



Forest Health

2023 highlights

◀ HAWAII ◀ MARCH 2024

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2023 Summary

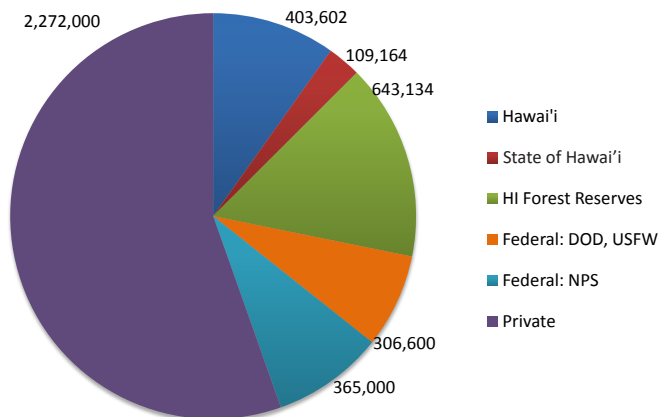
- **Rapid 'Ōhi'a Death (ROD)** continues to spread on the islands of Hawai'i and Kaua'i; O'ahu has had 15 detections of *Ceratomyces huliohia*, the less virulent ROD pathogen. The aggressive *C. lukuohia* has not been found on O'ahu, Maui, Moloka'i, or Lāna'i. Hawai'i Island continues to see higher levels of ROD in areas where hooved animals are damaging forests. Disease resistant screening efforts were scaled up to support a potential breeding program for 'ōhi'a restoration.
- **Coconut rhinoceros beetle (CRB)** efforts shifted from eradication to containing the beetle to O'ahu, in effort to prevent spread to other islands. However, in late 2023, CRB infestations were detected on Kaua'i, Maui, and Hawai'i islands. In addition, managers reported CRB damage to native **loulou (Pritchardia)** palms in forest areas on O'ahu for the first time.
- The Hawai'i Agriculture Research Center (HARC) in collaboration with DOFAW continued efforts at breeding disease resistant **koa (Acacia koa)** for commercial and restoration plantings. DOFAW is working with HARC to scale up reforestation efforts, targeting newly acquired lands on O'ahu and Maui for using koa and other native plants.

Forest Resources

This report is for the State of Hawai'i which includes eight main islands (Kaua'i, O'ahu, Moloka'i, Lāna'i, Kaho'olawe, Maui, Hawai'i, and, Ni'ihau) totaling 4.1 million acres. Public lands occur on all islands except Ni'ihau and Lāna'i, which are privately owned. Approximately 1.4 million acres of the state are considered forested. Non-forested areas include urban and agricultural areas, recent lava flows, and high elevation sites on Mauna Kea and Mauna Loa on Hawai'i Island and Haleakalā on Maui.

The State of Hawai'i Division of Forestry and Wildlife (DOFAW) manages 1,155,900 acres including 643,134 acres in forest reserves and 109,164 acres in the state's Natural Area Reserve System (NARS), which was created to preserve unique native Hawaiian ecosystems. Hawai'i's state forest acreage ranks as the 11th largest in the

Land Ownership in Hawai'i



nation. Federal lands account for 671,600 acres and are managed by the Department of Defense, National Park Service, and U.S. Fish and Wildlife Service. The National Park Service is the largest federal landowner, managing 365,000 acres. Although there are no national forests in Hawai'i, the Hawai'i Experimental Tropical Forest (HETF) was established in 2007 on the Island of Hawai'i as a partnership between the USDA Forest Service and DOFAW. The HETF comprises over 51,000 acres and is co-managed by the USDA Forest Service with DOFAW.

The remaining land – 2,272,000 acres – is privately owned. Increasing amounts of private forestlands are being managed in concert with publicly owned lands under public-private partnerships for watershed conservation in order to sustain Hawai'i's water supply. These watershed partnerships manage upland areas comprising a patchwork of federal, state, and private parcels. Eleven island-based Watershed Partnerships have been established on six islands to protect over 2.2 million acres (including non-forested lava flows and alpine areas). The partnerships actively manage approximately 300,000 acres of priority forest by removing invasive plants and animals.

Forest Health Monitoring in Hawai'i

Forest health monitoring occurs throughout the state on private, state, and federal lands. The spread and impact of invasive plants, invertebrate pests, diseases, ungulates, and biological control agents are monitored using ground surveys, transect monitoring, helicopter surveys, road surveys, photo points, and remote sensing techniques.

Monitoring forest health in Hawai'i presents many challenges associated with its climate and geology. Hawaii's extremely rugged terrain limits ground access to many areas and increases the difficulty of monitoring due to vertical slopes and shadow effects. Watersheds can have as much as half of total land area in near-vertical slopes. The exceptionally rugged terrain creates extreme temperature and rainfall gradients that result in diverse ecosystems in close proximity. These transitions occur over a very small scale, so monitoring data collected over large scales is not typically representative of widespread conditions. Identifying species and classifying them as diseased or infested is a complex and difficult task. Additionally, a thick layer of clouds present much of the year often limits or prohibits remote sensing and aerial surveys of mountainous areas where much of Hawaii's forests are located.

DOFAW is working with partners to utilize new technologies to collect forest health data at varying scales. UAS surveys for small areas, high resolution cameras mounted on helicopters and fixed wing aircraft and satellite imagery coupled with computer learning technology, and lidar combined with spectroscopy are examples of different technologies being used in Hawai'i to collect data on pest damage. In addition, the [USDA Forest Service Forest Inventory and Analysis](#) program has installed plots throughout the state, recently completing the second measurement.

Rapid 'Ōhi'a Death or *Ceratocystis* Wilt of 'Ōhi'a *Ceratocystis lukuohia* and *C. huliohia*.

'Ōhi'a (*Metrosideros polymorpha*) is the most common tree species in Hawaii's native forest, growing from sea-level to nearly 8,000 feet in dry, mesic, and wet forests. 'Ōhi'a-dominated forests cover 350,000 ha statewide, with 250,000 ha occurring on Hawai'i Island, and 'Ōhi'a trees account for 50% of all forest trees in the state. This abundant tree provides habitat to much of the native flora and fauna and also has significant cultural importance. The word 'ohi means 'to gather' in the Hawaiian language, referring to the tree's ability to collect water from the rain and mist, feeding the aquifers that sustain life on this remote archipelago.

Starting in 2010, residents in the Puna District of Hawai'i Island began noticing 'Ōhi'a trees on their property suddenly dying, while adjacent trees remained healthy. The symptoms appeared distinct from 'classic 'Ōhi'a dieback' previously observed on Hawai'i Island as a natural cohort senescence effect related to stand and substrate age. This new, rapid, dying phenomenon was coined Rapid 'Ōhi'a Death and researchers and managers began looking for a cause. Wood samples with dark gray discoloration were collected from symptomatic dead trees and were analyzed for the presence of pathogens. A fungus closely related to *C. fimbriata* was identified from samples using both morphological and molecular characteristics, and Koch's postulates for proving disease were completed with the pathogen on 'Ōhi'a seedlings by USDA Agriculture Research Service (ARS) in 2014 (Keith et al. 2015). Further surveys resulted in identification of two distinct but related species of *Ceratocystis* which were described as *C. huliohia* and *C. lukuohia* in 2018, the former a slow spreading canker disease and the latter an aggressive wilt disease causing most of the mortality seen on Hawai'i island (Barnes et al. 2018).

In 2023, Rapid 'Ōhi'a Death (ROD) continued to spread on Hawai'i Island, mostly filling in areas where only scattered mortality occurred. Areas with invasive hoofed animals are experiencing higher incidence of ROD, and scientists have been conducting research on interactions between ROD and animals (Perroy et al. 2021). The project's data manager produced a story map showing the interaction between ROD and feral animals: <https://storymaps.arcgis.com/stories/7f7a2bfd3ed142218998a7326f6006be>.

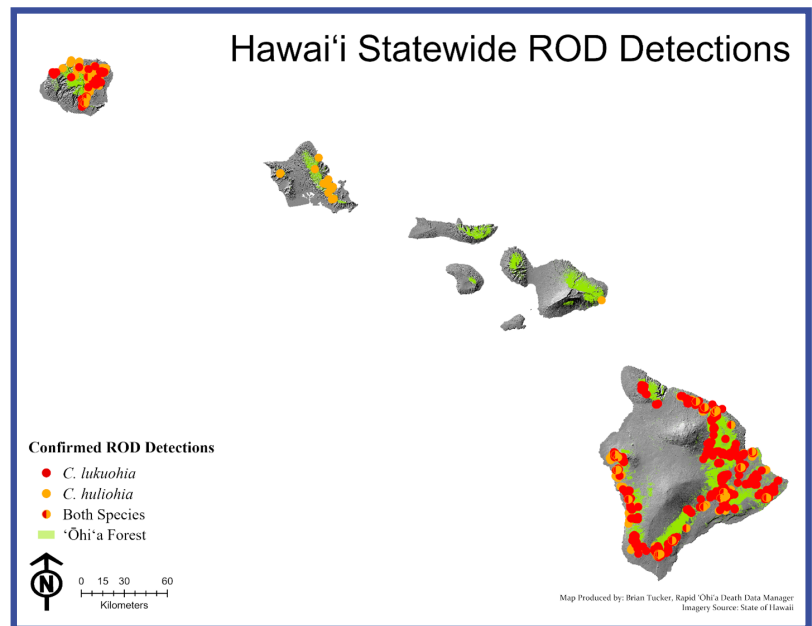


Figure 1. Rapid 'Ōhi'a Death detections.
Map credit: Brian Tucker, University of Hawaii



Figure 2. The ambrosia beetle *Xyleborus ferrugineus* attacking 'Ōhi'a.
Map credit: JB Friday, University of Hawaii

Invasive ambrosia beetles can vector ROD and release inoculum into the environment (Roy et al. 2020; 2023a). This includes four species: *Xyleborinus saxesenii*, *Xyleborus affinis*, *Xyleborus ferrugineus*, and *Xyleborus perforans*. The beetles have been documented to attack healthy, green 'ōhi'a trees as well as ROD-*Ceratocystis* infested trees. When the beetles create their homes or galleries in the xylem of 'ōhi'a trees, they kick out frass into the environment that can contain viable *Ceratocystis* chlamydospores (resting spores) that can survive in the environment for at least six months (Hughes et al. 2022). Two repellents, SPLAT Verb (verbenone) and SPLAT Beetle Guard (Verbenone + Methyl Salicylate) have been found to be effective at repelling the ROD-associated beetles, although they are not yet registered for use in Hawai'i. (Roy et al. 2023b).

DOFAW and its partners conducted semi-annual aerial surveys of the state's 'ōhi'a forests using the USDA Forest Service Digital Mobile Sketch Mapping tablet-based application to identify new disease outbreaks. On Kaua'i, both *Ceratocystis* species have been detected in multiple areas and managers on that island are responding with containment strategies. Only *C. huliohia* has been detected on O'ahu, while a single detection of *C. huliohia* on Maui was destroyed in 2019 and no further detections have been made on the greater Maui Nui area. Updated information and disease maps can be found on the Rapid 'Ōhi'a Death website at www.rapidohiadeath.org.

Koa Wilt

Fusarium oxysporum f. sp. *koae*

Over the past decade, DOFAW has worked with the Hawai'i Agriculture Research Center (HARC) in developing disease resistant koa (*Acacia koa*) for both commercial plantations and forest restoration. *F. oxysporum* causes a wilt disease in koa that can cause widespread mortality, especially at lower elevations. Screening koa families for disease resistance by ecoregion has been conducted by HARC and seed orchards have been established throughout the state for providing seed to DOFAW and private landowners.

DOFAW is working with HARC to utilize disease resistant koa to reforest recently acquired lands that have been added to the state's forest reserve system. Utilizing available, regionally specific, disease resistant planting stock will ensure healthy koa forests in the future. In 2022, DOFAW and HARC worked together to convert invaded albizia forests to a 5-acre koa and 'īliahi (sandalwood) seed orchard on the island of O'ahu. This seed orchard will provide seed for future restoration at the site and other locations on the island.

Fuller Rose Beetle

Naupactus cervinus

An outbreak of Fuller rose beetle on native koa trees was reported in late 2023 at multiple sites on Hawai'i Island. The introduced weevils have been present in Hawai'i for many years but have not been previously reported defoliating koa. It is not clear whether the outbreak is due to a climatic anomaly, but future monitoring is warranted.

Naio Thrips

Klambothrips myopori

Naio thrips were first detected attacking native naio (*Myoporum* spp.) plants in Hawai'i in 2009 on Hawai'i Island and continue to spread. Naio populates a wide range of habitats across Hawai'i Island, and the thrips is found throughout its population, while dry forests appear to be most vulnerable. The insects spread to O'ahu in 2019; despite rapid response efforts by DOFAW and the O'ahu Invasive Species Committee, the thrips have subsequently spread throughout the island to natural coastal naio populations. In December 2023 the thrips were detected on Moloka'i and response efforts are underway. Initial efforts to determine whether there is any variation in resistance or tolerance to the thrips is being pursued.

Coconut Rhinoceros Beetle

Oryctes rhinoceros

<https://www.crbhawaii.org/coconut-rhinoceros-beetle>

The coconut rhinoceros beetle (CRB) is a pest of many palm species and several non-palm plants and is native to South and Southeast Asia. The adult beetles damage trees by boring into tree crowns where they injure young, growing tissue to feed on sap. The subsequent damage can cause tree death. The beetles breed in moist, decomposing organic matter, especially dead coconut material, leading to a destructive cycle if left unmanaged. Although the beetles can fly up to two miles, regularly feeding on coconut palms and returning to breeding sites, spread is primarily through human movement of infested breeding material (e.g., green waste, dead trees, etc.).

The first detection of CRB in Hawai'i occurred on Joint Base Pearl Harbor



Figure 3. DOFAW staff member climbing a loulou palm during a training class at UH Lyon Arboretum. Photo credit: Hawai'i Department of Land and Natural Resources

– Hickam (JBPHH) on O‘ahu in December 2013 in a USDA trap. The amount and location of the infested mulch made destruction of the breeding population extremely challenging and required developing new tools. Currently, all green waste on JBPHH is being treated by the U.S. Navy through composting or incineration in air curtain burners.

The U.S. Navy also funds trapping, surveys, and treatments on JBPHH done by the CRB Response. The CRB Response is a control and eradication project funded by the USDA, U.S. Department of Defense, and the Hawai‘i Department of Land and Natural Resources and is housed and administered through the University of Hawai‘i. There is a multi agency state-wide effort using pheromone detection traps to delineate the infestation and detect new satellite populations. Crews also survey coconut palms for signs of CRB damage and mulch piles for breeding sites. The CRB Response is utilizing USDA-trained canine teams to detect breeding locations. The Hawai‘i Department of Agriculture (HDOA) has implemented two interim rules each lasting one year (July ‘22-‘23 and October ‘23-‘24) that regulate the movement of green waste and host palms between islands in order to stop the spread.

Unfortunately, beetles have been trapped throughout most of O‘ahu. The CRB Response funding from USDA has been restricted to control efforts around ports of entry and emergency responses to incipient populations to prevent CRB from establishing on the other islands. CRB has impacted natural forests on O‘ahu, and is impacting native loulu palms. This is of utmost concern, as loulu were previously known to be susceptible to CRB feeding damage, and many species are threatened or endangered. In particular, *Pritchardia kaalae*, is endemic to the Waianae mountain range and is threatened by newly established CRB populations.

In 2023, CRB was detected on Kaua‘i, Hawai‘i, and Maui. Eradication and monitoring efforts were put in place for these islands. Partially funded by a grant from the Genetic Conservation Resistance and Restoration (GCRR) program, DOFAW has begun implementing actions to protect loulu palms. There are five *Pritchardia* species found on O‘ahu, two of which are endangered species, and four of which are single island endemics to O‘ahu. In the first year of this project staff have implemented helicopter surveys to map the distribution of all five loulu species, and plan logistics for seed collection missions. Staff attended a tree climbing class, and are preparing to purchase the appropriate climbing gear. Staff have also purchased good nature A-24 rat traps and cages, which will be placed around and near some key wild loulu populations, to help protect seeds from invasive rat predation. A few early seed collection missions found fruit that were too immature for normal propagation in state nurseries, but seeds were taken to the University of Hawai‘i micropropagation lab. Staff plan to begin seed collection trips in the first quarter of the calendar year 2024.

Tree Ferns

Angiopteris evecta and *Sphaeropteris cooperi*

DOFAW is utilizing funding from Landscape Scale Restoration (LSR), Joint Chiefs, and Forest Health Protection grants to continue work on stopping the spread of invasive tree ferns to Hawaii’s remaining native forests. Aerial sprays targeting the mule’s foot fern (*A. evecta*) and the Australian tree fern (*S. cooperi*) were conducted in the high priority areas on O‘ahu totaling 68.1 acres and 48 staff hours. Additional aerial sprays, focused mostly on the Australian tree fern, were conducted in the Southern Hele-mano and Kīpapa management areas, covering roughly 31.4 acres. Follow-up on-the-ground control surveys are being planned to cull incipient invasive fern populations before they can establish in areas where they have not been previously reported.

Invasive plants on Kaua‘i and the Big Island

In 2023, the Big Island Invasive Species Council (BIISC) and Kaua‘i Invasive Species Council (KISC) began ground detection surveys for 14 high-risk invasive species across high-priority conservation landscapes on the islands of Hawai‘i and Kaua‘i (see list below). These plant species have been identified as high-impact weeds which can outcompete native plant species and alter the ecosystem biodiversity that hosts many endangered bird species. With active landowner participation, BIISC was able to survey 1,059 acres and treat 534 plants on the slopes of Mauna Loa and Kīlauea on the Island of Hawai‘i, while KISC was able to survey 55.45 acres and treat 38 plants in the native forests of Kōke‘e and Nā Pali on the island of Kaua‘i. Both councils seek to continue encouraging landowner participation in ground surveys and soon plan to share species-specific rapid-response plans with statewide partners to improve response time and eradication success.



Figure 4. Pre-control photo taken from sUAV (drone) of summit population flagged for aerial spray. Photo credit: Emma Yeun DOFAW

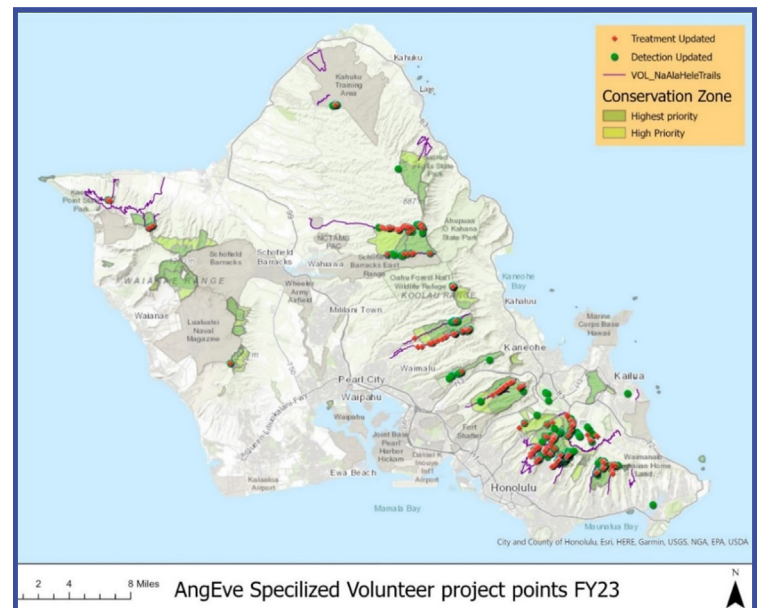


Figure 5. Treated and detected points of mule’s tree fern (*Angiopteris evecta*) across O‘ahu. Map credit: DOFAW

Hawai'i: Silverleaf cotoneaster (*Cotoneaster pannosus*), smokebush (*Buddleia madagascariensis*), Molucca raspberry (*Rubus seiboldii*), Dahoon Holly (*Ilex cassine*), Foxglove (*Digitalis purpurea*), Giant Burmese Honeysuckle (*Lonicera hildebrandiana*)

Kaua'i: Common rush (*Juncus effusus*), pink jasmine (*Jasminum polyanthum*), garden vetch (*Vicia sativa*), Kudzu (*Pueraria montana*), Bingabing (*Macaranga mappia*), southern wax myrtle (*Morella cerifera*), princess tree (*Paulownia tomentosa*), Barbados Gooseberry (*Pereskia aculeata*).

Pesticide Usage and Wildfire Mitigation

Approximately 240 acres of firebreaks and roads were sprayed with herbicide and maintained in Kūlani on the Island of Hawai'i, with target species being *Rubus argutus*, *Hypericum kouytchense*, and *Pyrocantha angustifolia*. Due to the unforeseen presence of endangered nēnē goslings and nests, the decision was made halt spraying until the end of June 2024. In the meantime, Hawai'i Wildfire Management Organization (HWMO) will be hosting a series of educational workshops with community members around wildfire preparedness following the devastating fires on Maui and the Big Island. These educational workshops aim to introduce community members to the Firewise Communities Program and train members in home ignition zone concepts, including home vegetation management and fuels reduction.

Forest Health Protection – Invasive Plants Grants

A USDA Forest Service Forest Health Protection grant was awarded to DOFAW for invasive plant species management in the native watershed forests on the island of Moloka'i. Extreme drought conditions have deemed these forests as high-risk fire areas, requiring firebreak and fuels management for wildfire mitigation efforts and protection of the island's sole source aquifer. This project supports the removal and spraying of invasive plant species from 70 acres across priority areas and maintenance of two-mile firebreak roads to protect the island's groundwater management areas.

The USDA Forest Service has also partnered with DOFAW on an LSR grant for the protection of native watersheds on the island of Kaua'i. This project intends to continue efforts in aerial mapping technology for detecting invasive species, such as ginger, strawberry guava, and the Australian tree fern, that when spread uncontrollably, can significantly alter ecosystem function. As these watershed areas are the primary source of drinking water for the island, the development for consistent control of these weeds is critical for ensuring future water supply and preventing spread into other protected areas.

Forest Health Protection – Bipartisan Infrastructure Law Invasive Species Grants

The State of Hawai'i Department of Land & Natural Resources received funding in 2023 from the Bipartisan Infrastructure Law Act—Invasive Species competitive grant program to reduce fire risk by strategically controlling invasive grasses in two areas of extreme fire risk: West Maui including areas above Lahaina and Wai'anae Valley on O'ahu. These complex landscapes that border conservation lands on the mauka side and communities on the makai side are critically in need of vegetation management to reduce risk of wildfire. On Maui, crews will control invasive grasses and shrubs using chemical and mechanical control, while on O'ahu, fencing will be installed to facilitate targeted livestock grazing of invasive grasses.

Bipartisan Infrastructure Law invasive species funds were awarded to the University of Hawai'i to develop immediate and long-term biocontrol options to manage coconut rhinoceros beetles populations and help mitigate its damage to palms and other host plants. This project will also actively work to disseminate any advances in biocontrol work throughout the Pacific Region.

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¹USDA Forest Service

²University of Hawai'i

³Hawai'i Agriculture Research Center

⁴Hawai'i Department of Agriculture

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Data Sources

The data sources used for this report include the Division of Forestry and Wildlife, US Forest Service Region 5, Hawai'i Department of Agriculture, University of Hawai'i College of Tropical Agriculture and Human Resources, Hawai'i Agriculture Research Center and other partner organizations.

Hawaii's Watershed Partnerships, the National Park Service, The Nature Conservancy of Hawaii, and DOFAW's Natural Area Partnership System also conduct monitoring of invasive plants and ungulates to improve the effectiveness of their management activities, but those data are not the focus of this report. The USDA Forest Service's Forest Health Forest Inventory and Analysis Program was recently introduced to Hawai'i, but results from the survey are not yet available.

Contacts

Rob Hauff, Forest Health Coordinator, Division of Forestry and Wildlife (DOFAW), Robert.D.Hauff@hawaii.gov
Cynthia King, Entomologist, Division of Forestry and Wildlife (DOFAW), Cynthia.B.King@hawaii.gov

Publication Design

Meghan Woods, GIS Analyst, Woodland Solutions Group, USDA Forest Service, Region 5

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