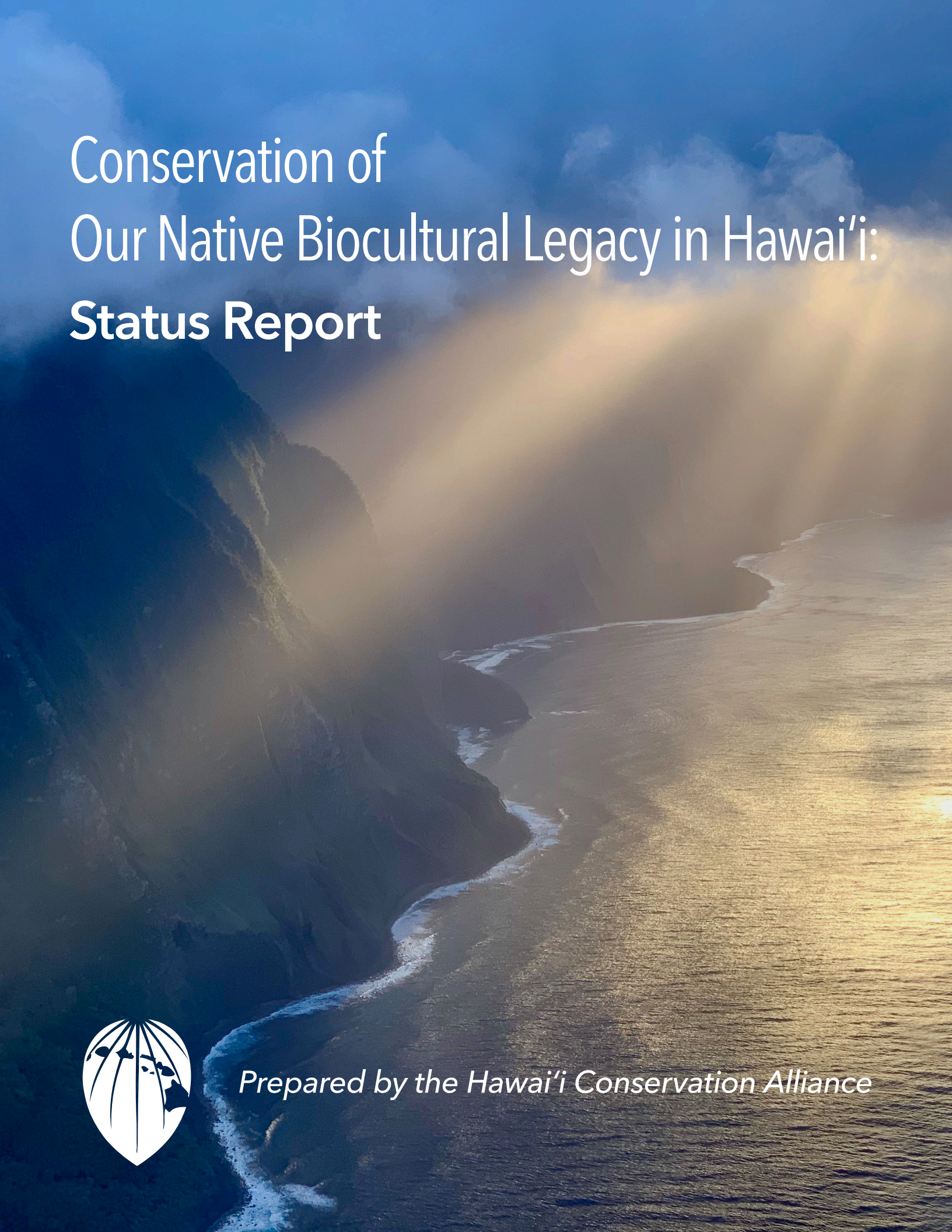
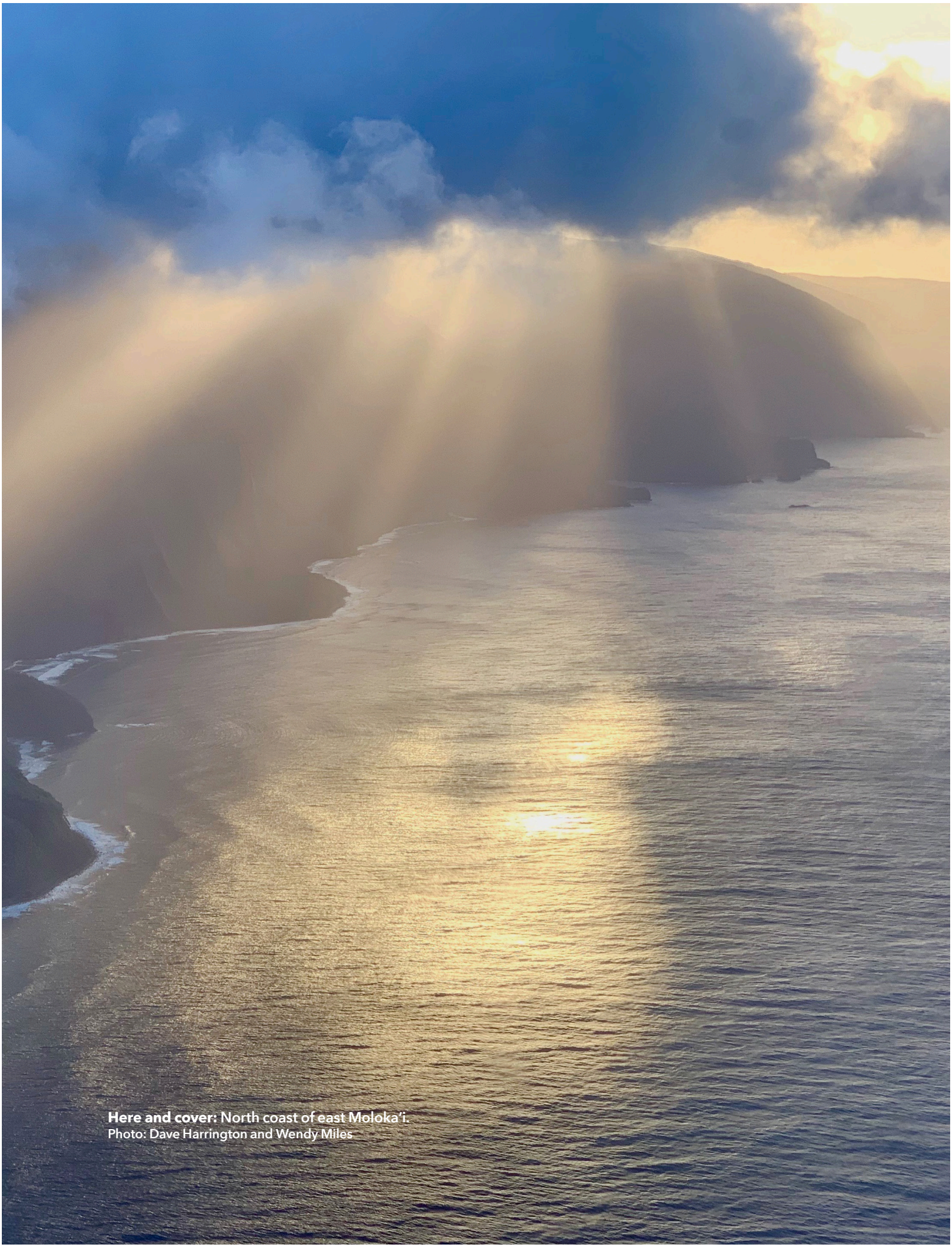


Conservation of Our Native Biocultural Legacy in Hawai'i:

Status Report

Prepared by the Hawai'i Conservation Alliance



Here and cover: North coast of east Moloka'i.
Photo: Dave Harrington and Wendy Miles

Conservation of Our Native Biocultural Legacy in Hawai‘i:

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HAWAI‘I CONSERVATION ALLIANCE

A Partnership Dedicated to Environmental Stewardship, Community Engagement, and Conservation Capacity

Hawai‘i Conservation Alliance FOUNDATION

www.hawaiiconservation.org

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‘Ilima and Hinahina at Ka‘ena, O‘ahu.
Photo: Jim Jacobi, USGS.

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Fourspot butterflyfish.
Photo: Christopher Teague.

Foreword

When our ancestors' canoes landed in the islands 1,000 years ago, they found a remarkable archipelago in the middle of the Pacific, the single most isolated high island archipelago on the planet. And they created a unique and rich culture and established a entirely self sustained footprint in these islands.

Hōkūle'a image ® Polynesian Voyaging Society.
Photo ©'Ōiwi TV. Photographer: Nā'ālehu Anthony.

Two hundred years ago, other voyagers arrived, and brought many things, including diseases we had no previous experience with; and within 50 years, 75% of Hawaiians had died. One hundred years ago Hawaiian language and culture was under active suppression, and disappeared from education in Hawai'i. The "black road of extinction" – cultural extinction – was being well-paved and it nearly succeeded in erasing the culture and beauty and amazing things about this extraordinary people who had so much to offer the Earth.

So when I graduated from high school in the 1960s, the process of Hawaiian cultural extinction was so nearly complete that I had no idea who my ancestors were, where they came from, or how they got here. They were the greatest explorers on the face of the earth, but the "black road of extinction" had erased them from our collective awareness.

But a series of miracles created a Hawaiian cultural renaissance, including resurrection of language and culture, and the "spaceship of our ancestors" Hōkūle'a, a voyaging canoe of ancient design seeking to show what most had rejected: that our ancestors, through knowledge and great skill, navigated without any instruments but what nature gave them, across the vast open ocean, across the daunting collision of the World's tropical wind belts, to get from Tahiti to Hawai'i. The first crew of Hōkūle'a set out from Hawai'i in 1976, and when they arrived in Papeete Harbor, to throngs of thousands, they changed the World that day. They gave us reason to be proud, to learn, to teach. They helped light the spark of a powerful cultural renaissance, instilling pride and hope in Hawaiians, and setting them on a course to recapture the traditional knowledge and skills that created both ecological sustainability and a remarkably rich society.

How do we measure when we've stopped extinction? On the cultural axis, it is when our children grow up grounded in knowing that they are the descendants of the great navigators. But there are so many metrics that arise from that – in 1976 there were less than 1,000 Hawaiian speakers. Today there are over 22,000. Other movements besides voyaging arose: recapture of Kaho'olawe, the re-emergence of hula, of language, and the cultural practices in healing, agriculture, art, and many others. We are never going back down that black road.

But our recovery is a never-ending process, and for all that we have achieved, we have so much more to learn, to do, and to teach.

The road of extinction in Hawaiian culture is paralleled by the extinction of the remarkable biocultural legacy in the native plants, animals, and ecosystems that comprised the foundation of what Hawaiian culture had achieved – the heritage and genealogy of 1,000 years of the genius of native Hawaiians who learned how to live on these islands sustainably. The same forces that nearly destroyed Hawaiian culture wrought great havoc on our island ecosystems, making Hawai'i to be called the "Extinction Capital of the World," a status that none of us are proud of.

But Hawai'i is a microcosm of the planet, and the solution to the World's problems lies in what we do here as a people to value our place and to express our love for Hawai'i in our action. Our lives are dependent on our islands, our planet, and we can either fall into black despair over the pathway of humanity and its relationship to the Earth, or we can take action, and combine the best tools in modern conservation practice within the context of the loving familial relationship that our ancestors had for their place. Hawai'i is the solution. Hawai'i is the school for the Earth. The most important thing that Hawai'i has to offer is that it's people and culture are still kind; that aloha lives here, and still has the power to direct how we behave toward each other, and to all the living elements of these islands.

This report on the many efforts to protect and care for the living elements of our remarkable islands is testimony of that aloha, that feeds the devotion of the many who devote their lives to Hawai'i. It documents the great strides we have made to take our living ancestors – our native plants and animals – off of the black road of extinction, and it shows how much further we need to go to truly succeed. Not only for the sake of Hawai'i and its people, but for the same challenges we face here in Hawai'i that threaten the future of our children, to take across the face of the planet.

The key is our young ones. We need to teach, and this report is part of the foundation of knowledge and history of effort upon which a new generation of kahu, caretakers, will stand and continue. We have kuleana – the responsibility and the privilege – to teach how to make the choices that yield true global sustainability, and that Hawai'i not only can, but must be the model for the World. How we care for our biocultural legacy here can make people all over the World believe that we can collectively make that change and win the race between those who are essentially hurting the Earth, and those who work to heal it. Here is the report of some of those healers, who know that nature is the core of our future. Let it be a guiding star for all of us.

Nainoa Thompson
Pwo Master Navigator
CEO, Polynesian Voyaging Society

Preface

This report has been produced by the Hawai'i Conservation Alliance (HCA), which is a partnership of organizations, agencies, and landowners working together to provide unified leadership, and collaborative action to conserve and restore native ecosystems and the unique biodiversity of our islands. The information contained in this document represents the most current data available from HCA partners and other organizations on the status of conservation resources, protection, and management for the Hawaiian Islands, spanning ma uka[1] (upland) to ma kai (to the ocean) across terrestrial, aquatic, and nearshore marine ecosystems.

This report synergizes with a number of related efforts in Hawai'i conservation and sustainability planning including, but not limited to, the Hawai'i Green Growth Aloha+ Challenge, and the Sustainable Hawai'i Initiative, which includes both terrestrial and marine (Holomua Marine Initiative) goals. Given the diverse expertise and experience of the Hawai'i Conservation Alliance member organizations, this report is also intended to complement efforts led and supported by HCA's member organizations, including NOAA's 2020 State of Papanahānaumokuākea Marine National Monument, NOAA's Coral reef condition: A status report for the Hawaiian Archipelago, The Nature Conservancy Hawai'i 2020 Impact Report, The Laukahi Network, and many others. HCA member contributions to this report guide and ground our efforts to characterize the status of conservation in Hawai'i in a way that draws from, builds upon, honors, and respects the numerous related conservation efforts across our islands over time

Although the main focus of this report is on the southern eight Hawaiian Islands, we also include some information on conservation status in the Northwestern Hawaiian Islands to provide a comparison with resource, protection status, and management conditions in the nearshore marine systems of the younger islands. The information in this report can be used as a source for education and outreach, and to support efforts to plan and evaluate conservation actions. This report is intended to serve as a baseline for future Hawai'i Conservation Alliance status reports that will compile and assess updated conservation information and document trajectories, positive and negative.

Herbivorous reef fish off of Ka'upulehu, Hawai'i Island. These fish keep dead reef surfaces clean so corals can grow, and so are the focus of statewide conservation efforts. Photo: Bryce Groark.

The preparation of this report was made possible through the collaboration of many people from the HCA Effective Conservation subcommittee and the HCA partners; as well as data, images, and related resources provided by The Laukahi Network and partners, Hawai'i Wildlife Center, San Diego Zoo Wildlife Alliance, Pūlama Lāna'i, Pacific Rim Conservation, Sam Aruch, Greg Asner, Reuben Wolff, Jack Jeffrey, Alan Friedlander, © Keoki Stender, Hi'ilei Kawelo, Will Weaver, Seana Walsh, Ruby Pap, Jeff Stallman, Rick Warshauer, Forest and Kim Starr, and many others. And special thanks to Stephanie Tom (TNCH) and Dwight Matsuwaki (DOFAW) for data and GIS support.

[1] Information on the correct spelling and definitions of Hawaiian words can be found at wehewehe.org

Hawai'i Conservation Alliance partners

Army Natural Resources Program on O'ahu (ANRPO)

Bernice Pauahi Bishop Museum

Conservation International Hawai'i (CI Hawai'i)

Hawai'i Association of Watershed Partnerships (HAWP)

Hawai'i DLNR Div. of Aquatic Resources (DAR)

Hawai'i DLNR Div. of Forestry and Wildlife (DOFAW)

Hawai'i Invasive Species Council

Hawai'i Invasive Species Committees

Kamehameha Schools

Kua'āina Ulu 'Auamo (KUA)

KUPU

NOAA National Ocean Service

NOAA National Marine Fisheries Service

National Park Service (NPS)

USDA Natural Resources Conservation Service (NRCS)

National Tropical Botanical Garden (NTBG)

Office of Hawaiian Affairs (OHA)

Pacific Islands Climate Adaptation Science Center

The Nature Conservancy, Hawai'i and Palmyra (TNC)

USDA Animal and Plant Health Inspection Service

U.S. Forest Service Pacific SW Region (USFS)

U.S. Forest Service Institute of Pacific Islands Forestry

U.S. Fish and Wildlife Service Ecological Services (USFWS)

U.S. Fish and Wildlife Service National Wildlife Refuge System

U.S. Fish and Wildlife Service Science Applications

U.S. Geological Survey Pacific Island Ecosystems Research Center (USGS)

University of Hawai'i at Hilo (UH Hilo)

University of Hawai'i at Mānoa, Center for Conservation Research and Training (CCRT)

University of Hawai'i at Manoa, School of Life Sciences (UHM)

Why we care

The Hawaiian Islands are home to some of the most remarkable ecological systems on Earth, containing a suite of species distinguished by their uniqueness – the vast majority of which are found nowhere else on the planet. The extreme isolation of this archipelago also gave rise to a rich and robust indigenous Hawaiian culture that closely connects with its diverse natural setting. The ridge-to-reef environments of Hawai'i are both awe-inspiring and delicate – encompassing native forests that can pull millions of gallons of water from passing trade winds to replenish our water supply, with the soft songs and brilliant feathers of native birds and the delicate color patterns on the body of a "happy-face" spider, to the coral reefs and their magnificent variety of sea life.

Maui coast above and under water. Photo: Lyle Krannichfeld.

Hawaiian ecosystems provide both tangible and intangible values that enhance our quality of life and support our existence. They provide ecological services supplied by watersheds and coastal ecosystems, genetic resources for medicine, agriculture, and education, provide a beautiful and truly unique environment for residents and visitors to live in and experience, and serve as foundation for the Hawaiian culture.

Sadly, the isolation and limited geographic scale of islands such as Hawai'i has also resulted in natural resources that are vulnerable to disruption and extinction. Any major ecological turmoil, natural or human-induced, can cause the loss of irreplaceable natural assets for current and future generations. Consequently, geography and human-caused impacts have combined to bring threats and some irreversible changes to our native ecosystems.

But despite a sobering history of species declines and extinctions, many native Hawaiian plants and animals are still thriving in functioning ecosystems. However, they continue to face serious threats, particularly from non-native invasive plants and animals, diseases, changing climate, and from human-related changes to the landscape and nearshore waters.

The purpose of this report is to help make Hawai'i's residents, leaders, and visitors more aware of our valuable natural resources and the collective challenges we face to sustain them for current and future generations. To that end, the Hawai'i Conservation Alliance – a dynamic collaboration among federal, state, and private agencies and organizations devoted to native ecosystem conservation in Hawai'i – has compiled this summary of Hawai'i's conservation status. This information can be used for evaluating our progress in conservation of these resources in both terrestrial and nearshore zones, and to help enhance outreach and education efforts to increase awareness and support for preserving Hawai'i's unique native biodiversity.

Back slope of Pelekunu Valley, Moloka'i.
Photo: Jim Jacobi, USGS.

Conservation indicators we are tracking

This report summarizes a wide range of information on the current status and trends of native terrestrial, aquatic, and nearshore marine biodiversity resources throughout the Hawaiian archipelago, as well as documenting the conservation efforts underway to protect these vital resources into the future. These key assessment indicators are grouped into four main categories:

Biological information

We track native and introduced species as well as ecosystems condition using both tables and maps. The information analyzed includes field data collected on all the islands as well as spatial models depicting current and projected future species and habitat distributions and projected distributions based on future climate scenarios.

Native species

- The number and status of native plants and animals
- Extent of and condition of native plant communities
- Status of stream habitats
- Status of wetlands
- Status of seabirds
- Status of coastal vegetation
- Coral reef status and distribution
- Nearshore marine species status

Endemic "happy-face" spider. Photo: ANRPO.

Introduced and invasive species

- The number and status of introduced plants and animals
- Distribution and impacts of invasive species
- Status and effects of disease and disease vectors
- Risk assessment for established and potential invasive species
- Effectiveness of biosecurity programs at minimizing species introductions

Introduced coqui frogs showing color variation. Photo: Maui Invasive Species Committee.

Status of ecosystems

The Hawaiian Archipelago spans across a vast array of climate zones, substrate types, and levels of disturbance since humans arrived here. Ecosystems range from atolls in the Northwestern Hawaiian Islands to habitats on the main Hawaiian Islands that extend from coastal strand communities, through wet, mesic, and dry forests as you move up in elevation or from windward to leeward exposures. A true alpine zone also exists on the tall volcanoes on East Maui and Hawai'i Islands. Similar ranges in habitat diversity are found in the marine ecosystems

based on substrate types, wave and surge exposure, and depth. **In this report we assess the status of these ecosystems from both a species diversity perspective as well as the degree that they are still dominated by native species.**

Protection status

For this report we are tracking two key protection metrics:

- Current location and extent of lands bearing protective designations
- Nearshore marine conservation and management zones

Biologically important lands and water benefit from protective designations that 1) recognize biological/ecological/cultural values of the living species and ecosystems within them, and 2) mandate or facilitate active management to mitigate threats or increase the viability of those resources. In Hawai'i there are many layers of protective designation, each of which may carry their own legal mandates. Some, such as the State Conservation District, regulate the type and intensity of land use, and often restrict land uses that destroy or damage biocultural resources. Others, such as parks and forest reserves, may include protection of resources but also allow for recreational or even limited extractive activities. Some are designations in name only, such as International Biosphere Reserves and International Wetland Reserves that recognize the biocultural values found there but have no mandates for active management. But even these designations can facilitate protective management and discourage incompatible land uses.

The strongest conservation protection designations provide a combination of 1) protection in perpetuity, 2) explicit restrictions on incompatible land uses or activities, and 3) mandates for management designed to maintain the integrity and health of the native species and ecosystems found within them.

While strong legal protection of landscapes and marine areas is a critical component of effective conservation, even areas with the strongest level of protection require some level of active management to overcome the impacts of invasive species.

Hawai'i Volcanoes National Park entrance. Photo: NPS.

'Āhihi-Kīna'u Natural Area Reserve signage. Photos: DLNR.

Pia Natural Area Reserve with Pua Heimuli. Photos: DLNR.

Hono O Nā Pali Natural Area Reserve entry. Photo: DLNR.

Conservation management

Management of areas for conservation values involves many types of activities such as control or exclusion of harmful invasive species, managing occurrence and impacts from wildfire, restoration of native plant communities and rare species, reducing downslope erosion and flooding, removing marine debris, and enforcement of hunting and fishing rules.

Workers on the Moloka'i fence crew. Photo: DLNR.

Management metrics

- Areas actively managed to reduce the impacts of non-native species
- Species and ecosystem recovery management and restoration actions
- Statewide biosecurity efforts to reduce introduction of invasive species
- Management actions to control or eliminate impacts of invasive species
- Efforts to control forest and wildlife diseases
- Partnerships established to manage conservation landscapes and seascapes

Management capacity has expanded beyond government agencies to include private-public collaborative watershed partnerships, invasive species committees, community-based stewardship groups, and diverse networks of agencies, organizations, and landowners that work together for the protection of vast landscapes and nearshore seascapes.

Workday at Huilua Loko I'a (fishpond), Kahana, O'ahu.
Photo: Mark Lee courtesy of KUA.

Among the main terrestrial ecosystem threats are hoofed animals such as cattle, pigs, goats, sheep, and deer which destroy forest vegetation through grazing, trampling, and rooting for food, leaving grounds bare and soils exposed; invasive weed species that can take over a once-native forest and impact its efficacy in water collection; wildfire; and forest pests and disease – all of which impact forest ecosystem health, functionality, and diversity. Additionally, predators such as rats, cats, and mongoose threaten birds, snails and plants with extinction, and avian diseases threaten the continued existence of native forest birds. Nearshore marine resource threats include over-exploitation, land-based sedimentation, pollution, invasive species, disease, and changing climate.

Across the State, large reforestation projects have begun and are expanding with the potential for generating carbon offset credits which can help to partially fund forest restoration. As of 2020, approximately 17% of the remaining wet and mesic native forests in Hawai'i were protected by fences to reduce impacts from hoofed animals. During the 2016 IUCN World Conservation Congress, then Hawai'i Governor David Ige announced a Sustainable Hawai'i Initiative goal with the Aloha+ Challenge to protect at least 30% of priority watersheds and nearshore marine ecosystems by 2030. Although management is more difficult in the marine environment, restoration of Hawaiian fishponds is occurring in many sites, such as He'eia on O'ahu, as well as programs to control invasive seaweed on coral reefs. Protection designations of the nearshore waters along selected coastlines help to reduce disturbance by human activity.

Cultural values as the foundation for community management [2]

Community and stakeholder involvement and support are critical to achieving effective conservation of our natural biocultural resources. Hawaiian cultural values and practices that are strongly protective of natural resources provide a solid foundation to help navigate the challenges of conservation today and into the future.

Cultural and community metrics

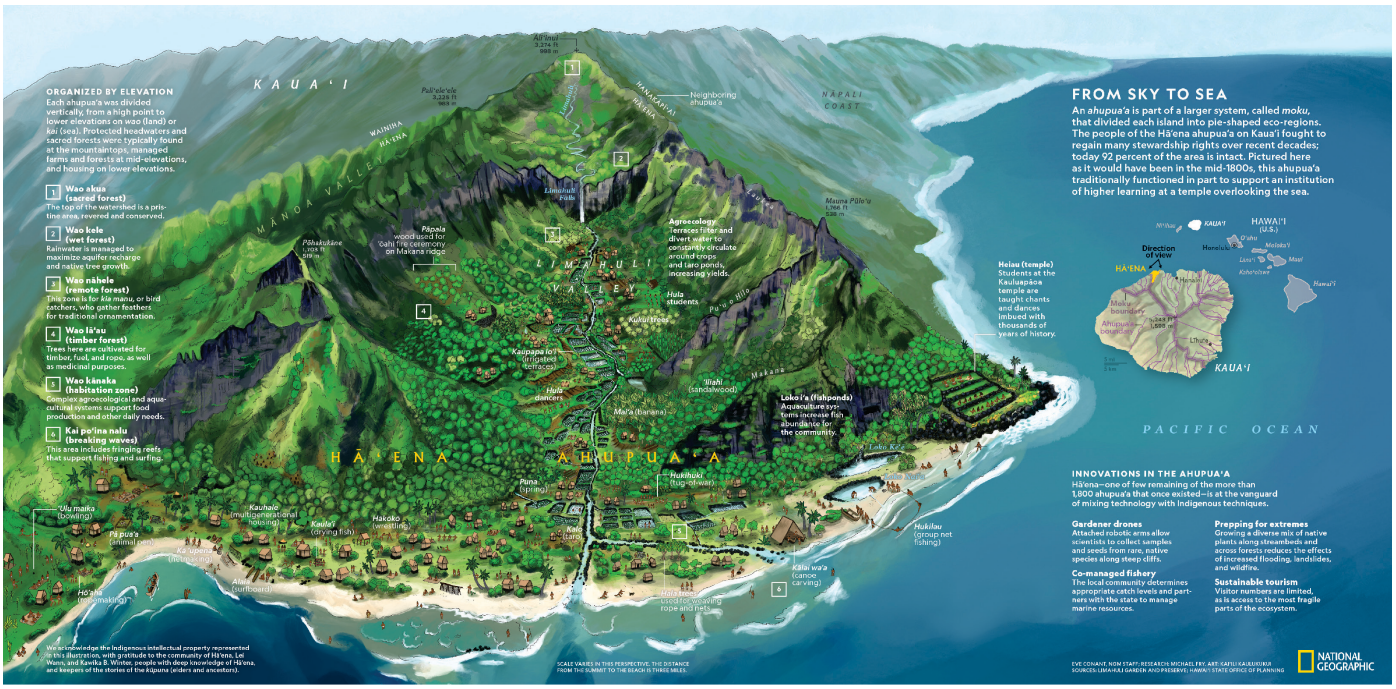
- Efforts to integrate Hawaiian cultural values with biodiversity management
- Community-based collaborative conservation efforts
- Conservation capacity to engage in management
- Conservation knowledge sharing, education, and outreach programs

Community volunteers at Kahanahāiki. Photo: ANRPO.

In a Kanaka 'Ōiwi (Native Hawaiian) worldview, kānaka (humans) are descendants of 'āina (land, sea, and sky), inclusive of the plants, animals, and ecological processes therein. Kānaka 'Ōiwi know 'āina as the shared ancestor that provides the foundations upon which all life in Hawai'i is maintained. The health of 'āina is inherently and reciprocally related to the well-being of its people, and therefore 'Ōiwi knowledge, practice, and identity are rooted in a reciprocal caring relationship with land and ocean.

Indigenous resource management (IRM), is the millennia-old foundation upon which community-based management in Hawai'i is built and applied. Applications of IRM in Hawai'i take the form of decentralized, but carefully organized, management built around ahupua'a – a Hawaiian conceptualization of community that extends

[2] Hawai'i Conservation Alliance Position Paper: Hawaiian Culture and Conservation in Hawai'i.



Conceptual diagram showing moku and ahupua'a divisions on an island in Hawai'i. Credit: National Geographic.

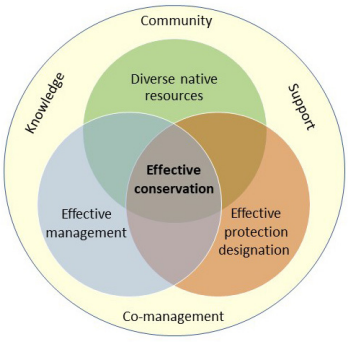
from the uplands into the sea, and that perceives humanity as a part of that living community. Within this context, resources were managed for abundance ('āina momona) for the benefit of ahupua'a residents. This was achieved by collaboratively managing species connectivity and population dynamics between ahupua'a in the context of their moku (larger island district). The mechanisms for governing human behaviors and actions was a system of kapu (sacred restrictions) and kānāwai (regulations to access scaredness), which had many forms, but ultimately served the function of maintaining stability and abundance in the system. The konohiki (person in charge of an ahupua'a) played a keystone function in Hawaiian IRM. It was their role to have intimate understanding of the population dynamics of all resource species from the mountains to the sea. To function in their role, they needed to possess an ability to invite cooperation to connect the will of the ali'i (regional chief) with the capacity of the maka'āinana (general population).

These traditional practices and perspectives of resource management profoundly inform contemporary community-based conservation efforts. Within the context of co-management efforts, contemporary community organizations fulfill the role of konohiki, and connect government agencies with the Native Hawaiian and local communities around the State to restore and maintain biocultural resource abundance.

Assessing effective conservation

Effective conservation is recognized as a combination of conditions that, when enacted together, ensure that native ecosystems and species have the highest likelihood of being sustained and viable into the future.

The main conditions contributing to effective conservation are: 1) presence of diverse conservation resources, typically native ecosystems and/or species; 2) protective designation applied to an area with the intent to limit incompatible land uses and enable or facilitate conservation management; 3) active management to prevent or offset resource threats, and enhance viability of



Conceptual diagram showing the key components of effective conservation. Source: Jim Jacobi.

ecosystems and species; and 4) all of these elements within the context of knowledgeagle and supportive communities that are actively involved with co-management of the biocultural resources.

Effective conservation can be considered successful when an important conservation area receives protective designation that enables active management that controls threats and leads to sustaining the conservation targets in the area. The long-term success of such management depends strongly on community and public involvement and support, which in turn feeds back into long-term management of the area, maintaining protected status designation, and continuing active care of the conservation targets.

Put another way, effective conservation is achieved when long-term, protective designation and threat management, supported by stakeholders and the community, results in an established record of stable or expanding native biodiversity and ecological processes in an area of conservation significance.

The photo to the left shows a pristine native wet forest that is protected and managed for threats in the Pu'u Ali'i Natural Area Reserve on the island of Moloka'i. This area is an important part of Moloka'i's watershed and provides managed and protected habitat for 37 rare plants and 7 rare animals.

A major goal of the Hawai'i Conservation Alliance's status assesment is to map areas on land and in the nearshore ocean to determine where resource value, protection status, conservation management, and community support occur and overlap. This information can then be used to identify other important resource areas that need additional protection or management to maintain the viability of the native species and habitats found there.

Native 'ōhi'a wet forest in the Pu'u Ali'i Natural Area Reserve, Moloka'i. Photo: Jim Jacobi, USGS.

Status of biodiversity and biocultural resources

Summary of plant and animal species in Hawai'i

A summary of native and established introduced species in Hawai'i has been compiled by the Bishop Museum's Hawaii Biological Survey since 1994. This list is regularly updated to locate, identify, and evaluate native and non-native fauna and flora found throughout the state. **The current list identifies a total of 15,266 native species, 61% of which are endemic to the Hawaiian Islands, and an additional 6,014 introduced species that are now established in the wild.**

Unfortunately, over 200 native species of Hawaiian plants and animals are believed to have gone extinct during the past 200 years and 546 are listed as either Endangered or Threatened by the U.S. Fish and Wildlife Service and the State of Hawaii. Equally concerning is the fact that over 10,000 species have been introduced, either on purpose or accidentally, into these Islands since human occupation, and this number increases every year. While many of these introduced species have not yet escaped into the wild, there is a growing number of both plants and animals that have become established (naturalized), and many are considered to be highly invasive with the ability to cause major impacts on the native ecosystems.

Taxon	Endemic	Percent Endemic	Native	Total Native	Threatened or Endangered	New Native Species (2000–2020)	Naturalized Non-native Species	Total Species
Flowering plants	956	90%	101	1,057	402	33	1,624	2,681
Bryophytes, leucophytes & ferns	326	54%	281	607	23	8	67	674
Cnidarians (corals, jellyfish, etc.)	118	32%	253	371	–	15	47	418
Mollusks – terrestrial and fresh water	769	98%	17	786	45	8	84	870
Mollusks – marine	338	27%	929	1,267	–	23	53	1,320
Annelids	112	28%	283	395	–	16	33	428
Crustaceans	57	4%	1,241	1,298	3	39	109	1,407
Echinoderms	153	49%	159	312	–	3	–	312
Other invertebrates	441	27%	1,192	1,633	–	1	61	1,694
Insects	5,501	98%	107	5,608	27	358	3,103	8,711
Other arthropods (spiders, mites, etc.)	356	85%	61	417	1	22	625	1,042
Fishes	59	5%	1,170	1,229	–	33	104	1,333
Amphibians	–	0%	–	–	–	–	7	7
Reptiles	–	0%	4	4	4	–	26	30
Forest birds	54	100%	–	54	25	–	–	54
Waterbirds	3	9%	30	33	4	–	–	33
Shorebirds	–	0%	34	34	–	–	–	34
Seabirds	2	3%	59	61	5	–	–	61
Other birds	4	36%	7	11	5	–	53	64
Mammals – terrestrial	1	100%	–	1	1	–	18	19
Mammals – marine	1	4%	25	26	1	–	––	26
TOTAL	**9,251**	**61%**	**5,953**	**15,204**	**546**	**559**	**6,014**	**21,218**

Data from **Hawaii Biological Survey**, Bishop Museum, Honolulu, HI; **Threatened or Endangered status from U.S. Fish and Wildlife Service.**


Photo: Amy Durham

One group not included in this summary table are the fungi which comprises a large, diverse group of organisms that are extremely abundant and widespread globally, including in Hawai'i. Although often overlooked, they are vitally important to ecosystems for their roles in nutrient cycling and range of symbioses with other organisms. Due to their usually microscopic size and cryptic life histories, inventories of fungi are incomplete globally, and the same is true for Hawai'i. One of the best-studied groups is the Agaricomycetes, a class of mushroom-forming fungi. Estimates of native Hawaiian Agaricomycetes species find endemism rates of 80–88%, including the endemic species *Hygrocybe noelokelani* (photo at left), listed by IUCN as endangered and found only in wet montane forests on the islands of Hawai'i and Kaua'i.

Preventing extinction of very rare species

There are several very important programs actively working to prevent the extinction of species that have populations so small they cannot be maintained in their natural habitats without extraordinary management. These efforts include:

- Collecting seeds and cuttings, eggs, and individuals for propagation
- Intensive local management in the field
- Reintroducing them back into the wild

Hawaiian snail propagation. Photo: Hawai'i Snail Extinction Prevention Program.

Plants

Of the 1,664 native plant taxa (species, subspecies, and varieties) known from Hawai'i, 425 are listed as Endangered by the U.S. Fish and Wildlife Service, and another nine are considered Threatened. However, over half (868) of native Hawaiian plants are considered to be "species of conservation importance". This is a broad category that includes not only rare species, listed or not, that are vulnerable to extinction, but also keystone species that are critical to the maintaining the structure and function of ecosystems and species that are important because of their cultural significance (Laukahi Network).

A: ***Cyanea grimesiana*** **subsp.** ***grimesiana.*** Photo: Tim Kroessig.

B: ***Hibiscadelphus woodii.*** Photo: Ken Wood, NTBG.

The Plant Extinction Prevention Program (PEPP) works to save the rarest of the rare native Hawaiian plants, focusing on over 270 taxa with 50 or fewer individuals remaining in the wild, another 78 that appear to have declining populations, and 45 more that may be more common on one island but rare on another. These species appear to be in imminent risk of extinction with a heightened need to protect all remaining plants. PEPP botanists on each island find and manage these species by collecting propagules, protecting their

habitats, outplanting plants grown in partner greenhouse facilities, monitoring extant populations, and surveying for new populations. The advancement of climbing technology in recent years, aided by the use of drones, has allowed for the re-discovery of previously presumed extinct species, like *Hibiscadelphus woodii* (photo on page 14) in a very remote location on the island of Kaua'i.

Propagation in greenhouse facilities is a very important step in the process of maintaining the genetic diversity of rare plant populations, especially when the number of wild mature individuals has severely declined. As natural resource managers can effectively protect a vulnerable species' habitat, stored seeds and greenhouse-grown plants can then be reintroduced into the wild. A coalition of botanical gardens, coordinated through the Laukahi Network, has been instrumental in helping to save Hawaiian plant species from extinction through *ex-situ* propagation. Additionally, greenhouse culture of more common native plants provides seeds and seedlings that can be outplanted into managed habitats to help restore the native plant communities. As of 2021, thousands of seedlings from 581 plant taxa that were propagated in cultivation, have been planted in various sites in the wild.

Growing native plants for restoration. Photo: Tim Kroessig.

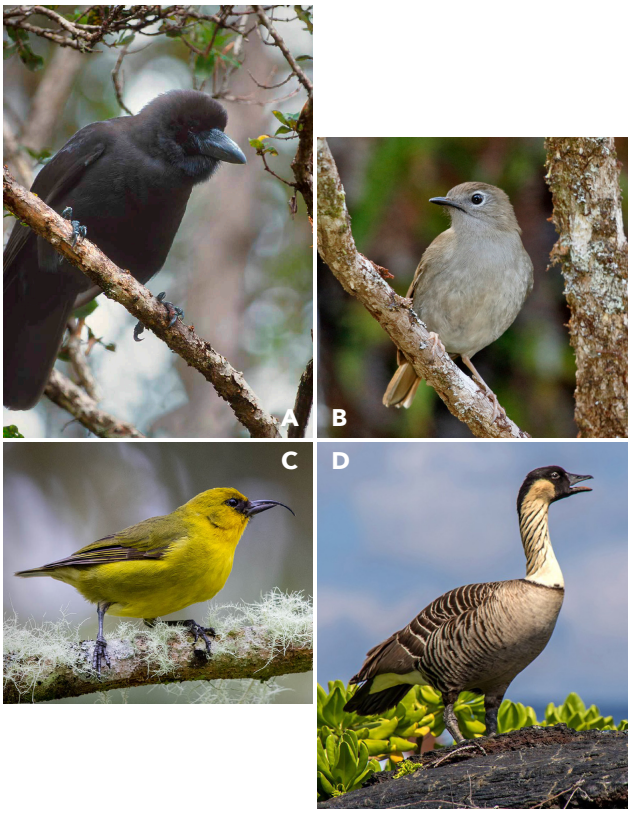
Birds

The Hawai'i Endangered Bird Conservation Program (HEBCP) works to prevent extinctions and promote recovery of wild bird populations using intensive techniques such as conservation breeding, reintroductions, and post-release support and monitoring. Since its inception in 1993, the HEBCP has cared for 16 different Hawaiian bird species and been involved in the hatching of over 1,420 eggs, rearing of over 1,150 nestlings, and releasing of over 840 birds into the wild.

Currently, the HEBCP focuses on rearing and supporting 'Alalā, which was saved from extinction by increasing the population from fewer than 20 individuals alive in the 1990s, to a peak of over 140 alive a few years ago. The HEBCP also currently focuses on 'Akikiki, which were successfully collected from the wild from 2015–2018 to initiate a conservation breeding program.

The parent organization of the HEBCP is the San Diego Zoo Wildlife Alliance, and activities are conducted throughout Hawai'i in close collaboration with the U.S. Fish and Wildlife Service, Hawaii Division of Forestry and Wildlife, and many partners throughout the community.

Nine species of forest birds, including the 'Alalā ("A" at right), Puaiohi ("B" at right), 'Akiapola'au ("C" at right), as well as the Nēnē (Hawaiian goose, "D" at right), and Koloa (Hawaiian duck) have been successfully bred in captivity and released back into



A: 'Alalā (Hawaiian Crow). Photo: © JackJeffreyPhoto.com.
B: Puaiohi. Photo: © JackJeffreyPhoto.com.
C: 'Akiapola'au. Photo: © JackJeffreyPhoto.com.
D: Nēnē (Hawaiian Goose). Photo: J. Wei, National Park Service.

the wild. Maintaining genetically viable populations in captivity and releasing birds back into wild habitats that are being managed to control threats are key components of conservation programs to save these declining species.

The Nēnē was once found on most of the larger Hawaiian Islands including Kauai, Moloka'i, Maui, and Hawai'i Island and may have numbered in the 20,000s prior to European settlement. Nēnē populations declined sharply due to a combination of hunting by humans and predation by introduced cats and mongoose, and by 1951, only 30 birds remained in Hawai'i. Starting in the 1950s, captive breeding programs were initiated in Hawai'i and zoos elsewhere to bolster the declining population. Nēnē were listed as Endangered by the U.S. Fish and Wildlife in 1967 and propagation efforts were increased by both the State and National Park Service with releases of birds on Maui and Hawai'i. The combination of captive breeding, habitat restoration, and active management have resulted in a current population of Nēnē estimated at 2,800 birds, leading to the downlisting of this species to Threatened status in 2019.

Snails

Over 750 species of terrestrial snails have been described and many were previously found commonly in the Hawaiian Islands, representing one of the most stunning examples of species radiations in the world. Sadly, it is estimated that over 90% of this diversity has been lost. Introduced ungulates such as pigs, goats, and deer degrade forest vegetation and fragment snail populations. In addition, predators such as rats, the rosy wolf snail (*Euglandina rosea*), and Jackson's chameleons all attack and kill Hawai'i's native snails.

To meet this dramatic decline in Hawaiian biodiversity, the Snail Extinction Prevention Program (SEPP) was created by the Hawaii Division of Forestry and Wildlife to protect Hawai'i's imperiled snail fauna. The SEPP Program, along with researchers at Bishop Museum, University of Hawai'i, and other organizations, serves to monitor, provide predator control, and habitat protection for snail species currently facing extinction. This program has been able to maintain and propagate 36 species of Hawaiian snails and successfully reintroduce seven species back into managed habitat in the wild.

Currently, Hawaiian snails that are reared in captivity can only be reintroduced into suitable forest habitat that has been protected by secure fences that exclude introduced animals including rats, cannibal snails, and other predators that feed on these spectacular jewels of the Hawaiian forest. An example of one of the intensively managed reintroduction sites is shown on the right.

Several spectacular species of Hawaiian tree snails.
Photos: Hawai'i Snail Extinction and Extinction Program.

Hawaiian tree snail management area.
Photo: Dave Sischo.

A: Native yellow-faced bee. Photo: Will Haines/ Cynthia King.
B: Kamehameha butterfly. Photo: Will Haines/Cynthia King.
C: Native damselfly (*Megalagrion blackburni*). Reuben Wolff image.

Arthropods

Hawai'i is home to over 5,000 described native terrestrial and aquatic arthropods, including insects, spiders, and several other related groups, and it is believed that there are perhaps thousands more that await discovery. Native arthropods provide essential ecological services: Hawaiian plant species could not exist without the pollination services and nutrient cycling which native arthropod communities provide, and Hawaiian birds and bats have evolved to depend on these diverse native arthropods for food resources.

Habitat loss and alteration, the introduction of non-native species, direct human uses, and climate change are current and expanding threats to Hawaiian invertebrates. The Hawaii Department of Land and Natural Resources' Hawaii Invertebrate Program (HIP) conducts research and management in conjunction with the U.S. Fish and Wildlife Service and researchers at the University of Hawai'i that focuses on Threatened or Endangered or otherwise rare native arthropod species with the goal of increasing populations of target species in habitat currently suitable for survival, as well as stabilizing and restoring habitat to support species reintroductions. HIP has worked in partnership with researchers and managers from the U.S. Fish and Wildlife Service and the University of Hawai'i to conduct captive propagation and translocation projects with Kamehameha butterfly, orange-black damselfly, and yellow-faced bees, and is expanding to work with additional damselflies, leafroller months, and picture-wing flies.

Wildlife rehabilitation

The Hawaii Division of Forestry and Wildlife permits and regulates wildlife rehabilitation in the State of Hawaii in combination with United States Fish and Wildlife Service Migratory Bird Treaty Act. There are currently two permitted rehabilitation facilities in the state of Hawai'i for birds, Save our Shearwaters (SOS) in Kapa'a, Kaua'i, and the Hawai'i Wildlife Center (HWC) in Kapa'au, Hawai'i Island and both focus on caring for injured native

Injured 'ōpe'ape'a (Hawaiian hoary bat) being examined. Photo: DLNR.

'A'o (Newell's Shearwater) getting cleaned. Photo: Hawai'i Wildlife Center.

Hawaiian species of birds and the Hawaiian hoary bat. Additionally, the Marine Mammal Center: Ke Kai Ola on Hawai'i Island is permitted for Hawaiian Monk Seal rehabilitation. In addition, DOFAW and USFWS permit other individuals or organizations for rehabilitation of specific species or short-term stabilization.

Save our Shearwaters (SOS) has been in operation since 1979 and has been integral for the response to downed and injured endangered *'A'o* (Newells Shearwater) and *'Ua'u* (Hawaiian Petrel) on Kaua'i. In addition, SOS has done substantial work with *'Ua'u kani* (Wedge-tailed Shearwater), *Nēnē* (Hawaiian Goose) and *Mōlī* (Laysan Albatross). They regularly care for over 400 birds per year, with most of them taken in during seabird fallout season in the fall.

Since opening in 2012, the Hawai'i Wildlife Center has partnered with local veterinarians and conservation organizations, including the SOS program on Kaua'i, to respond to wildlife care needs on throughout the state. Care of HWC patients is centralized at the main wildlife hospital in Kapa'au on Hawai'i Island, in conjunction with partners and volunteers throughout the state. The HWC cares for all native Hawaiian bird species as well as the 'ōpe'ape'a (Hawaiian hoary bat). Since its inception HWC has overseen the care of over 1,800 native birds representing over 40 different species, with 820 of those 1,800 patients seen in 2020 alone.

The Marine Mammal Center: Ke Kai Ola which opened in 2014 is the only hospital dedicated to treating and rehabilitating Hawaiian monk seals in Hawai'i. They provide veterinary care and long-term rehabilitation on injured or orphaned seals. They collaborate with state and federal agencies and other organization to take care of seals throughout the main Hawaiian islands and the Northwest.

Wildlife rehabilitation programs provide much needed medical care to native Hawaiian species and provide a resource of expertise in captive care of these species. They also involve the public in following the care of patients, which helps to improve awareness of native Hawaiian species and the challenges they face. The programs also provide educational opportunities to the local community through community events, volunteer opportunities and internship programs. In addition, they provide critical support and quick response capacity for emergency events such as oil spills and disease outbreaks.

Bonin petrel at Midway. Photo: Alex Wang.

Status of terrestrial ecosystems

While the Hawaiian Islands may often be thought of as being covered by wet forests, only 26% of the landscape has been mapped as wet habitat while most (45%) is considered to be dry habitat. The rest of the area (29%) lies within the moist habitat zone.

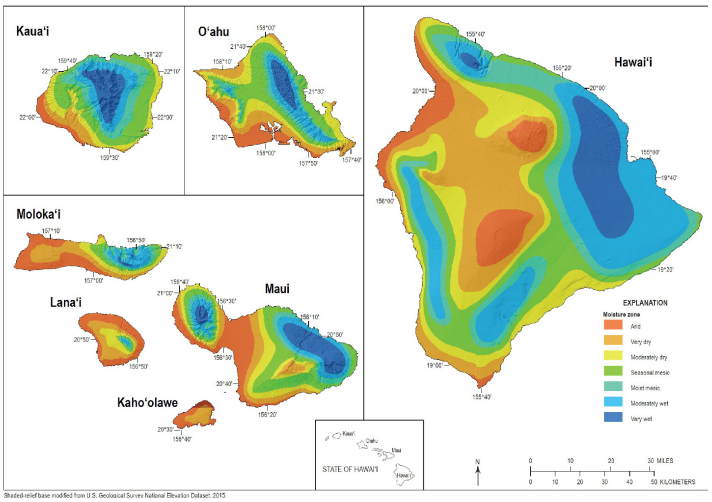
Before humans first came to Hawai'i, it is estimated that nearly 85% of these islands were covered with vegetation – ranging from lush mossy rainforests to coastal shrublands. The remaining lands were another unique ecosystem of barren lava, alive with pioneering insects and young plants. Today, less than half of the natural vegetated lands of Hawai'i remain, with most of this change in the lowlands. Most striking has been the loss of the native dry forests, which have been almost completely destroyed by wildfires, invasive plants, or hooved animals. These systems have been largely replaced by development, agriculture, or large areas of fire-prone non-native vegetation. The remaining third of our islands that still is dominated by native vegetation is almost entirely in upland rainforests. On Maui and Hawai'i, large tracts of subalpine shrublands also remain.

Although large areas on the main Hawaiian Islands are identified as degraded ecosystems, many of these habitats still have remnant populations of native plants and animals. Habitats in this category may be important sites where plant community restoration may be needed to protect native species that are only found in this zone.

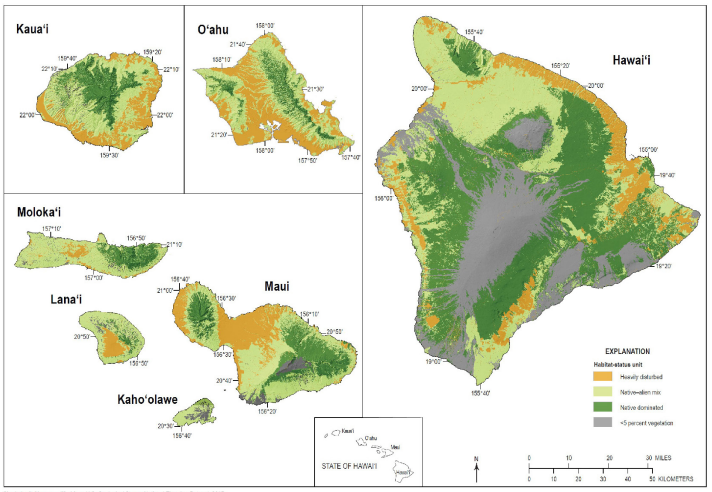
The status of biodiversity habitats was evaluated in 2010 as part of the Hawai'i Statewide Assessment of Forest Conditions and Trends. Five condition categories were mapped:

- Intact native ecosystems with highest diversity
- Intact native ecosystems with lower diversity
- Rapidly degrading ecosystems with high diversity
- Degraded ecosystems with limited diversity
- Areas where native ecosystems no longer exist

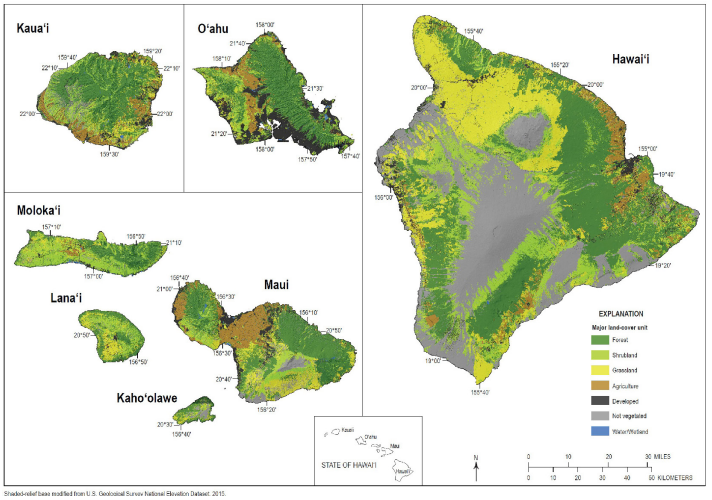
These maps will help focus attention on key conservation actions needed in high biodiversity areas that need added protection and management



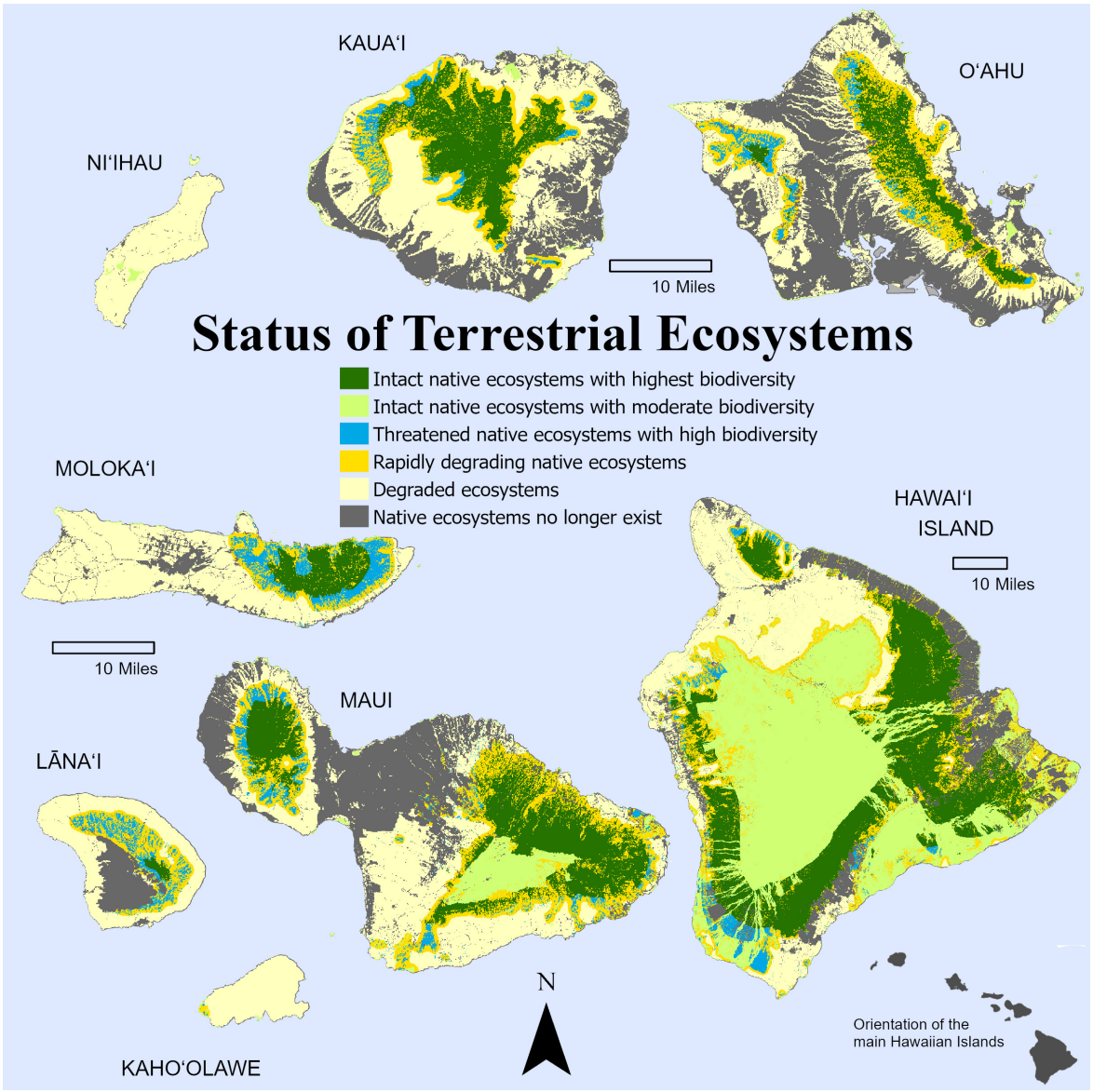
Moisture zones for the main Hawaiian Islands.
Source: **Price *et al.* 2012**.



Status of habitats on the main Hawaiian Islands.
Source: **Jacobi *et al.* 2017**.



Major land cover across Hawai'i. Source: **Jacobi *et al.* 2017.**



Status of native plant communities and habitats for the main Hawaiian Islands. Based on data compiled by J. Price, J. Jacobi and The Nature Conservancy of Hawai'i for the **Hawaii Statewide Assessment of Forest Conditions and Trends: 2010.**

Island	Intact Native Ecosystems with Highest Biodiversity	Intact Native Ecosystems with Moderate Biodiversity	Rapidly Degrading Ecosystems	Degraded Ecosystems	Native Ecosystems No Longer Exist
Kaua'i	23%	1%	14%	38%	25%
O'ahu	12%	1%	14%	30%	43%
Moloka'i	22%	1%	10%	58%	9%
Lāna'i	13%	0%	20%	46%	21%
Maui	23%	6%	17%	28%	26%
Kaho'olawe	0%	1%	2%	97%	0%
Hawai'i	24%	37%	12%	18%	10%
Status total	**22%**	**24%**	**13%**	**24%**	**17%**

Summary of the status of natural plant communities and associated resources by island and for the State. Data from the Hawaii Statewide Assessment of Forest Conditions and Trends: 2010.

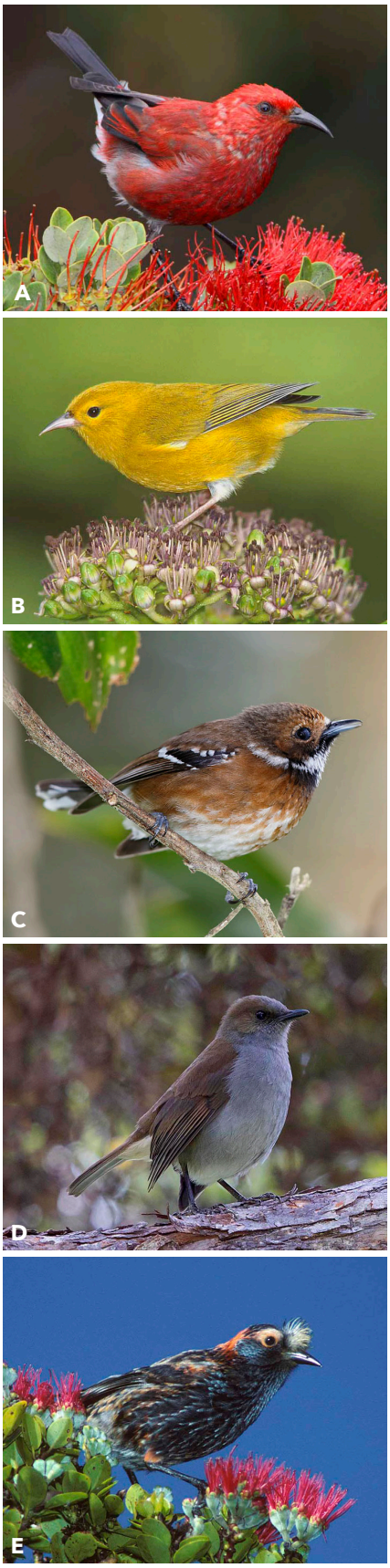
Status of native forest birds and Hawaiian bat

In an evolutionary supernova beginning about 5 million years ago in the Hawaiian archipelago, emerged an estimated 110+ Hawaiian bird species from only 20 colonizing events. Released from limiting resources, competitors, predators and most parasites and diseases resulted in rapid adaption and speciation, and the highest globally documented bird densities of 1,500–3,000 birds/km2 (3,900–7,680 birds/mi²). Within the Hawaiian songbirds, adaptive radiation resulted over 70 endemic species or sub-species. Of this astounding diversity of songbirds, one is extinct in the wild and only 24 species and sub-species still exist with three of those occurring only in the Northwest Hawaiian Islands.

There was a sharp decline in Hawaiian forest birds after Polynesian colonization and again after Western contact with continued declines resulting in the recent listing of 'Akikiki and 'Akeke'e and 'I'iwi as an endangered species by the U.S. Fish and Wildlife Service. Dramatic declines have also been seen in the endangered Kiwikiu and 'Ākohekohe with the reduction of 71% and 78% respectively of area occupied since 2001. The endangered Palila now occurs on just 5% of its historic range and has declined to an estimated 678 individuals.

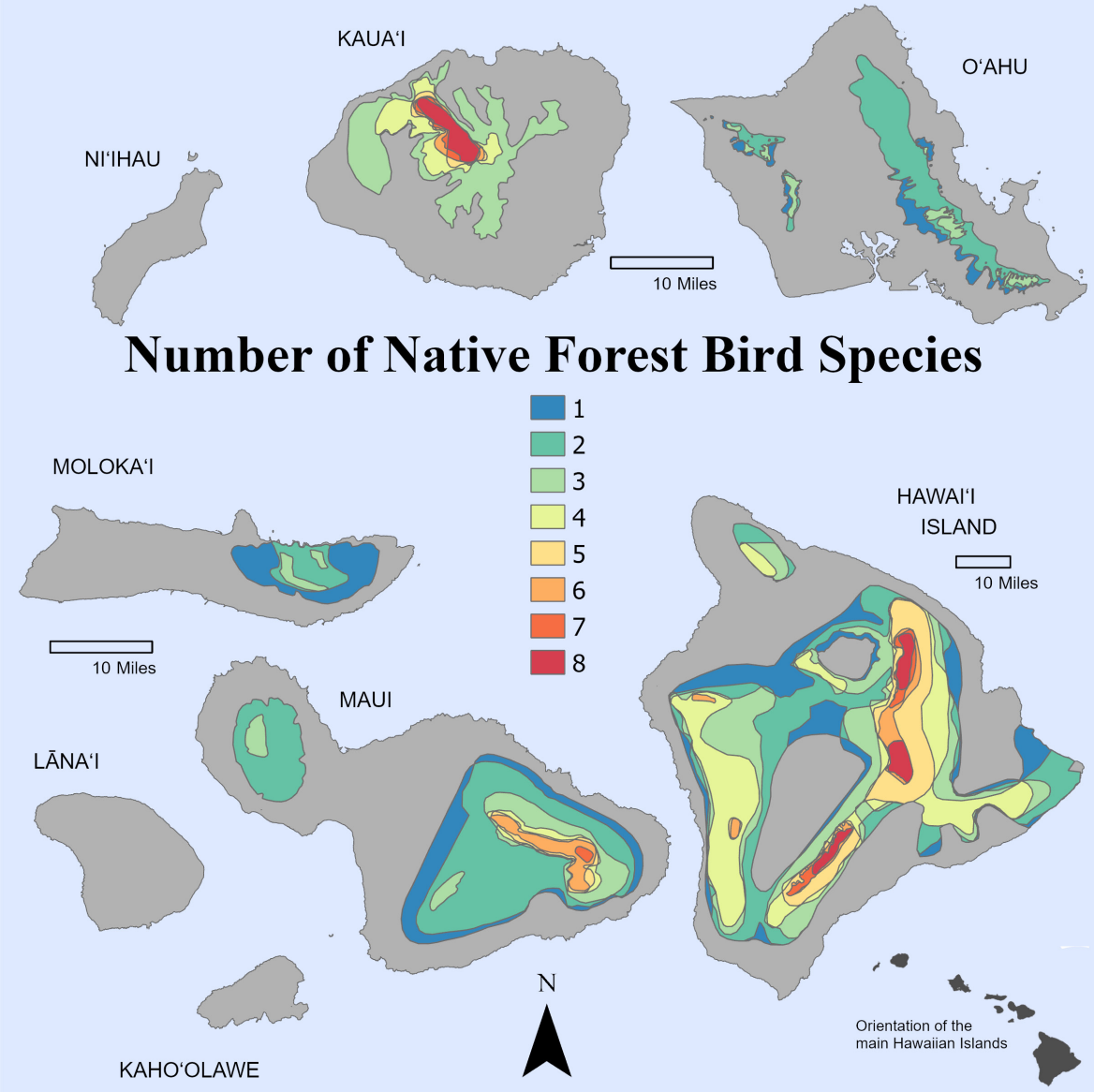
Many of the remaining songbirds are island endemics (that is, species found nowhere else) with Hawai'i Island having the greatest remaining native species richness (8 species; see map on page 22). Abundances of the surviving endemics span from a few hundred individuals to more than a million individuals. The rarest, endangered species range from just a few hundred 'Akikiki and Puaiohi on Kaua'i, O'ahu 'Elepaio, and Kiwikiu on Maui, to a few thousand 'Akeke'e on Kaua'i, 'Ākohekohe on Maui, and Palila and 'Akiapōlā'au on Hawai'i Island. Island endemic species and subspecies[3] numbering between 5,000 and 50,000 birds include the Kaua'i 'Amakihi, 'Anianiau, Hawai'i 'Alauahio, and Hawai'i 'Ākepa. More abundant are the Kaua'i and Hawai'i 'Elepaio, 'Ōma'o on Hawai'i, Hawai'i 'Amakihi on Maui and Molokai, O'ahu 'Amakihi, Maui 'Alauahio, and 'I'iwi numbering between 50,000 and 500,000 individuals. Hawai'i 'Amakihi on Hawai'i Island numbers more than 800,000 birds and 'Apapane remains the most abundant species at more than 1,300,000 individuals.

Since human colonization of the Hawaiian Islands the native avifauna has been impacted through hunting, introducing predators and avian diseases, and the destruction or degradation of important habitats (Pratt *et al.* 2009). Hunting, predation, and habitat modification likely caused the extinction of whole families of birds, such as the four species of moa-nalo and seven species of Rallidae, and significantly reduced other families of birds. Conversion of habitat to taro and cane fields, agriculture, and urbanization have altered most low elevation habitats on all islands. Habitat degradation by feral ungulates, invasive plants, and ranching have adversely impacted montane and sub-alpine habitats. Introduced avian diseases and their vectors have pushed native songbirds into high elevation refugia, which are now threated by Rapid 'Ohi'a Death and the climate



A: 'Apapane. B: 'Anianiau. C: 'Elepaio. D: 'Ōma'o. E: 'Ākohekohe.
All photos: © JackJeffreyPhoto.com

[3] For more information: dlnr.hawaii.gov/wildlife/birds/; www.fws.gov/project/saving-hawaiis-forest-birds



Density of forest bird species in the main Hawaiian Islands; based on species distribution maps summarized in Pratt *et al.* (2009) except for four species that were more recently updated by Judge *et al.* (2019) and one species on Hawai'i Island by Camp *et al.* (2009).

Hawai'i 'Ākepa.
Photo: © JackJeffreyPhoto.com.

Kaua'i 'Amakihi.
Photo: © JackJeffreyPhoto.com

crisis. As the climate warms, avian diseases are rapidly expanding into those refugia, and changing precipitation patterns and intensifying tropical storms and hurricanes are further stressing bird habitats, prey and nesting resources. Conservation remains a priority for natural resource managers, agencies and non-government organizations, and community outreach programs, such as by Birds Not Mosquitoes and the 'Ōhi'a Love Fest, are essential to protect our remaining forest birds.

Hawaiian hoary bat ('ōpe'ape'a)

The only endemic terrestrial mammal in Hawai'i is a species of bat, the 'ōpe'ape'a (*Lasiurus semotus*). Related to the hoary bat (*Lasiurus cinereus*) from North America, the 'ōpe'ape'a is believed to have become established in Hawai'i a little more than one million years ago and can currently be found on all of the major Hawaiian Islands. It was listed an endangered species in 1970 by both the U.S. Fish and Wildlife Service and the State of Hawai'i.

Unlike many other bat species, the 'ōpe'ape'a is a solitary rooster in trees. It feeds on insects that it captures at night using echolocation while flying. However, due to its nighttime foraging behavior and daytime roosting, there is limited knowledge on its abundance, distribution, and ecology, and it is rare for most people to encounter them. However, recent studies are providing a clearer understanding of some key aspects of this species. Current threats include disturbance of roosting and pupping sites from timber harvest, becoming entangled on barbed-wire fencing, impacts from pesticides, and fatal collisions with vehicles and wind turbines.

Its Hawaiian name, 'ōpe'ape'a, refers to the shape of its wings that resemble the ancient sails (pe'a) of Hawaiian canoes.

For more information: U.S. Fish and Wildlife Service; Pinzari *et al.* 2023.

A: 'Ōpe'ape'a in upside-down roosting position. Photo: Corinna Pinzari, USGS/HCSU.

B: 'Ōpe'ape'a being examined. Photo: DLNR.

Protection of terrestrial systems

Native riparian forest, Helemano, O'ahu. Photo: Will. Weaver.

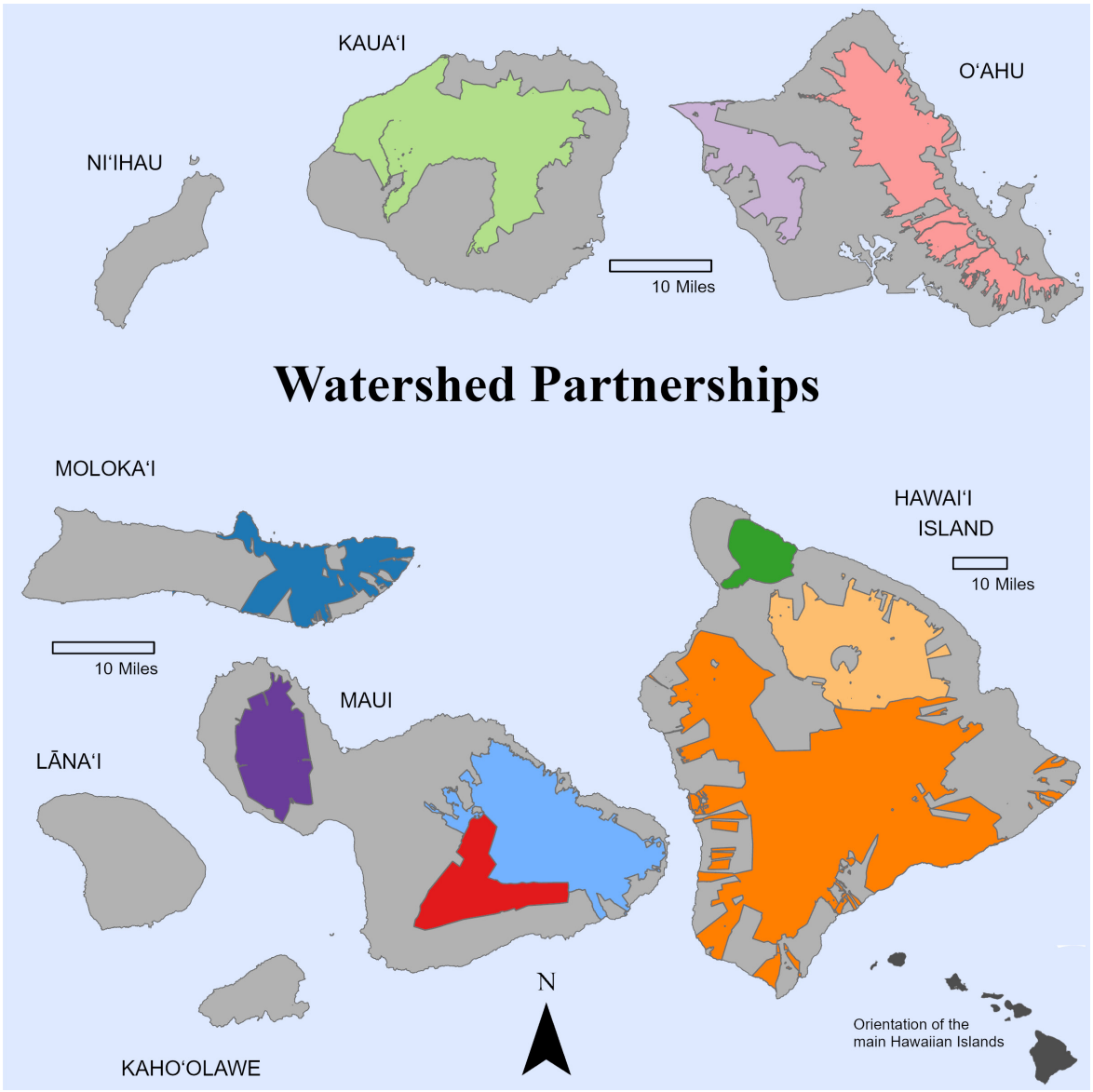
The dramatic losses of Hawaiian forests inspired the designation of State Forest Reserves and National Parks in the early 1900s and continued with the creation of Natural Area Reserves and other preserves, which are aimed to protect representative examples of each native Hawaiian ecosystem type so they could be enjoyed by current and future generations. Federal Refuges and State Wildlife Sanctuaries have also been established to protect Hawai'i's native forest birds. Various large private landowners are also contributing to conservation at the landscape level.

Watershed partnerships

In addition to legal protection status designated by government agencies, partnerships among state, federal, NGOs, and private landowners have come together to form what are known as Watershed Partnerships (WPs) to foster more efficient protection and management of important habitats across ownership boundaries. Although WPs by themselves do not carry legal protection or explicit long-term commitment, many of the lands within their boundaries include areas with official protection designation. Overall, the WPs greatly extend conservation management over areas that include important biocultural resources outside the traditional conservation protection footprint.

Mount Wai'ale'ale Crater, Kaua'i. Photo: Steve Perlman, NTBG.

The Hawai'i Watershed Partnerships are voluntary alliances of public and private landowners and managers that cooperate to protect and manage over nearly 81 million hectares (2 million acres) of forests that supply almost all of the hundreds of millions of gallons of fresh water needed in Hawai'i every year. The first Watershed Partnership was formed in 1991 on East Maui. Working across ownership boundaries, these innovative organizations pool resources to greatly increase efficiency. Each Partnership is independent but all are linked together through the Hawai'i Association of Watershed Partnerships (HAWP). HAWP currently comprises ten island-based Watershed Partnerships that work collaboratively with more than 90 public and private partners on five islands to protect vital forested watershed lands. The Partnerships have their own field work crews, working alongside and filling gaps with the Federal, State, and private land management crews. In many cases watershed partnerships overlap with portions of the two other protection designations and bring additional resources to help manage those areas. As of 2020, a total of 842,047 hectares (2,080,743 acres) of land were included in the combined Watershed Partnerships on five of the main Hawaiian Islands.



Map showing the current boundaries of the ten Watershed Partnerships.

Partnership	Island	Acres	Hectares	Percent of island
Kaua'i Watershed Alliance	Kaua'i	144,113	58,321	41%
Ko'olau Mountains Watershed Partnership	O'ahu	98,541	39,878	26%
Wai'anae Mountains Watershed Partnership	O'ahu	46,440	18,794	12%
East Moloka'i Watershed Partnership	Moloka'i	55,913	22,627	34%
Mauna Kahālāwai Mountains (West Maui) Watershed Partnership	Maui	47,287	19,136	10%
East Maui Watershed Partnership	Maui	119,346	48,298	26%
Leeward Haleakalā Watershed Restoration Partnership	Maui	43,008	17,405	9%
Kohala Watershed Partnership	Hawai'i	73,964	29,932	3%
Mauna Kea Watershed Alliance	Hawai'i	323,915	131,084	13%
Three Mountain Alliance	Hawai'i	1,128,215	456,573	44%
Total for all 5 islands combined		**2,080,743**	**842,047**	**51%**

Table showing the current area of the ten Watershed Partnerships.

Protection designation status

Hawai'i has seen a history of growth of protective designations, from the times of precontact Hawai'i, where the upland wao akua was mostly restricted from human access, and from any but a small set of limited extractive uses. The first major protective designation of modern times was the Forest Reserve system which was established by the Territorial Government of Hawaii in 1903. Creation of the NW Hawaiian Island Seabird Sanctuary followed in 1909 which would eventually be greatly expanded as Papahānaumokuākea Marine National Monument; and Hawai'i Volcanoes National Park, which eventually would be separated into Haleakalā National Park on Maui, and Hawai'i Volcanoes National Park on Hawai'i Island in 1916. Since that time, additional protection designations have been added including: the State Conservation District in 1961, the first of Hawai'i's Natural Area Reserves in the 1970s, the first Preserves of The Nature Conservancy in Hawai'i and the first US Fish and Wildlife Service Forest Bird Refuge in the 1980s, the first Watershed Partnerships in the 1990s, USFWS Critical Habitat for listed endangered species, and the first Community-based Subsistence Fishing Area in the 21st Century at Hā'ena, Kaua'i. Tracking the growth of protective designations is one important way to gauge progress in conservation of our biocultural resources.

For this report we have recognized three protection classes for terrestrial habitats:

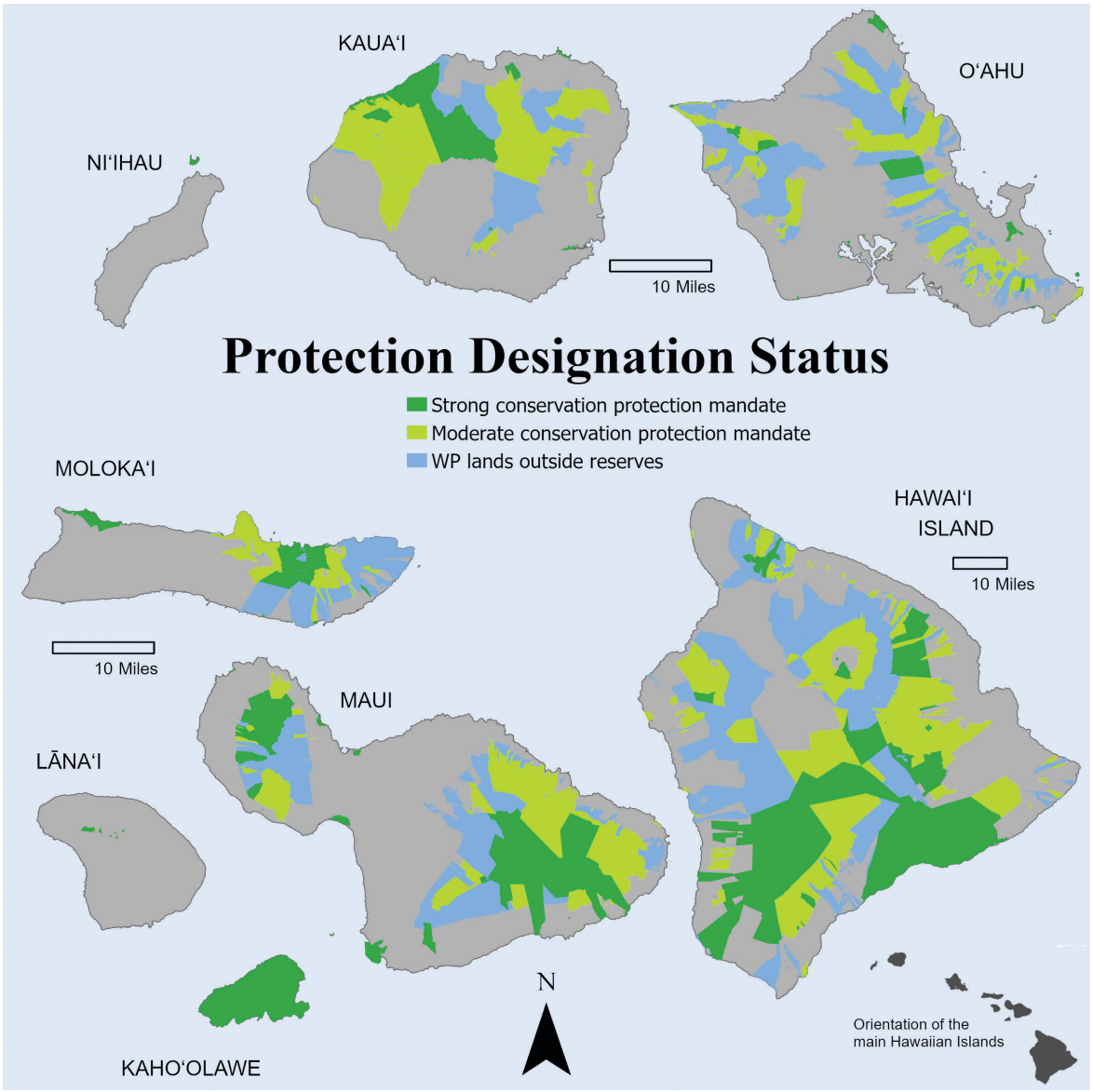
- Strong protection areas with permanent mandates for biocultural resource conservation (e.g., National Parks and Wildlife Refuges, State Natural Area Reserves and Wildlife Preserves)
- Moderate protection areas with short-term protection designation and mandates for multiple use including conservation (e.g., State Forest Reserves, private conservation areas)
- Watershed partnerships which have strong commitments for conservation management but may include areas with limited or no long-term commitment for conservation protection

Each of these categories of protection designation on both land and in the ocean over the past century reflects both an appreciation of the value of our irreplaceable native species and ecosystems, as well as a growing recognition of the great threats that face them. To date, 35 percent of Hawai'i's land area and numerous important marine areas have been assigned some kind of protective designation. This section provides a comprehensive overview of management and conservation efforts in these designated and focus areas, moving from terrestrial to marine habitats.

Change in protection status on the island of Maui

Over the past 50 years we have seen a steady increase in the amount of land that is protected for conservation. This trend is well illustrated by following the expansion of legal protection on the island of Maui from 1970 to 2020. Overall, these efforts by both state and federal agencies, as well as by private landowners has resulted in greater than a five-fold increase in protection areas on Maui, from 5,455 ha to 30,192 ha (13,480–74,606 acres) during this time. Additionally, three watershed partnerships were established on Maui since 1970 adding dedicated conservation management to an additional 56,000 ha (138,380 acres) of land

Clouds moving up the outer slopes of Haleakalā, Maui. Photo: Hank Oppenheimer.



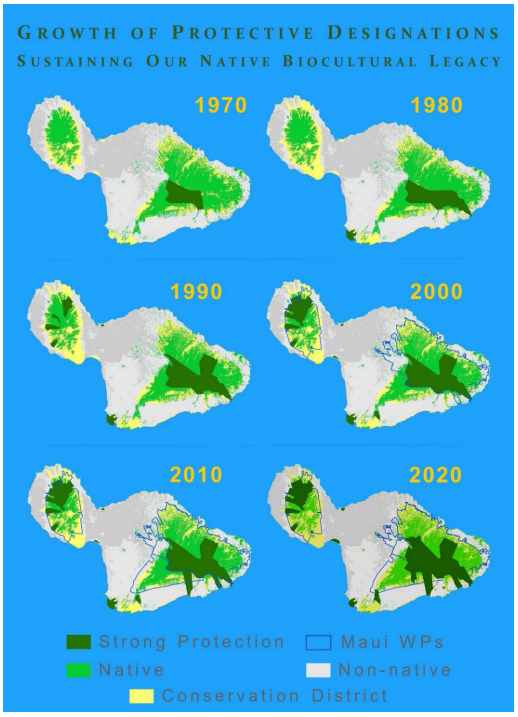
Status of areas with terrestrial conservation protection designation on the main Hawaiian Islands.
Data source: Hawai'i Conservation Alliance.

Protection designation status	Hectares	Acres	Percent of state
Strong conservation protection mandate	288,113	711,942	17%
Moderate conservation protection mandate	292,055	721,683	18%
Strong and Moderate combined	**580,168**	**1,433,625**	**35%**
Additional lands in WP	236,304	583,919	14%
All status types combined	**816,471**	**2,017,544**	**49%**

Size of areas with terrestrial conservation protection designation on the main Hawaiian Islands.
Data source: Hawai'i Conservation Alliance.

beyond strong protection status. Similar trends in expansion of conservation protection status have also been seen for important terrestrial ecosystems on the other main Hawaiian Islands.

While legal designation of lands and waters for protection is a critical step in conservation, this process needs to be coupled with effective management of these areas to achieve the goal of maintaining biocultural resources.



Change in areas with conservation protection status for the island of Maui 1970–2020.
Source: The Nature Conservancy of Hawai'i.

Invasive species impacts and management

Non-native invasive species of plants, animals, and diseases are among the greatest threats to conservation of Hawai'i's biocultural resources and can be seen in both terrestrial and marine ecosystems. Once established, invasive species can become extremely challenging to control or eradicate. Conservation actions used to control invasive species include biosecurity (preventing new introduced species from entering into Hawai'i); early detection (preventing new species from establishing); exclusion of large grazing and browsing mammals (ungulates) and predators from native ecosystems; direct mechanical or chemical control of weeds and disease vectors; and identifying and distributing biological control agents. While this report focuses on invasive species that threaten natural biodiversity resources, there is a great deal of overlap in impacts and control strategies for invasive species that also impact agriculture and human health in Hawai'i.

Snapshot of the status of actions in the Hawai'i Interagency Biosecurity Plan.

Biosecurity

The State of Hawai'i, with a broad coalition of stakeholders led by the Department of Agriculture and the Department of Land and Natural Resources, has adopted the State's first interagency and comprehensive biosecurity plan to protect Hawai'i's agriculture, environment, economy and health. This was developed in collaboration with groups including the Hawai'i Coordinating Group on Alien Plant Species (CGAPS), the federal Biosecurity Task Force, and the Pacific Basin Biosecurity working group.

The scope of the Hawaii Interagency Biosecurity Plan addresses three biosecurity components including pre-border (for example, agreements on handling and treatment of products before they enter the state), border (for example, inspection authorities and technologies), and post-border (for example, tools and capacity for response after invasive species have become established) actions. The benefit of a comprehensive interagency plan is that it facilitates policies and actions across a wide range of agencies and partners. The plan includes 147 specific actions assigned to various agencies and stakeholders, with details on how and when to best implement each action.

There are many challenges involved with developing and implementing an effective biosecurity program. These include funding, capacity building and coordination, public engagement and support, and identifying pathways that invasive species can enter Hawai'i. However, important progress has been made through this program to reduce potential impacts from new species that can be introduced into the State. The most recent accomplishments and recognized remaining needs are summarized in this graphic. More details can be found on the plan and action items in the 2023 Hawai'i Interagency Biosecurity Plan January Progress Report.

Predator impacts and management

Many native bird, invertebrate, and some plant species cannot recover without targeted control of cats, mongoose, dogs, pigs, rats, and mice. All types of birds are being impacted by predators, especially seabirds and waterbirds, which nest on the ground. In addition to the rodents that threaten birds, rare snails are also hunted by carnivorous, non-native snails and the introduced Jackson's Chameleons, which have been released into the wild from the pet trade. In the last few years, populations of Hawai'i's beautiful Kāhuli snails have plummeted and many species have gone extinct as these predators penetrate into the last remaining native snail habitat. Intensively managed predator proof fences are currently the only feasible way these species can remain safe in the wild. An intensive captive rearing program led by the Hawai'i Snail Extinction Prevention Program (SEPP) is breeding and rearing the few remaining Kāhuli individuals that are collected from the wild, and then released back into the small fenced areas. In these eleven small sites, the legacy of these "jewels of the forest" may survive and can be experienced as these colorful and delicate creatures adorn the trees in abundance.

Introduced rat preying on 'ua'u (Hawaiian petrel) eggs. Photo: Archipelago Research and Conservation.

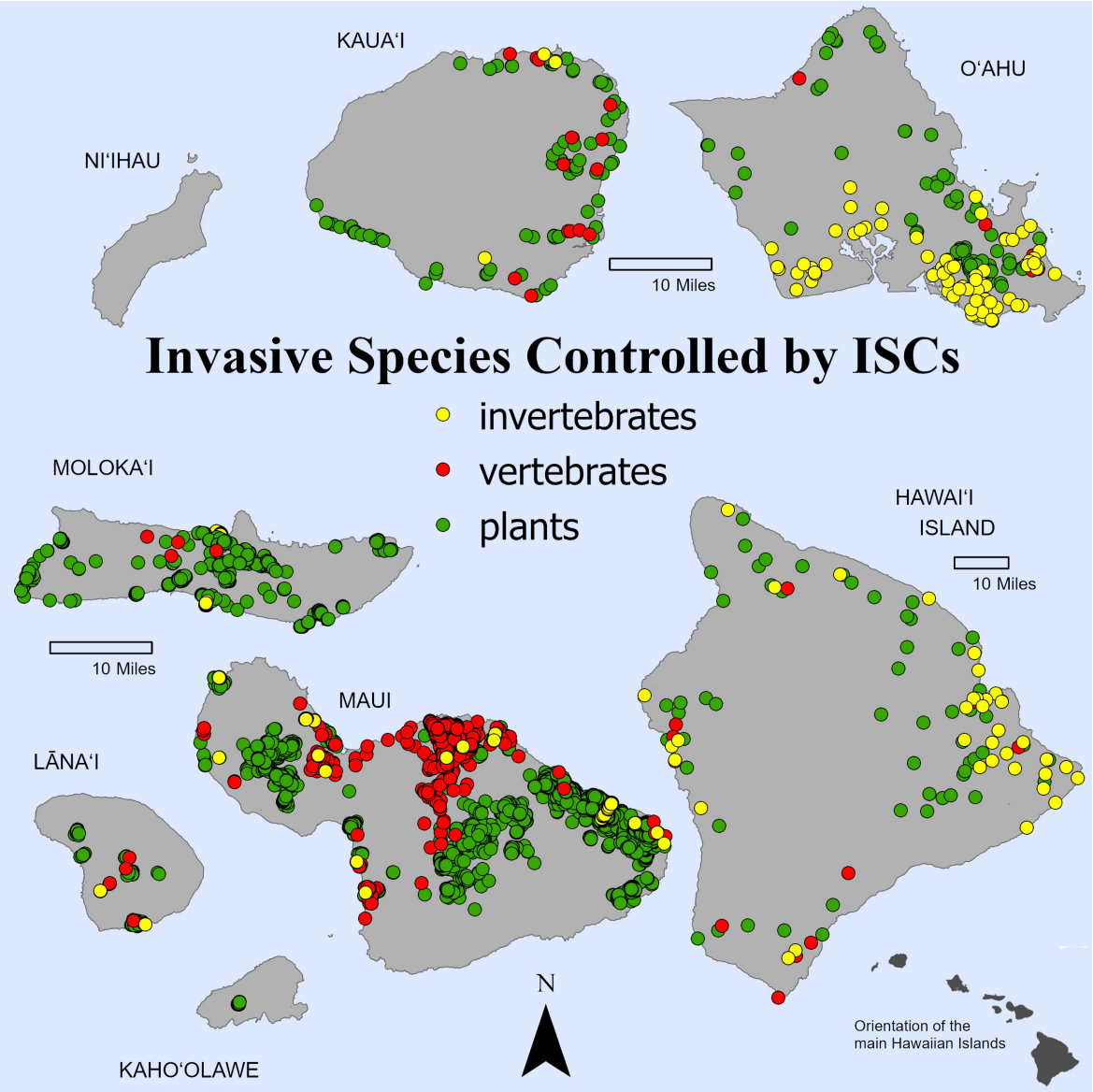
Pūpū kuahiwi (*Achatinella mustelina*) endangered Hawaiian tree snails. Photo: ANRPO.

Snail protection fence at Poamoho O'ahu. Photo: David Sischo.

Hawai'i's first large area predator proof fence was built at the Ka'ena Point Natural Area Reserve on the northwestern coast of O'ahu. This six-foot tall fence of wire mesh prevents all mammalian predators from entering. Even cats are blocked by a curved hood at the top of the fence. Each year brings record-breaking success as thousands of wedge-tailed shearwaters nest at Ka'ena, their population more than tripling since the fence was built. Also, increasing numbers of the majestic Laysan albatross now return to this protected area to mate and nest. This once barren area that had been badly damaged by vehicle tracks has now been converted to a vibrant native coastal shrubland alive with soaring seabirds and sleeping monk seals. Native plants and insects within predator-proof areas are also showing strong recovery from the pervious levels of damage.

Since the establishment of this first predator- proof fence at Ka'ena, similar fences have been constructed in fourteen other sites across the state including a fence enclosing 6.5 hectares (16 acres) on the James Campbell National Wildlife Refuge on O'ahu designed to protect nesting albatross and other seabirds and shorebirds from predators.

Laysan Albatross decoys attract wild birds. Photo: Jordan Akiyama, USFWS.



Map showing areas where invasive plants and animals are being controlled by the Invasive Species Committees.

Invasive plant management

Five **Invasive Species Committees (ISCs)** and the **Hawai'i Invasive Species Council** were created in Hawai'i to facilitate and expand invasive species control work that existing state and federal agencies had difficulties addressing due to gaps in jurisdiction, resources, or staffing. Serving as informal, inter-agency partnerships, the ISCs fill many of these gaps as they work to identify and eradicate some of Hawai'i's most threatening incipient pests. Additionally, many organizations and agencies across the state are actively controlling established invasive species using mechanical, chemical, and biocontrol methods.

Ko'olau Mountains Watershed Partnership staff controlling Mule's foot fern. Photo: Will Weaver.

The ISC Structure consists of a committee of interested parties, primarily natural resource managers, biosecurity experts, and scientists from federal, state, and county agencies, as well as from private organizations, landowners, or business associations.

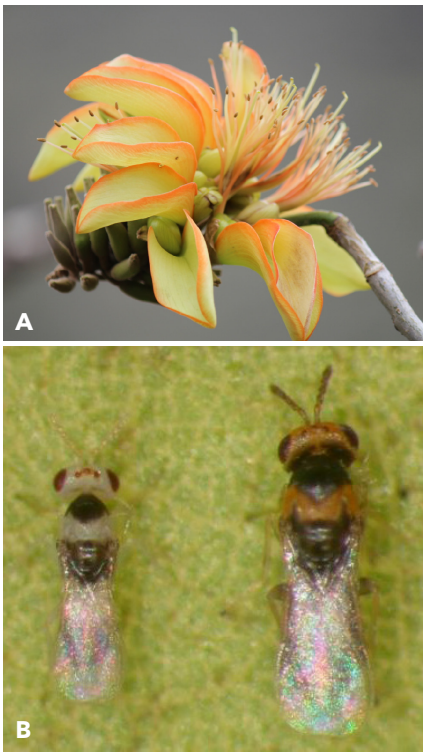
BIISC's staff teaching a group of neighbors how to properly mix up gel bait to control little fire ants. Photo: Big Island Invasive Species Committee.

Inset: Little fire ants attracted to peanut butter bait. Photo: Zach Pezzillo.

Each ISC develops action plans focused on their areas and carries out priority survey and control work, as needed. The ISCs also have a robust outreach program to educate and engage the public to report and participate in managing invasive species. Species targeted for control include plants, vertebrates, arthropods, and pathogens that impact Hawaii's ecosystems, economy, agriculture, human health, or way of life. Objectives on each island are diverse depending on what invasive species are found there, but all of the ISC programs include the detection and eradication of incipient species and community-based management of many widespread, established invasive species of plants and animals.

Biocontrol

Biological control (biocontrol) is the selection and introduction of a natural enemy of an invasive plant or insect pest which suppresses that pest in its home range, and the "reuniting" of this natural enemy with the invasive pest to provide long-term, cost-effective, and sustainable pest management. In modern biocontrol, extensive testing is done to ensure the natural enemy is specific to its host prior to release and will not cause impacts to native or agricultural species. Biocontrol projects in Hawai'i are cooperative efforts between multiple agencies and organizations, including the Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife, Hawaii Department of Agriculture, USDA Forest Service, University of Hawai'i, and international partners to plan, research, implement, and monitor projects.



A: Wiliwili flowers. Photo: Emily Grave.

B: Wiliwili gall wasps. Photos: Hawai'i Department of Agriculture.

A: *Miconia calvescens* detection. Photo: Kaua'i Invasive Species Committee.

B: Control of *Miconia*. Photo: O'ahu Invasive Species Committee.

Biological control has a long and active history in Hawai'i, with several hundred introductions made from 1890 to the present. Unfortunately, mistakes were made with early biocontrol efforts leading to the introduction of species that are now considered to be highly invasive including the mongoose and rosy

wolfsnail. Although most of the early activity targeted agricultural pests, many important invaders of natural areas have received attention in the last 50 years. Results of biocontrol in support of conservation have been mixed, with cases of natural enemies failing to establish, or often having relatively minor impacts, but also some instances of substantial suppression of weeds and insect pests. Beginning in the 1970s, increased emphasis was placed on selecting natural enemies that feed only on a narrow range of hosts which has led to a greatly improved control success and safety record. Cases of non-target impacts on native species, a significant problem from earlier biocontrol introductions, have been avoided completely in recent decades.

Examples of recent biocontrol successes include the halt of statewide extinction of native wiliwili trees by the *Erythrina* gall wasp following importation of a highly effective specialist parasite in 2008, and significant reduction of invasive banana poka vines over large areas of native wet forests due to a host-specific fungus introduced in 1996. Other invasive species that would continue to threaten natural and cultivated landscapes in Hawaii without recent biocontrol efforts include the *Acacia psyllid*, spiraling whitefly, nettle caterpillar, Hamakua pamakani and ivy gourd. However, other invasives including gorse, Clidemia and faya tree persist as major environmental weeds despite concerted efforts at biocontrol. These and other weeds, such as strawberry guava, miconia, albizzia, devil weed, and Himalayan ginger, are being focused on with currrent biocontrol research.

	Pending	Not established	Ineffective	Partial	Substantial	Total agents
Insect pests						
Acacia psyllid			1	1		2
Erythrina gall wasp					1	1
Nettle caterpillar					1	1
Spiraling whitefly				2	2	4
Weeds						
Banana poka		1	1		1	3
Clidemia			4	2		6
Firetree			2			2
Fireweed	1					1
Gorse		3	1	2		6
Hamakua pamakani				2	1	3
Ivy gourd		1		1	1	3
Lantana			1	1		2
Miconia				1		1
Russian thistle		2				2
Strawberry guava	1					1

Summary of recent biocontrol efforts and indication of their effectiveness or status. Data compiled by Hawai'i Dept. of Agriculture and U.S. Forest Service.

Rapid 'Ōhi'a Death and canopy dieback

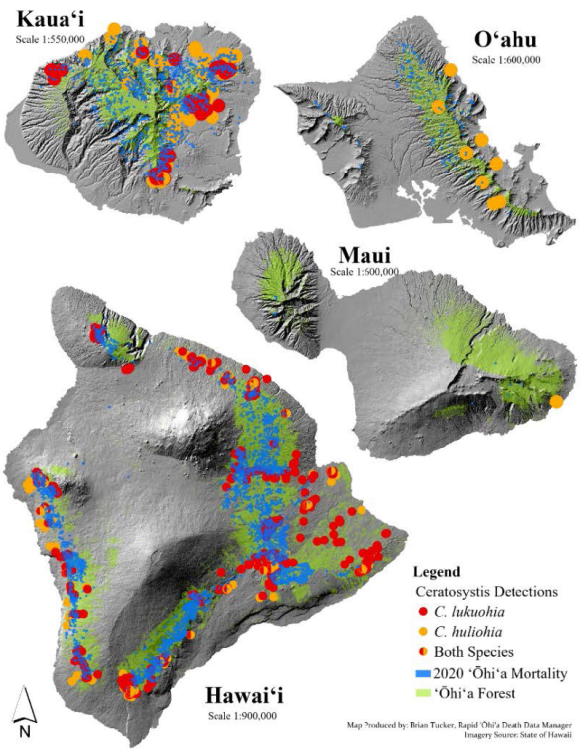
'Ōhi'a (*Metrosideros polymorpha*), the most abundant native tree in the state of Hawai'i, are being killed by a new fungal disease caused by two introduced pathogens, *Ceratocystis lukuohia* and *Ceratocystis huliohia*. On Hawai'i Island, hundreds of thousands of 'ōhi'a have already died from this fungus. Healthy trees appear to die within a few days to a few weeks from being infected, which is how the disease came to be called **Rapid 'Ōhi'a Death (ROD).**

Based on recent aerial surveys, more than 73,000 hectares (~180,000 acres) of forest contain 'ōhi'a trees showing symptoms of ROD disease on the Island of Hawai'i. ROD has been confirmed in all districts of Hawai'i Island, although areas of Hāmākua, Kohala, and North Kona remain priorities for early detection and rapid response efforts due to the low occurrence of the disease in those locations[4].

Both *C. lukuohia* and *C. huliohia* have also been detected on Hawai'i Island and Kaua'i. The more aggressive species of fungus causing ROD is *C. lukuohia*, which accounts for roughly 90% of detected infections on Hawai'i Island. The less aggressive species, though still fatal fungus *C. huliohia* has also been detected on both Maui and O'ahu. The ROD working group, in close coordination with the Invasive Species Committees on all islands and the Division of Forestry and Wildlife are continuing with surveys for ROD and follow-up management actions, as needed.

Rapid 'Ōhi'a Death remains a priority for natural resource management agencies in Hawai'i. This disease continues to kill 'ōhi'a trees and is now widely established on Hawai'i island and in several areas on Kaua'i. Resource managers across the state continue to respond to ROD detections to protect healthy forests, and researchers are tackling a wide array of topics to inform managers on the best strategies for controlling the disease. Community outreach is also an integral part of this effort to provide consistent messaging on the importance of 'ōhi'a forests and how residents and visitors can help protect them.

'Ōhi'a tree recently killed by *Ceratocystis lukuohia*. Photo: J.B. Friday.



Sites where either species associated with Rapid 'Ōhi'a Death have been detected. Source: ROD Working Group.

[4] Perroy, R.L., T. Sullivan, D. Benitez, R.F. Hughes, L.M. Keith, E. Brill, K. Kissinger and D. Duda. 2021. Spatial patterns of 'ōhi'a mortality associated with Rapid 'Ōhi'a Death and ungulate presence. *Forests*, 12, 1035. https://doi.org/10.3390/f12081035.

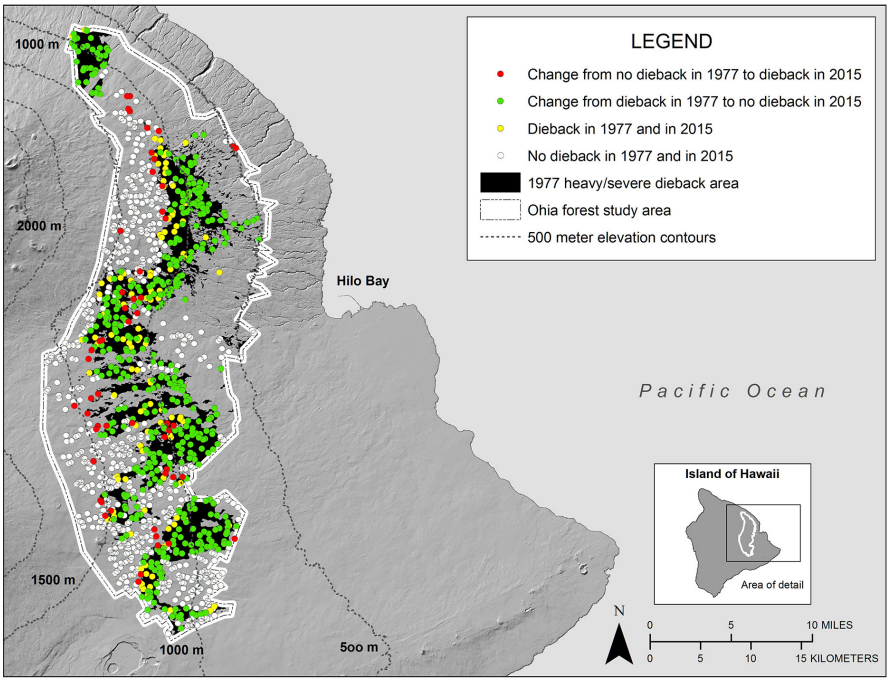
Fortini, L.B., L.R. Kaiser, L.M. Keith, J. Price, R.F. Hughes, J.D. Jacobi, and J.B. Friday. The evolving threat of Rapid 'Ōhi'a Death (ROD) to Hawai'i's native ecosystems and rare plant species. 2019. *Forest Ecology and Management* 448: 376-385.

Current ROD research and management highlights

- In 2018 researchers determined that two non-native, microscopic fungi new to science, Ceratocystis lukuohia and C. huliohia, are the primary cause of ROD.
- *C. lukuohia* a "wilt disease", quickly spreads throughout the trunks of trees, clogging the flow of water and causing the tree to die within months. In contrast, *C. huliohia* is characterized as a "canker disease", which affects trees more slowly and requires multiple infections to kill trees. There is some evidence that *C. huliohia* has been present in the islands longer that *C. lukuohia*.
- On Hawai'i Island, where these fungi were first detected in 2014, approximately 73,000 hectares (~180,000 acres) of ʻōhiʻa forest have some level of ROD, ranging from 95% mortality to less than 1%. ROD is now found in all districts of Hawai'i Island, and management has shifted to focus on reducing impacts to high-value forests.
- On Kaua'i, ROD was initially detected in a few trees in 2018. Since then, additional surveys have confirmed approximately 250 ROD trees, some with *C. huliohia* and some with the more aggressive *C. lukuohia*, and crews are working to contain the disease. On Maui, one tree with *C. huliohia* was discovered via public report in 2019 and subsequently destroyed. On O'ahu, nine trees with *C. huliohia* have been detected, all in the Ko'olau Mountains, resulting in the felling and tarping of trees where feasible.
- Landscape-level studies are finding significantly fewer dead 'Ōhi'a trees in areas fenced from hooved animals in ROD hotspots. Suspected ROD tree densities in neighboring unfenced areas were up to 69 times greater than those found in fenced, protected areas. (Perroy *et al.* 2021)
- The multi-agency framework of active surveillance, sampling, management, research, and outreach is ongoing with existing staff from agencies and non-government organizations, supplemented by over 20 positions funded through grants to the ROD Strategic Response.

More details can be found at cms.ctahr.hawaii.edu/rod

Another widespread defoliation and death of many thousands of ʻōhiʻa trees occurred on the windward side of Hawai'i Island in the 1960s–1970s. Although it was concluded that this dieback was primarily due to natural conditions resulting from nutrient limitations for maintaining the large canopy trees as they matured over time (Mueller-Dombois 1985), it resulted in the death or defoliation of the tree canopy over approximately 49,000 hectares (~120,000 acres) of native forest. Fortunately, recent studies have shown that in most of these areas ʻōhiʻa is recovering as young trees have recolonized the sites and are now developing back into a new forest (Mertelmeyer *et al.* 2019).



Changes in forest dieback status from 1977 to 2015. **Mertelmeyer, L., Jacobi, J. D., Mueller-Dombois, D., Brinck, K., & Boehmer, H. J. (2019).**

Ungulate impacts and management

Feral ungulates (hoofed animals including cattle, pigs, goats, sheep, and deer) are among the greatest threats to native ecosystems as they destroy vegetation leaving ground ground bare and soils exposed. Exposed soils then become spots where invasive plant species can easily become established. These changes can reduce water collection and infiltration, increase potential for wildfires, and promote forest pests and disease, all of which impact forest health and function.

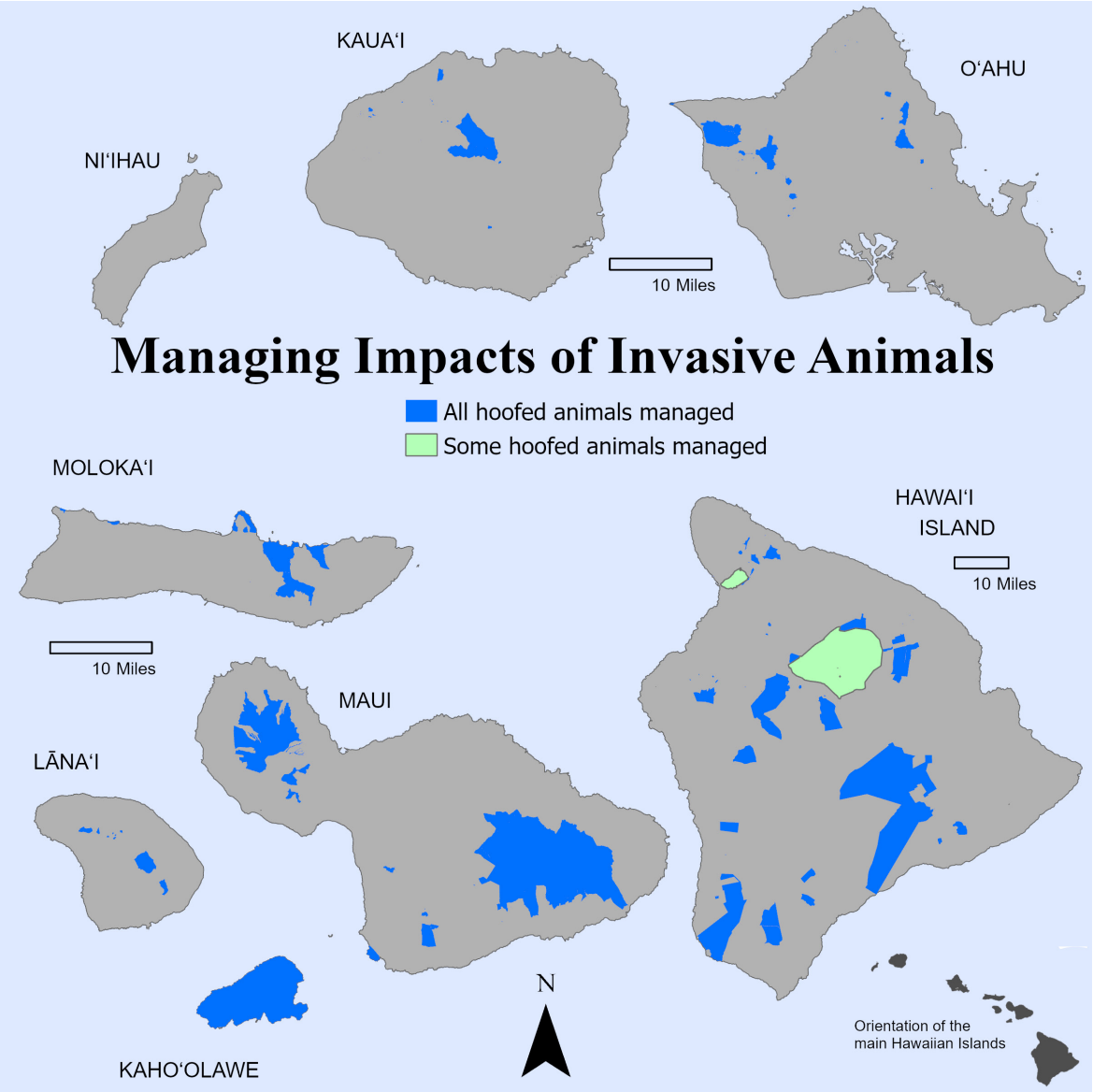
Approximately 17% of the remaining wet and mesic native forests in Hawai'i are currently protected by fences to exclude hoofed animals. We used these fenced areas as a proxy for effective management. During the 2016 International Union for the Conservation of Nature World Conservation Congress held in Honolulu, then Hawai'i Governor David Ige announced a Sustainable Hawaii Initiative goal to protect at least 30% of priority watersheds by 2030. To reach this goal, continued funding is needed to control damaging invasive species and diseases, plant native species, prevent wildfires, and educate the community about the importance of our forests. To date only 5% of the total land area in the main Hawaiian Islands are fenced to prevent entry of ungulates.

While hooved animals may be incrementally removed from portions of the remaining forests, damage from invasive weeds and wildfires can continue to escalate even in these managed areas over time. Similarly, the new threat of Rapid 'Ōhi'a Death (ROD), a fungal disease, is causing catastrophic losses of Hawai'i's dominant native tree. Damage to the trees by ungulates facilitates the spread of this disease. Fortunately, fencing and ungulate removal, or effective ungulate suppression, is likely to be among the most effective and practical means to reduce the spread of ROD at meaningful landscape scales.

Feral pig in native forest.
Photo: © JackJeffreyPhoto.com

Wild mouflon sheep.
Photo: Dan Dzurisin, USGS.

Feral goats.
Photo: National Park Service.



Intensive management of invasive animals on the main Hawaiian Islands. Data sources: Hawai'i DOFAW, National Park Service, U.S. Fish and Wildlife Service, Moloka'i Land Trust, Army Natural Resources Program.

Wildfire impacts[5]

Wildfire caused by 2018 eruption in the Puna District on the island of Hawai'i.
Photo: Jim Jacobi, USGS.

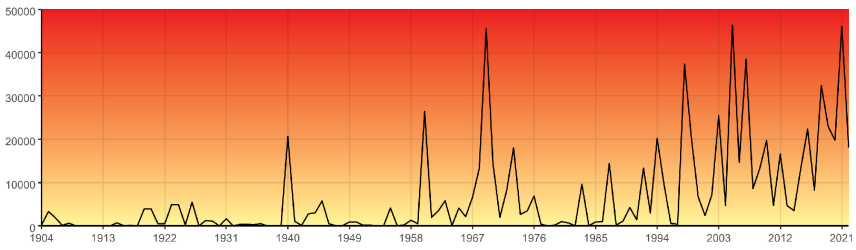
Prior to human settlement of the Hawaiian Islands, wildland fires were relatively infrequent, limited to areas of volcanic activity and rare lightning strikes. Fire was a critical tool of Hawaiians for agricultural land clearing and the management of plant resources, such as pili grass. European colonization introduced and expanded the range of many fire-prone and fire-adapted grasses and shrubs, particularly through the development of plantation agriculture and ranching. However, active grazing, agricultural infrastructure, and workers' cooperation with fire response agencies effectively reduced fire risk. More recent declines in agricultural land use have coincided with a 300% increase in the land area burned annually, such that the percentage of land area burned annually is on par with and often exceeds many western US states (Trauernicht *et al.*, 2015).

Three primary factors are driving this fire regime change: 1) Vast areas of unmanaged, fire-prone grasslands and shrublands now comprise approximately 25% of the state's total land area and encircle forested watersheds. 2) Human-caused ignitions account for ~99% of all fires and correlate directly with population growth. 3) The combination of wet and dry climate cycles lead to rapid biomass accumulation and subsequent curing in grass-dominated fuels, creating recurrent fire risk even in wetter, windward areas (Trauernicht, 2019). Fire risk models indicate the extent of high fire risk areas will expand and move upwards in elevation under climate change.

Aftermath of wildfire that burned through the native forest in the O'ahu Forest National Wildlife Refuge in 2015.
Photo: Clay Trauernicht.

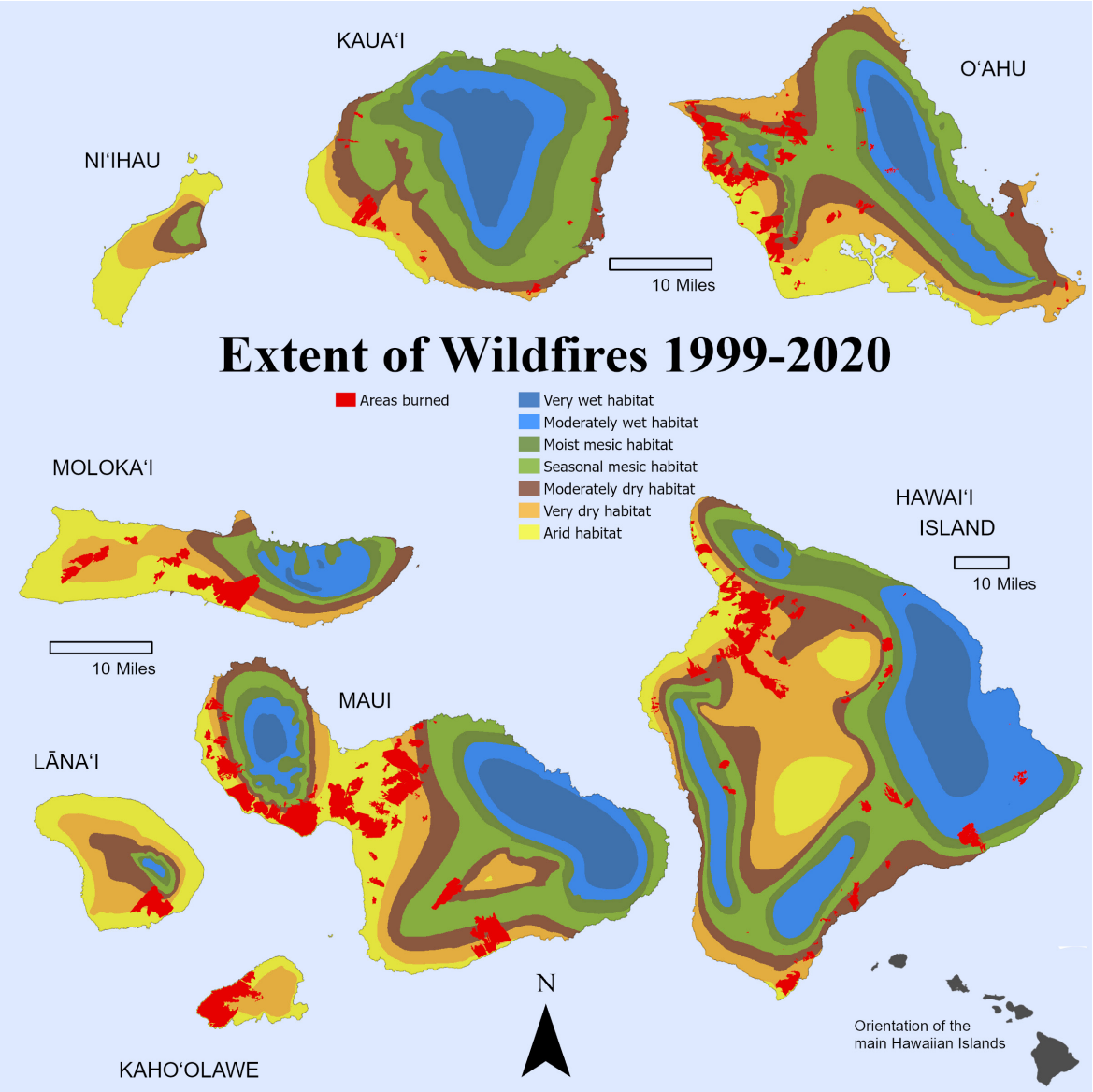
Although >95% of wildfires in Hawai'i are less than 4 hectares (10 acres) in size, the annual occurrence of large fires (e.g., >400 hectares, 1000 acres) poses serious threats to human lives, infrastructure and cultural and natural resources. The negative impacts of wildland fire are particularly acute in Hawai'i given the sensitivity of native ecosystems to fire disturbance, the high number of threatened and endangered species that persist in and adjacent to fire-prone areas, and the short ridge to reef linkages that increase the vulnerability to erosion impacts due to sediment transfer from watersheds to nearshore ecosystems.

In addition, predicting and mitigating wildfire risk is difficult in Hawai'i as available tools and funding programs are inadequate for the unique fuel types, dramatic environmental variability, extent of fire-prone fuels and fire-related information needs. Moreover, due to its geographic isolation and patterns of land ownership, Hawai'i lacks access the array of federal interagency resources for fire management and response available on the continental United States.

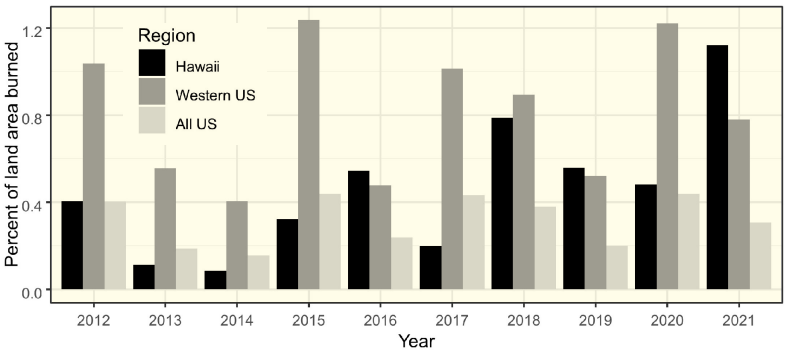


Area of land burned annually in the main Hawaiian Islands from 1904–2021.
Data compiled by C, Trauernicht, UH Cooperative Extension; trauerni@hawaii.edu, and available at PacificFireExchange.org)

[5] For more information of wildfires and fire management in Hawai'i visit Hawai'i DLNR Fire Management; and Pacific Fire Exchange–Hawai'i.



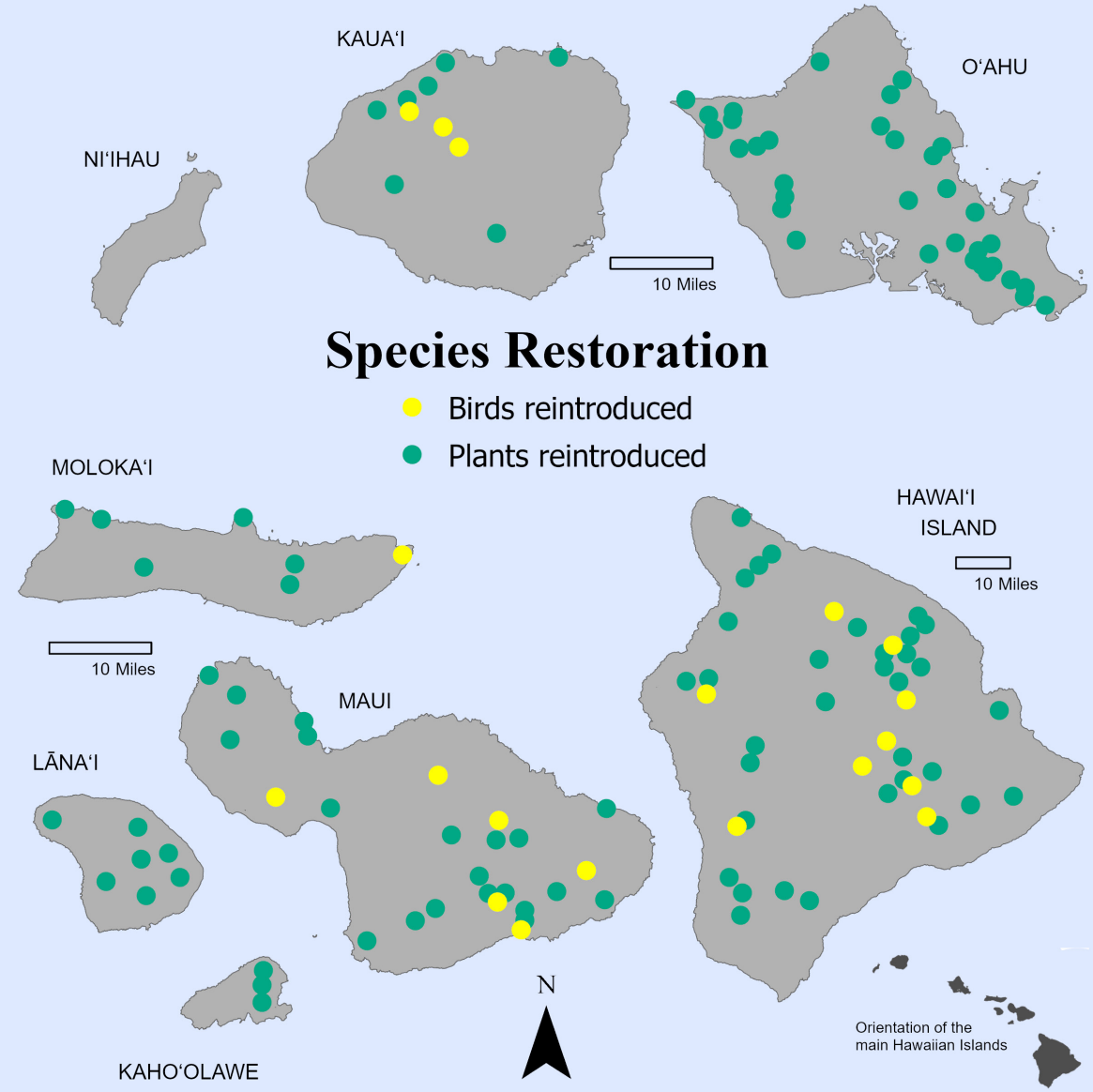
Extent of wildfires on the main Hawaiian Islands from 1999–2020. Wildfire data created and compiled by C, Trauernicht, UH Cooperative Extension; **trauerni@hawaii.edu**); moisture zones from **Price *et al.* 2012**.



The annual area burned as a percentage of total land area in Hawai'i as compared to other areas in the United States.
Source: **Trauernicht *et al.*, 2015**.

Island	Acres	Hectares	Percent of island
Kaua`i	8,046	3,256	2%
O`ahu	30,357	12,285	8%
Moloka`i	14,069	5,694	8%
Lāna`i	4,010	1,623	4%
Kaho`olawe	13,328	5,394	47%
Maui	67,067	27,141	14%
Hawai`i	147,617	59,739	6%

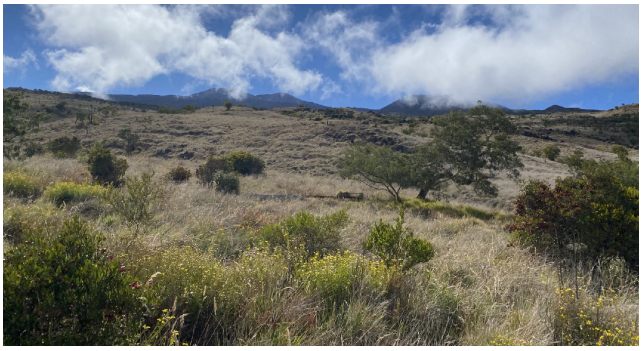
Table summarizing extent of wildfires on the main Hawaiian Islands from 1999–2020.



Locations of native plant and bird restoration sites in the main Hawaiian Islands. Data compiled by the Laukahi program and San Diego Zoo's Kilauea Bird Conservation Center.

Species and habitat restoration efforts

While protecting and managing existing forests is most cost effective, impressive success has also occurred with species and habitat restoration through reintroduction of plants and animals into managed conservation areas, in many cases conducted by community volunteers. For example, on the leeward (south) slope of Haleakalā, the **Auwahi Forest Restoration Project** has brought hundreds of volunteers to replant dryland species since 1997, completely transforming former pasturelands into a functioning native dryland forest. Studies have shown the capacity of these restored forests to recharge



Kanakaleonui Bird Corridor subalpine dryland forest, Mauna Kea. Photo: Amberly Pigao.

the arid areas' aquifer, increasing capture of cloud water, and absorbing water into the soil. Additionally, restoration projects have the added potential for providing carbon offset credits, and are essential to restore degraded upland habitats for forest birds above the projected impacts of avian malaria.

Nēnē goose. Photo: DLNR.

Native species being outplanted at Pu'uwa'awa'a on Hawai'i Island. Photo: Pu'uwa'awa'a Community-based Subsistence Forest Area.

Plants, birds, and some invertebrates have been out-planted or released into natural habitats in many sites throughout the main Hawaiian Islands. Many of these are rare species including forest birds, Nēnē, snails, and damselflies. Restoration of coastal vegetation is also being conducted on Midway Atoll and other sites in the Northwest Hawaiian Islands. From 2015–2020, twenty-two plant species have been out-planted on Midway to help with stabilizing beach dunes and to provide additional habitat for translocated Laysan teal.

Status of streams and watersheds[6]

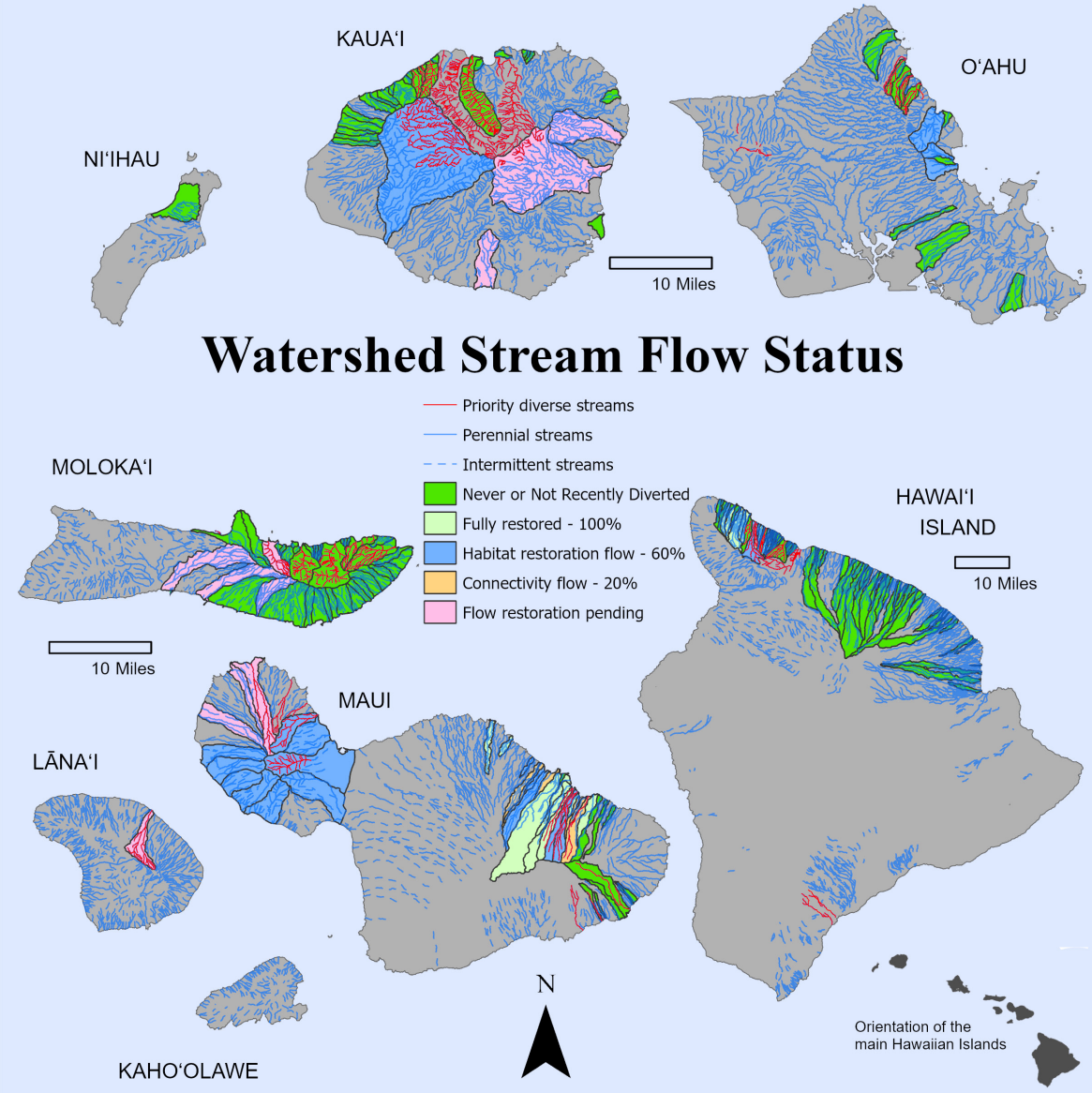
Due to their spectacularly steep terrain and copious rainfall, the Hawaiian Islands support hundreds of perennial streams, which descend from the flanks of the islands through steep valleys, often punctuated by scenic waterfalls. These streams were a source of sustenance for the Native Hawaiians, irrigating kalo lo'i (taro cultivation) and providing rich nursery areas for nearshore marine fisheries at their mouths. In addition, they support a rich variety of animal life, including many species endemic to the Hawaiian Islands.

Perennial streams are concentrated primarily on the wetter windward sides of the islands and have been subject to modification and disturbance since the arrival of the first Polynesian voyagers over one thousand years ago. The initial Hawaiian utilization of stream flows for agriculture largely involved 'auwai (traditional irrigation ditches), which diverted water from streams at mid and terminal reaches to irrigate terraced taro field complexes, and then returned flowing water back into the main stream. However, with the advent of European and American settlements in the islands, stream diversions became more extensive in order to support an expanding network of sugarcane plantations.

Undiverted Pelekunu stream on Moloka'i. Photo: Dan Polhemus.

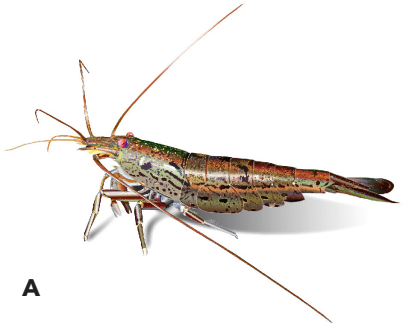
Removed diversion on Honopou Stream, Maui to allow passage of native stream fauna. Photo: Dan Polhemus.

[6] For more information: Atlas of Hawaiian Watersheds and their Aquatic Resources



Map showing water catchments where stream flow has been partially or completely restored.

The modern stream diversions were often quite efficient, and capable of collecting the entire base flows of streams during the dry summer months, leaving the downstream reaches dry. The result was extensive loss of perennial stream habitat in Hawai'i from the mid-1800s onward. In 1987, the State of Hawai'i passed into law the State Water Code (HRS 174C), which required the state to establish minimum instream flow standards so that basic ecological functions and traditional Hawaiian uses were ensured at some level before remaining flow was allocated to off-stream uses, such as industrial agriculture and urban development. The result has been that from 2000 to 2020, a significant number of Hawaiian perennial streams, many partially or fully dewatered for over a century, have seen significant restorations of flow. Hawaiian perennial streams now stand as one important native ecosystem class to have regained extent and function during the past two decades.



A

B

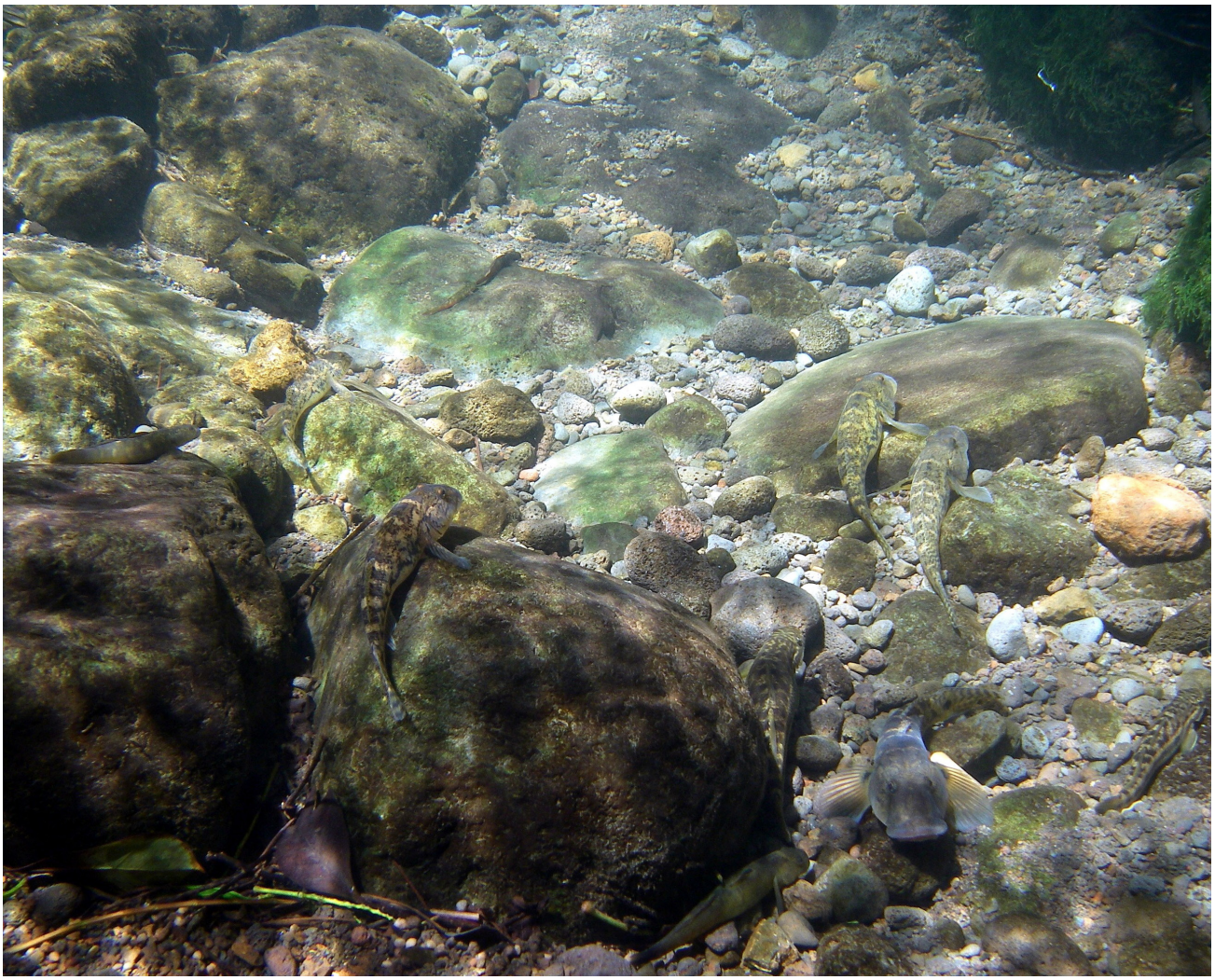
A: 'Ōpae kala'ole (*Atyoida bisulcata*). Image: Reuben Wolff.

B: 'O'opu naniha, Hawaiian goby. Image: Reuben Wolff.

These maps (page 41) indicate catchments in which flow restorations have occurred, and some indication of the amount of renewed base flow represented by such actions.

- Catchments indicated as "Never Diverted" represent those which have not been impacted by modern networks of ditches and intakes
- Catchments indicated as "Restoration Pending" are those where there are active negotiations or draft plans to develop instream flow standards
- Connectivity flows, which are up to 20 percent of the original base flow
- Habitat Restoration flows, which are more than 20 percent and up to 60 percent of original base flow
- Full Restoration flows, in which 100 percent of the original base flow now passes without being diverted

The majority of Hawaiian perennial streams do not currently lie within protected areas. Notable exceptions are Kalalau, Hanakoa and Hanakaipiai Streams on Kaua'i, in the Nā Pali Coast State Park; Kaluanui Stream on O'ahu in the Sacred Falls State Park and Kaluanui Natural Area Reserve; Pelekunu Stream on Moloka'i, in the TNCH Pelekunu Preserve; and 'Ohe'o Gulch on Maui, in the Haleakalā National Park.



Several species of 'O'opu fish on rocks in a Hawaiian stream. Photo: Reuben Wolff.

Status of wetlands

Due to their topography and locally high rainfall, the Hawaiian islands harbor a diverse set of wetland types, ranging from a hypersaline lake on Laysan Atoll in the Northwestern Hawaiian Islands, to acidic upland bogs such as found at Pepeopae on Moloka'i or in the Alaka'i Plateau on Kaua'i, to large freshwater marshes such as Kawainui on O'ahu, and also small coastal anchialine pools, primarily found on Hawai'i Island. Wetland habitats help regulate water flow and infiltration and provide habitat for a wide variety of wildlife species. Prior to Western contact the Native Hawaiians also created or modified coastal wetlands for kalo (taro) cultivation. However, these habitats continued to provide both ecological functions and wildlife habitat, as well as cultivation of a staple food element.

The spatial extent of these Hawaiian wetland ecosystem classes has been mapped using the most recent National Wetland Inventory (NWI) data available through the U. S. Fish & Wildlife Service. The NWI considers wetlands to be "Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water." As such, the NWI layers tend to over-represent coastal systems because features such as beaches, mudlflats, estuaries are included. In the uplands, areas with permanently waterlogged soils are also classified as wetlands, which includes broad areas along the middle elevation slopes of Haleakalā and Mauna Kea, where the lifting condensation level associated with the trade wind inversion causes clouds to preferentially bank against these mountainsides. These large extents of upland wetlands are very evident on the map included in this section, although their extent is generally under-appreciated because they lie in remote and rarely visited areas. In addition, because many coastal wetlands, stream mouth habitats, and anchialine pool systems are quite small, they do not resolve at the scale of spatial analysis used on the maps and are therefore mapped secondarily using symbols.

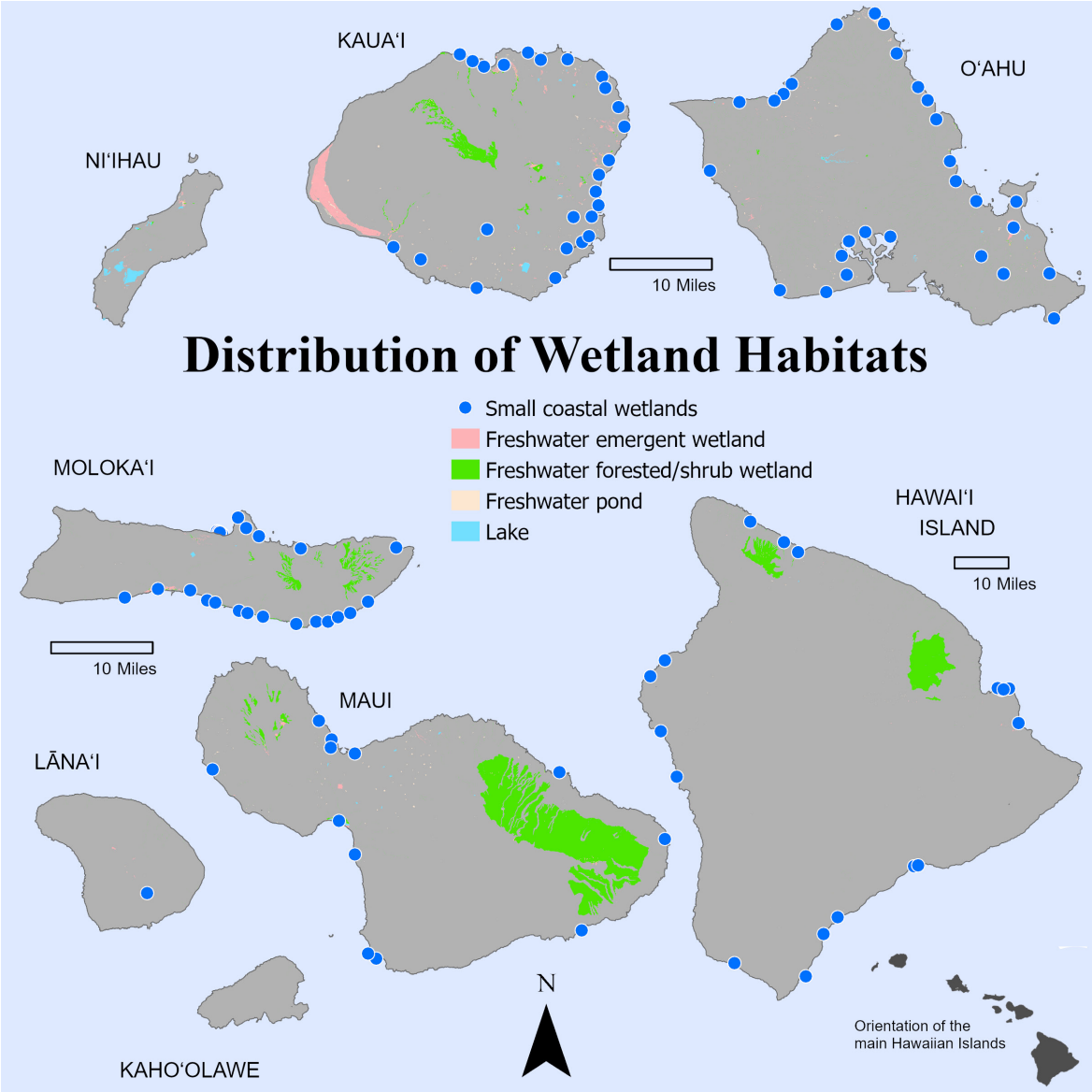
Recent assessments estimated that between 44–50% of the archipelago's wetlands lying below 300 m were destroyed during the past 200 years, largely due to agricultural conversion, resort or residential development, or land reclamation. Upland wetlands above 300 m fared somewhat better, but there is still a 3% rate of estimated loss in these systems over the same time due to drying climate trends. In total, approximately 15% of the original wetlands have been lost, although most of this loss comes from lowland systems.

Montane bog and pool in the Alaka'i region near Mt. Wai'ale'ale, Kaua'i. Photo: Dan Polhemus.

Dense understory in forested upland wetland on Mt. Ka'ala, O'ahu. Photo: Dan Polhemus.

Anchialine pool in the 'Āhihi-Kīna'u Natural Area Reserve, Maui. Photo: Dan Polhemus.

Lo'i kalo (taro terraces) at Limahuli, Kaua'i. Photo: Kim Rogers.



Distribution of wetland habitats on the main Hawaiian Islands. **Data from the U.S. Fish and Wildlife Service National Wetlands Inventory 2019.**

Looking forward, lowland wetlands in Hawaii will be impacted by sea-level rise in a number of ways. Initially, SLR will change the size, shape, and possibly the location of wetlands. Additionally, more frequent seawater infiltration during storms and high tides will alter water chemistry and habitats and may threaten some bird nesting areas and native plants. Sea-level rise will also lead to the upward displacement of the coastal groundwater table, creating new wetlands in places where they do not currently exist, while also subjecting these freshwater resources to loss in quality with increasing saltwater intrusion. Adaptation to such migrating wetland footprints will be a challenge for both managers and wildlife going forward.

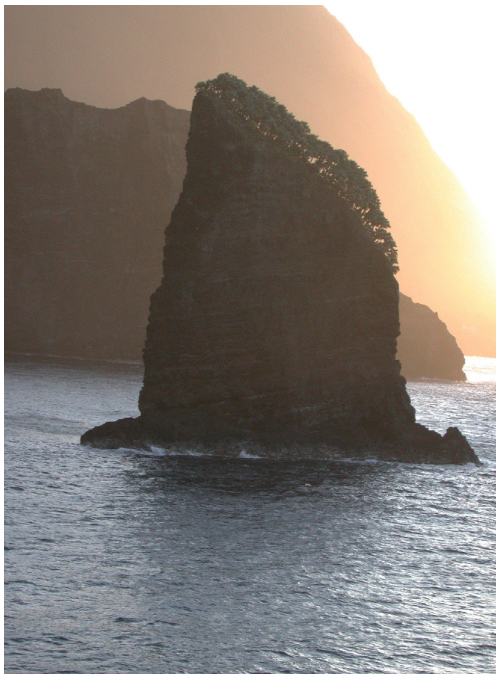
Ae'o (Hawaiian stilt) at Kanahā Pond, Maui. Photo: Fern Duvall.

Status of coastal vegetation

Hawaiian coastal vegetation is composed of plant species that are adapted to growing in extremely harsh conditions found in this habitat zone. These plant communities are both diverse and vulnerable with approximately 58 percent of the 44 native plant species that are endemic to Hawai'i.

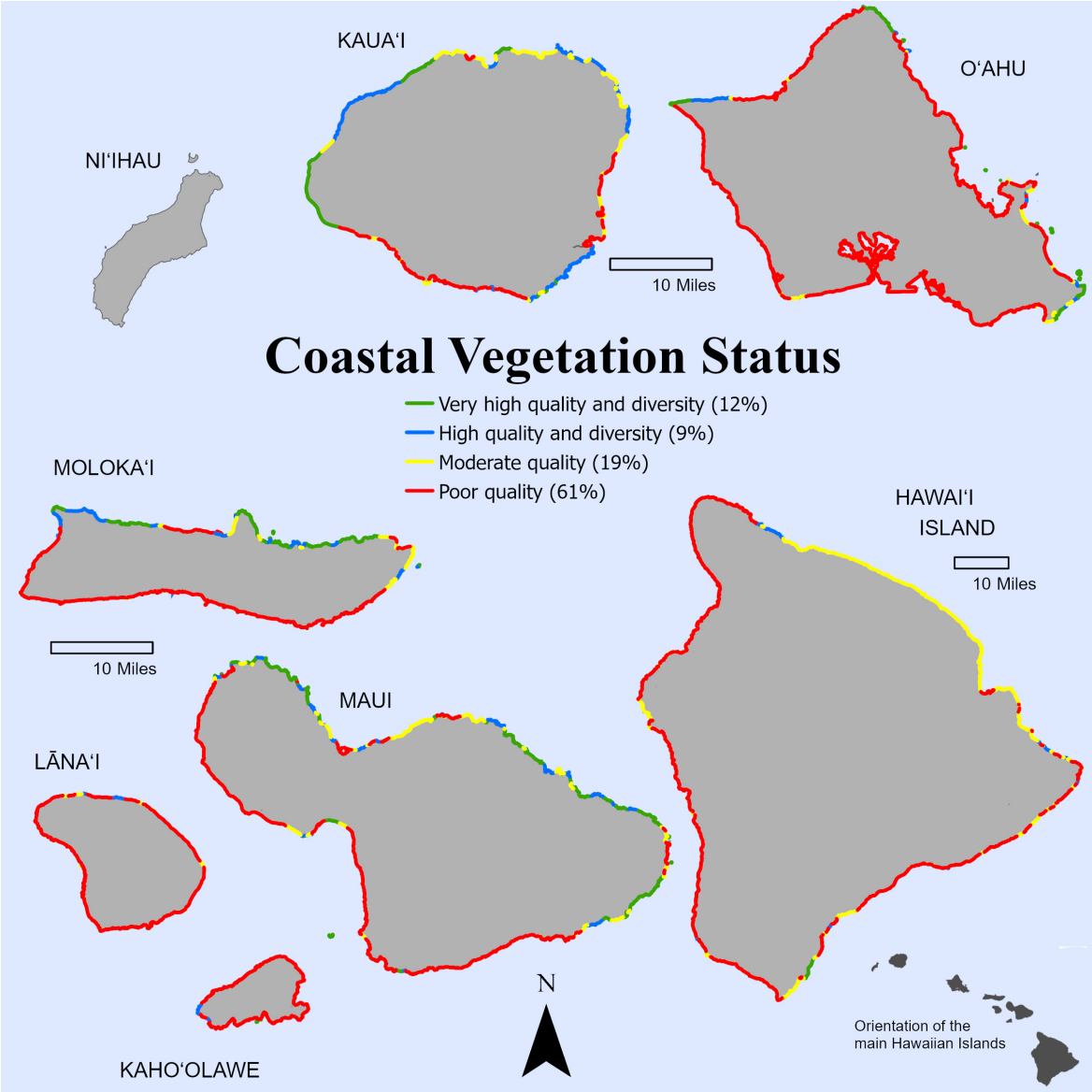
Prior to humans coming to these islands, Hawaiian coastal vegetation extended as a continuous ring around each of the islands, broken only by stretches of recent lava flows or unstable cliff faces. However, many areas that originally supported native coastal plant communities have been highly altered or the natural vegetation removed due to land use practices, use of fire, degraded by competition from invasive plants, or eaten by introduced ungulates.

A recent survey of coastal vegetation foun d 61 % of the coastline vegetation in the main Hawaiian Islands was highly disturbed poor quality status, 19 % in the moderate-status category, 9 % of the coastline was considered to be in high-quality status, and 12 % as very-high-quality status. However, Hawaiian coastal plant communities exhibit inherent resilience to disturbance since these communities and the species that comprise them have evolved to survive under the extremely harsh and changing conditions found along the coastline. If the coastal landscape is not actively disturbed by development and the most invasive plant and animal species are controlled or kept out of an area, the native Hawaiian coastal plants appear to be able to remain established or be restored following control of the threats.



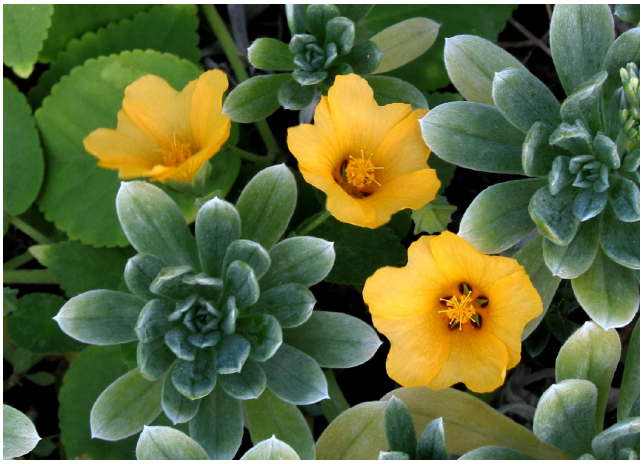
Huelo islet off the north coast of Moloka'i. Photo: Rick Warshauer, USGS/HCSU.

Hunakai (*Ipomoea imperati*) growing at Polihale, Kaua'i. Photo: Seana Walsh



Current status of Hawaiian coastal vegetation. Source: Jacobi and Warshauer (2017).

Coastal vegetation at Kalani, Moloka'i.
Photo: Rick Warshauer, USGS.



'Ilima and hinahina at Ka'ena, O'ahu.
Photo: Jim Jacobi, USGS.

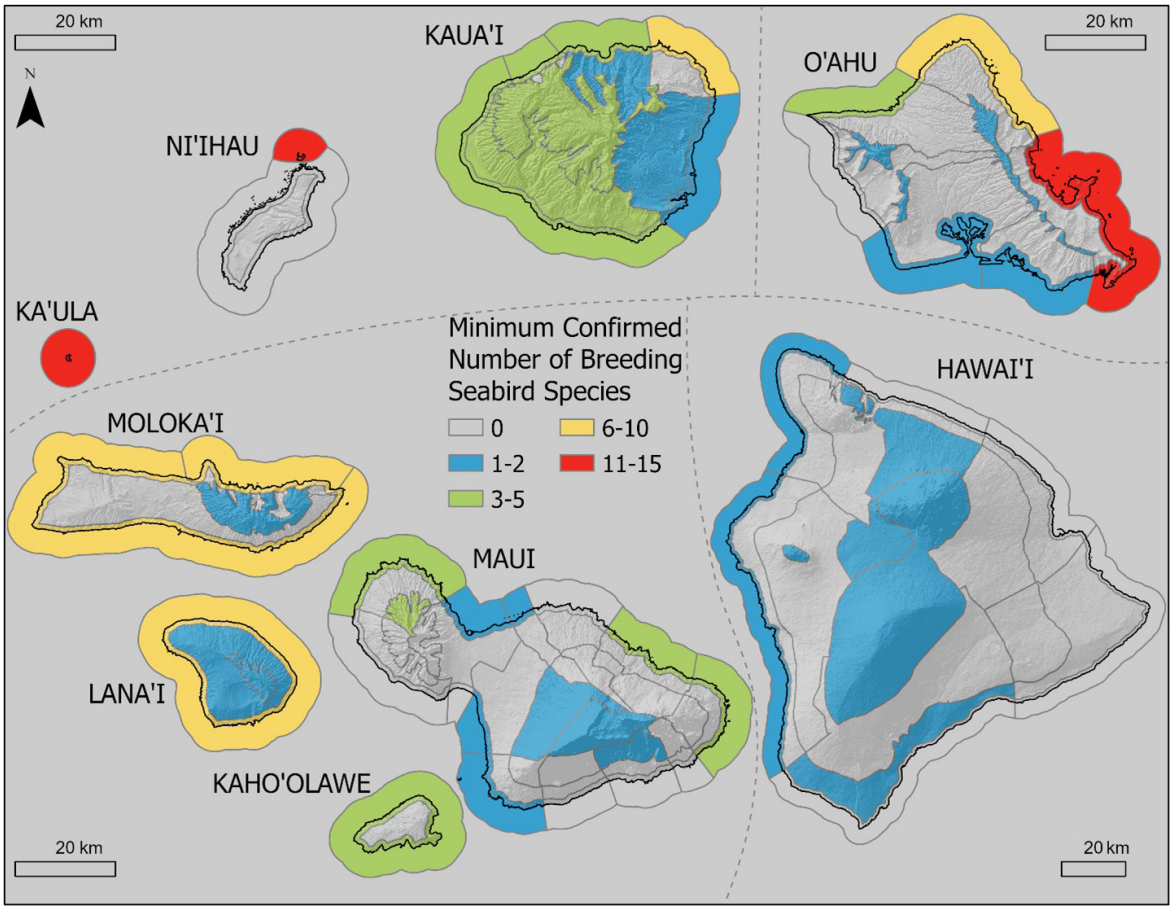
Manu-o-Kū (White tern, *Gygis alba*).
Photo: Koa Matsuoka, USFWS.

Status of seabirds

The Hawaiian Islands are globally important for seabirds, with tens of millions of individuals of at least 24 species breeding in two geographic regions: the Main Hawaiian Islands (MHI), including the larger islands and associated offshore islets from Hawai'i west to Ni'ihau, and the Northwestern Hawaiian Islands (NWHI) from Nihoa west to Kure Atoll. Collectively, the Hawaiian archipelago supports some of the largest tropical seabird colonies in the world. The seabirds of Hawai'i can be categorized into four taxonomic groups. Seabird breeding habitat within Hawai'i is variable, ranging from low-lying atolls most vulnerable to sea level rise in Papahānaumokuākea Marine National Monument, to remote, high-elevation montane areas on Maui and Hawai'i. The nesting seabird species vary in their distribution, with some species widespread and occurring on most islands in all regions (e.g., Wedge-tailed Shearwater [*Ardenna pacifica*], Red-tailed Tropicbird [*Phaethon rubricauda*], Black Noddy [*Anous minutus*]), and other species restricted to just one or a few islands in one region (e.g., Newell's Shearwaters [*Puffinus newelli*]).

While most seabird species within Hawai'i are declining in at least part of their range, three species (Newell's Shearwater, Hawaiian Petrel [*Pterodroma sandwichensis*] and Band-rumped Storm-petrel [*Oceanodroma castro*]) are listed under the US Endangered Species Act, and only two (Newell's Shearwater and Hawaiian Petrel) are endemic to Hawai'i. The latter are the focus of large-scale conservation projects on multiple Hawaiian Islands.

Within these taxonomic groups, several nesting habitats and foraging modes exist. Spatially, seabird nesting habitat can be broadly defined as surface, burrow, tree/vegetation, cliff, and rock piles/crevices. In this way, multispecies colonies can be vertically stratified. For example, a typical Hawaiian seabird colony may support



Seabird species richness in the Main Hawaiian Islands, represented as the minimum number of confirmed seabird species. Additional seabird colonies are suspected to exist, especially in the hard to reach and montane areas of the islands. Polygons in this map were derived from the **Hawaiian Aha Moku System** and used to summarize nesting seabird richness at the landscape scale, with elevational boundaries at 1-km inland to 3-km offshore (coastal), 1-km inland to 550-m elevation (inland), 550-m to 2000-m elevation (upland), and >2000-m elevation (alpine). Moku boundaries were dissolved within the highest elevation category on each island (e.g., "upland" for Kaua'i, O'ahu, Moloka'i, Lāna'i, and "alpine" for Hawai'i and Maui). Additional boundaries were placed around the islands of Ka'ula, Ni'ihau, and Lehua, making them three separate polygons within one moku zone. Data are from the comprehensive **Atlas and Registry of Breeding Seabirds in the Main Hawaiian Islands** (USGS and others, Unpublished Data).

Order	Group	Species
Procellariiformes	Albatrosses	Black-footed, Laysan, Short-tailed
	Petrels	Bonin, Bulwer's, Hawaiian
	Shearwaters	Wedge-tailed, Newell's, Christmas
	Storm-petrels	Band-rumped, Tristram's
Phaethontiformes	Tropicbirds	Red-tailed, White-tailed
Suliformes	Boobies	Brown, Masked, Red-footed
	Frigatebirds	Great
Charadriformes	Terns and Noddies	Least, White, Sooty, Grey-backed Terns; Black, Brown and Blue-grey Noddies

Above: Groups of seabird species with documented breeding colonies in the Hawaiian Islands.

Right: Booby and chick. Photo: Koa Matsuoka.

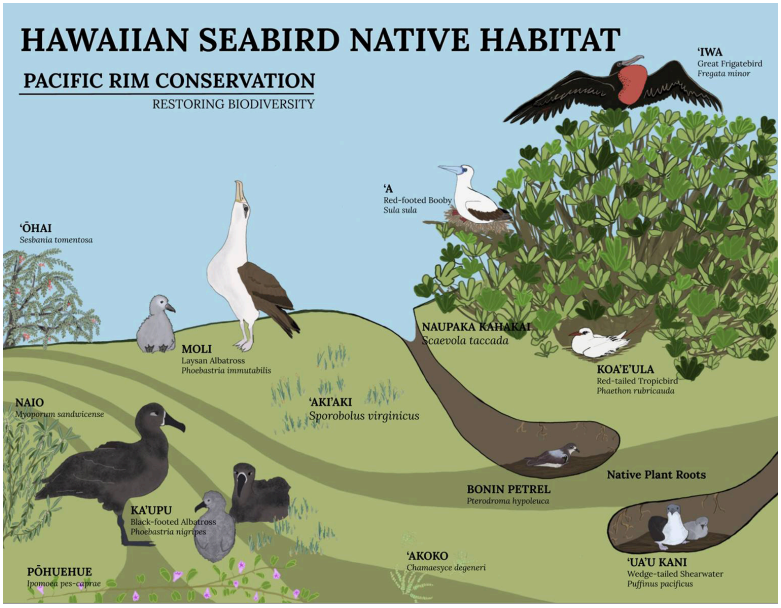
Wedge-tailed Shearwaters and Bonin petrels in burrows, surface nesting Laysan and Black-footed Albatrosses, storm-petrels nesting in adjacent rock piles, and Red-footed Boobies, Brown Noddies and Great Frigatebirds in trees or shrubs. Thus, a mere 2×2-m area can support 8 nesting species.

As with seabirds across the World, species in Hawai'i have been dramatically impacted by human activities. In Hawai'i, predation by invasive predators (such as cats, rats, dogs, pigs and Barn Owls) can have a devastating impact to breeding colonies, which is compounded by the spread of invasive plants and subsequent loss of habitat. In forested montane colonies, habitat loss is exacerbated by introduced ungulates like pigs and goats, and the increasing threat of Rapid 'Ohi'a Death. Habitat loss for coastal seabird species is further threatened by global warming and sea level rise, a particular concern for the low-lying islands of Papahānaumokuākea Marine National Monument. Human infrastructure also impacts many seabird species including collisions with powerlines (and other structures), light attraction especially among shearwater and petrel fledglings, and increasing coastal development. Lastly, seabirds are impacted by multiple threats at sea, including over-fishing, by-catch, plastic pollution (most well-known among albatross), and shifting prey availability due to climate change.

Due to the importance of the Hawaiian Islands for seabirds, there are many conservation organizations undertaking projects on a range of species. These projects include those focused on predator control (either ongoing predator control in open management areas or predator eradications within predator proof fences or on entire islets), translocation and social attraction projects aimed at protecting species impacted by climate change and predation, communication campaigns and legislation focused on reducing light in urban areas, seabird rescue and rehabilitation projects, and multiple Habitat Conservation Plans focused on endangered seabirds. To ensure that seabirds persist into the future, additional conservation science and effective resource management will be critical in the coming decades.

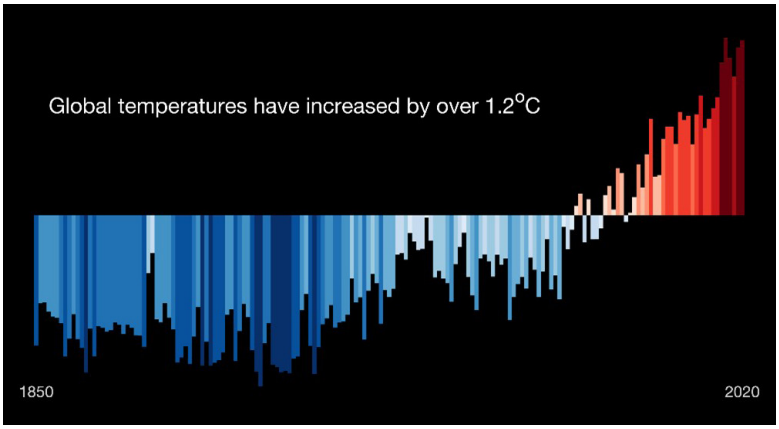
For more information: Hawaii Division of Forestry and Wildlife; US Geological Survey Western Ecological Research Center; Pacific Rim Conservation; Archipelago Research and Conservation.

A: 'Ua'u, Hawaiian Petrel (*Pterodroma sandwichensis*). Photo: Brett Nainoa Mossman.



B: Nesting habitats of Hawaiian seabirds. Source: Pacific Rim Conservation.

Impacts and implications of climate change



Long-term change in global average surface temperature.
Graphic by **Ed Hawkins, Climate Lab Book**.

Hawai'i's climate is changing rapidly, and will continue to do so for the foreseeable future, as human-caused heating affects the entire planet. Because the rate of change is unprecedented and ecological interactions are extremely complex, responses of ecosystems to global heating and associated atmospheric and ocean trends cannot be predicted exactly. However, major climate change related losses are already being observed on Hawai'i's coral reefs and with our endemic forest birds. The narrow climatic tolerances of many tropical species suggest further losses as global temperatures climb to levels not seen for millions of years. New weather extremes will have strong ecosystem impacts, and may appear well before they are projected to become normal. Conservation managers can no longer assume ecosystem stability or predictability, but can expect, and prepare for, ongoing change.

Impacts on pelagic and coastal marine systems

Global heating is causing expansion of the tropics (Polovina *et al.* 2011) which, together with ocean acidification, has implications for pelagic food webs and oceanic fauna (Karl and Church 2017), including changes in their distribution and abundance near Hawai'i (Woodworth-Jefcoats *et al.* 2019). Higher water temperatures increase metabolic rates and decrease dissolved oxygen. Mobile species may respond by moving poleward in latitude or deeper in the water column (Lenoir and Svenning 2014), but some sessile organisms like corals will experience stress or mortality. This will alter benthic species interactions and ecosystem composition. Current episodes of heat-induced coral bleaching are projected to become more frequent and lead to annual bleaching events in Hawai'i by mid-century (van Hooidonk, *et al.* 2016). Loss of reef-building corals due to these marine heatwaves is expected to reduce the structural complexity of reef environments and the number and species of fish and invertebrates found there. Unlike continental coastlines, isolated archipelagos such as Hawai'i may see sharp declines in marine biodiversity, as local extirpations and extinctions might not be balanced by an influx of species from warmer locations.

***Pocillopora meandrina*: a dominant Hawaiian reef coral.**
Photo: Mark Sullivan, USFWS.

Increased coastal wave surge resulting from sea level rise.
Photo: Ruby Pap.

Impacts on shorelines and coastal ecosystems

Shorelines currently buffered from storm waves by offshore reefs are projected to experience rapid increases in wave impact and runup as reefs degrade (Cornwall, *et al.* 2021) and are submerged by sea level rise (Storlazzi, *et al.* 2015), which will continue for centuries. Features such as dunes and beaches, and native species associated with them, will be unable to move inland as seas rise where their paths are blocked by steep slopes, alien vegetation, or human infrastructure (Jacobi and Warshauer 2017). Low islands will likely experience overwash events that impact nesting and resident species long before the islands are actually submerged by sea level rise (Storlazzi, *et al.* 2015). Rising water tables on flat coastal lands are expected to create new wetland areas and increase salinity of existing coastal freshwater wetlands (Rotzoll and Fletcher 2013), while those wetlands nearest sea level, including anchialine pools, will be lost as they become connected to the sea (Marrack, *et al.* 2021).

Impacts on stream habitats

Observed decreases in precipitation and streamflow on most islands may continue (Huang, *et al.* 2021), but current downscaled models differ in the distribution and amount of future precipitation, with some projecting wetter windward conditions. Hawaiian stream ecosystems are sensitive to reductions in flow, which affect stream temperature (Strauch, *et al.* 2015), connectivity, ecosystem function (Frauendorf, *et al.* 2019), and parasitism (Gagné and Blum 2015).

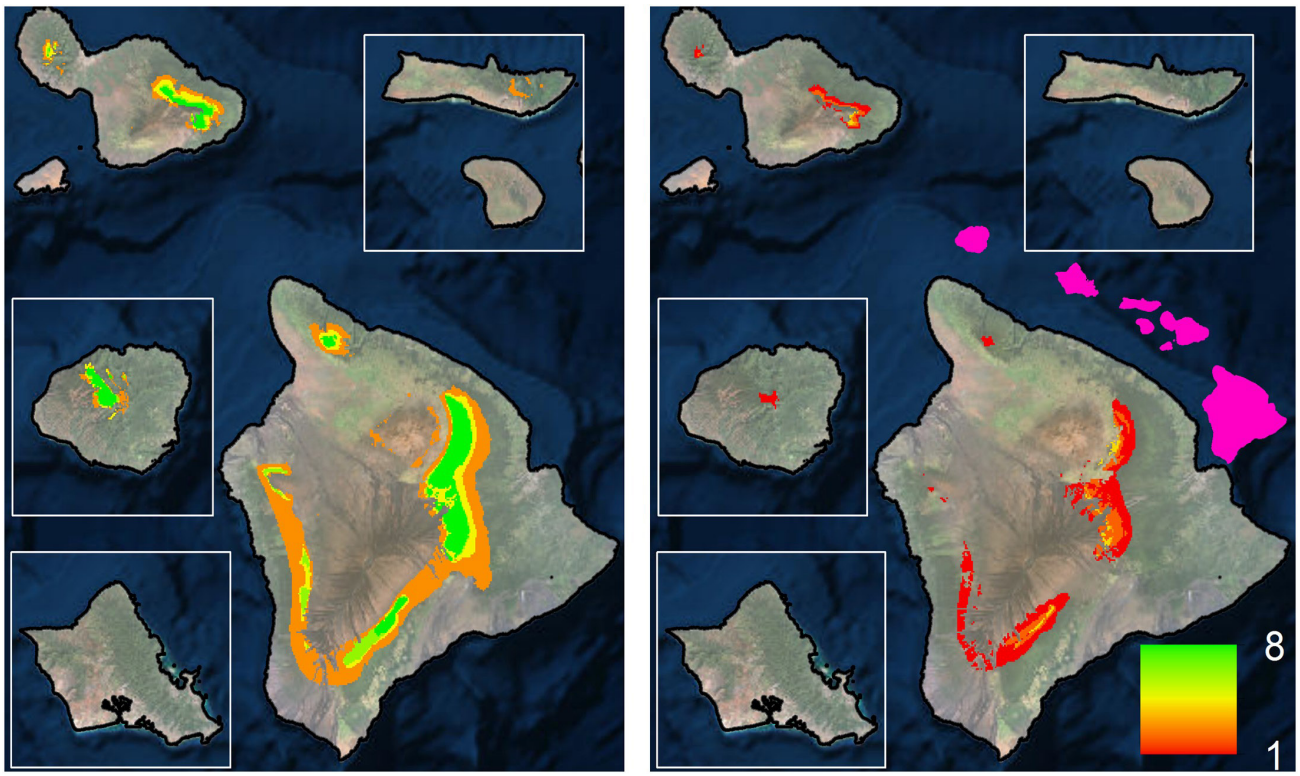
Pristine stream community on Kaua'i. Photo: Jim Jacobi, USGS.

Impacts on upland habitats

Global heating is projected to shift existing island temperature gradients uphill and create novel, hotter climates near sea level. With no higher, cooler habitat available, species restricted to peaks and ridges by current climatic conditions will decline or be extirpated (Fortini, *et al.* 2013; Fortini, *et al.* 2015). Spatial patterns of rainfall differ among downscaled models, making it difficult to determine where current combinations of temperature and precipitation will be in the future. Native species may need to move across the landscape to track their climate niche (Fortini, *et al.* 2013), although many now lack the reproductive and dispersal mechanisms to do so. Conditions suitable for most Hawaiian vegetation types are expected to shift in extent and location (Fortini and Jacobi 2018). Transitions to new species assemblages may be triggered by extreme climate events such as drought, or by climate-related disturbances such as fire. Fire risk to ecosystems may shift to higher elevations and formerly wetter sites (Trauernicht 2019).

Mosquito biting an 'Apapane. Photo: © JackJeffreyPhoto.com.

Avian malaria constrains many remaining Hawaiian forest bird species to high elevations where temperatures are too cool for the malaria parasite and its principal mosquito vector. Under a mid-range heating scenario, projections of climatic ranges linked to disease show that six forest bird species would lose all their range by the end of the century, three others would lose >90% of their range, and 10 more species would lose over half of their range (Fortini, *et al.* 2015).



Current (left) and future (right) forest bird number of species based on modeled range and available primary habitat of all extant species. Source: **Fortini, *et al.* (2015)**.

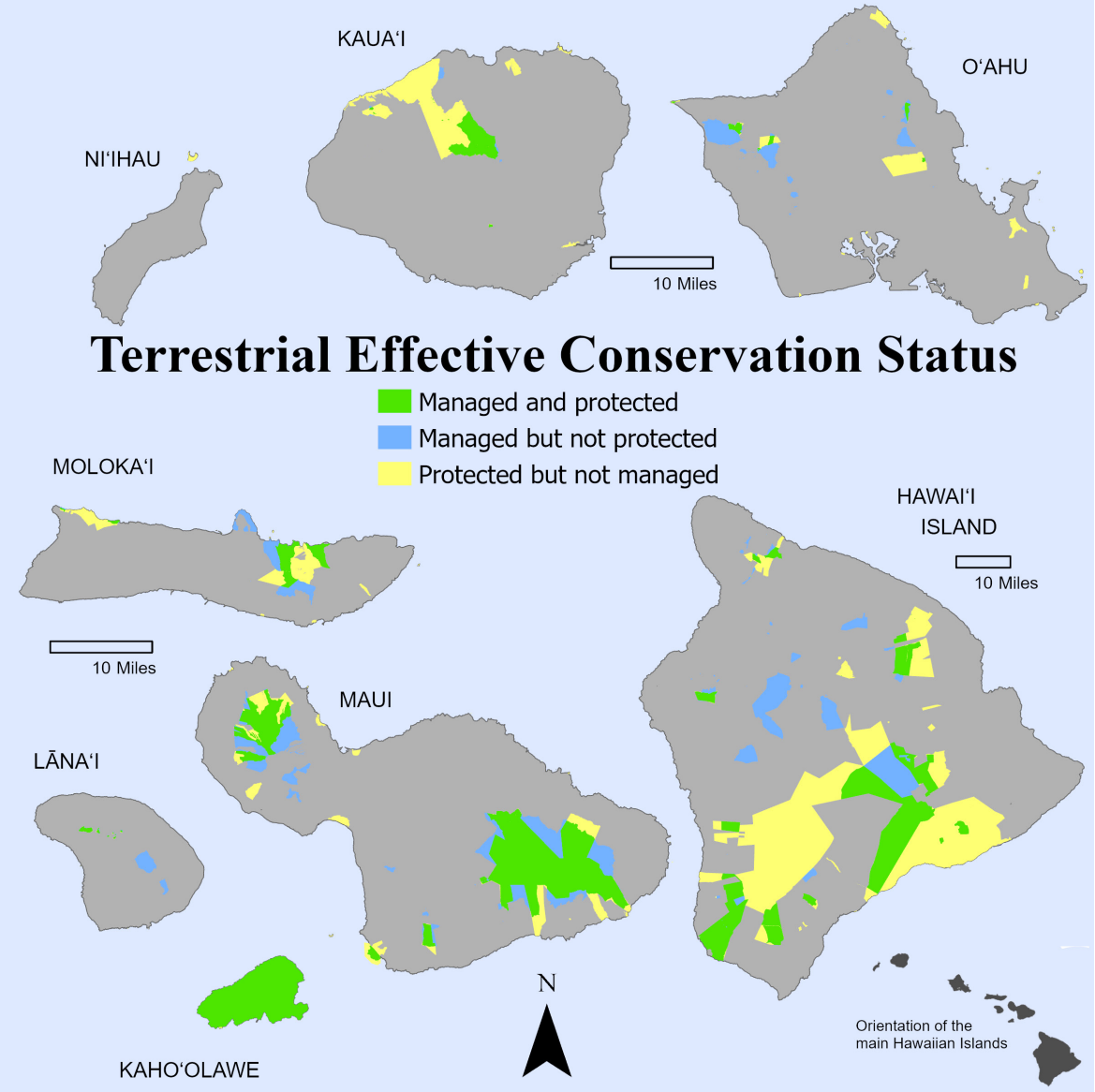
Kiwikiu (Maui parrotbill).
Photo: Robby Kohley, ABC Birds.

Hawaiian honeycreepers, like the kiwikiu, are an integral part of the cultural and biological diversity of Hawai'i. Non-native mosquitoes that carry avian malaria now restrict Hawaiian honeycreepers to the highest reaches of their historical habitats, where cool temperatures keep mosquitoes and avian malaria at bay. In recent decades, warming temperatures due to climate change have shrunk these remaining high-elevation refuges for the birds. In 2021 approximately 135 kiwikiu remained in the wild. Their year of extinction is estimated to occur between 2024 to 2032, most likely 2027 (USFWS 2022).

Implications for management

Wildfire management. **Photo: Hawai'i State DLNR.**

Climate change is irreversible and will eventually transform island ecosystems. Transforming the practice of conservation to cope with the reality of accelerating ecological upheaval is now an urgent undertaking for everyone in the field. Models cannot be definitive, so managers must use model projections as starting points for revisiting goals, exploring scenarios, planning management experiments, and conducting risk assessments of alternatives. Actions to resist climate trends or restore past conditions are likely to become more difficult and expensive over time. Directing ecosystem change through strategic interventions such as moving species might create better outcomes, but will require long-term planning, experimentation, and collaboration.



Status of conservation protection designation and management for the main Hawaiian Islands. Source: Hawai'i Conservation Alliance.

Effective conservation category	Hectares	Acres	Percent area
Areas with effective protection designation and management	112,437	277,838	7%
Areas with just effective management	52,306	129,250	3%
Areas with just effective protection designation	176,301	435,648	11%
Totals	**341,044**	**842,736**	**21%**

Summary of conservation protection and management status for the main Hawaiian Islands. Source: Hawai'i Conservation Alliance.

Effective conservation status in terrestrial ecosystems

Both protection and management of terrestrial conservation resources expanded greatly in recent years. However, many important habitats are still lacking these important actions. The information and maps provided in this report are intended to help identify remaining areas that need additional conservation if we are to be able to sustain these important resources for future generations.

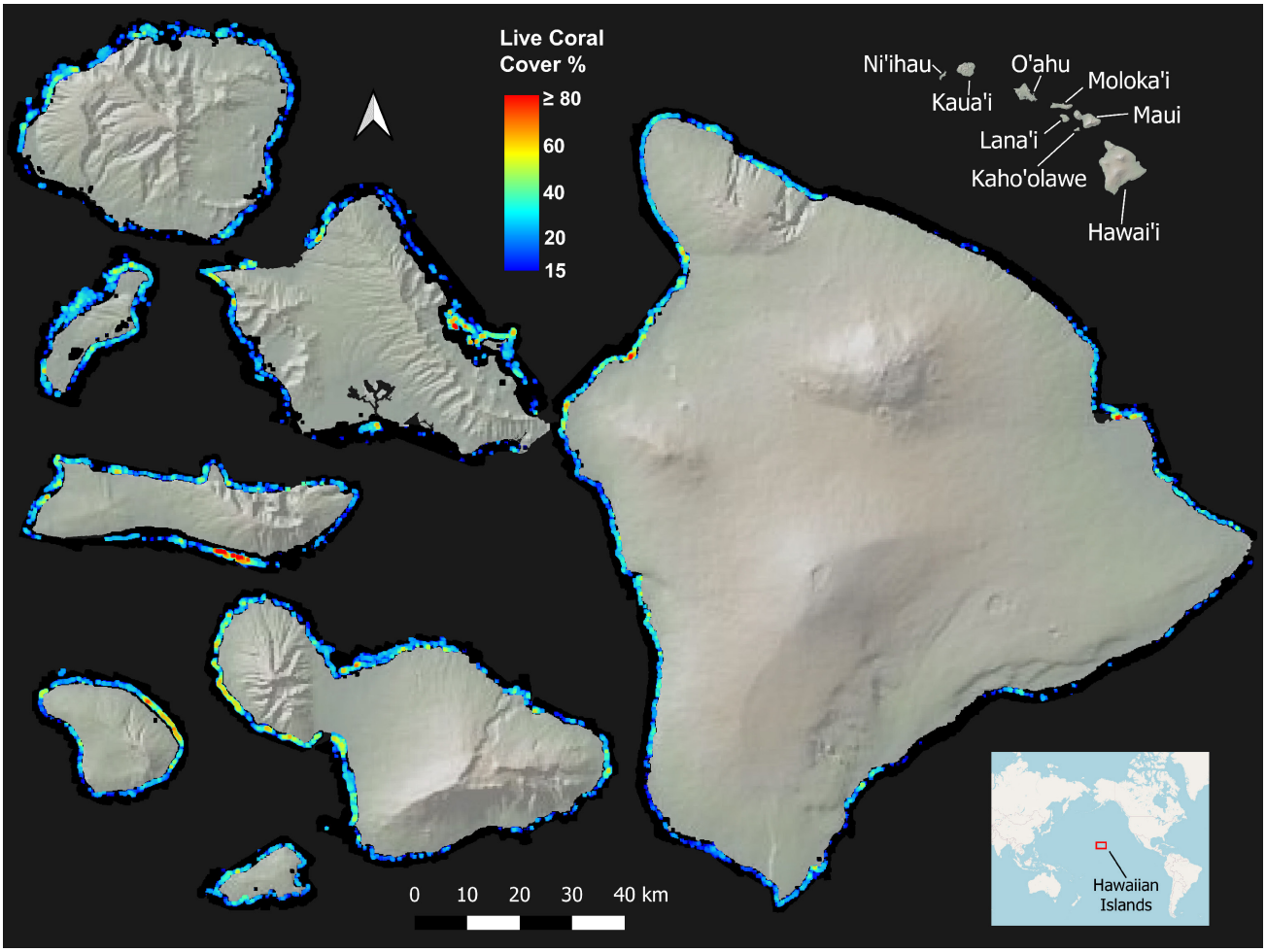
Nearshore marine ecosystems and species

Marine resource management in the Hawaiian Islands over the past 250 years has seen a transition from a traditional, decentralized system overseen by local entities, or konohiki, to a Western, centralized approach by the state government. In recent decades marine resource management regulations were developed and implemented by state and federal agencies. However, more recently community-led marine conservation programs are also being established and implemented with agency support. These have been developed in a number of localities, such as at Hā'ena on Kaua'i, Kipahulu on Maui, and Ka'ūpūlehu and Miloli'i on Hawai'i Island where the resource management programs are based on strong traditional cultural foundations.

Healthy reef ecosystem.
Photo: Andrew Gray, NOAA.

Status of coral reefs around the main Hawaiian Islands

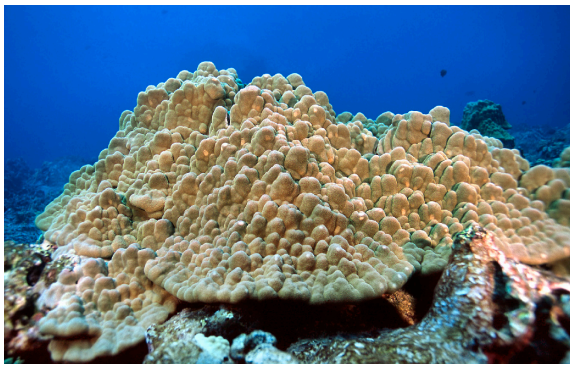
Coral reefs are the foundational element for nearshore marine ecosystems and provide key habitat for highly diverse communities of algae, invertebrates, and vertebrates. Hawaiian reefs can be classified into calcifying, turf algae and macroalgal/sand regimes depending on wave exposure, latitude, and anthropogenic influences



Distribution of live coral around the main Hawaiian Islands. Note the horizontal extent of the coral reefs have been slightly exaggerated to allow for better resolution of their distribution. Source: **Asner, G. P., *et al.* 2020.**

(Jouffray *et al.* 2015). Main threats to Hawaiian reef and nearshore ecosystems include overfishing, sedimentation and pollution, invasive species, and changing climate.

Monitoring projects conducted throughout the state have documented decline in coral cover, particularly following the 2015–2016 bleaching event. Although some sites have demonstrated little recovery, site and coral species recovery has varied.

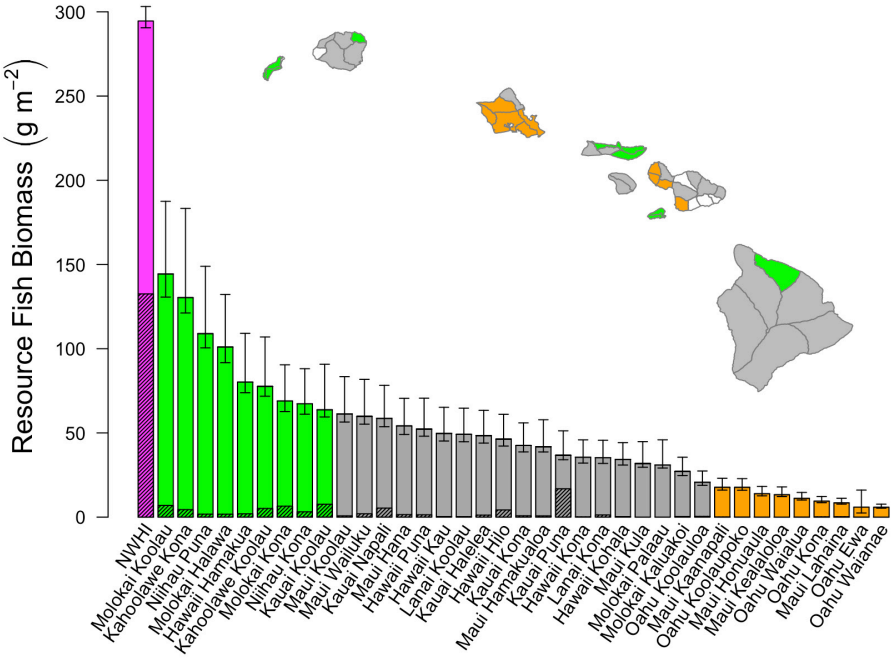


Brown lobe coral (*Porites evermanni*). Photo: © Keoki Stender.

A recent survey of coral reefs down to 16 meters in depth by Asner *et al.* (2020) provides one important baseline metric for assessing the status of nearshore marine systems. This study identified 20 reef sites with highest cover of live coral within the main Hawaiian Islands. The highest density coral sites were found on Hawai'i Island, followed in order by Maui, Kaho'olawe, Moloka'i, and Lāna'i. Although in this survey only one high density site was identified on O'ahu, and none on Kaua'i or Ni'ihau, the density of live coral is only one metric for the status of nearshore habitats. Areas, such as those exposed to high wave energy on the north and eastern sides of the islands, may not have high density of live coral but still have healthy reef communities.

Status of reef fish populations

An assessment of fish biomass throughout the entire Hawaiian Island chain found even the best sites in the main Hawaiian Islands have biomass values less than half of what was found for the relatively unfished Northwestern Hawaiian Islands (NWHI) (Friedlander *et al.* 2018). While several sites on the islands of Hawai'i, Kaho'olawe, Moloka'i, Kaua'i, and Ni'ihau had moderately high fish populations, most areas surveyed had less than 25% of biomass than found in the NWHI. One fish group that was found to be particularly depleted across all of the main islands were the top predators (sharks and jacks). This information emphasizes the negative impacts that humans have on the reef fishes in Hawai'i, particularly in the more heavily populated areas on the islands of Maui and O'ahu.

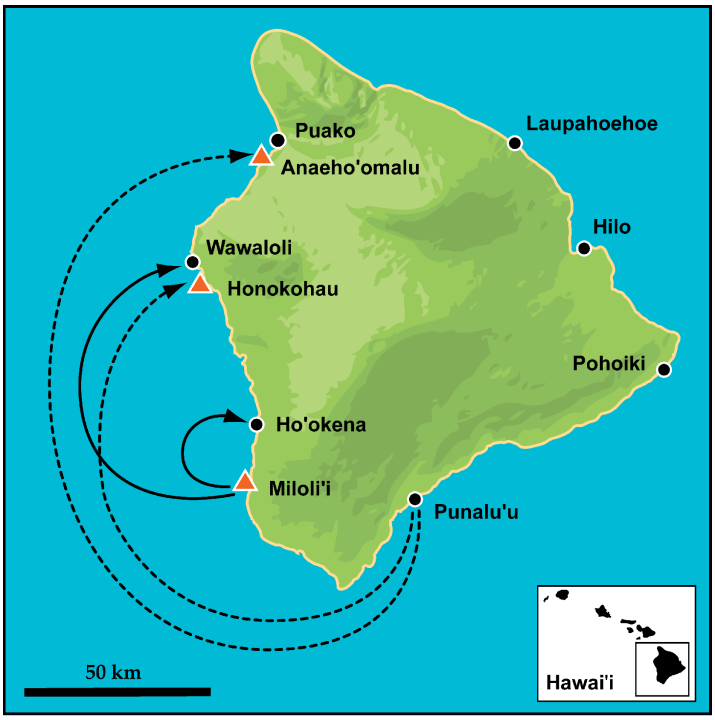


Resource fish biomass (g m−2) for each moku in the main Hawaiian Islands compared with NWHI (purple bar). Colors represent the lower (orange), and upper (green) quantiles of resource fish biomass in the MHI. Cross-hatched areas represent proportion of biomass comprising reef sharks and jacks. Source: **Friedlander *et al.* 2018**.

Pake ulua (Bigeye Trevally), one of the predatory jacks in Hawaiian waters. Photo: National Park Service.

Nadon (2017) conducted a formal stock assessment of reef fishes in the main Hawaiian Islands for the National Oceanic and Atmospheric Administration (NOAA). This assessment revealed that parrotfishes and surgeonfishes are particularly overfished. These herbivores are extremely important for keeping dead reef surfaces clean of benthic algae (seaweeds or limu) so that new coral can settle, survive, and grow (Hixon 2015), especially following ever-worsening coral-bleaching events (Williams *et al.* 2019). Consequently, conservation of coral-reef herbivores has become a top priority in Hawai'i (Chung *et al.* 2019).

A major challenge to managing and conserving stocks of coral-reef fishes is that, like most marine animals, they spawn tiny larvae that can drift great distances before settling back a reef. This open life cycle makes it difficult to understand both the geographical boundaries of populations as well as their dynamics. Recent genetic studies use parentage analysis to match parents and offspring, so that patterns of larval dispersal can be mapped (Christie *et al.* 2010).



Genetic parentage analysis revealed patterns of larval dispersal of Lau'īpala (Yellow Tang) around Hawai'i Island. Fin clips were taken from catch-and-release fish at all sites indicated, revealing four parent-offspring pairs. In all cases, larval dispersal was northward. The red triangles are Fishery Replenishment Areas. Source: **Christie *et al.* 2010**.

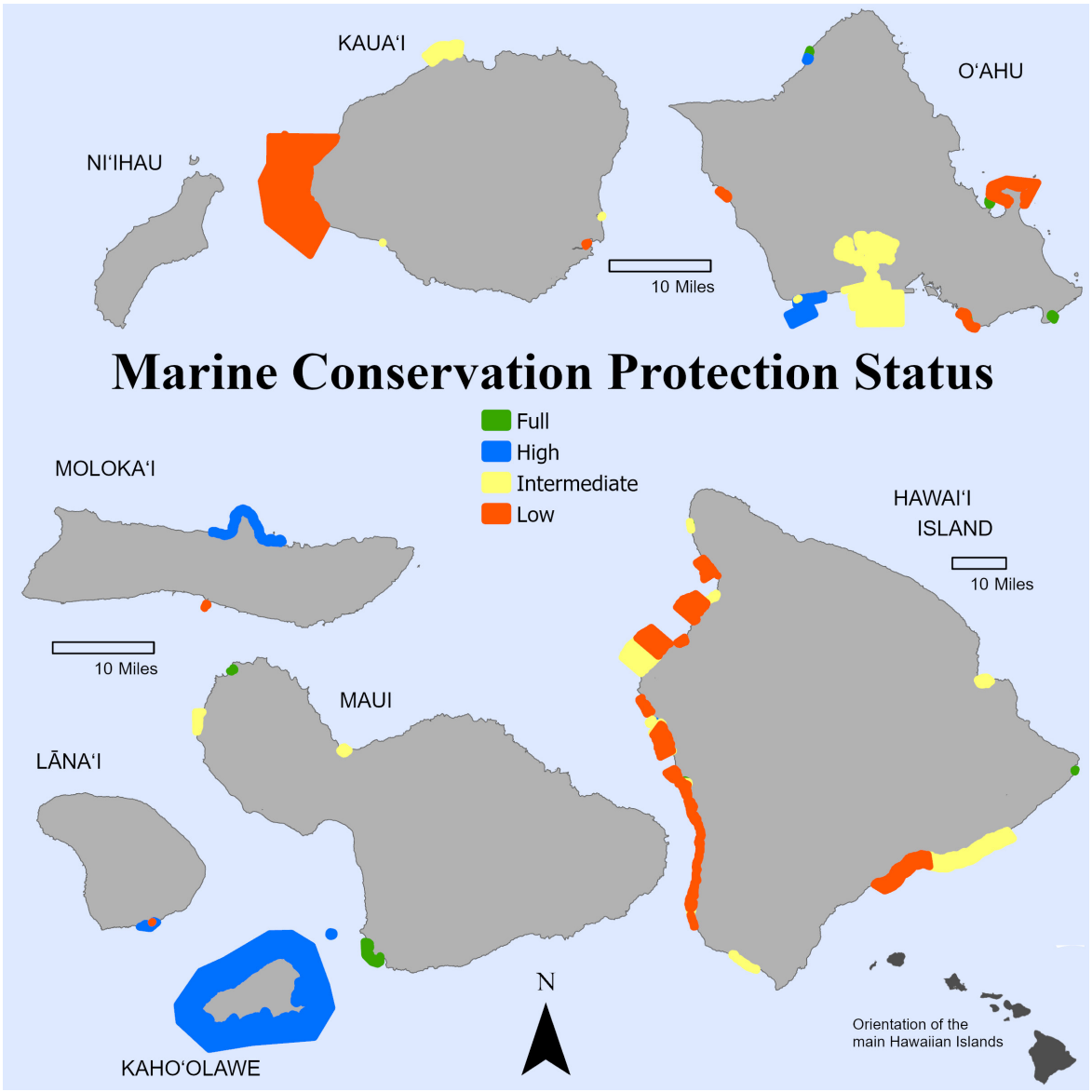
Marine protection status

Marine Protected Areas (MPAs) are areas in the ocean that have protection designation as one means to conserve biodiversity resources. The level of protection varies among different types of MPAs, ranging from seasonal protection for selected components (e.g., species of fish), to full protection areas where the specific mandate is for conservation of all of the natural resources and habitats within an area. A recent review of MPAs in the main Hawaiian Islands by Friedlander et al (2019) divided MPAs into four categories: Full, High, Intermediate, and Low, based on the level of conservation protection.

Main Hawaiian Islands

The current spatial network of marine managed areas in the main Hawaiian Islands was for the most part established decades ago, starting with Hanauma Bay and Moku o Loe in 1967, although a few additions have occurred in the past 20 years. Approximately 12% of the nearshore waters (within the 50 m depth contour) and 5% of waters within state jurisdiction (≤3 nmi offshore) surrounding the southern eight Hawaiian Islands (or main Hawaiian Islands) have some form of marine management. Fully protected marine reserves comprise <0.5% of nearshore waters, and combined with highly protected MPAs, account for 3.4% of the coastal marine habitat. Most of the existing MPAs are small, with a median area of 1.2 km² (Friedlander *et al.* 2019).

Overall, the marine protection status in the main Hawaiian Islands is still relatively limited in extent and there are few areas that are primarily mandated for full conservation protection. However, in 2016 the State initiated the Sustainable Hawai'i Initiative that committed to effectively managing Hawai'i's nearshore waters by 2030

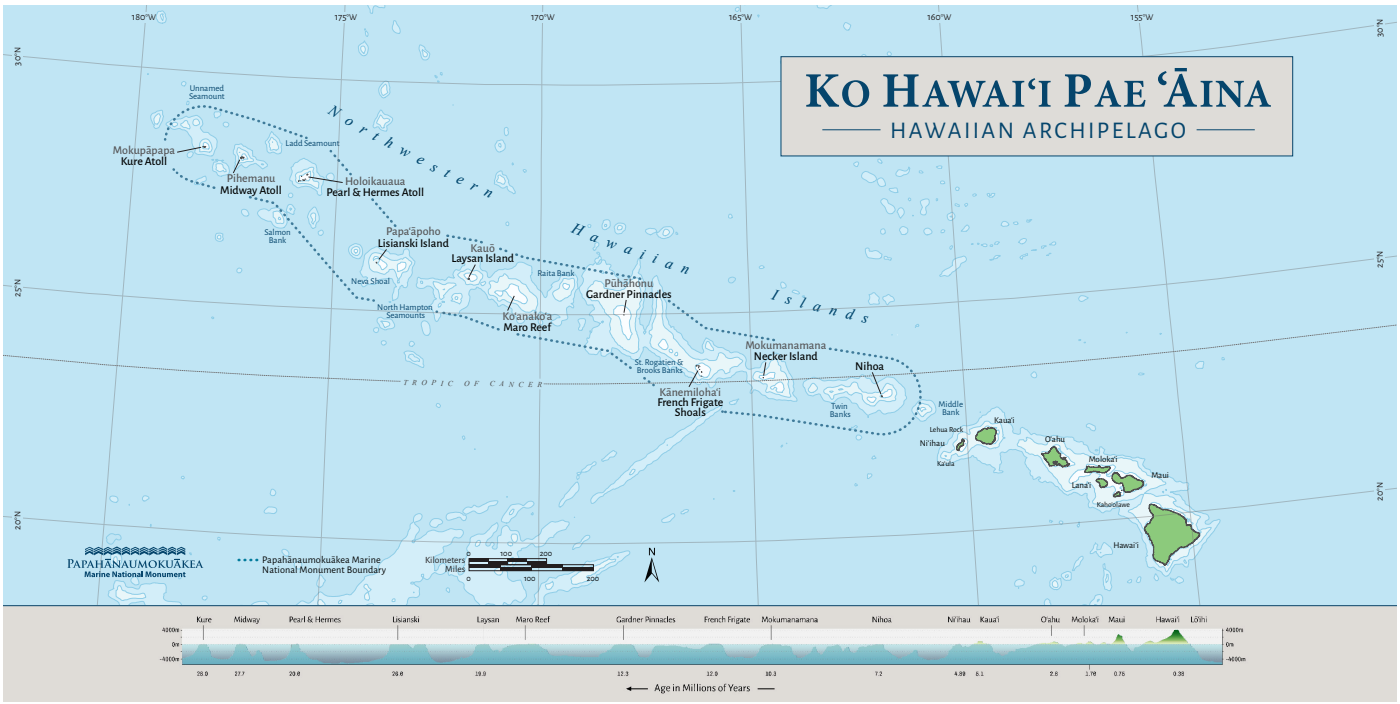


Status of marine conservation protection in the main Hawaiian Islands.
Source: **Hawai'i DAR; Friedlander, *et al.* (2019).**

(the Holomua Marine Initiative). While this effort is led by the State DAR, many other organizations have made similar pledges to assist with achieving this goal. Additionally, the State of Hawai'i has recognized the importance of herbivore protection to improve reef conditions and ensure healthy reefs. A small herbivore management area was created at Kahekili West Maui, and the state has prepared a statewide marine herbivore management plan. A limited nuisance algal control program exists for Kāne'ohe Bay.

A summary of the status of ocean health and associated resources for the main Hawaiian Islands has been compiled as part of the Ocean Health Index project.

Humuhumunukunukuāpua'a or Wedge Triggerfish (*Rhinecanthus rectangulatus*), the state fish of Hawai'i. Photo: © Keoki Stender.



Map of the northwestern Hawaiian Islands and the Papahānaumokuākea Marine National Monument. Credit: NOAA.

Northwestern Hawaiian Islands

The largest contiguous marine reserve in the United States, and one of the largest in the world, is the **Papahānaumokuākea Marine National Monument**, which was created in 2006 and is managed jointly by the National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service, the Hawaii Department of Land and Natural Resources, and the Office of Hawaiian Affairs. This marine reserve encompasses 1,508,870 square kilometers (582,578 square miles) of the Pacific Ocean surrounding the Northwestern Hawaiian Islands, stretching approximately 1,350 miles northwest from beyond Ni'ihau to Kure Atoll. In addition to its diverse and intact marine ecosystems and biodiversity, the Papahānaumokuākea Marine National Monument is extremely rich in cultural sites and resources which has led to it being recognized as a **UNESCO World Heritage Site** based on its significant combination of biological and cultural resources. The entire Papahānaumokuākea Marine National Monument is considered to be in full protection status. A recent report describes the current status and trends of natural and cultural resources within the Monument (NOAA National Marine Sanctuaries).

Laysan albatross. Photo: © Keoki Stender.

Community-led conservation efforts

The values and ethics of aloha 'āina and the practice of mālama 'āina are lauded in principle among Hawai'i's conservation agencies and organizations, but are still greatly underappreciated in practice. However, this situation is changing. Actions and interests in collaborative community-based terrestrial and marine conservation in Hawai'i are growing in ways that elevate the care of Hawai'i once again as a cultural imperative. For example, the **Ahupua'a Accelerator Initiative** is a priority program of the Hawai'i Conservation Alliance and is one of several local efforts to support community and culturally-centered stewardship by appropriately accelerating both the enabling conditions and desired outcomes of ahupua'a restoration and conservation in present day.

Volunteers at He'eia Fishpond helping to fill in a restored section of kuapā (fishpond wall). Photo: Mark Lee.

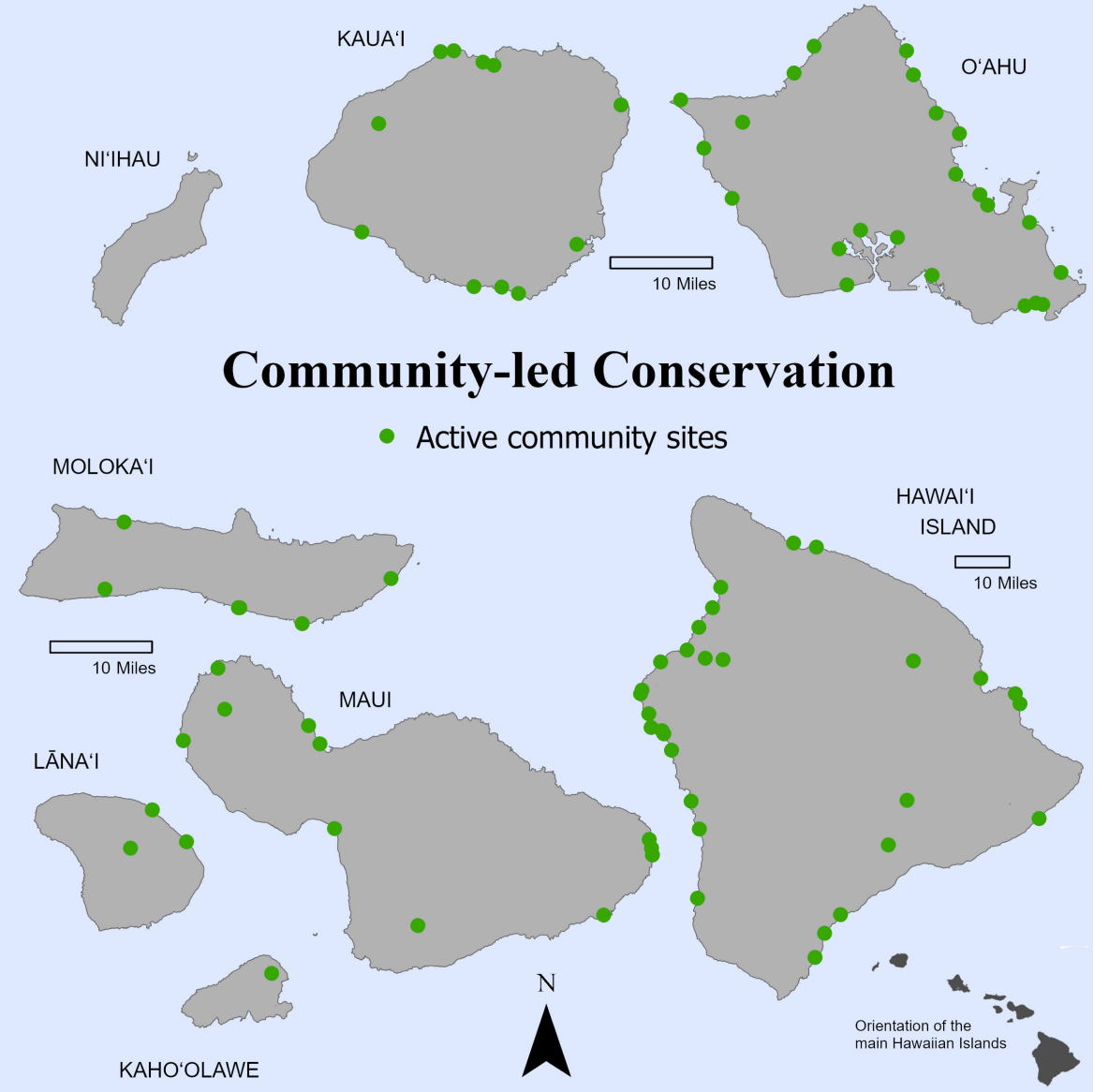
Ahupua'a Accelerator Initiative

Indeed, there is a growing global movement for Iindigenous people and local community empowerment in conservation. Today nation-states, including the U.S.A. are awakening to **Other Effective Conservation Measures** (OECM) and **Indigenous and Community Conserved Areas** (ICCA) which lie outside of conventional "fortress conservation" models. Initially, in Hawai'i, most community-led conservation efforts were focused on managing coastal resources. However, in recent years emphasis has been expanded to include upland sites, such as at Pu'uwa'awa'a on Hawai'i Island

Agency is the ability and capacity to act in one's own self interests. Forms of Native Hawaiian agency are not only constitutionally protected but persist and are still held in many communities around the state. In many instances, specific manifestations of and practices relating to these forms of Indigenous agency are reaffirmed in case law. Hawai'i's Indigenous traditional pre-western history demonstrates that building a culture where communities work together with governing institutions that have the right leadership and processes is necessary for achieving abundance and conservation outcomes.

The movement for community-led natural resource management has grown over the last decade by group, region and subject matter as the map below demonstrates. An ethic of caring for Hawai'i in its rural and Native Hawaiian communities is becoming more sophisticated with time, and these opportunities, if built upon with supporting policy, resources and education, can shift our broader culture toward one that increases community driven and supported conservation.

Volunteers in the field at Pu'uwa'awa'a, Hawai'i Island. Photo: Pu'uwa'awaa Community-based Subsistence Forest Area.



General locations of community-led biocultural conservation efforts across the state. Data primarily from Kua'āina Ulu 'Auamo with additional sites provided by other HCA partners.

Some highlights of recent community-led conservation efforts include:

- The emergence of a movement for community-based fishery management, for example the community-based subsistence fishing area (CBSFA) law HRS §188-22.6 led to the first officially adopted CBSFA at Hā'ēna, Kaua'i. Around the same time, the first community-driven 10 year rest area was also established at Ka'ūpūlehu, Hawai'i Island.
- These accomplishments are a part of a broader push for CBSFA initiatives at Mo'omomi (Moloka'i), Miloli'i (Hawai'i island), Kīpahulu CBSFA (Maui), and fisheries management areas in Maunalua and other emerging initiative areas.
- A streamlined permitting process for restoring loko i'a (fishponds), was established by the Hawaii Department of Land and Natural Resources to aid in a future vision of loko i'a contributing to the replenishment of nearshore fisheries through restorative aquaculture.
- Establishment of the He'eia National Estuarine Research Reserve in 2017, its 560 hectares (1,385 acres) including the He'eia fishpond in Kāne'ohe Bay, conserved by the Native Hawaiian NGO Paepae o He'eia.

- The State of Hawaii's leadership's **Holomua Marine Initiative** for nearshore fishery management cannot be accomplished without significant community collaboration.
- The State of Hawaii DLNR has developed positions in DOCARE and DAR with explicit roles toward development of stronger community collaboration in natural resource management and governance.
- The recent pandemic highlights the need for green career pathways, policies and practices that link environment, food, community and governance, recent legislation currently recognizes greater need to generate resources for conservation, as well as a conservation workforce.
- There is also growing interest to expand terrestrial community-based stewardship areas. For example the **Pu'uwa'awa'a Community Based Subsistence Forest Area** is working to formalize a community based stewardship plan for the restoration of an 34 hectare (84 acre) unit in the dryland forests on leeward Hawai'i Island.

Outreach and education

Students at 2016 World Fish Migration Day at Papahana Kuaola learning about Hawai'i's migratory 'o'opu, native Hawaiian goby (see page 42).
Photo: Tina Lee, Hawai'i Conservation Alliance.

People are integral to 'āina and are a vital part of Hawai'i's landscapes and seascapes; our interactions and relationships with 'āina are critical to its care and growth. Access to and exposure to 'āina through outreach and educational opportunities are essential for building meaningful pilina (association, connection) with the natural and cultural resources of Hawai'i. Outreach and education serve as powerful vehicles for developing and enhancing perspectives regarding the state of our environment, help to enact positive change and support for conservation efforts, and contribute to the environmental and cultural vitality of Hawai'i. Conservation organizations can utilize 'āina as a platform to teach across multiple disciplines and ultimately help people of all backgrounds to connect to place, culture, and each other fostering a character of aloha. Programs that integrate education with capacity building foster a clearer understanding and appreciation of the value of our biocultural resources and also help communities to make more informed decisions about the resources in their ahupua'a/home. The health of our people and our 'āina go hand in hand so developing reciprocal relationships with our place is key in our efforts to perpetuate the legacy of Hawai'i's ancestors and to shape a future rooted in love of land.

The next generation of land and ocean stewards. Photo: DAR.

Outreach and education are critical to help bridge the physical and mental distance between people and place that have negatively impacted Hawai'i's environment. By providing a wide range of opportunities for residents and visitors of all ages, abilities, and time availability, to see, learn about, and engage with 'āina and kai (land and sea), we can help to invoke wonder and, hopefully, appreciation for all of the unique species and landscapes of Hawai'i while emphasizing key messages and needs. Outreach and education, whether they take place in classrooms, learning centers, field trips, or work days, help to build awareness of our biocultural resources, as well as the threats to those resources. Without this awareness, there is limited understanding or appreciation of their value.

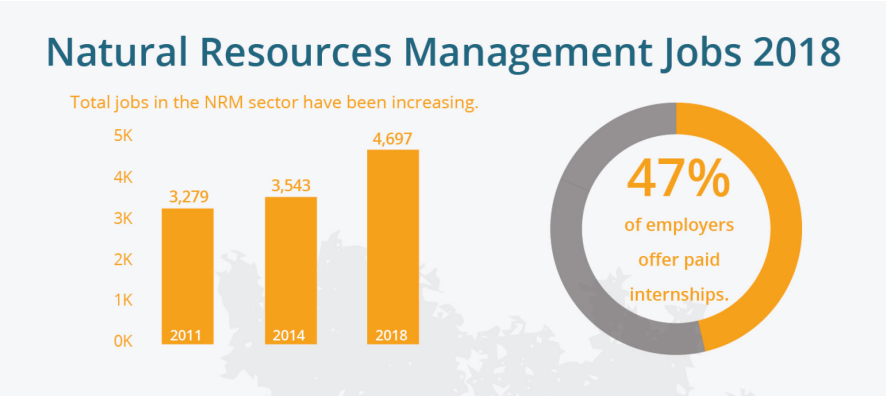
Local conservation capacity

Investments in emerging conservation professionals and programs (short, medium and long range) are critical to integrate our past, present and future to support our next generation of leaders, managers, practitioners and educators, who play key roles in the sustainability of biocultural resources. To accomplish these goals, organizations throughout Hawai'i and across the Pacific have developed and invested in programs and projects that provide multi-generational place-based opportunities along with world-class resource management strategies that integrate knowledge from multiple sources, including traditional and local knowledge and contemporary science.

Mentor and Mentee Next Generation Panel at the Hawai'i Conservation Conference 2024. Photo: Hawai'i Conservation Alliance.

These activities and pathways cross both terrestrial and marine environments, from ma uka to ma kai. This convergence of academic and hands-on experiences developed in culturally competent, respectful programs and projects allow for place-based learning that supports and encourages long-range workforce and community investments in biocultural resources management and ultimately 'āina momona.

The most successful workforce development and engagement programs in Hawai'i involve partnerships between federal, state, county, and community organizations. In addition, programs that incorporate cultural understanding in resource management and practices provide opportunities for growing the next generation of managers with the ability to work across programs and interests. Collaboration and cultural competency are extremely vital skills for the future of effective conservation management.



Source: **Burnett, K. and C. Wada (2019)**. Characterizing Hawai'i's Natural Resource Management Sector: Jobs, Education, Salaries, and Expenditures. Honolulu, HI, The **Economic Research Organization at the University of Hawai'i** (UHERO).

The Hawai'i Conservation Alliance recognizes the importance of nurturing and empowering Hawai'i's youth to fill conservation management roles and positions in Hawai'i as they enter adulthood. Homegrown Hawai'i youth typically have a deeper connection to Hawai'i's natural resources and feel a sense of kuleana to protect its resources and biodiversity. Through the Hawai'i Conservation Alliance's Nāhululeihiwakuipapa (Next Generation) Subcommittee, and the Conservation Career Compass, the Hawai'i Conservation Alliance provides programming to develop support among Hawai'i Conservation Alliance partners for Hawai'i's youth to develop the necessary leadership skills and opportunities to become the next generation of conservation leaders.

There are many diverse and growing efforts across the state of Hawai'i working to nurture Hawai'i's next generation of conservation leaders. In addition, there are many stakeholders who fund and support this important work of growing a local and capable workforce dedicated to Hawai'i's biodiversity. The Nāhululeihiwakuipapa Subcommittee has developed a digital appendix of programs and conservation partnerships to reflect the growing opportunities dedicated to Hawai'i's youth.

Over the past 25 years with the development of 'āina career pathways and strategies to encourage more resource management positions and training, there has been noticeable growth with local Hawai'i representation in all areas of Hawai'i's conservation and biocultural resources management efforts. As the staffing changes, there are additional methods and approaches, cultural awareness, and sensitivity, as well as collaborations and relationships that have become increasingly intertwined and advanced with community efforts as described in the Community-based Management section of this report. Rewardingly, many of Hawai'i's youth have had the opportunity to fulfill their kuleana [responsibility] to the environment and the sustainability of our island communities and incorporate that commitment into career pathways and positions that serve their communities.

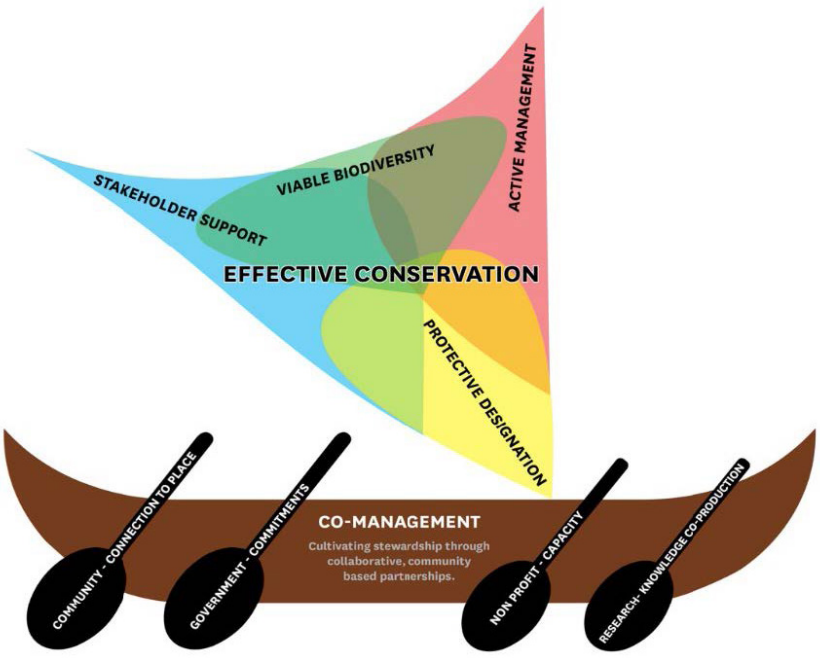
Winners of the 2023 Hawai'i Conservation Conference Student Presenter Awards. Photo: Hawai'i Conservation Alliance.

Call to Action:
Conservation Over the Next Decade

The pū (shell trumpet) sounds a call to action.
Photo: Megan Nagel, USFWS.

Now is the time for practitioners, resource managers, researchers, and all of Hawai'i to come together, and ensure that our biocultural treasures are passed intact to future generations.

I ola nā kini – that the multitudes thrive.



Conceptual diagram showing the key components identified by the Hawai'i Conservation Alliance needed to achieve effective conservation.

Working together, diverse partners from government, civil society, communities, landowners and more have made significant progress in protecting biocultural resources in Hawai'i over the past 50 years. Yet we still are losing Hawaii's native species and ecosystems to local and global impacts and threats. To manage these threats and ensure thriving lands and seas for future generations, we must scale up conservation actions across the archipelago.

Hawai'i has collectively recognized the importance of our natural resources with leaders in all sectors signing commitments such as the Aloha+ Challenge, Promise to Pae'aina, and the Hawai'i Commitments. In order to continue this work, there are critical actions needed to restore and conserve our biocultural resources.

Critical conservation needs

We recognize the following critical issues that need to be adequately addressed to effectively conserve Hawai'i's rich biocultural heritage:

- Providing adequate resources for conservation
- Protecting rare species
- Controlling invasive species
- Increasing habitat protection and management
- Adapting to changing climate
- Increasing public connection with conservation
- Expanding community-led conservation
- Integrating biocultural values into conservation

Ōhi'a mamo flowers. Photo: Will Weaver.

Providing adequate resources for conservation

Reliable, long-term funding is critical for achieving effective conservation. Just one gap year can reverse decades of progress, as fences fail and new invasive pests get established. In Hawai'i, many conservation funding sources are short-term and subject to annual fluctuation, making planning and progress very difficult. Conservation work also requires a strong source of committed conservation professionals who bring place-based values and the best-available knowledge and training to their work.

- Secure a diverse set of funding streams to support biocultural resource conservation efforts in Hawai'i.
- Support and increase green career pathways for Hawai'i's youth to increase our conservation workforce, particularly as we address climate change and many other challenges facing our islands.
- Integrate conservation education and values in diverse career fields.

Protecting rare species

As a hotspot for endemism and extinction, Hawai'i requires continued support for existing rare species programs that research, protect, and reintroduce rare and endangered species. The multitude of endemic species in Hawai'i are the foundation of our ecosystems, yet many of them are rare, threatened, or extinct due to many threats.

- Expand funding for existing programs that conserve and restore rare native plants and animals and their habitats to prevent extinctions.
- Invest in technology and workforce development for recovery of rare species, including control and/or eradication of non-native species, distribution modeling and genetic analysis of rare species, plant storage and propagation techniques, captive propagation, habitat fencing, and remote monitoring.
- Identify, protect, and restore important areas of native habitat within each ecoregion to protect all species of conservation importance.
- Provide sufficient funding, facilities, and capacity to support injured native wildlife rehabilitation.

Mauna Loa silversword (ʻāhinahina).
Photo: Jim Jacobi, USGS.

Controlling invasive species

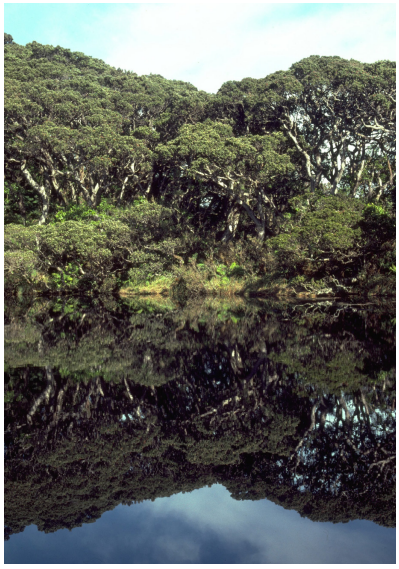
Effective conservation requires both control of established invasive species and prevention of new introductions. Prevention is always much more effective and cheaper than remediation. Hawai'i needs more staff, funding, partnerships and policy tools to detect and prevent new invasive pests from coming to our islands. For established invasive pests, we need to scale up proven management tools, such as ungulate and weed control, and develop new technologies such as biocontrol for mosquitos and eradication of introduced algae.

Brown tree snake introduced to Guam; this is a priority biosecurity prevention species for Hawai'i. Photo: Lori Oberhofer, USDA.

- Enhance biosecurity capacity and effectiveness to prevent and control invasive pest species statewide to protect agriculture, health, economy and biocultural resources through the full implementation of Hawai'i Interagency Biosecurity Plan.
- Expand the use of proven invasive species management efforts in native habitats, especially increasing ungulate control in priority native forests and shrublands ma uka to ma kai.
- Expand invasive species management using existing or new tools to control the most invasive pests that threaten Hawai'i's biocultural diversity.
- Increases support for the partners leading invasive species management actions statewide, especially the island Invasive Species Committees (ISCs), Hawaii Invasive Species Council (HISC), and Coordinating Group for Alien Pest Species (CGAPS).

Increasing habitat protection and management

Preserving Hawai'i's natural and cultural heritage requires legal protection of important natural areas coupled with active management. Thanks to collaboration among public and private partners, effective conservation of our native forests and upland habitats has significantly improved in recent years. Maintaining this momentum is important as we face impacts of climate change and the introduction of new invasive species. Unfortunately, lowland, coastal, and nearshore habitats have less legal protection or active management, and are heavily impacted by human activity.



Pristine native forest around Lake Wai'ānapanapa, Maui. Photo: Jim Jacobi, USGS.

- Complete and maintain fencing and ungulate control for priority watersheds and upland habitats.
- Increase conservation of lowland, coastal, and wetland habitats on all islands.
- Identify new opportunities for conservation in areas such as unencumbered State lands, agricultural lands, and private lands that include important biocultural resources.
- Expand protection and management of nearshore marine areas to meet 30 by 30 goals.
- Identify additional stream and riparian habitats in need of restored stream flow and active management.
- Expand strategies and support capacity to effectively respond to increased risk of wildfire impacts associated with new invasive species introductions and changing global climate.

Adapting to changing climate

Climate change will alter every Hawaiian ecosystem. Transforming the practice of conservation to cope with the reality of accelerating ecological upheaval is an urgent undertaking for everyone in the field. Actions to restore past conditions are likely to become more difficult and expensive over time. Guiding the ecosystem changes underway through strategic interventions might create better outcomes, but will require long-term planning, experimentation, and collaboration.

***Porites* coral bleaching offshore of Waimānalo, O'ahu.** Photo Dan A. Polhemu.

- Build an expanded vision of what futures are possible in a changing climate. Enhanced climate impact models, vulnerability assessments, scenario planning, and the RAD (Resist-Accept-Direct) framework are all useful for elucidating the drivers of ecosystem change, and can support conservation managers' ability to intentionally manage for change.
- Include biocultural resource needs and metrics in State, County, and private climate change mitigation planning.
- Incorporate ecological values into planned responses to sea level rise.
- Develop collaborative processes to prioritize, plan, and implement movement of species within and among islands to avoid climatically-driven extinction.
- Foster peer-to-peer learning in Hawai'i and the larger Pacific to accelerate the innovation and uptake of climate resiliency efforts.
- Incorporate climate change adaptation (resilience-building) and mitigation (GHG emissions reductions) across management plans and actions.

Increasing public connection with conservation

Hawai'i enjoys general public support for conservation. However, the connections between our biocultural resources, our economy, disaster preparedness, and other public priorities are not always well-understood or supported. While there are currently many conservation-based outreach and education programs in place, closer integration of those efforts and adding new components will help expand public knowledge and support of conservation actions more efficiently and effectively.

- Expand, coordinate and increase the knowledge and respect for Hawai'i's biocultural resources through education curricula and outreach efforts by government, schools, and other partners.
- Connect people more effectively and easily to Hawai'i's wonderful wild places and conservation action through increased media coverage, expanded outdoor activities for both residents and visitors, and fostering biocultural-ly sensitive ecotourism.
- Highlight conservation success stories and the urgent need for community support and action through media releases and public forums.

Ecotour group viewing native forest birds. Photo: Rob Pacheco, Hawai'i Forest & Trail.

Expanding community-led conservation

The natural environment is critical to local communities for food, cultural practices, recreation and as a source of multidimensional wellbeing. In response, some communities are leading conservation efforts to protect and manage local resources. These community-led efforts should be expanded and fully supported to empower local management and long-term restoration efforts. Programs like the Ahupua'a Accelerator Initiative, for example, work with Indigenous and local community stewardship practitioners using an approach centered on trust and relationship-building across sites and sectors as a foundation from which to guide rapid deployment of innovative conservation actions.

Community-led conservation is essential for successful long-term conservation. Hawai'i communities have many proven policy tools and the principles of community-based management are well-established. These tools should be rapidly scaled up to empower communities statewide.

- Empower more communities to implement Community-Based Subsistence Fishing Areas in nearshore waters that meet the criteria of the legislation.
- Develop policy and management tools for terrestrial community-based conservation.
- Apply community-based management values and processes to enhance protection, management, and restoration actions.

Community meeting at Halemano. Photo: DLNR.

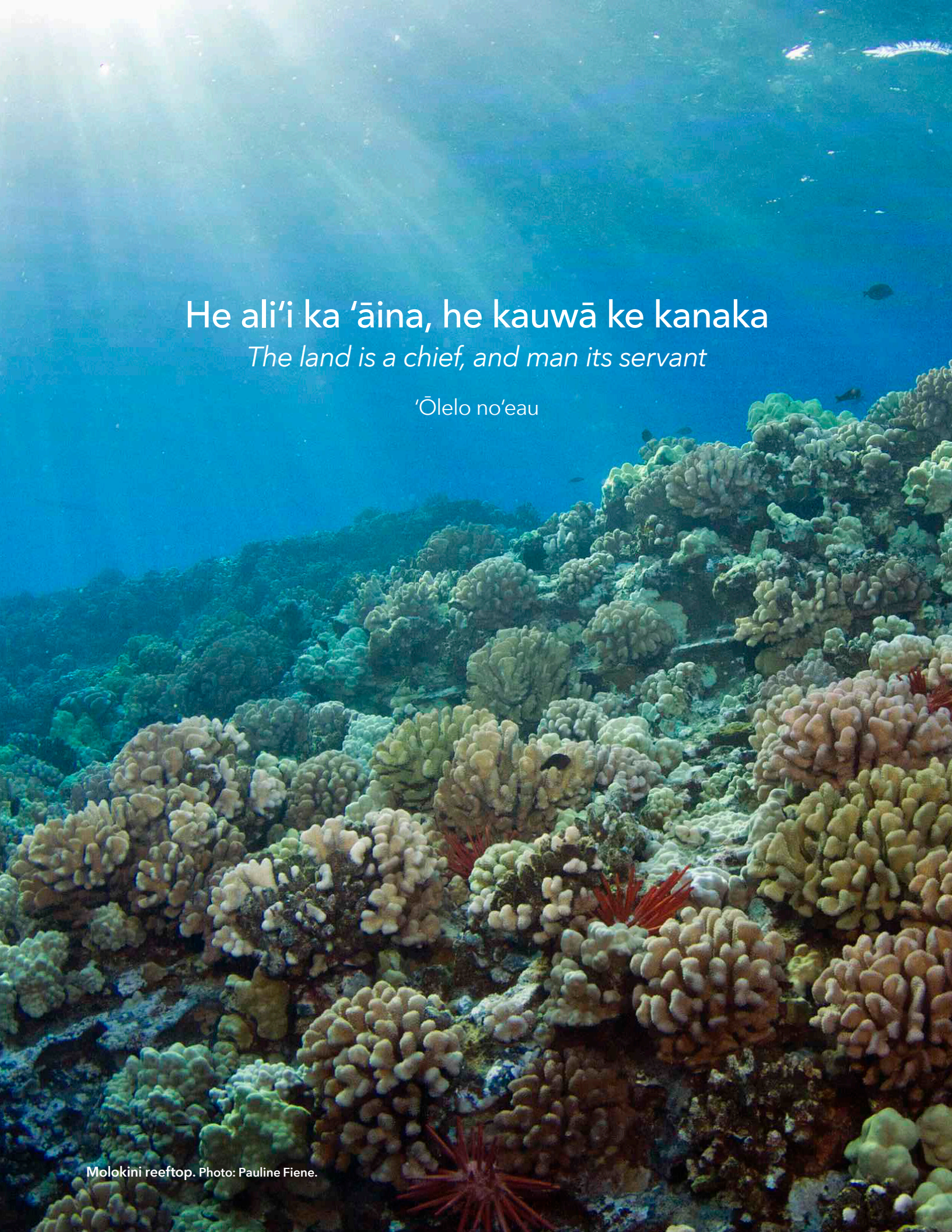
Wetlands and coastal vegetation in the James Campbell National Wildlife Refuge, O'ahu. Photo: Dan Polhemus.

Lineal descendants Reggie Lee, Leina'ala Lightner, and Hannah Kihalani Springer at Ka'ūpūlehu, home of the first community-led 10 year marine rest area in Hawai'i. Photo: Living Ocean Productions.

Integrating biocultural values into conservation

In Hawai'i, Hawaiian cultural values are closely linked with conservation values. This connection is now being recognized at higher administrative levels and needs to be fully integrated into conservation policy and management efforts.

- Incorporate Hawaiian biocultural values into agency and organization training for conservation professionals.
- Promote policies and practices that more closely link actions to environment, food, water, energy, community and governance.
- Recognize and protect indigenous knowledge
- Key policy documents:
  - White House Executive Order 14031
  - Usage of Indigenous Traditional Ecological Knowledge
  - Joint Secretarial Order 3403 regarding co-stewardship of federal lands and waters
  - Guidance Document for Characterizing Native Hawaiian Cultural Landscapes



He aliʻi ka ʻāina, he kauwā ke kanaka

The land is a chief, and man its servant

ʻŌlelo noʻeau

Molokini reeftop. Photo: Pauline Fiene.