HAWAI'I
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Forest Health 2015 highlights

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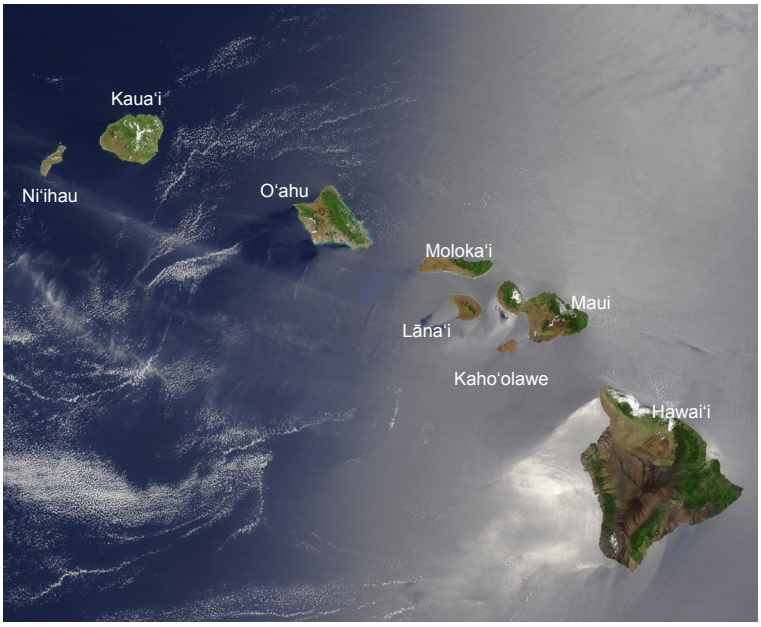
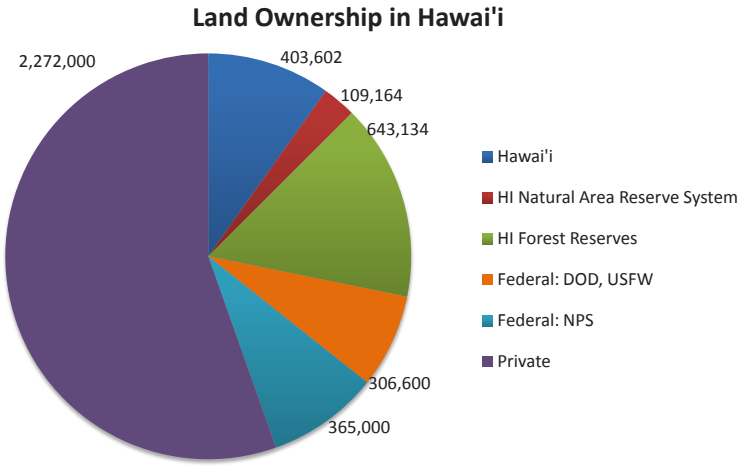
Forest Resource Summary

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

The State of Hawai'i Division of Forestry and Wildlife (DOFAW) manages 1,155,900 acres including 643,134 acres in forest reserves and 109,164 acres in the state's Natural Area Reserve System (NARS), which was created to preserve unique native Hawaiian ecosystems. Hawai'i's state forest acreage ranks as the 11th largest in the 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 Hawai'i, the Hawai'i Experimental Tropical Forest (HETF) was recently created on the island of Hawai'i 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 Hawai'i's water supply. These watershed partnerships manage upland areas comprising a patchwork of federal, state, and private parcels. Eleven island-based Watershed Partnerships have been established on six islands to protect over 2.2 million acres (including non-forested lava flows and alpine areas). The partnerships actively manage approximately 300,000 acres of priority forest by removing invasive plants and animals.

Forest Health Monitoring in Hawai'i

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

Monitoring forest health in Hawai'i presents many challenges associated with its climate and geology. Hawai'i'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 Hawai'i's forests are located.

Rapid 'Ōhi'a Death or Certatocystis Wilt of 'Ōhi'a

Ceratocystis fimbriata

'Ōhi'a (*Metrosideros polymorpha*) is the most common tree species in Hawai'i's native forests, growing from sea-level to nearly 8,000 feet and in dry, mesic, and wet forests. 'Ōhi'a-dominated forests cover 864,868 acres statewide, with 617,763 acres occurring on Hawai'i Island. This abundant tree provides habitat to much of the native flora and fauna and also has significant cultural importance. The name 'ōhi'a 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.

Beginning as early as 2010, residents in the Puna District of Hawai'i island began noticing 'ōhi'a trees on their property suddenly dying, while adjacent trees remained healthy. The symptoms appeared distinct from 'classical 'ōhi'a dieback' previously observed on the big island as a cohort effect related to stand age. 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 'ōhi'a seedlings by USDA Agriculture Research Service in 2014 (Keith et al. 2015).

In 2015, Rapid Ohia Death continued its alarming spread on Hawai'i Island, with positive detections in the Wailuku watershed above Hilo, on the Kona side of the island, as well in the Ka'u region on the southern end of the island (see distribution map of positive detections). Aerial surveys of 'ōhi'a forests on the island using US Forest Service Digital Mobile Sketch Mapping technology were scheduled for early 2016 to identify disease outbreaks and better quantify the area affected by the disease. USDA ARS has developed molecular tools for rapid detection and samples from the forest are processed in their laboratory to confirm disease presence.

An emergency quarantine rule was established in August 2015 by the Hawai'i Department of Agriculture (HDOA). The rule prevents the movement of 'ōhi'a wood and plant material from Hawai'i Island to the other islands, except by permit. Working with USDA Agriculture Research Service, HDOA has regulated commodities tested for *C. fimbriata*. Negative results result in the issuance of a DOA permit. Several shipments of 'ōhi'a construction poles were denied due to detection of *C. fimbriata*. The disease has not been detected on any of the other islands.

It is still not known how the disease is spreading or where this pathogenic genotype came from. It is suspected that the spread is facilitated by beetles attacking trees that have been killed by the disease. The frass and boring dust created by beetles may be spread by the wind. Researchers are developing techniques to detect spread by frass/boring dust and studying insects associated with the frass/boring dust. The disease has been documented on agricultural crops such as sweet potato and taro in Hawai'i for years, but the 'ōhi'a disease is a different genotype. It is hoped that further genetic analyses may shed light on the origins of this disease and its relatedness to different strains causing disease in forest trees globally.

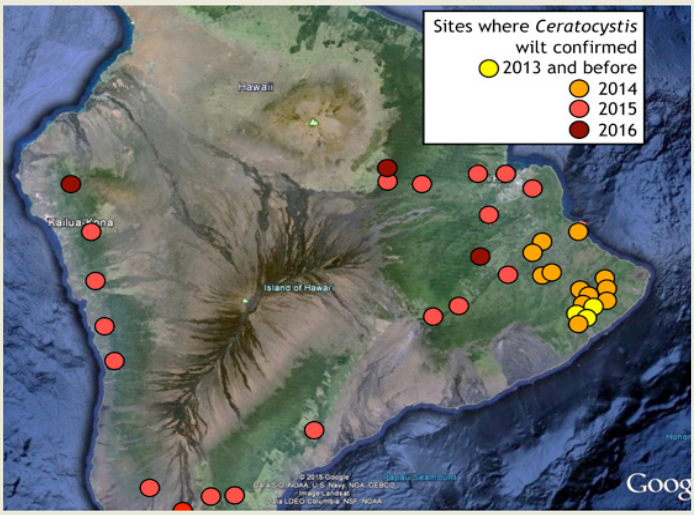


Figure 1 (top): Mature stand of 'ōhi'a (Metrosideros polymorpha) in Malama Ki Forest Reserve heavily impacted by the vascular wilt pathogen Ceratocystis fimbriata. Figure 2 (center): 'Ōhi'a tree killed by Ceratocystis fimbriata. Figure 3 (bottom): Distribution of positive detections of Ceratocystis fimbriata.

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 ʻōhiʻa 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 ʻōhiʻa trees. A study conducted in Brazil found ʻōhiʻa 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 Hawai'i from accidental introduction of additional, more harmful strains of the disease. In addition, monitoring continues to document disease impact on ʻōhiʻa, especially vulnerable seedlings, as well as disease host range which currently number 38 species, 5 of which are native to Hawai'i.

Other Disease

Work on breeding disease resistant koa (*Acacia koa*) continued in close collaboration with the Hawai'i Agricultural Research Center (HARC). Koa is an ecologically, culturally, and economically important tree species that only grows in Hawai'i 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 Hawai'i has yielded resistant families for planting on each of the main Hawaiian Islands.

Work continued in 2015, identifying resistant families for 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 mortality. In collaboration with US Forest Service PSW, a genetic study of koa throughout the archipelago was initiated 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 5). 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 (top): Koa plantation in the Kapapala Forest Reserve on Hawaii Island.
Figure 5 (left): Koa guitar produced by Taylor Guitar Company from a twenty-year old koa tree grown at HARC's Maunawili Research Station on Oahu.

Insect Pests

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 tree 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 Hawai'i occurred on Joint Base Pearl Harbor – Hickam on Oʻahu in December 2013 in a USDA trap. A nearby breeding population in a large mulch

Figure 6: Adult male coconut rhinoceros beetle, sitting on a gloved hand.

pile was discovered shortly thereafter at a golf course near the main runway of Honolulu International Airport. Hawai'i 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 Hawai'i, 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 O'ahu. No beetles have been detected on other islands in the archipelago, and eradication on O'ahu is still the project goal. Numbers of trapped beetles have declined in the original infestation area, and area infested did not increase in 2015.

Figure 7: Boring and feeding damage caused by coconut rhinoceros beetle.

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 Hawai'i 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 Hawai'i 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 Hawai'i where the pest was first detected in 2009. Rapid response plans have been developed for the other main Hawaiian islands in anticipation of 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 detections beyond Hawai'i island. Populations from throughout the archipelago are being tested for resistance to the insect pest.

Monitoring of the **lobate lac scale** (*Paratachardina pseudolobata*) continued on the island of O'ahu in 2015. Detected in 2012 near Honolulu International Airport, the pest is causing damage to non-native *Ficus* spp. planted in the urban landscape and has also been found on approximately 20 native species. Surveys by the University of Hawai'i in 2015 found the scale to be present in forests on both native and non-native ficus, although causing less damage than in urban settings. So far the scale has only been detected on O'ahu.

Hala scale (*Thysanococcus pandani*) which has been damaging native hala (*Pandanus tectorius*) on Maui since 1995 was recently found to have spread to O'ahu and Moloka'i. 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 the ability of hala stands to regnerate. In 2015, the Hawai'i Department of Agriculture (HDOA) eliminated all known infestations of hala scale on O'ahu. HDOA has also begun searching for biological control agents in Southeast Asia to control this damaging pest.

HPWRA & Plant Pono

Hawaii-Pacific Weed Risk Assessment (HPWRA) and Plant Pono

CGAPS continued to raise awareness and use of the Hawai'i Pacific Weed Risk Assessment system and the website PlantPono.org. In 2015, CGAPS staff conducted direct outreach to the nursery and landscape industry and coordinated training sessions on the islands of Maui and Hawai'i for deeper awareness. This past year also marks the launch of the next phase of the Codes of Conduct project. The Big Island Invasive Species Committee and the Kauai Invasive Species Committee have each launched nursery endorsement programs entitled Plant Pono. The businesses agree to use the HPWRA for new plants and discontinue promotion or sale of high-priority invasive plants. Plant Pono worked with Walmart stores of Hawai'i to achieve a state-wide commitment to stop the sale of the two most common invasive plants found in Big Island nurseries—Medinilla (*Medinilla* spp., Melastomataceae) and night blooming jasmine (*Cestrum nocturnum*, Solanaceae). Walmart is working toward the complete endorsement, and now faces stiff competition from Home Depot to be the first statewide Pono business.

Figure 8: Aloha Green employees show off recently acquire Plant Pono endorsement. Photo credit Hawaii Tribune Herald.

Albizia

Falcataria moluccana

Albizia, a large, fast growing tree from Southeast Asia, has overtaken at least 6,000 acres and 300 miles of road on Hawai`i island, creating a public safety hazard widely publicized by the disastrous effects of Tropical Storm Iselle which hit the island in August 2014. Albizia trees invade native forest with minimal disturbance, taking advantage of any light gap. Native ʻōhiʻa forests invaded by albizia may have as few as 5% living ʻōhiʻa trees remaining. Invasive understory species are stimulated by albizia's nitrogen input, and its fragile branches are a serious hazards for residents living in areas invaded by albizia.

The Big Island Invasive Species Committee (BIISC) is a partnership of local agencies focusing on invasive species threats to Hawaiʻi Island. The project continued to work on albizia in 2015, focusing on two main efforts. The first is training communities to manage both the physical control and regulatory procedures needed to slow the spread and manage albizia hazards in their neighborhoods. Trainings typically take place on the border between residential areas and forest reserves, taking advantage of hundreds of volunteer hours to reclaim native forests. The second is a collaboration with agencies who manage transportation and power grids, to cut hazardous trees back from roadsides, and create wide safety buffers along rights of way. BIISC has continued to seek funding for the removal of albizia along waterways, to prevent catastrophic flooding and eliminate nitrogen inputs to streams. A simple study of changes in stream biogeochemistry after removal is expected to demonstrate a rapid reduction from the current nitrogen inputs, which are comparable to run-off from industrial corn cropping.

The US Forest Service PSW has begun exploratory work for classical biological control of albizia. In 2015, an exploratory trip was made to Indonesia to search for potential candidates. One complication with biocontrol for albizia is that the candidate agent must be very specific. Koa (*Acacia* koa), one of Hawaiʻi's most important forest species is closely related to albizia and non-target testing will need to satisfy regulators that no harm will come to koa if a release occurs.

Figure 9 (above) and Figure 10 (left): Big Island Invasive Species Committee crews controlling albizia on Hawaiʻi Island.

Hawaii Pest Risk Assessment

In 2015, a team of forest pathologists and entomologist working for the Forest Service completed a technical report on forest pests that could affect 13 tree and shrub species that play an important role in native Hawaiian forest ecosystems. The report was requested by Hawaii's state forester after the recent introduction of several damaging forest pests. The science team authoring the report compiled lists of pests posing potential risk to Hawaii and conducted pathway risk assessments for 24 of the pests identified in the report, 16 of which were assigned high risk potentials.

The report highlights the risk of living plant material and wood packaging material imported into Hawaii, neither of which are sufficiently inspected and/or regulated. It also points to the mainland United States and Asia-Pacific as the main sources of introductions. While foreign imports are inspected by federal agencies, regulations in place often do not take full consideration of Hawaii's unique climate and ecosystems. Commodities leaving Hawaii for the mainland receive federal inspection, but no equivalent exists for commodities entering the state from the mainland US, leaving state regulations as the only line of defense for pests already established on the continent.

The state of Hawaii and its partners are using the report to develop better quarantine policies. Working with both federal and state quarantine agencies and political representatives, it is hoped this document will provide an impetus for improving the state's overall biosecurity. The technical report can be found at http://www.fs.fed.us/psw/publications/documents/psw_gtr250/.

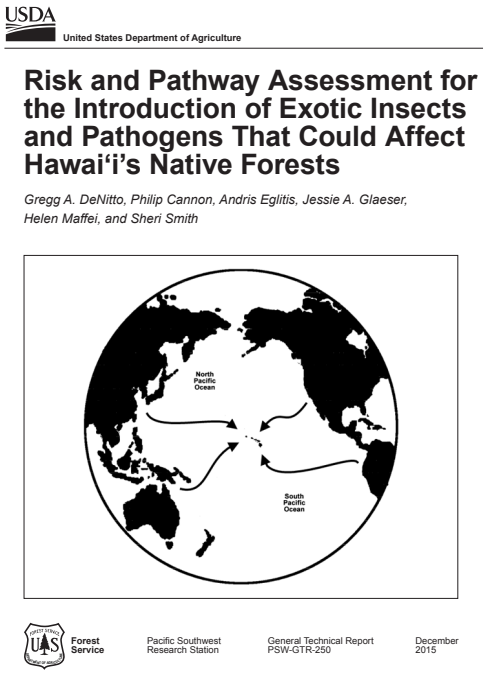


Figure 11: Front cover of the Hawaii Pest Risk Assessment

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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.

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