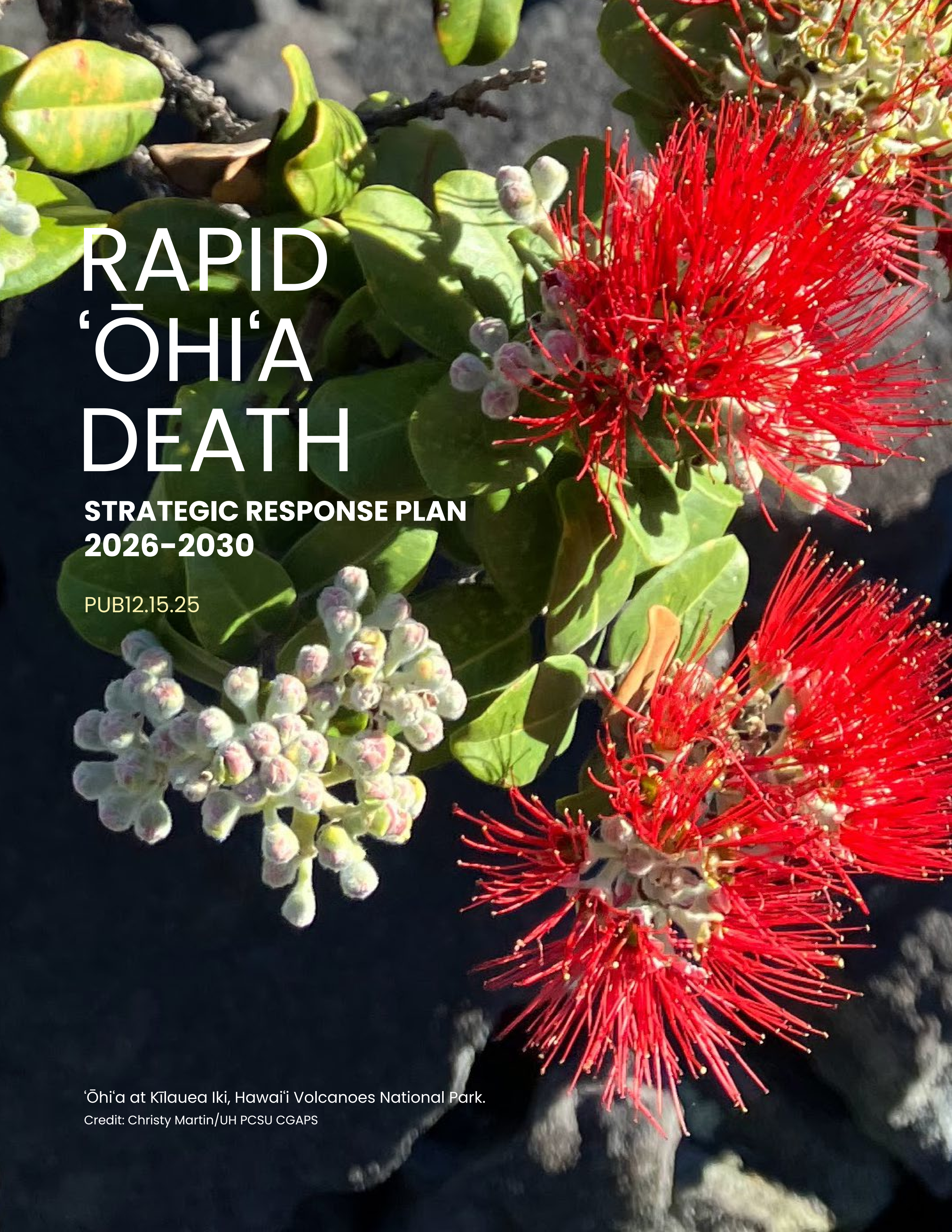
RAPID ʻŌHIʻA DEATH

STRATEGIC RESPONSE PLAN 2026-2030

PUB12.15.25



ʻŌhiʻa at Kīlauea Iki, Hawaiʻi Volcanoes National Park.
Credit: Christy Martin/UH PCSU CGAPS

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Strategic Response Plan Team

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- Dr. Marc Hughes, USDA Forest Service IPIF: research on forest pathology and disease resistance
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- Dr. J.B. Friday, UH CTAHR-Cooperative Extension: public engagement and coordination of research
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We greatly appreciate the following for the review of the plan:

Dr. Joshua Atwood, Nicholai Barca, Dr. Faith Campbell, Dr. Charles Chimera, Alan Holt, Dr. Noelani Puniwai, and Emma Yuen.

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Acronyms

CGAPS: UH Coordinating Group on Alien Pest Species

CTAHR: UH College of Tropical Agriculture and Human Resilience

DLNR: Department of Land and Natural Resources

DOI: Department of the Interior

DMSM: Digital Mobile Sketch Mapping

EDRR: Early detection/rapid response

HDAB: Hawaiʻi Department of Agriculture and Biosecurity

ISC: Invasive Species Committees including KISC (Kauaʻi), OISC (Oʻahu), MISC (Maui), MoMISC (Molokaʻi) or BIISC (Hawaiʻi island)

NPS: National Park Service

ODRP: ʻŌhiʻa Disease Resistance Project

PCSU: UH Pacific Cooperative Studies Unit

RCUH: Research Corporation of the University of Hawaiʻi.

ROD: Rapid ʻŌhiʻa Death

SDAV Lab: Spacial and Data Analysis and Visualization Lab at UH Hilo

UH: University of Hawaiʻi

USDA FS IPIF: U.S. Department of Agriculture-Forest Service, Institute of Pacific Islands Forestry

USDA ARS PBARC: U.S. Department of Agriculture-Agricultural Research Service Pacific Basin Agricultural Research Center

USGS: U.S. Geological Survey

Drone image of an ʻōhiʻa forest in Kohala, Hawaiʻi Island. Leaves on newly killed ʻōhiʻa trees turn reddish brown and over time the leaves drop and the wood turns white.
Credit: SDAV Lab/UH Hilo

INTRODUCTION

The two fungal pathogens (*Ceratocystis lukuohia*, the more virulent of the two pathogens, and *C. huliohia*) that cause Rapid ʻŌhiʻa Death (ROD) continue to infect and kill native ʻōhiʻa lehua (*Metrosideros polymorpha*) in high numbers. Almost all of the ROD mortality in outbreak areas has been associated with *C. lukuohia*. In some places on Hawaiʻi Island, the mortality is significant and widespread, while in others, the current infection rate and mortality are low but expected to rise when the right conditions present themselves. On Kauaʻi, both pathogens are also present and responsible for killing an estimated 1000+ ʻōhiʻa. On Oʻahu, only the less virulent of the two pathogens (*C. huliohia*) has been found in 16 trees in isolated occurrences. In January 2025, the less virulent ROD pathogen was found in ʻōhiʻa in an ornamental setting on Maui, and the trees were quickly removed and destroyed. ROD remains absent from Molokaʻi and Lānaʻi. In this 2026-2030 update to the 2020-2024 ROD Strategic Response Plan, we describe our progress in understanding and addressing ROD and the priorities for research, prevention, response, management, and public engagement over the next five years. As with previous plans, cost estimates for priority actions are provided. Components of this current plan were developed in stages, including a progress review and discussion at the ROD Science Symposium held in July 2024, followed by the drafting of each section by small teams led by section editors. The draft plan was collated and edited, then reviewed by an interdisciplinary group of experts, both internal and external to the response, before publication. At the close of 2025 as this document was being formatted for printing, *Ceratocystis lukuohia* was detected for the first time in a plant other than ʻōhiʻa. Dead camphor trees (*Cinnamomum camphora*), a non-native species that is considered established, were investigated on Kauaʻi and tested positive for the ROD pathogen. The ROD pathology team is following up with additional surveys and tests to determine if ROD can infect and kill this species of tree, how widespread it is, and the potential implications it would have for ROD management. Because this discovery is so recent, details are not reflected in other sections of this plan.

Why ʻŌhiʻa Matters

ʻŌhiʻa forests cover 865,000 acres across the State of Hawaiʻi, and ʻōhiʻa trees are responsible for roughly two-thirds of the forest canopy cover on Hawaiʻi Island. ʻŌhiʻa is foundational to the native forests of Hawaiʻi, growing from sea level to the high-elevation tree line, on barren lava flows and in dry-desert-like settings, mesic savanna woodlands, wet forests, and dwarf-forest bogs. The growth forms of ʻōhiʻa are diverse: mature trees may reach only two feet in height or tower to over one hundred feet; they sport leaves that may be fuzzy or glossy, and thick or thin depending on variety, species, and location. Perhaps best known for their striking red, orange, or yellow blossoms, ʻōhiʻa lehua are one of the iconic images and symbols of Hawaiʻi.

ʻŌhiʻa has long been recognized as a critically important component of watershed forests where rain and mist soak into mosses, lichens, ferns, and create the conditions for other plants to grow on and in ʻōhiʻa forest stands. Today we know that, compared to forests invaded by non-native strawberry guava trees, ʻōhiʻa forests are up to 50% more effective at capturing and holding precipitation, feeding streams, and recharging our aquifers in the process. As the dominant tree in many watershed forests, the health of ʻōhiʻa also supports local agriculture, the visitor industry, communities, and even coral reef health. Furthermore, our ʻōhiʻa forests store more carbon than any other forest type in the state, comprising nearly 40% of the total estimated aboveground forest carbon in Hawaiʻi.

ʻŌhiʻa is also the foundation of Hawaiʻi's forests, a keystone species upon which thousands of other native Hawaiian plants and animals depend for survival. Nearly 500 species of native arthropods have been collected from ʻōhiʻa canopies, almost all of them found only in Hawaiʻi. ʻŌhiʻa forests also provide critical habitat for 18 of the 19 threatened or endangered forest bird species, including ʻiʻiwi, ʻapapane, ʻakiapōlāʻau, and the newly reintroduced Hawaiian crow, ʻalalā.

When the first Polynesians arrived in Hawaiʻi, ʻōhiʻa forests blanketed the valleys and slopes of the islands, and the relationship between Kānaka Maoli (the Hawaiian People, the Indigenous People of Hawaiʻi) and ʻōhiʻa took on multiple aspects, many of which continue today. Some Kānaka Maoli consider plants and animals as direct family members of their ʻohana (kin),

Compared to forests invaded by non-native strawberry guava (left), ʻōhiʻa forests are up to 50% more effective at capturing and holding precipitation. ʻŌhiʻa forests (right) are vital for water recharge and are keystone species that support hundreds of other native species.

Credit: (left) Jack Jeffrey, (right) JB Friday/UH CTAHR and themselves as their caretakers. ʻŌhiʻa are particularly important and sacred: they represent manifestations of Kū, one of the four principal Hawaiian deities, as well as Laka, the goddess of hula, and Pele, the goddess of fire. ʻŌhiʻa use is ubiquitous in Hawaiian culture: it is used for spiritual practice, traditional Hawaiian medicine, food and agriculture, and woodworking. The brightly colored blossoms and cherished liko (new leaves) are referenced in countless traditional and contemporary texts, songs, and stories, and they are adorned in lei for special occasions and celebrations.

In little more than a decade since a multi-agency effort responded to the mysterious and rapid dying of ʻōhiʻa on Hawaiʻi Island, we have identified the causal pathogens, the ways the pathogens spread, and tools to protect ʻōhiʻa. While many questions remain and the work of surveying for and responding to ROD continues, this work includes planning and actions to restore ʻōhiʻa forests for future generations. Landscape-scale management approaches to protect extant ʻōhiʻa forests are ongoing and need to be expanded. In addition, the first ROD-resistant ʻōhiʻa was planted at the U.S. Forest Service on ʻŌhiʻa Lehua Day in April 2024. Despite the tragic loss of over a million ʻōhiʻa due to ROD, hope remains for the resiliency of ʻōhiʻa, through the collaboration of researchers, managers, and the community:

ʻA ʻohe puʻu kiʻekiʻe ke hoʻāʻo ʻia e piʻi;
No problem is too great when one tries hard to solve it.

A proverb from *ʻŌlelo Noʻeau: Hawaiian Proverbs and Poetical Sayings*, by Mary Kawena Pukui

There are two non-native fungi that can each cause Rapid ʻŌhiʻa Death (ROD), a devastating disease affecting ʻōhiʻa trees (*Metrosideros polymorpha*) in Hawaiʻi. Scientists and resource managers have developed different management strategies based on the differences between these two pathogens and on location-based environmental factors.

Difference	***Ceratocystis lukuohia***	***Ceratocystis huliohia***
Meaning of Name	Destroyer of ʻŌhiʻa	Disruptor of ʻŌhiʻa
Source Region of Related Taxa	Caribbean	Asia
Virulence	More aggressive, causes rapid tree death	Slower progression; requires multiple infections to kill the tree
Impact to Tree	Quickly spreads through the vascular system, blocking water flow to the canopy	Causes localized cankers leading to branch dieback
Tree Symptoms	Sudden wilting and browning of the entire canopy	Dieback occurs branch by branch
Time to Mortality	Weeks to a few months	Months to years

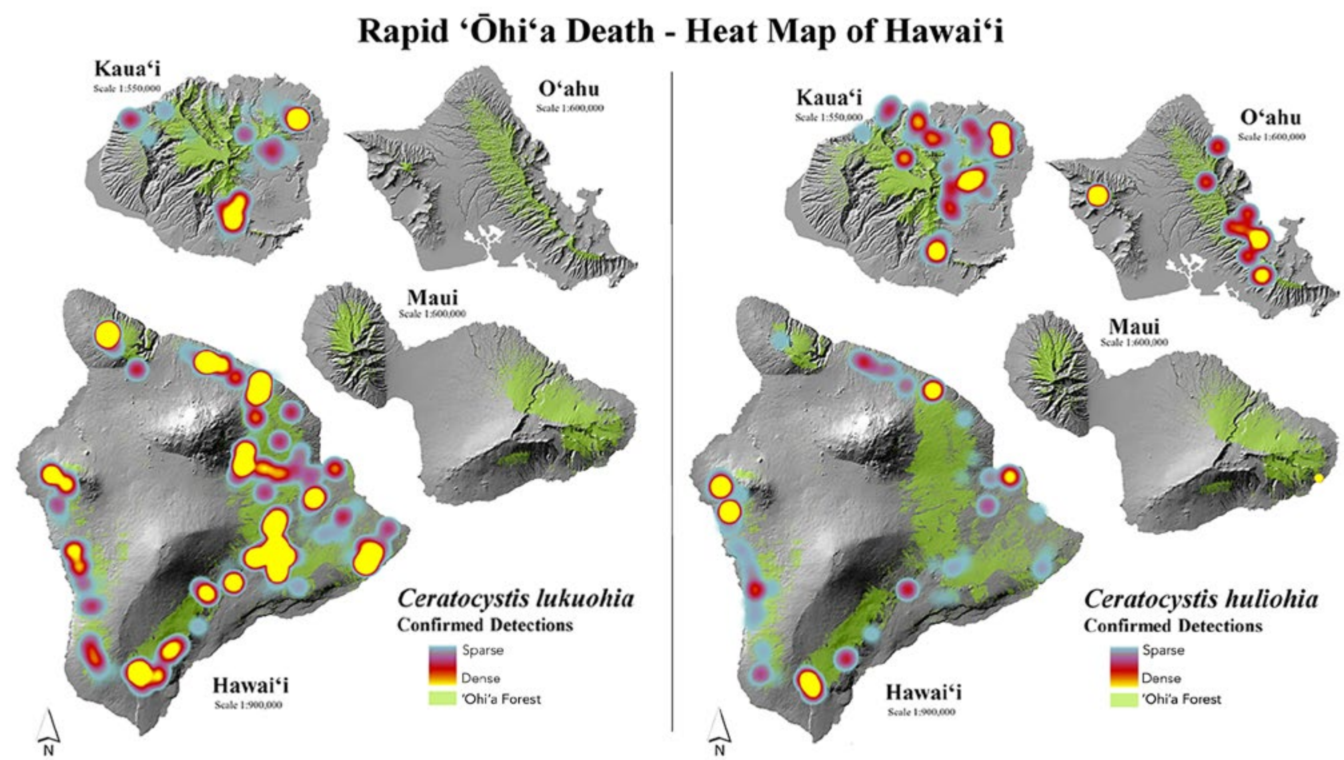
Overview And Situation Update

To date, *Ceratocystis lukuohia* and *C. huliohia* are both present and extensively distributed on Hawaiʻi Island, with mortality in excess of a million trees. On Kauaʻi, both pathogens are present, with an estimated 1,000+ ʻōhiʻa succumbing to ROD. Only 16 trees have been detected infected with *C. huliohia* on Oʻahu and five on Maui, but no trees have been detected infected with the more virulent *C. lukohia* on either of those islands. Neither fungal pathogen species has yet been detected on Lānaʻi or Molokaʻi.

Researchers established that two non-native fungi, both new to science, *Ceratocystis lukuohia* and *C. huliohia*, are the causal agents of ROD.

C. lukuohia, a "wilt disease", is considered the more virulent pathogen. Once inside the tree, it quickly spreads throughout the trunks of trees, clogging water flow and causing the tree to die within months. In contrast, *C. huliohia* is characterized as a "canker disease", which affects trees at a slower rate and may require multiple infections to kill trees. Ongoing research suggests that *C. huliohia* has probably been present in the islands for close to a century or more, whereas *C. lukuohia* likely arrived in Hawaiʻi within the past 20 years. It is unknown how these pathogens arrived in Hawaiʻi.

ROD spreads via multiple pathways but can only infect an ʻōhiʻa tree through open wounds. Ambrosia beetles are particularly important in two ways. First, the beetles are attracted to stressed and dying trees and can carry the disease on their bodies, infecting trees as they bore into the wood. Second, when they bore into trees that are already infected with ROD, they push out large quantities of frass (wood dust) that can carry the pathogens and travel by wind to other trees. Researchers have confirmed that frass carrying the pathogen can land on an open wound on a nearby ʻōhiʻa and cause



Map Produced by: Brian Tucker, Rapid ʻŌhiʻa Death Data Manager. Imagery Source: State of Hawaiʻi disease. Similarly, felling and chipping trees releases windborne dust that may contain the pathogens. Hoofed animals are also known to wound ʻōhiʻa trees via scuffing of roots by hooves, by digging for food, direct herbivory, and rubbing of horns, antlers, tusks, and bodies against ʻōhiʻa trees. There is also strong evidence that hoofed animals may be able to carry viable pathogen spores on their bodies. It is unknown if they can transmit the pathogen in a way that may enter tree wounds. Trees can also be wounded during wind or storm events or by people conducting landscaping such as pruning or weedwacking. The pathogens can also be spread on cutting tools when moving from infected to healthy trees.

Fencing and removal of hoofed animals from ʻōhiʻa forests is, so far, the only management approach that has shown to be effective in reducing infection rates over large forested areas of Hawaiʻi Island. On islands where ROD is not yet established, early detection surveys and rapid response have proven effective, including the felling of ROD trees, followed by various management actions, such as removal and burning where possible.

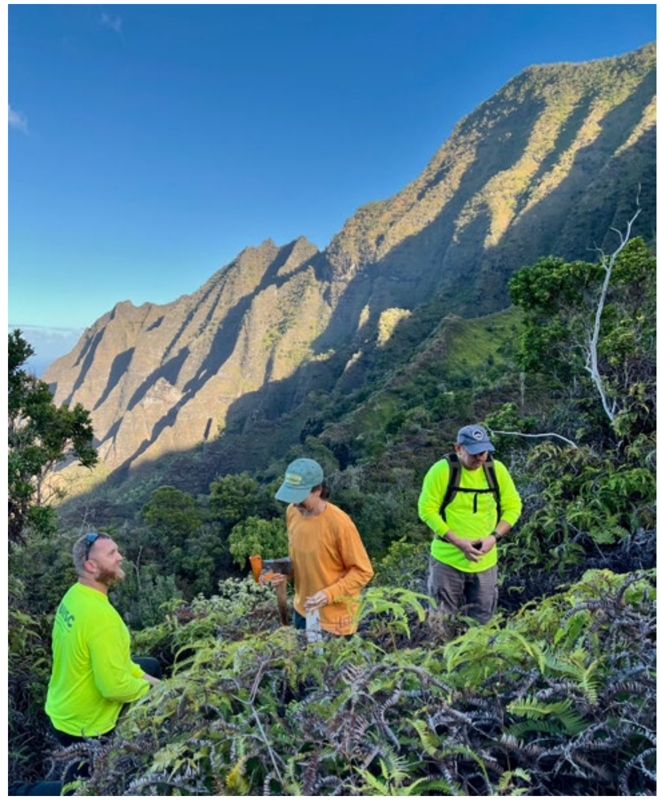
Research has also shown that there are some ʻōhiʻa that are naturally resistant to the pathogens, although in areas of abundant mortality, invasive weeds and trees quickly invade, underscoring the importance of restoration work.

The multi-agency framework of active surveillance, sampling, management response, research, and community engagement is ongoing. This work is being conducted by existing staff from agencies and non-governmental organizations, supplemented by over 20 positions funded through Federal, State, and private foundation grants for the ROD Strategic Response. Reductions to any part of this response could seriously impact the Strategic Response.

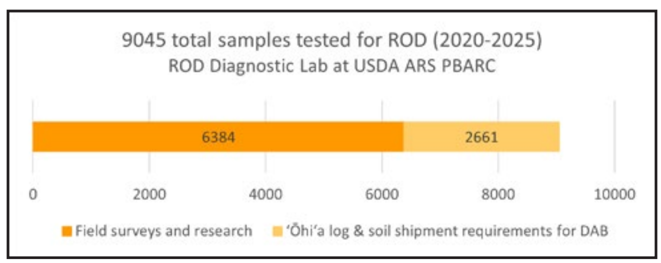
ROD pathogens produce a fruity odor that attracts ambrosia beetles (left). When these beetles bore into infected trees, they push out "frass" or sawdust containing the ROD pathogen (right). These beetles play direct and indirect roles in the spread of ROD.
Credit: Kylle Roy/USDA FS IPIF

Summary of Accomplishments

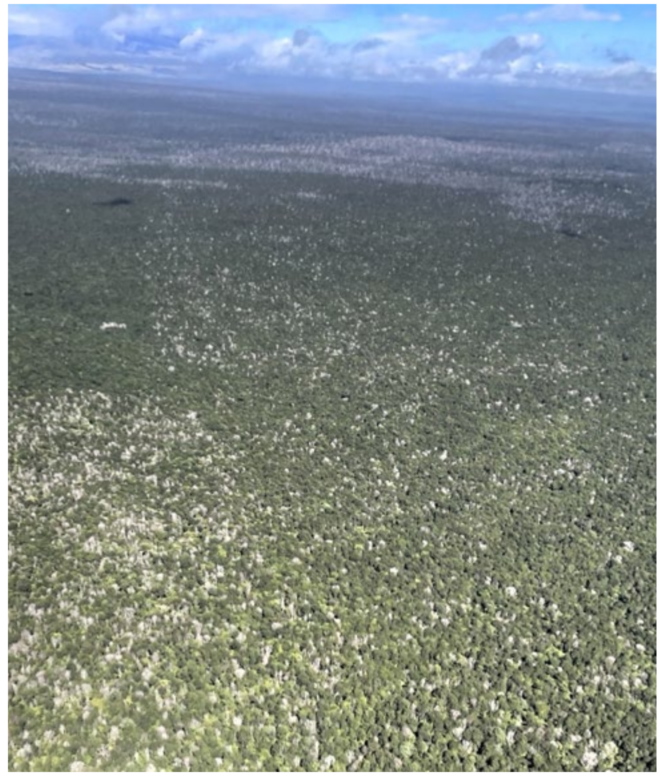
- Conducted aerial surveys at least twice per year across all ʻōhiʻa forests statewide to detect new ROD outbreaks.
- Survey crews from each island followed up on reports and collected more than 4,500 samples that were processed by the USDA ARS PBARC ROD Diagnostic Lab in Hilo.
- Discovered lower disease occurrence in forest areas where hoofed animals were removed and excluded by fences.
- Confirmed that wild pigs can transport the ROD pathogens.
- Discovered and determined that four non-native invasive ambrosia beetle species (*Xyleborus saxesenii, X. affinis*, *X. preforans*, and *X. bispinatus*, formerly identified as *X. ferrugineus*) can directly vector the pathogens on their bodies to stressed trees and can also indirectly spread ROD through the production of frass, which contains long-lived spores that can remain viable in cool, humid environments for at least 6 months.
- Identified two beetle repellents (SPLAT Verb and SPLAT Beetle Guard) as potential management tools. Determined that the pheromone verbenone, when applied to ROD-killed trees, can repel subsequent ambrosia beetle attacks, helping prevent direct spread by beetles and reducing the spread related to frass production.Tested and found that a latex paint-based pruning sealer (B-LOCK Vine Seal), which contains boric acid, a natural fungicide, was more effective in protecting pruning wounds than oil paint-based pruning seals.
- Determined that the pathogens produce fruity odors in ʻōhiʻa that attract ambrosia beetles. These volatiles can be detected by detector dogs and sensors up to nine days before ROD symptoms appear.Documented that dead ʻōhiʻa that have been left standing can continue to attract ambrosia beetles that produce frass containing viable ROD spores for over two years.
- Determined that felling of ROD trees and tarping using 6 mil clear plastic sheeting reduces the amount of live pathogen in the wood and physically prevents frass dispersal.
- Developed remote sensing tools using satellite imagery and machine learning as additional tools for ROD detection.



Field crews on each island collect samples from suspect ROD trees and send them for analysis at the ROD Diagnostic Lab in Hilo. BIISC provided hands-on training to support the ROD response on Kauaʻi, shown here with KISC staff.
Credit: KISC/UH PCSU



- Modeled disease distribution related to Tropical Storm Iselle to better understand storm-related spread and implications for management.
- Determined that ʻōhiʻa seedlings do not get ROD when outplanted in areas where soils are infested with the ROD pathogen, while also finding that seedlings instead die from competition with invasive plants or from feeding or damage by hoofed animals, resulting in a lack of natural regeneration of ʻōhiʻa forests in lower elevation mixed forests.
- Developed the ʻŌhiʻa Disease Resistance Screening Program, which tested thousands of rooted cuttings and seedlings from survivor parent trees in areas heavily impacted by ROD. Several of these have shown resistance to ROD when purposefully inoculated with the ROD pathogens. Confirmation of natural genetic resistance of some survivor trees and research showing that the major barriers to natural regeneration in mixed forests used to inform management and restoration strategies.
- Installed and maintained boot brushes and sanitation stations at strategic trailheads throughout the state to prevent the spread of ROD by hikers.
- Tested and showed that standardized heat treatments of ʻōhiʻa logs are an effective treatment that kills the pathogens in logs from ʻōhiʻa that were killed by ROD.
- Produced and broadcast an Emmy-award winning documentary, Saving ʻŌhiʻa, to raise awareness about ROD, and a follow-up short video to explain how fences and the exclusion of hoofed animals protect ʻōhiʻa and the importance of community engagement in forest management decisions.
- Conducted over 20 in-person community engagement events statewide each year and directly engaged 20,000+ individuals to raise awareness of the ʻōhiʻa quarantine rule, the importance of ʻōhiʻa, and the five actions to take to protect ʻōhiʻa.



A National Park Service survey in 2024 of the ʻŌlaʻa Forest on Hawaiʻi Island shows a clear pattern of dead and living trees. The green rectangle in the upper left of this image shows an ʻōhiʻa forest with few dead trees where fencing and the removal of hoofed animals provides measurable protection from ROD.

Credit: Stacey Torigoe/NPS

- Supported student-driven advocacy that passed a law naming ʻōhiʻa lehua an official symbol of Hawaiʻi, the State Endemic Tree, and annual citizen-driven advocacy to proclaim April 25th ʻŌhiʻa Lehua Day. Conducted statewide public awareness and opinion surveys through a research firm, showing that awareness of ʻōhiʻa increased to 89% in 2022, up from the 2017 baseline survey when 68% of residents said they had heard of ʻōhiʻa or ʻōhiʻa lehua. Resident awareness of ROD also increased to 80%, up from 48% in 2017.

Each year the ROD Community Engagement team hosts a "train the trainers" workshop to equip outreach partners from across the state with the information they need to incorporate ROD into their outreach. In 2024, the workshop included seeing ROD fungal spores during a visit with ROD Diagnostician Xiaohua Wu (center) in the USDA ARS PBARC lab.
Credit: JB Friday/UH CTAHR

- Secured contributed and in-kind partner support and additional funds from federal, state, and private foundations for research, management, and community engagement functions to accomplish much of the 2020-2024 ROD Strategic Response Plan, including recurring state funds in DLNR's budget. These resources, which include both grants and agency-funded positions working on ROD, total between $3-4M annually.

2026-2030 ROD STRATEGIC RESPONSE PLAN FRAMEWORK

This plan details the priorities for continuing the multi-agency response, research and management actions, and community engagement to minimize the harm caused by ROD. In addition, this plan builds on previous findings to guide forest management work, including protecting and enhancing watershed, ecological, and cultural functions, and preventing the permanent conversion of ROD-impacted areas to degraded, weed-dominated forests.

Management Actions - survey, response, and control

Priority Objectives

- *Continue regular statewide surveys for ROD with follow-up ground sampling.*
- *Respond to disease detections in new areas using the latest recommendations from ROD Science Team.*
- *Integrate new imagery and technologies for detecting ROD outbreaks remotely.*
- *Inform and support land management actions to decrease the impacts of hoofed animals through fencing, animal removal, and other strategies.*

Managing ROD in areas or islands where ROD is absent or numbers are low involves following a multi-partner early detection and rapid response (EDRR) plan. Each island ROD working group has developed island-specific EDRR plans, which will be updated following the publication of this plan to incorporate the latest research summarized above.

Aerial surveys are conducted to 1) identify suspected ROD-infected trees (trees with crowns that have recently died and turned reddish brown) at new sites and 2) map the progression of ROD in forests where it is established. New detections by air or by public reports are then sampled by ground crews and samples are sent to the USDA ARS PBARC lab in Hilo to identify which of the two pathogens is present or if the tree died from other causes. Trees found to be positive for ROD are, where appropriate, felled and may be covered with tarps or otherwise managed based on current research recommendations and safety considerations. Felling and tarping are two actions that reduce ambrosia beetle activity and the related spreading of the disease. Where felling and tarping may not be feasible, alternatives have been developed. These include the wrapping of trees in sticky wrap to reduce ambrosia beetles, and temporary fencing around an infected tree where pig activity is present. EDRR teams also support ongoing research in order to better understand the disease and find new ways for managing the impact of ROD in our forests. The major costs associated with continuing these proven EDRR activities are helicopter contracts, personnel support for the island-based Invasive Species Committees, support for the USDA ARS PBARC lab technician that processes the samples, and support for a full-time data manager. State

Semi-annual helicopter surveys are conducted of all ʻōhiʻa forested land. On Hawaiʻi Island, disease progression is mapped, while on other islands, suspected ROD trees are mapped and land-based field crews follow up to take samples. Samples are then sent to the ROD diagnostic lab at USDA ARS PBARC to determine if the tree was killed by ROD and which of the two pathogens, or sometimes both, are responsible.
Credit: DLNR DOFAW Maui

Managing the spread of ROD in sensitive areas like Hawaiʻi Volcanoes National Park relies on tools researched and developed by the ROD Science Team.
Credit: Dustin Swan/BIISC

and federal agency staff also provide in-kind support to carry out these activities.

Hawaiʻi Island continues to see an expansion of both pathogens, which have already impacted tens of thousands of acres of native forest and have killed well over one million ʻōhiʻa trees. Although this is a high number of trees, there are estimated to be more than 250 million ʻōhiʻa trees on Hawaiʻi Island. EDRR crews are focusing on detecting and managing ROD trees located in high-priority forest conservation areas where disease occurrence is still limited.

On Kauaʻi, the two ROD pathogens are considered established across the island, but with fewer than 400 confirmed ROD detections, at significantly lower levels than Hawaiʻi Island. Because of dangerous terrain, not all symptomatic ʻōhiʻa are safely able to be sampled. Therefore, approximately 1,000 trees are estimated to have died of ROD across Kauaʻi. Due to the number of detections of the more virulent *C. lukuohia*, the Kauaʻi response has had to prioritize response actions to focus on native ecosystems and high-value watersheds. These ROD-positive trees are cut down where feasible and portable fencing is installed in the immediate area to exclude wild animals such as pigs, goats, and black-tailed deer.

The Oʻahu response has detected only the less virulent *C. huliohia* and responded to all of the 16 detections to date by felling and, where possible, tarping the infected trees based on recommendations from ROD researchers. The Maui Nui response team continues to survey for ROD, and in January 2025, they responded, sampled, felled, and then burned four trees infected by *C. huliohia in an ornamental planting*. These actions show the value of a coordinated ROD Strategic Response.

Early detection and ongoing monitoring of ʻōhiʻa forests occur in several ways. First, helicopter surveys of ʻōhiʻa forests on each island are conducted two to four times a year by DLNR

The UH SDAV Lab developed a method for cutting and sampling branches of suspected ROD-infected trees using a drone.
Credit: SDAV Lab/UH Hilo

Forestry and Wildlife and invasive species committee (ISC) personnel using tablets and the Digital Mobile Sketch Mapping app. These surveys allow rapid data collection while spotting and mapping suspected ROD trees for follow-up sampling by ground crews. Helicopter-mounted imaging systems have also been deployed to various sites, capturing high-resolution imagery across thousands of acres. This plan recommends continuing these surveys, which are at the core of the ROD response. Funding is required to support helicopter contracts and ISCs to assist agencies in field sampling and management response.

Drones continue to play a key role in supporting survey and response efforts. Ground crews use drones to spot the exact locations of ROD trees that are only visible from the air. Crews can use a drone attachment developed by the Spatial Data Analysis and Visualization (SDAV) Lab at UH Hilo to cut and collect ʻōhiʻa branches for disease sampling. Advancements in drone capabilities are leading managers to explore thermal imaging and radio collar tracking to better understand the population densities and locations of hoofed animals in native forests. Drones are also being used for long-term monitoring of disease progression by capturing high-resolution images at regular intervals at select sites on Hawaiʻi Island and Kauaʻi.

High-resolution satellite imagery is also helping researchers and land managers better locate ʻōhiʻa mortality in isolated and often inaccessible sections of forest, including areas with flight restrictions. For example, in the Hakalau Forest National Wildlife Refuge on Hawaiʻi Island, individual suspect trees mapped using satellite images led to the first detection of ROD in this critical high-elevation native bird habitat. A computer recognition algorithm has been developed and is being improved with the goal of retrieving available imagery on a regular basis and automating the tracking of mortality in ʻōhiʻa forests across the state. Funding is needed to continue this work, which may eventually reduce the need for helicopter surveys.

Disease mapping from aerial images on Hawaiʻi Island provides strong evidence that fencing, combined with the removal of hoofed animals, is effective in significantly reducing ROD mortality. Fencing is currently the only landscape-scale tool that can protect large tracts of ʻōhiʻa forest from ROD. It is important to note that these fences are designed to protect forests from introduced, hoofed animals and, where possible, still allow human access to public forests through gates and step-overs. The loss of well over one million ʻōhiʻa trees due to ROD heightens the urgency of advancing and funding the Watershed Initiative, a statewide goal to protect 30% of priority watershed forests by 2030 by constructing fences and removing hooved animals from those fenced units. Currently, 22% of priority watershed forests are protected. The remaining 78% (over 650,000 acres) that are unprotected are highly vulnerable to ROD mortality. These forests must be protected before they are lost to ROD. The DLNR has been seeking approximately $5 million per year in Capital Improvement Project funding to protect these forests with fences. Additionally, more operational funding is needed to support ongoing hoofed animal control. Research into additional management tools will continue.

Research and Development Actions – ʻŌhiʻa Forest Mortality Patterns, Dynamics, and Impacts

Priority Objectives

- *Continue to map and monitor ʻōhiʻa mortality, assess distribution, patterns, impacts, and potential mitigations on affected islands, and also further evaluate the likely role of weather events and wind as a mechanism of spread.*
- *Test and develop additional treatments and control tools to reduce ambrosia beetle numbers and beetle-related spread of ROD pathogens.*
- *Assess the ability and relative importance of the different species of hooved animals in the direct and indirect spread of ROD pathogens to ʻōhiʻa.*
- *Support the adoption and usage of new permit conditions requiring heat treatment for the movement of ʻōhiʻa logs from Hawaiʻi Island.*
- *Continue disease resistance testing and build reforestation program.*

Findings from seven years of monitoring ʻōhiʻa mortality from a sampling network of 230 quarter-acre forest monitoring plots across Hawaiʻi Island have revealed critical information, including the distribution, patterns, and impacts of ROD. In forest stands where C. lukuohia-infected trees occurred, annual ʻōhiʻa mortality rates ranged from a high of 44% in some areas, to 0% in other areas, with an average of approximately 9%. In contrast, annual mortality rates were less than 2% in areas where only C. huliohia-infected trees were present or where neither of the ROD pathogens have been detected, suggesting that this represents a background mortality rate. As reported in the 2020-2024 ROD SRP, forests on younger lava flows with smaller stature ʻōhiʻa exhibit lower annual rates of mortality compared to forests on older lava flows with larger stature ʻōhiʻa trees.

In the next five years, this work led by the USDA Forest Service IPIF will expand by utilizing the inventory plots to determine the degree to which ROD changes species composition in forests, particularly regarding non-native, invasive species dominance and its physical structure and carbon storage capacity.

Remote Sensing and Drones

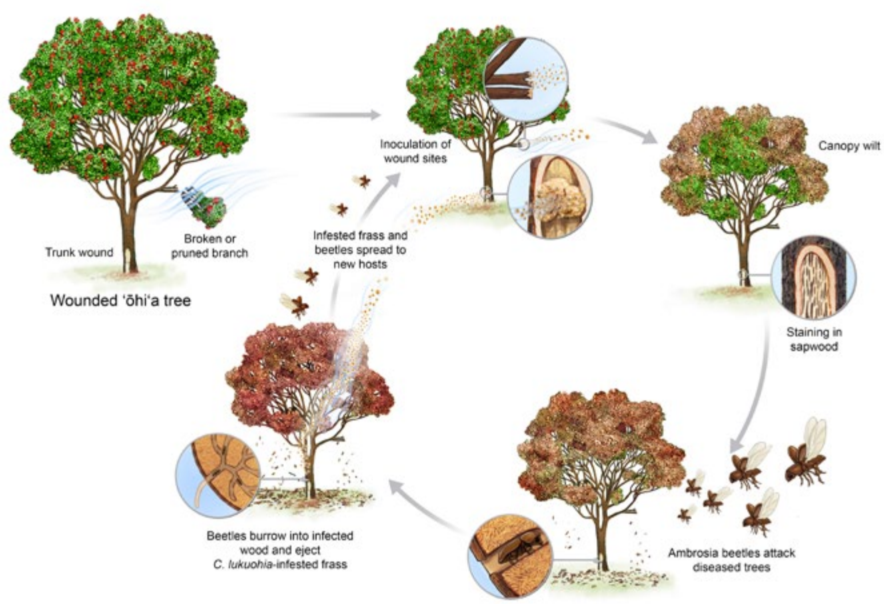
Significant advancements have been made in mapping ʻōhiʻa distributions, ROD-associated mortality, and new outbreak areas using drones, aerial imagery, and satellites. Machine learning algorithms were developed that can now automatically identify ROD symptomatic trees in drone and helicopter-based imagery, thereby minimizing the time and workload needed for processing. Improvements to helicopter-mounted imaging platforms have greatly increased the range of survey flights, and the development of a drone-operated branch sampler has increased monitoring and access to hard-to-reach trees and branches for diagnostic testing. Cameras and processing techniques that capture non-visible wavelengths (near infrared and others) from tree canopies are being refined for detecting ROD-infected trees before visual symptoms appear. These tools may also help us identify disease-resistant trees.

Ongoing work and technological advances will also collect and analyze remote sensing data at a landscape scale at very fine spatial resolution. Analysis of these large, detailed data sets will improve the monitoring of forest health across the state while reducing the hazards associated with manned helicopter flights.

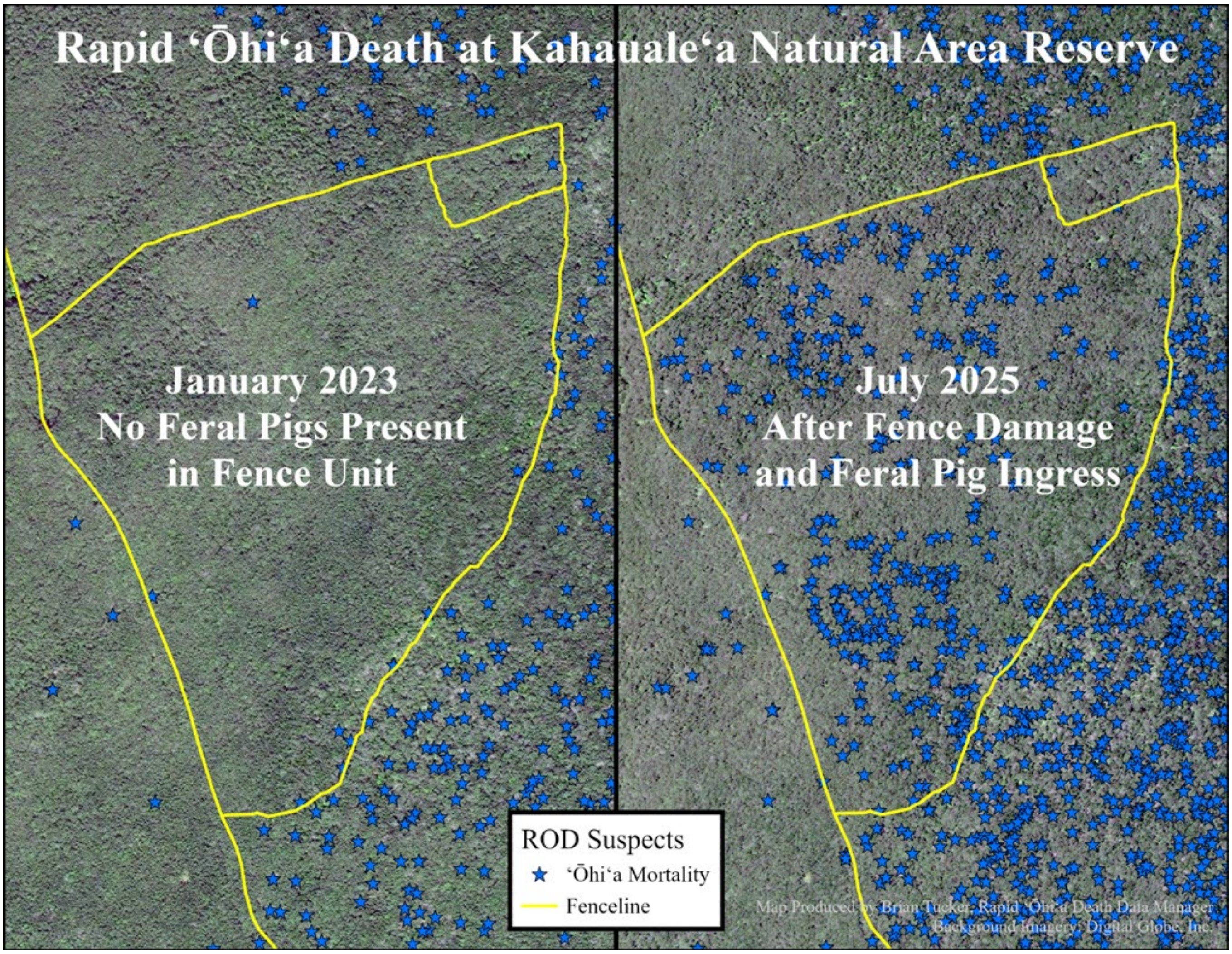
Role of Beetles in the Spread of ROD

Four non-native ambrosia beetles play an important role in the ROD disease cycle, and they are present on all affected islands. They can directly spread ROD by carrying *Ceratocystis* spores on their bodies when the beetles bore into stressed and/or wounded trees, and are also indirectly linked to the spread of ROD through the frass (wood dust) that the beetles eject while burrowing into infected trees. Within the next five years, scientists will work to understand how various factors, such as elevation, climate, and host tree preference, affect ambrosia beetle species distributions and how these potential factors can limit their spread across the islands.

Research has shown that two different beetle repellents (SPLAT Verb and SPLAT Beetle



Non-native ambrosia beetles directly spread ROD by carrying disease spores on their bodies which they transfer to ʻōhiʻa trees as they bore into them. Ambrosia beetles also contribute to the spread of ROD by boring into infected trees and pushing out sawdust, or "frass", which is contaminated with ROD disease spores. Additional research into the roles of animals, people, wind, and storm events in the spread of ROD is ongoing. Credit: USDA FS IPIF



A break in the fence at Kahaualeʻa Natural Area Reserve in 2024 led to the incursion of feral pigs and subsequent loss of many ʻōhiʻa due to damage and spread of ROD.
Credit: Brian Tucker/UH PCSU

Guard) effectively deter ambrosia beetles from attacking healthy trees and from boring into *Ceratocystis*-infested trees, reducing ambrosia beetle breeding and frass production. SPLAT Verb is now registered for use in Hawaiʻi and registration of SPLAT Beetle Guard is underway. For effective deployment of these repellents, research is needed to determine the repellents' area of effect and duration of efficacy, and to develop innovative, efficient deployment techniques such as the use of drones.

Because repellents do not completely protect trees may not be appropriate for landscape-scale use, the exploration for host-specific biological control agents for ROD-associated ambrosia beetles is warranted. Reducing ambrosia beetle populations would reduce direct transmission and indirect spread by reducing the amount of Ceratocystis-infested frass they produce.

Role of Hoofed Animals in the Spread of ROD

Forests on Hawaiʻi Island where hoofed animals (e.g., pigs, cattle, sheep, or goats) were excluded by perimeter fences exhibited substantially lower levels of ROD mortality compared to adjacent areas where hoofed animals were still present. This was likely due to reduced tree wounding in these fenced areas. In one location, an unfenced area with abundant feral pigs had as many as 69 times more wilted and dying trees than those found in nearby fenced areas without hoofed animals. Subsequently, a breach in the fenceline of this previously pig-free area led to a sudden and dramatic rise in ʻōhiʻa mortality, highlighting the need for hoofed animal control and monitoring.

In partnership with community hunting groups and their organized tournaments on Hawaiʻi Island, researchers have been working to better understand the role of pigs in the spread of *Ceratocystis*. DNA from the pathogen was detected on the bodies of wild-caught pigs, suggesting that they may transport it. However, much more research is needed to understand if the *Ceratocystis* carried by pigs is still active, capable of causing disease, and the degree to which pigs or other hoofed animals could potentially transmit it to ʻōhiʻa wounds. To further explore this, motion-activated camera stations have been set up in fenced and unfenced ROD forest plots to monitor animal abundance, factors attracting them to ʻōhiʻa, and their behaviors (i.e. rubbing, tusking) around the trees.

Research is also needed to map the distribution and density of hoofed animals across the landscape, ensuring that populations within fence units are completely removed, and to identify where incipient populations of certain animals, such as feral cattle, should be controlled.

Role of Wind and Storms in the Spread of ROD

It is hypothesized that the high-speed winds of Tropical Storm Iselle (2014) caused widespread branch and canopy wounding to ʻōhiʻa trees across Hawaiʻi Island, while also spreading *C. lukuohia* through the wind via ambrosia beetle frass. This scenario and timeline are consistent with what appeared to be an increasing number of infected trees and an expanding distribution of the disease in the years following the storm. Through various air-sampling methods, researchers can detect frass and the DNA of the ROD pathogens in air currents. However, living fungus has not been cultured from air samples. Improving our understanding of how wind and storms disperse the pathogens can lead to more effective management strategies.

Differing environmental conditions between the islands requires the development of island- and area-specific management techniques. Managers on Kauaʻi experimented with different strategies for preventing beetles from infesting ROD trees and keeping wildlife away.
Credit: KISC/UH PCSU

Tools to Manage ROD		
Tool	**Importance**	**Recommendations/Next steps**
Ambrosia beetle repellent	Tool to minimize frass production and tree attack by ambrosia beetles	SPLAT Verb is registered in Hawaiʻi; SPLAT Beetle Guard requires EPA and HDAB registration.
Fences and hoofed animal exclusion	Tool for landscape-scale protection from ROD. Fenced areas that are free of hoofed animals experience markedly lower rates of ROD	Continue constructing new fences to exclude hoofed animals in ʻōhiʻa forests, maintain existing fences, and employ other tools to reduce populations
Tree wound sealant	Tool to protect trees from ROD infection after pruning or wounding occurs	Develop usage recommendations for public and tree care professionals
Wood heat treatments	Kills fungus in infected logs and wood products	Develop phytosanitary protocol for operational use with HDAB and industry
Disease resistance	ROD-resistant trees can serve as the foundation for future ʻōhiʻa restoration efforts	Plan and conduct, with the ʻŌhiʻa Disease Resistance Program and partners, pilot restoration projects

Differences in ROD Across Islands to Inform Management

Hawaiʻi Island was the first of the Hawaiian Islands affected by ROD and has both *Ceratocystis* pathogens. It also has the most ʻōhiʻa forest. Thus, most of the research activities to date have occurred there. However, since ROD incidence has increased on Kauaʻi and the disease patterns on Kauaʻi differ from Hawaiʻi Island, research is needed to improve our understanding of how localized patterns underlie ROD infection and whether different management strategies are necessary. This is also true for Oʻahu, where only the less aggressive *C. huliohia* has been detected.

Therefore, additional research goals are to:
1) better understand drivers of ROD on Kauaʻi,
2) assess detection and management priorities and strategies for islands affected only by *C. huliohia* (i.e. Oʻahu and Maui), and, 3) assess the vulnerability and potential effects of ROD on other Hawaiian *Metrosideros* taxa on islands not widely affected by ROD.

Epidemiology and the Sources of the ROD Pathogens

Both ROD pathogens are introduced fungi, with the closest relative of *C. lukuohia* from the Caribbean and *C. huliohia* related to a group from Asia. Analyses of Ceratocystis genetic markers support the hypothesis that there was a single introduction of *C. lukuohia* to Hawaiʻi Island, likely around the Hilo or Puna area since this is where the greatest genetic diversity exists. The Kauaʻi population of *C. lukuohia* is less genetically diverse than the Hawaiʻi Island population, and is likely derived from it. Data suggest that on Kauaʻi *C. lukuohia* established west of Līhuʻe before spreading to other parts of the island. Populations of *C. huliohia* on Kauaʻi and Hawaiʻi Island are distinct from each other and are more genetically diverse than their respective *C. lukuohia* populations, suggesting that *C. huliohia* has been present in the state longer than *C. lukuohia*.

Tools to Reduce the Long-distance Movement of ROD

Inter-island quarantines were established to prevent the movement of *Ceratocystis*-infested ʻōhiʻa plants, plant parts, wood, and soil from Hawaiʻi Island to other islands. Similar introductions of *Ceratocystis* species have been associated with symptomless, vegetatively propagated plant material and nurseries, and imported live plants remain a threat for *Ceratocystis* introductions to Hawaiʻi or further inter-island spread. Spread of the pathogens in moist timber is also a possibility. Research and testing of kiln heating for ʻōhiʻa logs has shown to be effective at killing the ROD pathogens. Specific treatment times and temperatures were developed and tested, and can now provide a more efficient and effective treatment option. Further work with HDAB and forest industry partners to develop awareness and support the adoption of heat treatment as a permit condition for the movement of ʻōhiʻa wood from Hawaiʻi Island is needed.

Economic Impacts

Rapid ʻŌhiʻa Death is resulting in significant but so far unquantified economic costs, including losses to property value, the eco-tourism economy, and critical ecosystem services such as wildlife habitat, watershed function, and carbon sequestration. This SRP includes an estimate for work to quantify the economic costs of ROD and the economic benefits of protecting and restoring ʻōhiʻa forests.

Disease Resistance and the Development of Restoration Techniques

There is a need to intentionally grow and plant ʻōhiʻa, in perpetuity. ROD has, and will continue to have, devastating impacts on ʻōhiʻa forests and ecosystems. However, results from a previous study have shown that some seedlings can survive the purposeful introduction of ROD in a laboratory setting, suggesting genetic resistance. Additionally, offspring of survivor trees from otherwise ROD-devastated areas have shown increased levels of resistance. These findings led to the formation of the ʻŌhiʻa Disease Resistance Program, a multi-agency collaborative led by the USDA FS IPIF and the Akaka Foundation for Tropical Forests, to produce disease-resistant ʻōhiʻa for the restoration of native forests and the perpetuation of ʻōhiʻa in our biocultural landscapes. Through its steering committee, the program builds on lessons learned from other tree disease resistance programs and experts across the country. The many plants needed to be grown for disease resistance screening required an expansion of staff and nursery space at USDA FS IPIF. Through these efforts, dozens of potentially ROD-resistant mother trees have been discovered. These resistant ʻōhiʻa are the basis for future field planting trials, which will determine if the resistance can persist long-term in areas of naturally occurring ROD.

In addition, several of the thirteen species and varieties of *Metrosideros* that are native to Hawaiʻi have yet to become naturally infected by either ROD pathogen, raising the question of whether or not they too can become infected. Recent inoculations of pōhutukawa (*Metrosideros excelsa*), a New Zealand relative of ʻōhiʻa, showed no signs of disease, suggesting high levels of resistance. Similar levels of resistance may exist for these untested *Metrosideros* taxa in Hawaiʻi.

Over the next five years the program will 1) improve to operational-level disease resistance screening capacity for the state and its partners, 2) establish field survivorship trials using the best selections from greenhouse inoculation, 3) screen commercially available ʻōhiʻa from local wholesale nurseries from across the state for disease resistance, 4) screen open-pollinated ʻōhiʻa seed families, and 5) refine inoculation protocols to better understand the potential effects of dosage and temperature for a more robust screening methodology.

Additional work must also be done to reduce the threats to natural ʻōhiʻa recruitment, seedling survival, and growth. This entails managing weedy species and hoofed animal impacts where possible and most effective. Work is also needed to identify ways to enhance or improve conditions for natural ʻōhiʻa recruitment.

Reforestation must include outplanting of not just ʻōhiʻa but also other native trees, shrubs, ferns, herbs, and grasses in areas most likely to succeed. In some cases, the exclusion of hoofed animals is an absolute necessity, as these animals can quickly harm or destroy new outplants. While remote, high-elevation forests may be dominated by native understory species, lowland forests, even if they have a native canopy, are likely to have a largely non-native understory composed of plants like strawberry guava (*Psidium cattleyanum*) and/or Koster's curse (*Miconia crenata*), which quickly overtake a forest once the ʻōhiʻa canopy is lost. Natural regeneration may suffice in high-elevation, pristine forests, but lowland forests will likely need active restoration.

The increased pursuit and use of host-specific biological controls is also necessary to reduce the competitive ability of targeted invasive plants, giving native forests a chance to compete for space and resources.

Some ʻōhiʻa have shown a naturally-occurring resistance to ROD, both on the landscape and in the lab. Part of the ROD Science Team, Forest Pathologist Dr. Marc Hughes shows offspring of survivor trees in otherwise ROD-devastated areas, which have shown increased levels of resistance where they can survive infection.
Credit: UH PCSU CGAPS

Field work on Hawaiʻi Island has shown that very few ʻōhiʻa seedlings are able to germinate and grow in forests below approximately 3,000 feet elevation, probably because of weed competition. Once weedy species are controlled, native trees can be planted. Restoration may lead to a forest that is not exactly the same as it was before ROD but rather one with fewer ʻōhiʻa and a greater number of native canopy species, such as koa and ʻohe mauka (*Polyscias spp.*). Once disease-resistant ʻōhiʻa seedlings are available in large quantities, they may become an essential tool in restoring forests.

Restoration of ROD-affected forests may best succeed if they are integrated into priority watershed protection areas or landscape-scale restoration efforts, such as those at the Hakalau Forest National Wildlife Refuge or Hawaiʻi Volcanoes National Park, compared to areas that are already severely degraded or those that lack management plans. Support should also be given to community groups interested in managing urban or community forest areas. Careful planning with community groups will be needed to ensure the best use of limited resources and in the interest of working together to perpetuate healthy forests. Other community-related restoration activities are reflected in the Community Engagement section.

Community Engagement

Priority Objectives

- *Continue outreach and engagement to maintain or increase awareness of ʻōhiʻa, ROD, and how to protect and perpetuate ʻōhiʻa lehua.*
- *Provide targeted information and assistance to industries and organizations that interact with ʻōhiʻa.*
- *Support ROD researchers in identifying, developing, and delivering messages for general and targeted audiences.*
- *Review and revise publications and available information to ensure accuracy and accessibility.*
- *Expand engagement messages and activities to incorporate and support restoration priorities.*

People can unknowingly spread ROD by moving infected ʻōhiʻa plants, plant parts, logs, and contaminated materials such as soil. Healthy ʻōhiʻa can be put at risk of infection by damaging or cutting into ʻōhiʻa, and can cause a tree to become infected when contaminated tools and equipment cut into healthy trees. Community awareness, support, and behavior change can reduce the spread of the disease and protect healthy ʻōhiʻa and are also necessary to support landscape-scale initiatives such as fencing and hoofed animal exclusion and restoration of native forests. The ROD Outreach Team, a statewide group of professional outreach and extension staff, engages with communities to understand concerns and behaviors related to ʻōhiʻa. This team supports the researchers and resource managers by identifying and conveying key messages to stakeholders and communities. The goal of this work is to foster awareness of ʻōhiʻa and its importance, the threats posed by ROD.

The basic outreach and extension messaging continues to support the “Five Things” that researchers have found effective for protecting ʻōhiʻa from ROD:

1. Avoid injuring ʻōhiʻa
2. Don’t move ʻōhiʻa wood or parts
3. Clean your gear and tools, including shoes and clothes, before entering and after leaving forests
4. Wash tires and undercarriage of vehicles to remove all soil or mud
5. Don’t transport ʻōhiʻa inter-island

Recent research findings will also be incorporated into messages. This includes two new messages for arborists and landscapers regarding the use of pheromone-based beetle repellents (once registered for use in Hawaiʻi) that may be applied to infected trees in ornamental settings, and the use of more effective pruning sealants to reduce infection of pruning wounds and other injuries to ʻōhiʻa. These messages will also be incorporated into communications with lei makers and hālau hula.

Community engagement will continue to be a priority. As more research and evidence shows the significant protection provided by fences and hoofed animal exclusion, resource managers and communities need to work together to determine when and where to apply protective actions, and also where such actions are not in the collective best interest.

The ROD outreach team will continue to work with the local wood and nursery industries to facilitate compliance with HDAB's quarantine rule, businesses that use earth-moving equipment, landscapers and arborists, off-road enthusiasts that may enter ROD-impacted forests, eco-tour operators, forest resource users, and others.

The use of boot brushes combined with isopropyl spray continues to be a priority message, and the redesign and production of new brush stations will make them easier to use. Social science research conducted by the Big Island Invasive Species Committee showed that more trail users used boot brush stations when the signage said what they should not do, e.g. "Do not proceed down this trail without using this boot brush." New signage will also be produced for the boot brush stations.

Many of the educational products and the RapidOhiaDeath.org website need review and reorganization. As part of this work, the URL

ROD Outreach Workshop participants from across the state visit a community restoration site at Keauʻohana Forest Reserve where the ʻōhiʻa overstory has been decimated by ROD. Partnering with community restoration groups to manage forests is vital.
Credit: UH PCSU CGAPS

ohialove.org has been secured to add a positive message to some outreach and educational products. Both URLs will continue to be used and will lead users to the main ROD website.

Recent research has also shown that ʻōhiʻa planted in soil contaminated with the ROD pathogens had surprisingly low infection rates. Younger ʻōhiʻa are less likely to become infected than trees that are 30+ years old. Yet another finding documented the lack of seedling success due to competition from invasive weeds and the impacts of hooved animals. This strategy plans for the availability of nursery-reared ʻōhiʻa from disease-resistant trees for community planting projects, and the engagement strategy aims to help communities to take action to perpetuate ʻōhiʻa and native forests. The message that should be communicated is to plant ʻōhiʻa. While community forest management is relatively young in Hawaiʻi, there are some good examples. The program will identify ways to engage and empower community actions such as seed saving, planting ʻōhiʻa in yards and communities, and community-based forest management.

Planting native trees and shrubs in urban areas can help create green corridors that improve air quality, provide shade, reduce urban heat islands, and enhance the aesthetic appeal of neighborhoods. Engaging local communities in restoration projects fosters a sense of ownership and stewardship. This can be achieved through educational programs, volunteer tree planting events, and citizen science projects. Community involvement ensures that restoration efforts are maintained and supported long-term. Programs that involve residents in planting and caring for trees can also strengthen community bonds and promote environmental awareness.

Although urban plantings of ʻōhiʻa are common on the windward side of Hawaiʻi Island, ʻōhiʻa are seldom used as landscaping elsewhere in the state. Many people believe, incorrectly, that ʻōhiʻa can only live at high elevations in the mountains. Encouraging more use of ʻōhiʻa in planted, urban landscapes where people live and work could improve people's understanding and appreciation for this culturally and ecologically important native tree.

Community engagement objectives are led by three full-time staff to focus on statewide messaging and engagement coordination, and messages on Hawaiʻi Island and Kauaʻi. Several agencies and organizations partner to extend the reach and a train-the-trainer strategy further expands the capacities of this small team. There is nearly one million acres of ʻōhiʻa forest and the vast majority of trees are susceptible to ROD. The composition, form, and function of these forests is at risk, yet land managers and communities can take action by using the tools and information developed through the ROD Strategic Response to perpetuate ʻōhiʻa and forests for the future.

RAPID ʻŌHIʻA DEATH STRATEGIC RESPONSE PLAN BUDGET 2026-2030

Annual Resource Needs

This budget reflects current annual spending and in-kind project costs, in addition to estimated costs of new initiatives identified in the plan. At the printing of this plan, the situation with federal funding and salaries remains uncertain, and additional non-federal funds may be needed to sustain current efforts and implement new projects in this plan.

Management Actions - Survey, Response, and Control

Program Area	Personnel/Item	Lead Agency	Annual
Hawaiʻi Island	staff	DOFAW; UH PCSU	$300,000
	staff	NPS-Hawaiʻi Volcanoes	$650,000
Kauaʻi	staff	DOFAW; UH PCSU	$200,000
	contractual (sampling)	DOFAW	$30,000
Oʻahu	staff	DOFAW; UH PCSU	$100,000
Maui Nui	staff	DOFAW	$50,000
Statewide	project coordination	DOFAW; UH PCSU	$85,000
	helicopter contracts	DOFAW	$150,000
	data manager	DOFAW	$140,000
	supplies	DOFAW	$50,000
	diagnostic lab technician	UH CTAHR/USDA ARS	$150,000
			$1,905,000

Research & Development

Program Area	Personnel/Item	Lead Agency	Annual
Plot-based Monitoring	staff	USDA Forest Service; UH PCSU	$400,000
Forest Entomology	staff	USDA Forest Service; UH PCSU	$240,000
Ungulate Research	staff	USDA Forest Service; Akaka Fndn.	$150,000
Forest Pathology	staff	USDA Forest Service	$150,000
Storm & Wind Modeling	staff	UH Mānoa, Dept. of Meteorology	$150,000
Remote Sensing	staff	UH Hilo, SDAV Lab	$200,000
Genetic Analysis	staff	Colorado State University	$30,000
Economic Analysis	staff or contract	TBD	$150,000
Disease Resistance Project	staff	USDA Forest Service; Akaka Fndn.	$300,000
Restoration Coordinator	staff	DOFAW	$150,000
Field and Lab Supplies	staff	USDA Forest Service; UH	$100,000
Wood Treatment Implementation	staff	UH CTAHR; HDAB	$100,000
			$2,120,000

Public Engagement

Program Area	Personnel/Item	Lead Agency	Annual
Statewide ROD Outreach Coordinator	staff	UH CTAHR; UH PCSU	$100,000
Hawaiʻi Island Extension	staff	UH CTAHR	$160,000
Kauaʻi Outreach Coordinator		UH PCSU	$95,000
Maui Outreach Coordinator		DOFAW	$25,000
KUPU Intern		DOFAW	$30,000
Workshops and Campaigns	travel and materials	UH CTAHR	$50,000
Contracts and Materials	printing; PSAs, etc.	DOFAW	$50,000
Boot Brush Stations	construction, maint.	DOFAW	$150,000
			$660,000

Annual total: $4,685,000

ACKNOWLEDGMENTS

Mahalo to the following agencies, institutions, and organizations for supporting the 2020-2024 ROD Strategic Response through funding or the in-kind contribution of staff time, resources, or other support. We tried to list all of the collaborators, but we have surely missed a few. Our apologies and our thanks.

"ʻAʻohe hana nui ke alu ʻia" translated, ***"No task is too big when done together by all"***

ʻŌlelo Noʻeau: Hawaiian Proverbs and Poetical Sayings, by Mary Kawena Pukui

Akaka Foundation for Tropical Forests
Arizona State University-Center for Global Diversity and Conservation Science
Colorado State University
Coordinating Group on Alien Pest Species
Counties of Maui, Kauaʻi, and Hawaiʻi Island
Department of Land and Natural Resources
Hauʻoli Mau Loa Foundation
Hawaiʻi Agriculture Research Center
Hawaiʻi Army National Guard Keaukaha Military Reservation
Hawaiʻi Conservation Alliance
Hawaiʻi Department of Agriculture and Biosecurity
Hawaiʻi Forest Industry Association
Hawaiʻi Invasive Species Council
Hawaiʻi Seed Banking Partnership
Hawaiʻi State Legislature
Hawaiʻi Tourism Authority
Hawaiian Electric Company
Iowa State University
Kamehameha Schools
Kanakaʻole family & Foundation
Kokeʻe Resource Conservation Program
Laukahi: Hawaiʻi Plant Conservation Network
Merrie Monarch Festival
National Park Service-Hawaiʻi Volcanoes National Park
National Tropical Botanical Garden
Office of Hawaiian Affairs
Representative Ed Case and staff
Representative Jill Tokuda and staff
Senator Brian Schatz and staff
Senator Mazie Hirono and staff
The Invasive Species Committees of Hawaiʻi
The Nature Conservancy of Hawaiʻi
The Watershed Partnerships & Alliances
U.S. Army Garrison Pōhakuloa Training Area and Army Natural Resources Program on Oʻahu
U.S. Department of the Interior-Office of Native Hawaiian Affairs
U.S. Fish & Wildlife Service
U.S. Geological Survey-Pacific Island Ecosystems Research Center
University of Hawaiʻi Foundation
UH Mānoa-College of Tropical Agriculture and Human Resources, Pacific Cooperative Studies Unit, and Department of Atmospheric Sciences
UH Hilo-Spatial Data Analysis and Visualization Lab
USDA Agricultural Research Service- Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center
USDA Animal and Plant Health Inspection Service
USDA Forest Service Institute of Pacific Islands Forestry