'o, and 'ōpe'ape'a (Hawaiian Hoary Bat) also occurs here. Ka'ū Forest Reserve also contains habitat for three endemic species of Pinao or Hawaiian Damselfly: *Megalagrion blackburni*, *Megalagrion calliphya* and *Megalagrion xanthomelas* (the latter known from Hīlea gulch (Parham et al. 2008). Migratory waterfowl including Green-winged Teal have been observed using the flooded areas.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, groundwater seeps cover a large area.
- Inputs: Groundwater seeps and perennial streams
- Outflows: Groundwater

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Botulism control	3
Human disturbance control	1
Invasive plant control	1

- **Threats**

- Predators
- Ungulate incursions
- Wildfire
- Hunting dog packs
- Trampling by cattle

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	< 5% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 9.0 km +

- **Knowledge Gaps and Planning / Research Needs**

- Research is needed to understand the potential of the site for use by native waterbirds other than nēnē.
- A strategy needs to be developed for installing a predator-proof fence on this large, seasonally changing wetland.
- **Challenges**
  - Funding
  - Capacity
  - Difficulties of fencing the wetland environment
  - Politics of negotiating out of a grazing license
  - Given that ranching leases tend to be year-to-year, which does not coincide with ranching action/investment timeframe, ranchers are not encouraged to use long-term or low-impact practices and tend to overuse ranch lands.
- **5–10 Year Conservation Priority Actions Needed**
  - Secure additional funding.
  - Expand staff capacity.
  - Suppress invasive grasses.
  - Outplant native plants.
  - Install predator-proof fence.
  - Initiate and maintain long-term predator control, especially for cats.
  - Convert land use from agriculture to restoration.
  - Control erosion of upland and surrounding areas to control flooding events within the stream corridor.
  - Conduct a hydrological survey to strategize flood risk.
  - Include nēnē and other waterbirds in future management plans.
- **Benefits to T&E birds / MBTA birds**
  - Being a mauka wetland, this site will not be affected by sea level rise, so it will provide secure long-term habitat for any native or migrant waterbirds as coastal sites are impacted by seawater incursion.
  - This site represents promising habitat for nēnē and potentially other waterbird species.
- **Benefits to People**

**Ecosystem Services:** Wetland habitat in the Kaʻū Preserve provides flood storage in heavy rainfall events.

**Education:** The site is open to the public during monthly volunteer activities.

**Sustainable food:** Hunting is permitted at the site.

**Fishing:** None.

**Recreation:** Hunting is permitted at the site.

**Cultural:** The forest contains vital resources for Hawaiian cultural practices including plants such as maile, māmakī, palapalai, ‘a‘ali‘i, and olonā. Water is collected from springs for ceremonial purposes, and hunters continue to use this area as a means of subsistence.

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ISLAND: HAWAI'I

LOCATION: 'Aimakapā Fishpond and Kaloko Fishpond (Kaloko-Honokōhau National Historical Park NHP)

DESCRIPTION OF SITE: Kaloko-Honokōhau NHP is managed by the National Park Service for the preservation, interpretation, and perpetuation of traditional native Hawaiian activities. Many of the activities in the over 1200-acre park are geared towards cultural landscape rehabilitation. Approximately half of the park is dedicated to protecting nearshore marine environments, and half to the terrestrial landscape. There are more than 200 anchialine pools and numerous archeological and cultural sites. Many of these sites have been preserved nearly intact from prehistoric times. The two key wetland locations are:

#### *'Aimakapā Fishpond*

'Aimakapā Fishpond was formerly a marshland with no open water. Through land subsidence in this area, the wetland and open water habitat was formed. Hawaiians created a loko pu'uone, a Hawaiian fishpond characterized as a large body of water separated from the ocean by a naturally formed sand berm. This aquaculture system was used to grow and raise fish. The fishpond is being restored, with large-scale invasive plant removal underway. An Environmental Assessment / Fishpond Management plan was completed in 2015, and ongoing restoration activities have continued since 2016. The fishpond is used by ae'o and 'alae ke'oke'o for breeding and provides foraging habitat for many migratory shorebirds and waterfowl.

#### *Kaloko Fishpond*

Kaloko was a naturally formed, shallow water embayment and then a loko kuapā. The fishpond is currently undergoing restoration to remove invasive plant species and rebuild the kuapā (fishpond wall), which fell into disrepair; restoration began in the late 1990s. This will ultimately restore fishpond functionality and allow aquaculture production to recommence. Restoration efforts by park staff at Kaloko are supported by Hui Kaloko-Honokōhau, a community organization, and the many school groups who visit and volunteer with the park.

Site Information								
Site	Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
'Aimakapā Fishpond	0	20	40	Loko i'a	NPS	NPS	\$2–5+ million	Restoration underway

Kaloko Fishpond	0	15	15	Loko i'a	NPS	NPS	\$250–500k	Restoration underway
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Bird Information								
T&E Bird Species Present								
		‘alae ‘ula	‘alae ke‘oke‘o	ae‘o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
‘Aimakapā Pond	Present		x	x	x		Core	Yes
	Breeding		x	x	x			
Kaloko Pond	Present		x	x	x		Core	Yes
	Breeding				x			

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: U.S. Fish and Wildlife Service, U.S. Geological Survey, Hui Kaloko Honokōhau.

Conducts site-based waterbird monitoring (not including SWBC): No

### ● Other Wildlife of Note

An endangered species of nalo meli maoli (Hawaiian yellow-faced bee), ‘ōpe‘ape‘a (Hawaiian hoary bat), ‘ōpae ‘ula (endangered shrimp; *Procaris hawaiiāna*), honu (Hawaiian green sea turtle), ‘ilio holo i ka uaua (Hawaiian monk seal), loulou (endemic fan palm, *Pritchardia maideniana*), and other T&E plants are known to be present at this site.

### ● Hydrology

Has there been a formal hydrological survey:

- ‘Aimakapā Fishpond: No
- Kaloko Fishpond: No

At both sites:

- Springs: Yes
- Inputs: Groundwater and tidal inflow from the ocean
- Outflows: Ocean
- Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)

Site	Key Management Action	Score
'Aimakapā Fishpond	Invasive plant control	2
Kaloko Fishpond	Predator control	1
	Human disturbance control	3
	Invasive plant control	2

- **Threats**

- Predators
- Runoff and nutrient inputs from development around the park
- Ungulates
- Invasive plants

- **Climate Change Threat**

Projected Climate Change Impacts (both sites)				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
> 75% of wetland inundated	< 5% of wetland inundated	> 75% of wetland inundated	< 5% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- A hydrological survey on the groundwater system and future groundwater availability is needed. There are large concerns about the continued groundwater flow into the park. Both the quantity and quality of fresh groundwater flowing into the park is paramount to the health of these Groundwater Dependent Ecosystems (GDE's).

- **Challenges**

- Funding
  - Staffing
  - Increasing salinity
  - Continued maintenance of the site
  - Controlling / regulating pollution from adjacent developed areas
  - Lack of support for a predator-proof fence in the community
  - Concerns over future water availability and quality
- **5–10 Year Conservation Priority Actions Needed**
    - Maintain long-term predator control.
    - Remove invasive plants.
    - Restore the fishpond.
    - Remove sediment in the pond.
    - Remove tilapia in 'Aimakapā pond
  - **Benefits to T&E birds / MBTA birds**
    - Site management includes active predator control, invasive plant removal, and native outplanting.
    - Loko i'a habitat can provide life cycle needs for T&E waterbirds and migratory birds and contributes to a continuum of available habitat in the region.
    - This site is near Kealakehe Sewage Treatment Plant, which is an ecological sink for ae'o. Restoration of the fishpond would likely increase available habitat for ae'o and may draw some individuals away from the treatment plant.
  - **Benefits to People**

**Ecosystem Services:** Invasive plant removal and removal of sediment will improve water quality, and the restoration of the fishpond will provide sediment and flood control as well as making the site better able to serve as a critically important nursery ground for native fish. The site also has extensive anchialine pool habitats which host unique communities of organisms.

**Education:** The park has a visitor center that has information about the park, brochures, Junior Ranger booklets, and a bookstore. The park also hosts educational programs, research projects, cultural activities, and school and community groups for restoration activities.

**Sustainable food:** None.

**Fishing:** Yes.

**Recreation:** The park is open to the public for birding, fishing, snorkeling, visiting cultural sites including heiau and petroglyphs, visiting Honokōhau beach, and visiting both Hawaiian fishponds.

**Cultural:** Kaloko-Honokōhau National Historical Park protects numerous sites and ancient Hawaiian settlements, including two fishponds, agricultural sites, multiple heiau, house site platforms, and petroglyphs. Both 'Aimakapā and Kaloko Fishponds were modified aquaculture

systems used to raise fish. Efforts are underway to restore both fishponds for potential future aquaculture activities and cultural demonstrations.

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ISLAND: HAWAI'I

LOCATION: Kapo'ikai ('Ōpae'ula Pond)

DESCRIPTION OF SITE: Kapo'ikai (meaning 'the sea breaking'), also known as 'Ōpae'ula Pond, is a large anchialine pool on the north Kona coast. It is used by T&E native and migratory birds, and the surrounding anchialine pool complex hosts unique organisms including the endemic 'ōpae'ula (Hawaiian red shrimp). It is an important habitat for waterbirds along a coastline with few wetlands. Inlets and peninsulas along the pond edge support communities of emergent vegetation. Water levels at this fresh to brackish wetland fluctuate with ocean tides, rainfall, and freshwater seepage.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3	7.5	8.5	Loko wai'ōpae and loko pu'uone	Kamehameha Schools	Kamehameha Schools	\$500k–1 million	Restoration planning underway

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x			Supporting	Yes
Breeding		x	x				

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: None.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

A large variety of other shorebirds and migratory birds utilize the site including 'akeke'e (Ruddy Turnstone), hunakai (Sanderling), kolea (Pacific Golden Plover), koloa māpu (Northern Pintail), and koloa mōhā (Northern Shoveler). 'Ōpae'ula (Hawaiian red shrimp) are found in the surrounding anchialine pool complex, and 'ilio holo i ka uaua (Hawaiian monk seals) and honu (Hawaiian green sea turtle) are found nearby on the beach.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes
- Inputs: Rainfall, freshwater seepage from mauka, seawater seepage from makai, and occasionally seawater input from waves
- Outflows: None
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	3
Botulism control	1
Invasive plant control	1

- **Threats**

- Unleashed dogs
- Extreme weather events (e.g. tsunamis)
- Sedimentation
- Feral ungulates (e.g. goats)
- Non-native predators (e.g. feral cats, rats, mongooses)
- Non-native vegetation
- Trespassing
- Trash and other human debris

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
< 5% of wetland inundated	5-25% of wetland inundated	< 5% of wetland inundated	> 75% of wetland inundated	Likely: all or most of the surrounding land is undeveloped and is zoned for conservation

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 7.0–8.9 km
- **Knowledge Gaps and Planning / Research Needs**

- Research is needed to understand the carrying capacity of the site for waterbirds.
- **Challenges**
  - Limited vehicular and/or pedestrian access to site
  - Obtaining necessary permits and/or funding
  - Unmanaged invasive vegetation
- **5–10 Year Conservation Priority Actions Needed**
  - Develop a waterbird management plan.
  - Maintain long-term predator control efforts.
  - Remove invasive plants at the site.
  - Outplant native plants, particularly to establish a native bioshield or shrub barrier on the beach side.
  - Continue waterbird monitoring.
  - Conduct a hydrological survey.
- **Benefits to T&E birds / MBTA birds**
  - This wetland is north of Kona and provides a continuum of available habitat for waterbirds along the northwest coast of Hawai'i island in an area that otherwise has few wetlands.
- **Benefits to People**

**Ecosystem Services:** Invasive plant removal will improve water quality and expand habitat for waterbirds. This surrounding complex of pools is an important anchialine system and supports 'ōpae'ula and a unique assemblage of organisms.

**Education:** The site has been used for anchialine pool and 'ōpae'ula research by students from various universities. It is also featured in an online virtual field trip for Makalawena developed by KS and Arizona State University.

**Sustainable food:** Kapo'ikai once operated as a fishpond, but currently it is not being managed with the intention for food production.

**Fishing:** None.

**Recreation:** Public access is not permitted.

**Cultural:** The endemic 'ōpae'ula shrimp were highly valued as bait for 'ōpelu (mackerel scad). These ponds and 'ōpae'ula are connected to the traditional fishing practices and their continuation along the north Kona coast.

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ISLAND: HAWAI'I

LOCATION: Kaumaui Loko Wai

DESCRIPTION OF SITE: Found on the Keaukaha coastline, the loko wai (anchialine pools) at Kaumaui are part of a historic fishpond site, formerly used for āholehole (flagtail) aquaculture. Kaumaui is composed of two pond systems. These ponds are separated from the ocean by the highway, but the water level fluctuates with the tide. The makai pond may have formerly been connected to the ocean before the road was built, but it currently does not have natural fish recruitment from the ocean. The mauka pond system is 15–20 feet deep, with cold fresh water. Salinity is 2–7 ppt (makai pond) and 2-5 ppt (mauka pond). Hui Ho'oleimaluō are conducting research into the impact of sea level rise on the site and how water level and temperature will be impacted over time. The site is used by nēnē as well as many migratory shorebirds. Kaumaui is privately owned by Hui Ho'oleimaluō. In conjunction with Hawai'i Land Trust, they are working to secure a conservation easement that would safeguard Kaumaui for community and education in perpetuity.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
8	2.5	3	Loko i'a	Hui Ho'oleimaluō	Hui Ho'oleimaluō	\$500k–1 million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present					x	Other	Yes
Breeding					x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Ka 'Umeke Kā'eo; Kamehameha Schools; Pawanka Fund; Seed, Soil, and Culture; Hawai'i Tourism Authority; Sea Grant; Ke Ana La'ahana; Hawai'i People's Fund.

Conducts site-based waterbird monitoring (not including SWBC): No

- **Other Wildlife of Note**

‘Auku‘u (Black-crowned Night-Heron), and ‘io (Hawaiian Hawk) are regularly found at the site. Native fish include ‘ama‘ama (striped mullet), āholehole (flagtails), ‘o‘opu (Hawaiian diadromous gobies), and ‘o‘opu ‘akupa (Hawaiian sleeper goby), and nonnative fish include tilapia and western mosquitofish (*Gambusia affinis*). ‘Ōpae ‘oeha‘a (Hawai‘i river prawn) and introduced river prawns (*Macrobrachium* spp.) are also present.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, a couple have been identified since acquisition of the property with more expected to be opened as restoration continues.
  - Inputs: Groundwater springs and tidal influence
  - Outflows: Through substrate to ocean
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Predator control	1
Human disturbance control	3
Invasive plant control	1

- **Threats**

- Unfenced property
- Main road immediately adjacent to site with a lot of traffic
- Powerlines
- Possibility of harmful bacteria in wastewater runoff from nearby neighborhood
- Invasive plants trapping sediment in the ponds

- **Climate Change Threats**

- Site added after climate analysis
- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- A hydrological survey is needed to understand the ponds’ connection to the ocean.
- Develop a strategy on how to deal with sediment control.

- Develop a strategy to restore the site for aquaculture.
- **Challenges**
  - Influx of tourists in the area and limited space to accommodate the traffic
  - Limited opportunities for people living in the area to get involved with local coastal conservation
  - Difficulty navigating permitting around building traditional structures and doing restoration work in a residential area; codes around construction of simple traditional structures and restoration currently not distinct from building complex modern structures.
- **5–10 Year Conservation Priority Actions Needed**
  - Secure a conservation easement to safeguard Kaumau for community and education in perpetuity.
  - Obtain support with permitting authorities for restoration activities at the site.
  - Increase funding to provide a career path in restoring wetlands.
  - Increase staff.
  - Initiate and maintain long-term predator control efforts.
  - Remove invasive plants and outplant native plants.
  - Conduct a hydrological survey.
  - Develop a strategy to remove sediment.
  - Restore aquaculture to the site.
- **Benefits to T&E birds / MBTA birds**
  - This site has suitable habitat for many migratory birds and supports breeding nēnē.
  - This site is one of five fishponds in close proximity to each other, east of Hilo, that provide a suitable habitat network for migratory and T&E waterbirds in the area.
- **Benefits to People**

**Ecosystem Services:** This site acts as a nursery for juvenile fish, endemic seaweed, and native plants.

**Education:** Hui Ho'oleimaluō works on curriculum development for grades K–12 with Hawaiian immersion schools in the Keaukaha area (Ke Ana La'ahana Public Charter School and Ka 'Umeke Kā'eo Public Charter School) to develop the next generation of fishpond stewards and prepare them for employment after graduation. Students also engage in restoration activities like invasive plant removal and pond maintenance. Hui Ho'oleimaluō also provides after-school programs and programs during school breaks that include paddling, farming kalo, fishpond restoration, hula classes, and imu classes.

**Sustainable food:** This site was used until relatively recently as an active fishpond and with further restoration has the potential to once again provide fish for the community.

**Fishing:** This site is not used for fishing.

**Recreation:** This area is closed to the public and primarily used for education.

**Cultural:** The ponds on the Kaunani property are historic fishponds that once supported the community in the area. Today they are used for educational purposes, to preserve the area's cultural history, provide habitat for native species, and produce food for the community (Kaunani, n.d.).

## References

Anthony, K., personal communication, September, 2023.

Kauanoe, K. (2022). *Hawaiian Fishponds Are Rebounding In The Face Of Rising Seas And Invasive Species*. Honolulu Civil Beat. <https://www.civilbeat.org/2022/07/hawaiian-fishponds-are-rebounding-in-the-face-of-rising-seas-and-invasive-species/>.

Hui Ho'oleimaluō. (n.d.). *Kaunani*. Retrieved October 2, 2023, from <https://www.huihooleimaluo.com/kaunani>.

ISLAND: HAWAI'I

LOCATION: Kea'au Pond (Ke'anae Pond)

DESCRIPTION OF SITE: Kea'au Pond is a spring-fed pond connected to the ocean. It has a wall and mā kāhā system from its historical use as a fishpond. The pond is on Shipman family property and has been protected by the family for many generations for the nēnē that breed on site. The site is also used by other T&E birds and migrants including koloa mōhā (Northern Shoveler), koloa māpu (Northern Pintail), American Wigeon, Eurasian Wigeon, and Greater/Lesser Scaup.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
5	7.2	1914.7	Loko i'a	Private	Peggy Farias	\$2–5+ million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x	x	x	Supporting	Maybe
Breeding			x		x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: Ke Kula 'o Nāwahīokalani'ōpu'u Hawaiian Immersion School, DOFAW, Nā Ala Hele.

Conducts site based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

'Io (Hawaiian Hawk), auku'u (Black-crowned Night-Heron), multiple species of 'o'opu (native diadromous gobies and sleeper goby), 'ama'ama (Striped mullet).

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes

- Inputs: Spring(s)
- Outflows: Channel to Hā'ena Beach
- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Human disturbance control	3
Invasive plant control	3

- **Threats**

- Feral and off-leash dogs
- Cats and mongooses
- Salinification of pond from king tides and storm surges

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	25-50% of wetland inundated	<5% of wetland inundated	50-75% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**
  - 9.0 km +
- **Knowledge Gaps and Planning / Research Needs**
  - Develop solutions for an eroding shoreline to protect the area between the pond and the ocean.
- **Challenges**
  - Funding
  - Capacity
  - Limited staff for a large area with many goals
  - Lack of restoration expertise among staff
  - Cat feeding in the area

- Protecting coastline from erosion despite current policies not allowing hardening of seashore.
- **5–10 Year Conservation Priority Actions Needed**
  - Expand and maintain long-term predator control, especially for cats.
  - Eliminate cat feeding in the area.
  - Install predator-proof fence.
  - Remove ungulates.
  - Continue removal of invasive plants and outplanting of native species.
  - Ensure provision of freshwater into future.
- **Benefits to T&E birds / MBTA birds**
  - This is a regular breeding site for nēnē that has active management in place geared towards their protection, including predator and invasive plant control.
- **Benefits to People**

**Ecosystem Services:** This site helps capture sediment and reduce runoff to the nearshore coastal ecosystem including offshore reefs. Further removal of invasive plants and the restoration of the site with native plants will enhance the marsh's capacity to capture sediment. There is also a large flow of freshwater out of the pond into the nearshore environment that promotes the growth of several species of limu and creates a feeding ground for honu (green sea turtle). Over 40 honu have been recorded resting on the beach at low tide.

**Education:** Whenever possible, the landowners accommodate requests to visit the site made by groups who have a specific educational or cultural reason for visiting either the pond or the beach. Groups that have visited in recent years include Keonepoko Elementary School, Kamehameha Schools Hawai'i, Ke Kula 'o Nāwahīokalani'ōpu'u Hawaiian Immersion School, Lili'uokalani Trust, and multiple hula halau. Groups are limited in size to 50 people and generally interact with the pond in areas closer to the ocean, away from nēnē and ae'o breeding sites at the back of the pond. Kumu Henani Enos at Ke Kula 'o Nāwahīokalani'ōpu'u uses the pond as a teaching laboratory for his students.

**Sustainable food:** This site could potentially be used for aquaculture given its history as a fishpond.

**Fishing:** This site is on private property with no public fishing access.

**Recreation:** A public hiking trail is nearby, but the property itself is private.

**Cultural:** This site retains the wall and gate system that were part of its historical use as a fishpond.

## References



Farias, P., personal communication, September, 2023.

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaii*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](#).

U.S. Fish and Wildlife Service. (2011). *Recovery Plan for Hawaiian Waterbirds, Second Revision*. U.S. Fish and Wildlife Service, Portland, Oregon. xx + 233 pp.  
[https://ecos.fws.gov/docs/recovery\\_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf](https://ecos.fws.gov/docs/recovery_plan/Hawaiian%20Waterbirds%20RP%202nd%20Revision.pdf).

ISLAND: HAWAI'I

LOCATION: Kealakehe Wastewater Treatment Plant

DESCRIPTION OF SITE: The Kealakehe Wastewater Treatment Plant is just north of Kailua-Kona and contains five purpose-built, lined ponds. These ponds are frequented by T&E waterbirds as well as migratory shorebirds and waterfowl. This site has ongoing habitat management including predator control under an Endangered Species Act Section 7 permit and is heavily used by ae'o.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
15	30	53	None	County of Hawai'i	AECOS, Inc. / Reginald David	n/a	No restoration

Bird Information							
T&E Bird Species Present							
	'alae 'ula	'alae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x			Other	No
Breeding							

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: None.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

None

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: None
- Inputs: Processed and pumped wastewater; rainfall.
- Outflows: Wastewater is processed and discharged into a pit located in a permeable lava field half a mile upslope from Honokōhau Harbor.

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
None scored 3 or less	

- **Threats**

- Predators including mongooses, cats, and native Black-crowned Night-Herons
- Water quality
- Wastewater infrastructure

- **Climate Change Threat**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand?
<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	<5% of wetland inundated	Not likely: most or some of the surrounding land is undeveloped but zoned for urban development

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0-2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- None

- **Challenges**

- Ae'ō try to nest at this site each year, and their eggs and chicks get predated, mainly by Black-crowned Night-Herons. Heron management, potentially hazing, would be needed to keep this site from being a biological sink for ae'ō.
- Ensuring treated water does not impact nearshore ocean water quality

- **5–10 Year Conservation Priority Actions Needed**

- Continue habitat management actions and protocols for T&E waterbirds as agreed to under the ESA Section 7 permit.
- Develop a Black-crowned Night-Heron hazing strategy, and seek applicable permits to reduce heron predations.
- **Benefits to T&E birds / MBTA birds**
  - This site is heavily utilized by ae'o but is currently a biological sink, as breeding is attempted each year but is unsuccessful due to predation by herons.
- **Benefits to People**

**Ecosystem Services:** This site provides water treatment for the community. Proposed upgrades to the site would increase the value of that service.

**Education:** None.

**Sustainable food:** None.

**Fishing:** None.

**Recreation:** Bird watching is possible from the edge of the property.

**Cultural:** None.

## References

David, R., personal communication, August, 2023.

Hawai'i Free Press. (2023). *Earthjustice Files Lawsuit to Clean Up Kealakehe Wastewater Treatment Plant Sewage Discharges into the Pacific Ocean*. Retrieved October 23, 2023, from [Earthjustice Files Lawsuit to Clean Up Kealakehe Wastewater Treatment Plant](#).

Henry, A. R. (2006). *Strategic plan for wetland conservation in Hawaii*. Pacific Coast Joint Venture: Honolulu, HI, USA. [HWJVStrategicPlan-3.pdf \(pacificbirds.org\)](#).

U.S. Fish and Wildlife Service. (2011). *Recovery Plan for Hawaiian Waterbirds, Second Revision*. U.S. Fish and Wildlife Service, Portland, Oregon. xx + 233 pp. [Hawaiian Waterbirds RP 2nd Revision.doc](#).

Wilson Okamoto & Associates, Inc. (2001). *FINAL ENVIRONMENTAL ASSESSMENT: KEALAKEHE WASTEWATER TREATMENT PLANT, EFFLUENT REUSE MASTER PLAN*. Prepared for: County of Hawaii, Department of Environmental Management. Hilo, Hawaii. Retrieved November 13, 2023, from [2001-06-08-HA-FEA-Kealakehe-Wastewater-Treatment-Plant.pdf \(hawaii.gov\)](#).

ISLAND: HAWAI'I

LOCATION: Loko Waiāhole and Loko Kapalaho

DESCRIPTION OF SITE: Loko Waiāhole and Loko Kapalaho are two traditional fishponds on the coast, east of Hilo. They are connected to each other by an 'auwai and to the ocean by a channel that runs under the road. The ponds are brackish but due to high freshwater flow the salinity and temperature remain low. Native fish including 'ama'ama (striped mullet), āholehole (flagtails), and 'o'opu (Hawaiian diadromous gobies), as well as three species of 'ōpae (Hawaiian shrimp) are found in the pond. This site is actively used for science education and fishpond research by Kumuola Marine Science Education Center. They are also restoring the site by removing invasive plants and controlling introduced predators. T&E native and migratory birds regularly use this site.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
4	5	10	Loko i'a	Kamehameha Schools	Kamehameha Schools / Kumuola Marine Science Education Center	\$2–5+ million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x		x	x	Other	Yes
Breeding				x	x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: University of Hawai'i, Hawai'i Pacific University, Kua'āina Ulu 'Auamo (KUA).

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

'Io (Hawaiian Hawk)

- **Hydrology**

Has there been a formal hydrological survey: Yes

- Springs: Yes, under the lava shelf surrounding the pond there are many springs that seep into the pond.
- Inputs: Rainfall and tidal input through a lava tube connected to the ocean feed the pond.
- Outflows: Channel to the ocean

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Invasive plant control	1
Predator control	2
Botulism control	3

- **Threats**

- Unfenced road hazardous to birds
- Predators including mongooses, cats, pigs, and rats

- **Climate Change Threats**

- Site added after climate analysis

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km

- **Knowledge Gaps and Planning / Research Needs**

- There is ongoing research into the natural fishpond hydrological cycling.
- There is ongoing research into how the traditional fishpond dynamics are affected by the change in landscape around the pond and the climatic changes impacting the pond.

- **Challenges**

- Lack of capacity to address the largest issues facing the pond, like invasive plants

- **5–10 Year Conservation Priority Actions Needed**

- Ongoing removal of invasive plants and outplanting of native plants.
  - Continue and expand predator control efforts.
  - Continue community involvement and participation in work at the site.
  - Expand adaptive management that reflects the changes in the site seen in data collection.
  - Install fencing and vegetation to protect birds from the road and predators.
- **Benefits to T&E birds / MBTA birds**
    - This site is adjacent to the largest population of ‘alae ke‘oke‘o on Hawai‘i Island at Lokowaka Pond and provides additional habitat for that population and other native and migratory waterbirds.
  - **Benefits to People**

**Ecosystem Services:** Invasive plant removal will improve water quality, and the restoration of the fishpond will provide sediment and flood control as well as serving as a critically important nursery ground for native fish.

**Education:** The site is used for native wetland and ecological education.

**Sustainable food:** This site has the potential to produce fish for the community when fully restored.

**Fishing:** None.

**Recreation:** Bird watching is possible from the edge of the property.

**Cultural:** Waiāhole and Kapalaho fishponds are connected via ‘auwai and are part of a larger system of fishponds in this area that includes Lokowaka and Hale O Lono. Together these ponds would have provided the community with a range of fish species.

## References

Kumuola Marine Science Education Center. (n.d.). *Home*. Retrieved August 22, 2023, from [www.sites.google.com/ksbe.edu/kumuola-msec/home](http://www.sites.google.com/ksbe.edu/kumuola-msec/home).

Mead, L., personal communication, June, 2023.

ISLAND: HAWAI'I

LOCATION: Lokowaka Pond

DESCRIPTION OF SITE: Lokowaka is one of the largest fishponds on Hawai'i Island and has the most important population of 'ālae ke'oke'o on the island. It is used by other T&E native and migratory birds and is in the vicinity of several other fishponds which serve as habitat for these species. The land is leased from the State by the Seaside Restaurant and Aqua Farm. Invasive plants are reducing the pond's extent and its fish production capacity. The 'Āina Ho'ōla Initiative are managing the land and hold regular volunteer events to conduct invasive plant removal and predator control.

Site Information							
Elevation in m (from msl)	Wetland ac.	Site ac.	Indigenous agriculture	Land Ownership	Land Manager	Est. \$ for restoration	Restoration status
3	~30	50.89	Loko i'a	Department of Land and Natural Resources - DOFAW	Seaside Restaurant / 'Āina Ho'ōla Initiative	\$2–5+ million	Restoration underway

Bird Information							
T&E Bird Species Present							
	'ālae 'ula	'ālae ke'oke'o	ae'o	koloa maoli*	nēnē	USFWS Recovery Plan Status	Suitable for Predator Proof Fence
Present		x	x	x	x	Core	Yes
Breeding		x		x	x		

\*presumed koloa maoli x mallard hybrid

SUPPORTING PARTNERS: University of Hawai'i at Hilo, Seaside Restaurant, Cafe Pesto, Express Waiters, DLNR-DOFAW, Community volunteers, Ola Brew Company, SCP Hotel, Hawai'i Tourism Authority, Hawai'i Tourism Japan, Big Island Love, Nēnē Research and Conservation, Kanu Hawai'i.

Conducts site-based waterbird monitoring (not including SWBC): Yes

- **Other Wildlife of Note**

Native and/or canoe plants found at Lokowaka Pond include 'ae'ae (water hyssop), hau (sea hibiscus), milo (portia tree), hala, and limu pālahalaha. Naupaka kahakai (beach naupaka) and nanea (beach pea) have been reintroduced. Aquatic fauna includes 'o'opu nākea, 'ōpae'ula



(Hawaiian red shrimp), 'ōpae huna (feeble shrimp), 'ōpae 'oeha'a (Hawai'i river prawn), 'alamihī, 'āholehole (flagtails), 'ama'ama (striped mullet), and pāpio (trevallies).

Multiple migratory birds visit the site (including kōlea or Pacific golden plover, 'ūlili or Wandering tattler, 'akekeke or Ruddy turnstone, Spotted sandpiper, Belted Kingfisher, Osprey, American Wigeon, Blue-winged teal, Bufflehead, Canvasback, Cinnamon teal, Eurasian Wigeon, Gadwall, Greater Scaup, Green-winged teal, Lesser Scaup, Koloa māpu or Northern Pintail, Northern Shoveler, Pied-billed grebe, Ring-necked duck, and White-faced ibis.) 'Auku'u or Black-crowned Night-heron are also regularly found at the site.

- **Hydrology**

Has there been a formal hydrological survey: No

- Springs: Yes, many inside and surrounding the pond
- Inputs: Rainfall and tidal input from the ocean
- Outflows: Ocean

- **Status of Key Management Actions (scored 3 or less, with 1 being no current management in place)**

Key Management Action	Score
Invasive plant control	1

- **Threats**

- Unfenced road hazardous to birds
- Predators including mongooses, cats, rats, and feral pigs

- **Climate Change Threats**

Projected Climate Change Impacts				
Marine inundation by 2050	Groundwater inundation by 2050	Marine inundation by 2100	Groundwater inundation by 2100	Space to retreat/expand
<5% of wetland inundated	> 75% of wetland inundated	<5% of wetland inundated	> 75% of wetland inundated	Possible: all or most of the surrounding land is undeveloped and is zoned for ag or rural

- **Spatial connectivity — Proximity to state waterbird survey / managed wetlands**

- 0–2.9 km
- **Knowledge Gaps and Planning / Research Needs**
  - Regular surveys are needed to understand the dynamics of the ‘alae ke‘oke‘o population at the pond and the impact of predators at the site.
  - A hydrological survey is needed.
- **Challenges**
  - Currently there is no funding for the restoration work at the site and all work is done on a volunteer basis.
- **5–10 Year Conservation Priority Actions Needed**
  - Expand staff and funding for work at the site.
  - Get assistance with grant proposals.
  - Restore Ki‘onakapahu and ‘Akahi Ponds and the surrounding area which are adjacent to Lokowaka Pond and part of the Lokowaka complex.
  - Expand waterbird surveys to determine the status of the large ‘alae ke‘oke‘o population.
  - Conduct a hydrological survey.
  - Expand predator control efforts.
  - Remove invasive plants, particularly California grass, *Brachiaria mutica*, *Shiebutton ardisia*, and *Ardisia elliptical*, and outplant native plants.
- **Benefits to T&E birds / MBTA birds**
  - This site is one of the largest wetlands in the Hilo region and supports the largest population of ‘alae ke‘oke‘o on Hawai‘i Island. With expanded predator control, invasive plant removal, and native plant outplanting, it has enormous potential to contribute to T&E waterbird recovery and to provide habitat for migratory birds.
- **Benefits to People**

**Ecosystem Services:** Invasive plant removal will improve water quality, and the restoration of the fishpond will provide sediment and flood control. Restoration will help the pond to serve as a critically important nursery ground for native fish.

**Education:** The site is publicly accessible for roadside observation and has the potential to be used for native wetland and ecological education.

**Sustainable food:** Fish are harvested from the fishpond and sold at the adjacent Seaside Restaurant and Aqua Farm.

**Fishing:** None.

**Recreation:** Bird watching is possible from the edge of the property.

**Cultural:** Lokowaka is an important place in the legend of Pele and Waka, with the Lokowaka Pond being the final resting place of the mo’o Waka after her battles with Pele (Manu, 1899; Wolforth, 2016).

## References

Hasegawa, K., personal communication, July, 2023.

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Manu, M. (Tone-lahuanu-Tahuirā-larafrie). (1899). *A Hawaiian Legend of a Terrible War between Pele-of-the-Eternal-Fires and Waka-of-the-Shadowy-Waters*. Translated by M. K. Pukui. From Ka Loea Kalaiaina, May 13-December 30. Hawaiian Ethnological Notes 2:942 to 1008. Bishop Museum Library, Honolulu.

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Wolforth, T. (2016). *Battles in Ka’ū*. Hawaiian Warfare: Chronicling the Battles of Ancient Chiefs. <http://www.hawaiianwarfare.com/pages/battles-big-island/kau.php>