HAWAIʻI
APRIL 2017

Forest Health
2016 highlights

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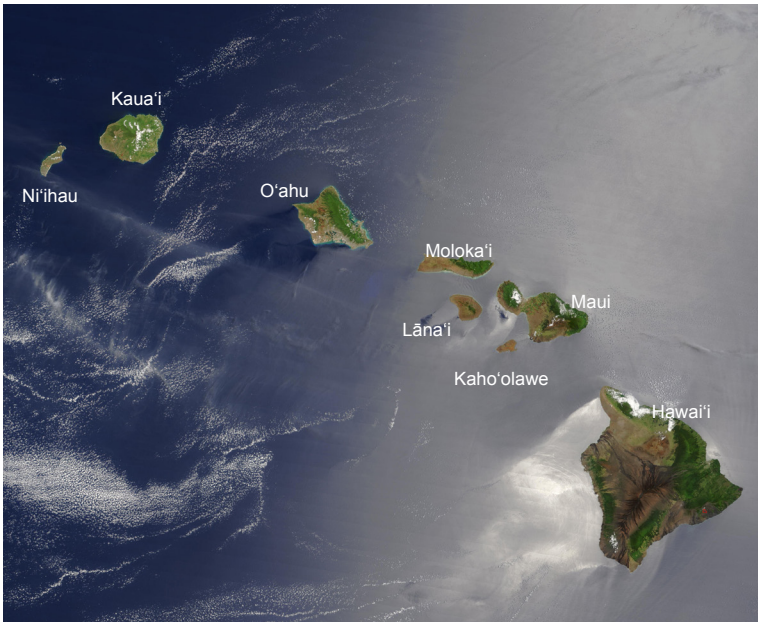
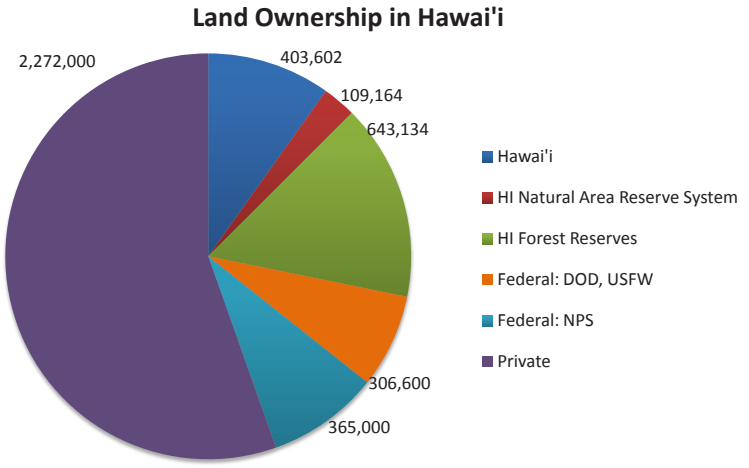
Forest Resource Summary

This report is for the State of Hawaiʻi which includes eight main islands (Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Kahoʻolawe, Maui, Hawaiʻi, and, Niʻihau) totaling 4.1 million acres. Public lands occur on all islands except Niʻihau and Lānaʻi, 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 Keʻa and Mauna Loa on Hawaiʻi and Haleakalā on Maui.

The State of Hawaiʻi 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. Hawaiʻi's state forest acreage ranks as the 11th largest in the nation. Federal lands account for 671,600 acres and are managed by the Department of Defense, National Park Service, and US Fish and Wildlife Service. The National Park Service is the largest federal landowner managing 365,000 acres. Although there are no National Forests in Hawaiʻi, the Hawaiʻi Experimental Tropical Forest (HETF) was recently created on the island of Hawaiʻi as a partnership between USDA Forest Service and DOFAW. The HETF comprises over 51,000 acres and is co-managed by the 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 Hawaiʻi'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 Hawaiʻi

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

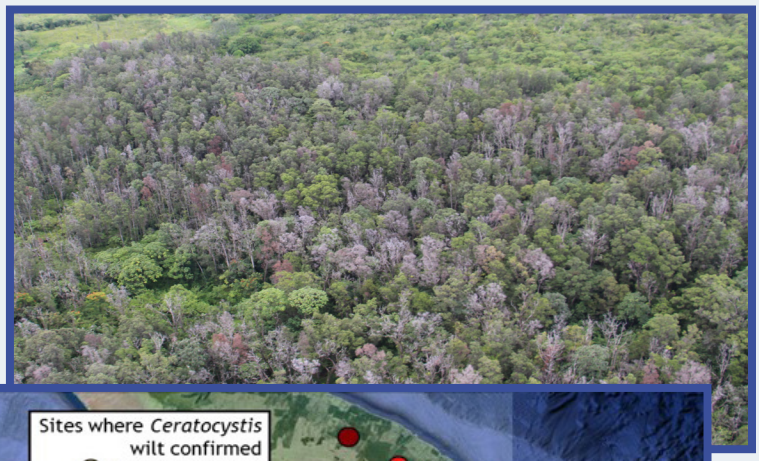
Monitoring forest health in Hawaiʻi presents many challenges associated with its climate and geology. Hawaii's extremely rugged terrain limits ground access to many areas and increases the difficulty of remote monitoring due to vertical slopes and shadow effects. Watersheds can have as much as half of 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.

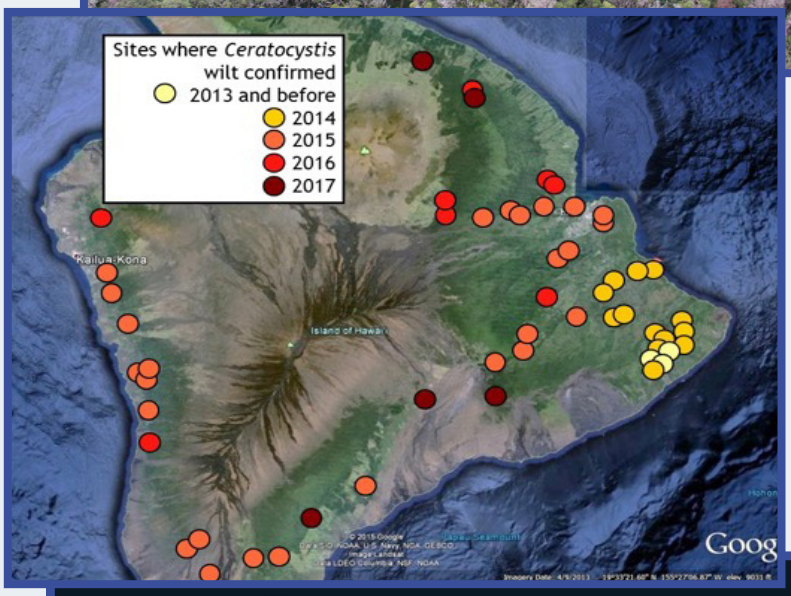
Rapid ʻŌhiʻa Death or Certatocystis Wilt of ʻŌhiʻa

Ceratocystis fimbriata

ʻŌhiʻa (*Metrosideros polymorpha*) is the most common tree species in Hawaii's native forests, growing from sea-level to nearly 8000 feet and in dry, mesic, and wet forests. ʻŌhiʻa-dominated forests cover 350,000 ha statewide, with 250,000 ha occurring on Hawaiʻi Island, and ʻōhiʻa 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 name ōhiʻa 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 Hawaiʻi island began noticing ōhiʻa trees on their property suddenly dying, while adjacent trees remained healthy. The symptoms appeared distinct from 'classical ōhiʻa dieback' previously observed on the big island as a cohort effect related to stand age and natural senescence. The phenomenon was coined Rapid Ohia 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 presence of pathogens. The fungus Ceratocycstis fimbriata was isolated from the samples using both morphological and molecular characteristics, and Koch's postulates were completed with the pathogen on ʻōhiʻa 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 are currently being taxonomically described and characterized.



In 2016, Rapid Ohia Death continued its alarming spread on Hawaii Island, with positive detections as far north as Laupahoehoe Forest Reserve (see Figure 2). Aerial surveys using Digital Mobile Sketch Mapping mapped approximately 50,000 acres on Hawaii Island showing ROD-like symptoms (see Figure 3). The surveys were carried out statewide, and ground crews have collected samples from mapped area for laboratory analysis. So far, no samples from other islands have been positive. USDA ARS has developed molecular tools for rapid detection and samples from the forest are processed in their laboratory to confirm disease presence.

It is still not known how the disease is spreading or where this pathogenic genotype came from. It is suspected that the spread in the environment is facilitated by beetles attacking trees that have been killed by the disease. The frass and sawdust created by beetles are then spread by the wind and can infect trees through wounds. Human activities such as moving ohia wood, plants, or soil from infected area can also spread the disease and the Hawaii Department of Agriculture has placed quarantine restrictions on such products leaving Hawaii Island. Researchers are developing techniques to detect spread by frass and studying insects associated with the frass.

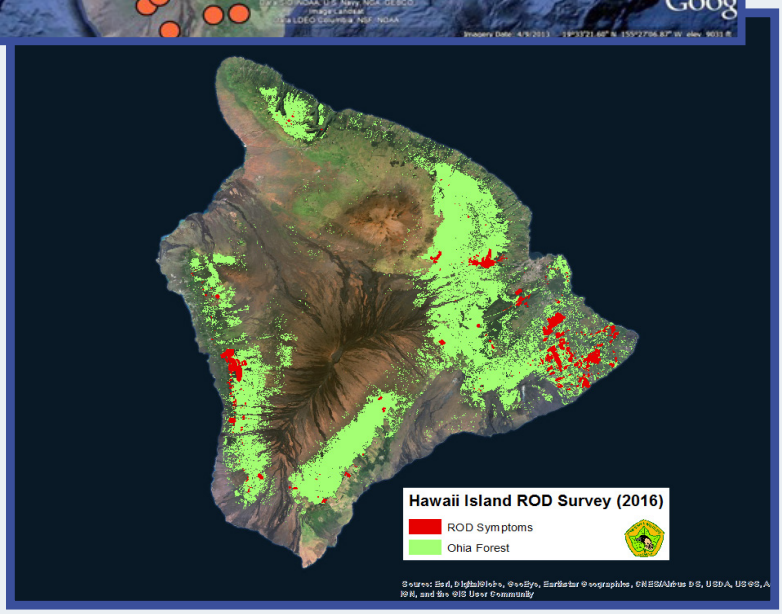


Figure 1 (top): Mature stand of ʻōhiʻa (Metrosideros polymorpha) in Malama Ki Forest Reserve heavily impacted by the vascular wilt pathogen Ceratocystis fimbriata. Figure 2 (center): Distribution of positive detections of Ceratocystis fimbriata from ground surveys on Hawaiʻi Island. Figure 3 (bottom): Rapid ʻŌhiʻa Death Aerial Survey Results, 2016.

Myrtaceae Rust

Puccinia psidii

A rust disease on ʻōhiʻa lehua (Metrosideros polymorpha) seedlings was first detected in a nursery on Oʻahu in 2005. The disease was eventually identified as Puccinia psidii, commonly known as "guava rust" in Florida and as "eucalyptus rust" in Brazil. It is considered to be a serious threat to several hosts in the Myrtaceae family in numerous tropical and subtropical countries. The disease is referred to locally as "'ōhi'a rust" because of the importance of this native tree, but it infects many species in Myrtaceae present in Hawai'i. The disease is present on all major islands and can cause severe injury to 'ōhi'a seedlings growing in nurseries.

Multiple strains of Puccinia psidii have been found to be associated with different hosts in Brazil (Graca et al., 2011). Fortunately, only a single strain of Puccinia psidii is known to occur in Hawai'i, and this strain has not caused excessive injury to 'ōhi'a trees. A study conducted in Brazil found 'ōhi'a families to be more susceptible to several of the strains isolated in Brazil (da Silva et al., 2014). This information is being used by quarantine officials at state and federal levels to protect Hawaii from accidental introduction of additional, more harmful strains of the disease. In addition, monitoring continues to document disease impact on ōhi'a, especially vulnerable seedlings, as well as disease host range which currently number 38 species, 5 of which are native to Hawai'i.

Koa Wilt

Fusarium oxysporum f.sp. *koae*

Work on breeding disease resistant koa (Acacia koa) continued by the Hawaii Agricultural Research Center (HARC). Koa is an ecologically, culturally, and economically important tree species that only grows in Hawaii and is the second most abundant tree in the islands. The wilt disease (Fusarium oxysporum f.sp. koae) has been found to cause high mortality in young koa plantations and in natural forest in localized areas. Screening of koa families from various eco-regions within Hawaii has yielded resistant families for planting on each of the main Hawaiian Islands.

Work continued in 2016 screening families for disease resistance in additional eco-regions and establishing seed orchards to provide resistant stock for both commercial forestry and restoration in the future. Seed orchards distributed across the major islands have been established and are surveyed annually for growth and morality. In collaboration with US Forest Service PSW, a genetic study of koa throughout the archipelago was made to better define genetic variation among eco-regions on which the project bases its disease resistance development.

In 2015, after 20 years of care and management, several surviving koa trees from the 1994 HARC koa planting had reached harvestable size and were evaluated for wood quality. This work was done in cooperation with Taylor Guitar Company and Pacific-Rim Tonewoods. One of the trees produced instrument grade wood quality, with exceptional wood color, figure and density (Figure 4). The project showed that wilt resistant koa populations provide the opportunity to grow high quality trees in condensed rotations, improving the economics of koa timber production and reducing project risks.

Figure 4: Susceptible koa

Figure 5: Resistant koa in orchard.

Figure 6: Koa guitar produced from a twenty-year old koa tree.

Coconut Rhinoceros Beetle

Oryctes rhinoceros

The coconut rhinoceros beetle (CRB) is a pest of coconut trees and other palms and is native to South and Southeast Asia. The adult beetles damage trees by boring into tree crowns where they injure young, growing tissue and feed on sap. The subsequent damage can cause trees death. The beetles breed in moist, decomposing organic matter, especially dead coconut trees, leading to a destructive cycle if left unmanaged. Although the beetles can fly up to 2 miles, regularly feeding on coconut palms and returning to the breeding site, spread is primarily through human movement of breeding materials (e.g., green waste, dead trees, etc.).

The first detection of CRB in Hawaii occurred on Joint Base Pearl Harbor – Hickam on Oahu in December 2013 in a USDA trap. A nearby breeding population in a large mulch pile was discovered shortly thereafter at a golf course near the main runway of Honolulu International Airport. Hawaii Department of Agriculture and USDA APHIS quickly mobilized, setting up a multi-agency response team using the Incident Command System (ICS) to respond to the incursion. The amount and location of the infested mulch made destruction of the breeding population extremely challenging and required developing new tools. Currently infested material is being treated through composting or incineration in air curtain burners.

In cooperation with the U.S. Navy and the University of Hawaii, the project is using pheromone detection traps around the island 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. So far, the main infestation is located in and around the military base, with one outlying population on the leeward coast of Oahu. No beetles have been detected on other islands in the archipelago, and eradication on Oahu is still the project goal. Numbers of trapped beetles have declined at the original infestation, and there were no increases in area infested in 2016.

Other Insect Pests

The native wiliwili trees (Erythrina sandwicensis) continue to recover from infestation by the Erythrina gall wasp (Quadrastichus erythrinae) following the release of a biological control agent in 2011. On-going monitoring in collaboration with the University of Hawaii and funded by FHP has documented tree recovery, while also indicating continued damage to inflorescences and seed pods. Release of an additional agent being held in containment facilities in Hawaii is planned to alleviate damage to the trees' reproductive capacity. The invasive seed boring bruchid beetle, Specularius impressithorax, continued to be observed damaging seed production.

Myoporum thrips (Klambothrips myopori) continued to damage and kill native naio (Myoporum sandwicensis) shrubs and trees on the island of Hawaii where the pest was first detected in 2009. Rapid response plans have been developed for the other main Hawaiian islands in anticipation to the pest spreading by hitchhiking on plants or people. Early detection surveys were carried out in collaboration with the island-based invasive species committees resulting in no new island detections. Testing for resistance to the insect pest with populations from throughout the archipelago is underway.

Hala scale (Thysanococcus pandani) which has been damaging native hala (Pandanus tectorius) on Maui since 1995 was recently found to have spread to Oahu and Molokai. The pest damages the leaves of this important cultural plant, making them unusable for weaving. It is also known to kill young hala plants, jeopardizing that ability of hala stands to regnerate. The Hawaii Department of Agriculture (HDOA) has eliminated all known infestations of hala scale on Oahu. HDOA has also begun searching for biological control agents in SE Asia to control this damaging pest.

Invasive Plants

Albizia

Falcataria moluccana

Hurricane Iselle struck Hawaii Island on August 7, 2014. It was the third strongest storm to impact Hawaii since 1950, exhibiting heavy rain, sustained winds of 80 m.p.h., and gusts greater than 110 m.p.h. Costs associated with the damage from Iselle reached into the tens of millions, primarily due to damage to papaya crops, roads and power lines. The bulk of the damage was caused by trees felled by Iselle's high winds; which overwhelmingly consisted of 100 to 130 ft. tall stands of the highly invasive, fast-growing albizia trees (Falcataria moluccana). In days immediately following Iselle the Hawaiian Electric and Light (HELCO) spent nearly $1 million to clear roads of downed trees in the devastated areas so that HELCO employees and contractors could begin the process of restoring operation of the power grid, a process that took weeks to complete and cost many more millions of dollars. Similar costs were incurred by state and county departments of transportation, and costs to residents of the impacted areas were incalculable but comparably substantial. As a result, a broad coalition of Hawaii's residents, national, state, and county legislators, governmental agencies, and public and private utility companies galvanized around the need to eliminate stands of albizia that could pose threats to public health and welfare. This concern resulted in a request from Hawaii's congressional delegation to the USDA/USDI Secretaries to assist Hawaii with current

and future problems posed by albizia. An Albizia Task Force was organized and directed to provide a comprehensive strategy to eliminate albizia trees from priority areas and control their spread and establishment.

In 2015, the US Forest Service (Institute of Pacific Island Forestry and State and Private Forestry) in partnership with the Big Island Invasive Species Committee and the University of Hawaii (Hilo) initiated a project to provide science-based documentation of the response of forest ecosystems to the removal and/or killing of albizia stands. This project is tracking forest succession following albizia control actions and measuring specific parameters of species composition, forest structure, biomass accumulation, and soil and plant tissue nutrient dynamics. Five study sites were identified in 2015 in which measurements and monitoring of compositional, structural, and functional dynamics of albizia stands following herbicide treatment are now, or soon will be, occurring (Figures 7 and 8). Collectively, study sites were located across 3 different volcanoes and three distinct soil types on soils ranging in age from 200 to 75,000 years and at elevations ranging from 28 to 378 m above sea level. Pairs of 0.5 ha monitoring plots were established at each of the 5 study sites; in one plot of each pair – all albizia trees were killed by treating them with Milestone herbicide. In the other plot of the pair (i.e., the control plot), albizia trees were not treated with herbicide (Figures 9 and 10). Albizia treatment and plot establishment occurred between March and November of 2015 at 4 of the 5 study sites, and the control and treatment plots of the remaining fifth study were established in February, 2016. Monitoring occurred on all of all plots in 2016 and will occur again in 2017. This project is intended to provide in depth information regarding the response of vegetation – particularly albizia – to planned broad-scale control efforts and inform future management decisions and best management practices.

Figure 7 (left) and Figure 8 (above): Locations (red circles) of study site pairs established on varying substrate ages and types across the eastern, windward side of Hawaii Island (left), and an aerial image (right) of the northernmost site (Akaka Falls site) showing the nature of the paired side-by-side treatment (albizia killed – red dot) and control (blue dot) plots. Flint Hughes – US Forest Service, PSW, IPIF

Figure 9 (top) and Figure 10 (bottom): Treated and untreated albizia in plots at the South Hilo Sanitary Landfill study site. Flint Hughes – US Forest Service, PSW, IPIF

Acknowledgements

This report relied on information from a long list of collborators including: Christy Martin (CGAPS), Sheri Smith (USFS FHP R5), Phil Cannon (USFS FHP R5), Leyla Kaufman (UH), Flint Hughes (US Forest Service, IPIF), Hawai'i Department of Agriculture, Springer Kaye (Big Island Invasive Species Committee), J.B. Friday (UH), Janice Uchida (UH), Aileen Yeh, Nick Dudley, and Tyler Jones (HARC).

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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, Mason, Bruce & Girard, Inc, USDA Forest Service, Region 5

United States Department of Agriculture