Big Island Invasive Species Committee
Report on HISC Grant 2022 for Detection & Control of Invasive Species on the Island of Hawai'i
Rapid ʻŌhiʻa Death (ROD) Program
Submitted by Franny Brewer, July 2023

The arrival of Rapid ʻŌhiʻa Death (ROD), a lethal and rapidly spreading disease caused by two invasive fungal pathogens *(Ceratocystis lukuohia and C. huliohia*), threatens the survival of Hawaii's forests, watersheds, and unique biodiversity. Our native forest birds, invertebrates, understory plants, ferns and moss that capture mist and rain to recharge the watershed all rely on ʻōhiʻa for food, shelter, and structure. Our farms and drinking water rely on that recharge, and the appeal of our unique native biodiversity and viewscapes does as well.

The response to ROD has been a large-scale, coordinated multi-agency effort since its identification in 2015. BIISC is a part of this much larger effort, and works with many partners at the federal, state, and local levels to implement priority needs as identified by the state-wide and Hawaii Island ROD working groups. BIISC coordinates and carries out aerial surveys and mapping via UAV and helicopter with DOFAW guidance. BIISC manages the response on private lands, including sampling and felling trees and coordinating access for partners and for the science team. The BIISC ROD team provides staffing to carry out research-related field tasks (i.e. felling trees or seed collection activities). BIISC staff contribute significant effort to educating the public about ROD and helping to coordinate events, such as the November 2022 ʻŌhiʻa Love Fest in Pahoa. The outcomes below by no means provide a comprehensive picture of all of the work that BIISC staff contribute to the critical ROD mitigation efforts.

Goal: The state-wide effort to understand and manage Rapid ʻŌhiʻa Death (ROD) will be informed by up to date distribution data and supported by a highly skilled work force.

Objective #1: Map changes in the distribution of ROD across Hawaii Island at 3- and 6-month intervals.
Expected outcome: Two aerial surveys totaling 830,000 acres will be completed.
Outcomes & Discussion:

Using Digital Mobile Sketch Mapping (DMSM) developed by the US Forest Service, BIISC surveyed 822,092 acres (Figure 1) over 3 aerial flights. Due to budget constraints and the wider distribution of ROD, helicopter survey objectives shifted this year. "Priority areas," which in the past were surveyed more frequently to facilitate a rapid response, are flown 2 times per year, while island wide surveys of all ʻōhiʻa forests on Hawaii Island are conducted once a year. To avoid duplicate reporting, these acres are not included in the tabular datasheets submitted every six months to HISC, but are logged in the statewide ROD GIS system.

During this year, unmanned aerial systems were fully integrated into ROD response efforts, using two primary work flows. The first is to deploy a UAV to spot and obtain a precise GPS coordinate for one or more suspect trees previously identified during aerial surveys. Once the GPS coordinates are obtained, staff can load the points onto a hand-held device and quickly walk to each suspect tree to obtain a sample. Alternatively, the UAV may be sent along pre-defined transect lines to map out suspect trees across a large area of concern. The imagery collected by the UAV is "stitched" into a precise map of the area, and individual suspect trees can be located using ArcGIS. The final map can then be used to plan the collection

of samples and response operations. In 2022 BIISC surveyed 3,100 acres via UAV in support of the ROD response project.

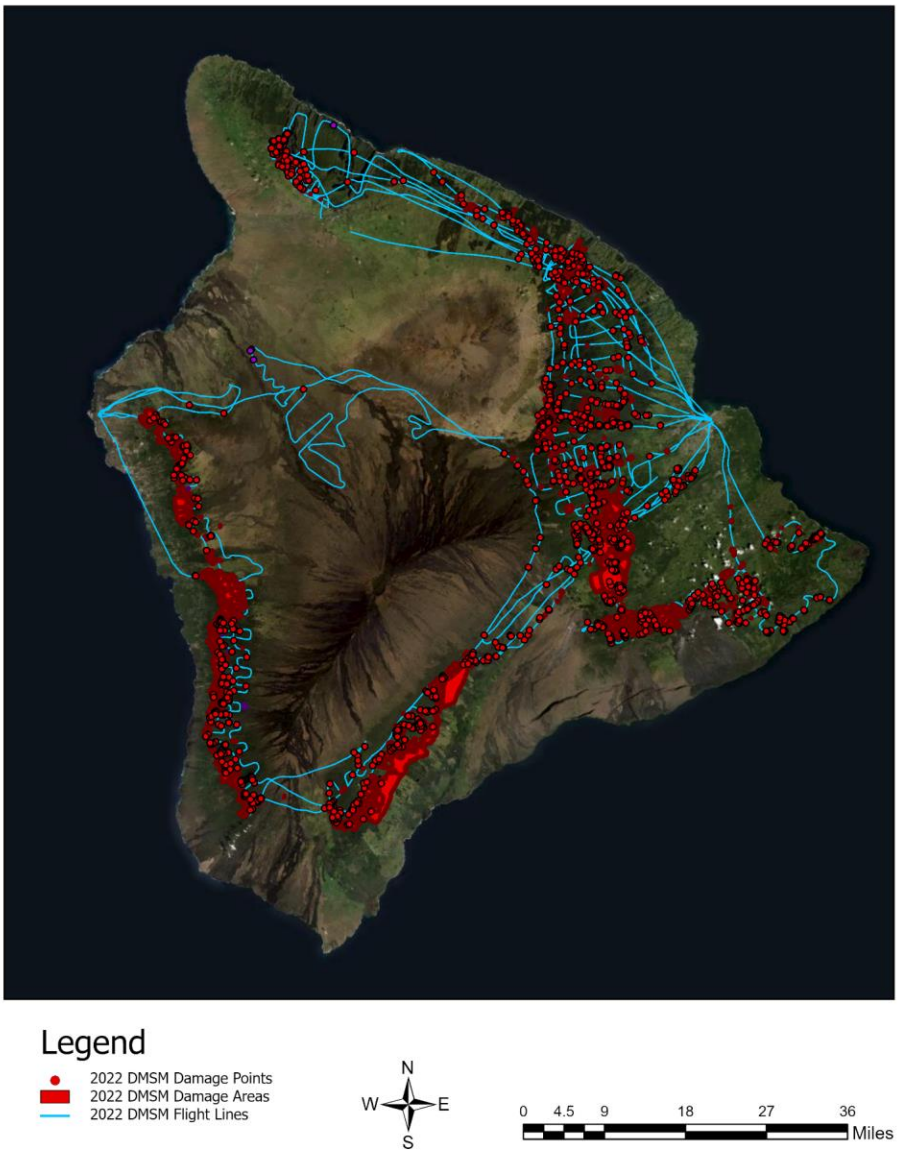

Figure 1: Suspect trees mapped via helicopter during Digital Mobile Sketch Mapping surveys.

Objective #2: Contain new outbreaks of ROD where possible and efficacious by felling trees or working with partners to have them removed.

Expected outcome: *Follow-up sampling will be conducted to verify ROD presence in suspect trees. An average of 300 trees are sampled each year. An anticipated 240 trees will be felled and tarped or removed where practical.*

Outcomes & Discussion:

Aerial surveys led to targeted sampling of 249 suspect trees (Figure 2) and ground and UAV surveys of 7,590 acres in suspected new outbreak areas, using 1,950 hours of staff time. Ceratocystis continues to be sparsely scattered within the Kohala Mountains and the main section of Hawaii Volcanoes

National Park, though the disease has been confirmed at both priority sites. There is significant ongoing mortality in the Ka`u Forest Reserve, and an increase of mortality thought to be attributed to ROD is being mapped throughout the lower sections of North and South Kona Districts (Figure 1). Our team continues to map ʻōhiʻa mortality in the Upper Waiākea Forest Reserve, Kipuka Ainahou (DHHL), and Keauhou Ranch (KS), however, ongoing testing for Ceratocystis comes back as "non-detected." We have coordinated site visits with researchers, scientists, and land managers to help dissect trees for a more comprehensive analysis in an attempt to understand the cause of dieback in these forests.

Twenty-six ʻōhiʻa were felled by the BIISC team in 2022. As management response strategies shifted during 2021 and into 2022, felling as a tool for managing outbreaks was found to be a less useful or practical tool than originally hoped. Trees in forested settings could not be felled without risking damage to nearby apparently healthy trees. Felling continued to be utilized in limited circumstances and for research and education purposes, but at a much lower rate than initially predicted.

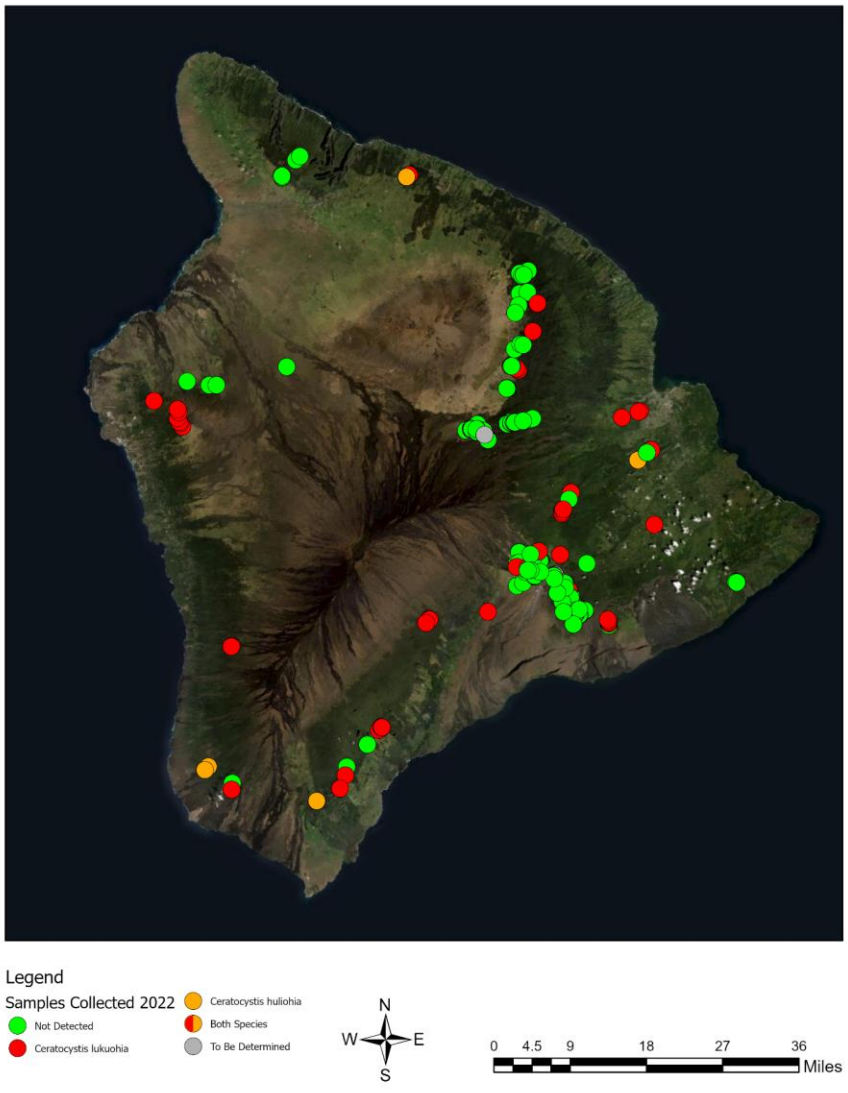

Figure 2: Samples collected to confirm Ceratocystis presence in suspect trees in 2022.

Objective: Provide field support to ROD research efforts.

Expected outcome: *Up to five peer-reviewed articles will be supported by BIISC field efforts.*
Outcomes & Discussion: BIISC spent 24 crew-days assisting partner agencies with research objectives. Part of these efforts were removing fencing and other materials from multiple sites from a previous research project (*Survival of `ohi`a seedlings in ROD-infected forests. S. Yelenik, USGS*). Other efforts contributed to are listed below:

1. **Felling ROD-inoculated trees for research, Kylle Roy, USDA Forest Service**. Goal of the research project was to determine effectiveness of repelling ambrosia beetle attacks in *Ceratocystis lukuohia* infected trees using SPLAT Verb, a pheromone based repellent. **BIISC Role:** Felling, dissecting, debarking, and hauling the trees out of the forest for use in the study. Findings: *In Progress*. Related publications*: HCC Presentation 2023: The Efficacy of the Semiochemical Repellent Verbenone to Protect Healthy and Ceratocystis-infected ʻŌhiʻa from Attack by Ambrosia Beetles.*
2. **Ground-truthing points collected by remote sensing application (satellite aerial imagery), Nai'a Odachi, University of Hawaii Hilo Spatial Data and Visualization Lab (SDAV**). Goals of the project were to improve the efficiency and accuracy of aerial surveys using remote sensing technologies, to map the distribution of ROD at a higher frequency, and to determine whether interventions such as ungulate fences have a significantly positive impact on forest resilience. **BIISC Role:** Collect samples from suspect trees identified from satellite imagery. The first ROD detection in the main Hakalau NWR site (and neighboring Piha Forest) was found using this method. Findings: When available, high-resolution satellite imagery is a cost-effective method for identifying past and current ROD outbreaks. DMSM helicopter surveys can be scheduled around weather events and are useful for verifying new outbreaks, but these operations are costly, hazardous, and produce significant carbon emissions. Satellite imagery is valuable for ongoing ROD monitoring. Dedicated tasking and advancements in sensor technology can make it even more robust and useful. Related publications: *International Congress on Biological Invasions Poster 2023: A Comparative Analysis of Monitoring Methods for Rapid ʻŌhiʻa Death in Hawaiʻi: High-Resolution Satellite Imagery and Digital Mobile Sketch Mapping Surveys.*
3. **Finding an effective wound sealant, Marc Hughes, USDA Forest Service**. Purpose of the project was to identify an effective wound sealant for landscapers and home owners to use when pruning ʻōhiʻa to prevent infection from *C. lukuohia* or *C. huliohia*. **BIISC Role**: BIISC assisted with the application of various sealants and simulated inoculation of the sealed wound of ʻōhiʻa at the study site. Findings: *In progress*.
4. **Genetic analysis of *Ceratocystis* species, T. Harrington, Iowa State University.** Purpose of this work was to better understand the molecular genetic relationships among the two *Ceratocystis* species infecting ʻōhiʻa, and to use molecular markers to map the likely pattern of dispersal of *C. lukuohia* throughout the state. **BIISC Role:** Guide researchers into areas to collect molecular isolates, and/or collect samples and submit them to the lab on behalf of the scientists. Findings: Ongoing mapping of the likely pattern of dispersal of ROD throughout the state, based on molecular markers (how and when did ROD move throughout the island and island chain). Evidence of genetic exchange between the two species of Ceratocystis, despite being sexually incompatible. Related publications: *Mayers, C. G., T. C Harrington, A. Wai and G. Hausner, 2021. Recent and ongoing horizontal transfer of mitochondrial introns between two fungal tree*

pathogens. Frontiers in Microbiology https://doi.org/10.3389/fmicb.2021.656609HCC Presentation 2021: Genetic Fingerprinting Traces the Introduction and Movement of Ceratocystis lukuohia on Hawai`i and Kaua`i Islands.

5. **Soil sample collection and plot measurements with Flint Hughes, USDA Forest Service**. Goal was to evaluate forest soils for presence and abundance of *C. lukuohia* inoculum and determine the likelihood of feral ungulates playing a role in the transmission of ROD. **BIISC Role**: Soil sample collection and plot measurements at a research site in Ka'u Forest Reserve. Findings: Results provide insight and strong evidence supporting the need to eliminate exposure of such forests to feral ungulate damage to suppress the spread and impact of Rapid ʻŌhiʻa Death. Related Publications: *HCC Presentation 2023: Ceratocystis lukuohia Inoculum in Ohia Forest Soils and its Relationship to Ungulate Activity: Implications for Management.*

Objective #4: Ensure all staff are trained in essential conservation workforce skills including survey methods, plant ID, data collection, project management, decontamination procedures, wilderness first aid, and the safe and appropriate use of tools and pesticides.
Expected outcome: *Staff will receive all necessary training to skillfully and safely conduct operations.*
Outcomes & Discussion:

The end of 2021 and beginning of 2022 saw some significant staff changes in the long-standing ROD team at BIISC. Original Forest Response coordinator Bill Buckley moved to the mainland, and his shoes were filled by veteran staff member Dustin Swan. Field crew leader Kristin Hofer followed shortly after, and crew member Nate Friday was promoted to replace her. Nate and another staff member were trained for aerial mapping/DMSM and Wilderness First Aid in 2022. By the end of the year we had brought on a third crew member who then completed all RCUH and BIISC required safety trainings including Wilderness First Aid and ATV Safety Training, and acquired his Pesticide Applicator's License. The team is now fully staffed and trained with a Coordinator, Field Crew Leader, and two crew members.

HISC Funding Priorities

The *HISC & CGAPS 2025 Joint Strategy: In Support of the Hawaiʻi Interagency Biosecurity Plan* provides a guideline for how to plan and prioritize efforts in invasive species work across the state. Our work on rapid ʻōhiʻa death focuses on the second of the five identified priority areas: *Management of Inter-Intra Island Movement of Invasive Species*. The fungi that cause ROD are invasive to Hawai'i and the decline of our keystone forest tree species, ʻōhiʻa lehua, is the biggest threat faced by our Hawaiian watersheds since the days of intentional deforestation. Developing effective management tools, mapping new outbreaks, and providing field support to scientists to better understand the biology and dispersal of this disease are among BIISC's most important jobs.