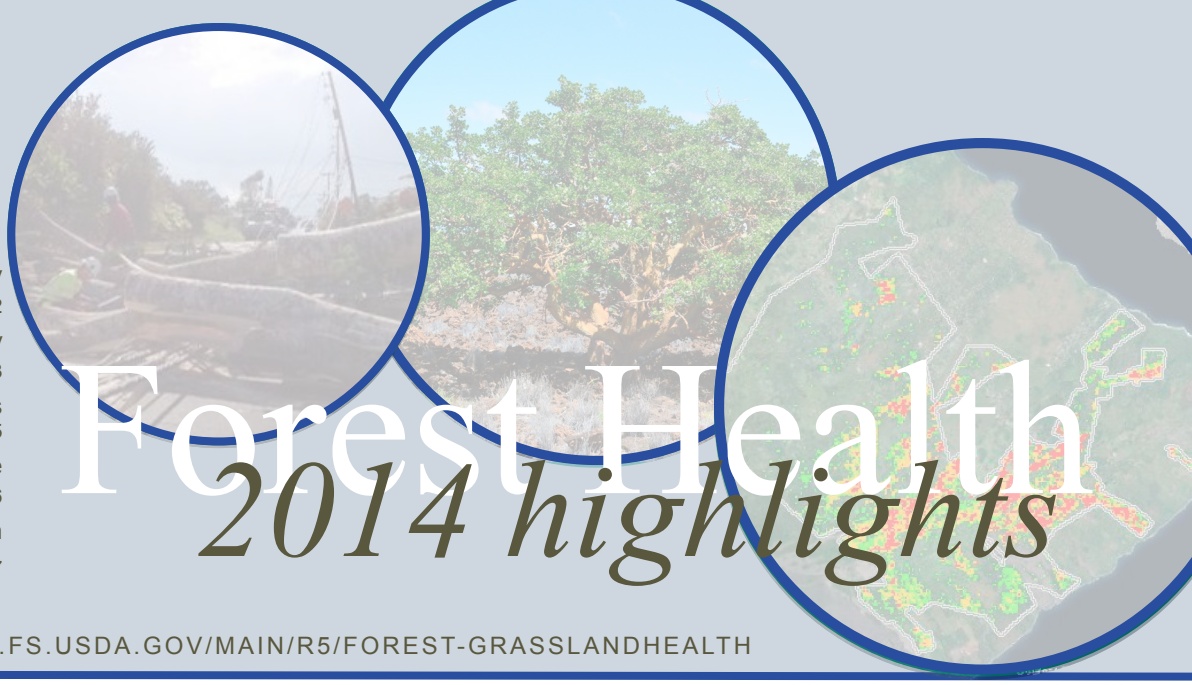
HAWAI'I
JUNE 2015



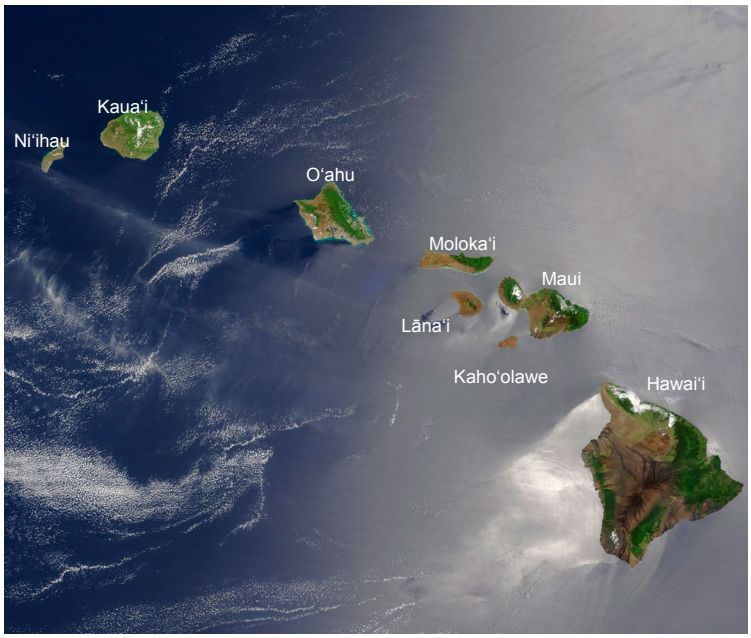
Forest Health 2014 highlights

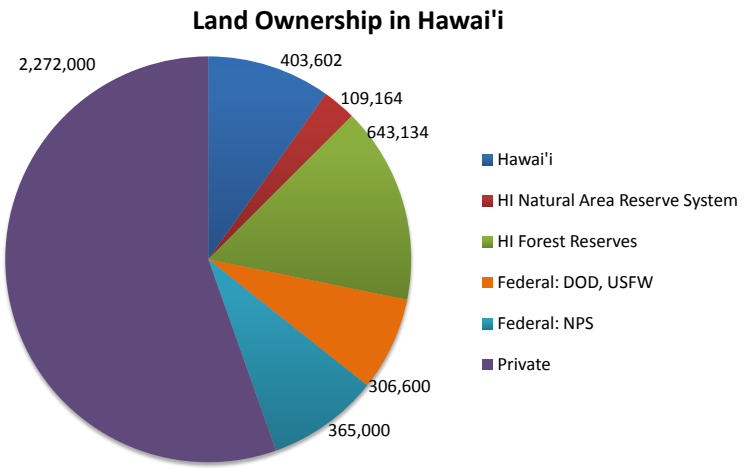
VISIT US ON THE WEB: WWW.FS.USDA.GOV/MAIN/R5/FOREST-GRASSLANDHEALTH

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. Hawaii'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 was recently created on the island of Hawai'i as a partnership of 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 sustain Hawaii'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, 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. 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 ‘Ōhi‘a Death or Certatocystis Wilt of ‘Ōhi‘a
Ceratocystis fimbriata

‘Ōhi‘a (*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. 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 the ‘classical dieback’ ōhi’a frequently experiences on the big island as a cohort effect related to stand age. Remote sensing imagery from 2012 and 2014 was used to map dead ohia in the area to determine the extent of the die off. In 2012, 2,261 acres with >10% dead ohia trees were mapped, and in 2014 the number had grown to an alarming 15,822 acres (Mortenson et al., 2014). Scientists began using the term “rapid ohia dieoff” or ROD to describe the phenomenon and distinguish it from “ohia dieback” (Mueller-Dombois and Boehmer, 2013) or “ohia decline” (Hodges et al. 1986).

Figure 1. Aerial photos of a healthy ohi’a (*Metrosideros polymorpha*) forest stand in 2008 (above) and the same Ohia stand in 2012 (below) that has been heavily impacted by the vascular wilt pathogen *Ceratocystis fimbriata*. (Photos by J.B. Friday). Mature Ohia trees in photo are 20 to 25 m in height.

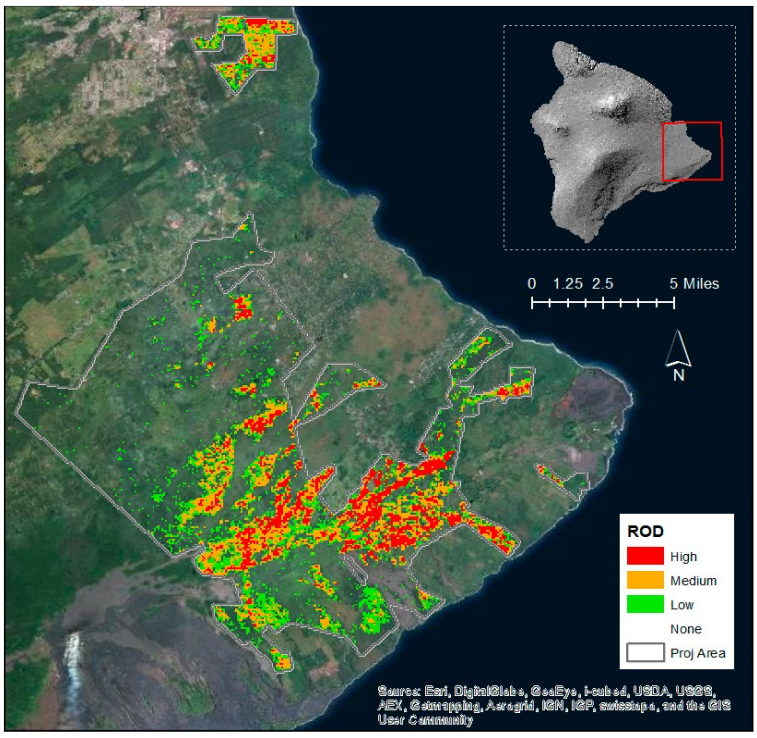


Figure 2. Distribution of forests experiencing “Rapid ohia dieoff” (Data by L. Mortenson)

Scientists from USDA Forest Service PSW Research Station, Institute of Pacific Islands Forestry, USDA Agricultural Resources Service, and University of Hawaii, College of Tropical Agriculture and Human Resources, all located in Hilo, Hawai‘i worked together to determine the cause of the die off. Branch samples with dark gray discoloration were collected from symptomatic dead trees and were analyzed for presence of pathogens. *Ceratocycstis fimbriata* was identified from the samples using both morphological and molecular characteristics, and Koch’s postulates were completed with the pathogen on ‘ōhi’a seedlings (Keith et al. 2015).

It is still not known how the disease is spreading or the environmental conditions it requires, or where this pathogenic genotype came from. The disease has been documented on agricultural crops such as sweet potato in Hawai‘i for years. Further genetic analyses will hopefully shed light on the origins of this disease and its relatedness to different strains causing disease in forest trees globally.

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.

Figure 3. Typical rust damage on ohia (*Metrosideros polymorpha*). (A. Yeh)

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 stains 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.

Other Disease

Work on breeding disease resistant koa (*Acacia koa*) continued in close collaboration with the Hawaii Agricultural Research Center. 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 2014 identifying resistant families for additional eco-regions and establishing seed orchards to provide resistant stock for both commercial forestry and restoration in the future. This long-term Forest Health Protection project continues to show promise for Hawaii's premier forestry species.

Insect Activity

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 infested breeding materials (e.g., green waste, dead trees, etc.).

The first detection of CRB in Hawaii occurred on Joint Base Pearl Harbor – Hickam military facility 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 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.

Figure 4. Adult coconut rhinoceros beetle.

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-caused 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.

Little Fire Ant
Wasmannia auropunctata

In 2014, new populations of little fire ant (LFA) were detected on Oahu and Maui. This harmful invasive ant species has been present on Hawaii island since the 1990's. The tiny arboreal ant is a serious threat to forests in Hawaii. Uniquely, the ants inhabit tree canopies where they farm scales which cause direct damage to trees. These arboreal ants pose an additional threat to native birds and invertebrates. LFA forms multiple queen colonies that result in spectacular population densities. Because of the ants' painful sting, forests that have been infested by LFA on the big island are no longer accessible to residents who enjoy strolling in the woods, to native Hawaiians collecting cultural plants, and even to resource managers conducting routine work. Regular application of pesticides is the only way to makes these areas accessible.

Figure 5. Little Fire Ant (Hawaii Ant Lab)

Spread of this species to neighbor islands has raised concern among policy makers and agencies that regulate the movement of agricultural commodities, the highest risk pathway for LFA. The two major priorities are developing systems that minimize further spread of this species and mitigating the impacts of current incipient infestations on Maui (3 populations) and Oahu (2 populations), as well as an additional population under eradication on Kauai. The Hawaii Ant Lab (HAL) housed by Hawaii Department on Agriculture in Hilo and funded by the Hawaii Invasive Species Council and Forest Service FHP has developed effective survey and treatment tools for eradication on islands where LFA is not widespread, and for management by government agencies, farmers, and residents on Hawaii island where the problem too extensive for island scale eradication. More information on LFA in Hawaii can be found on HAL's website (www.littlefireants.com).

Figure 6. Surveyors place vials in LFA habitat to detect new populations. (J. Fisher, USF&WS)

Other Insect Pests

The koa moth (*Scotorythra paludicola*) outbreak that occurred in 2013 on the island of Hawaii ended in 2014. While forests on the island have largely recovered, post-outbreak mortality and branch dieback of koa was observed. In a post-outbreak survey of recently installed FIA plots (36) located in koa forests around the island, only 8% of koa trees on the plots died (Hughes et al. 2014). Data collected on the island during and following the outbreak by the University of Hawaii, US Forest Service IPIF, USGS, and US Fish & Wildlife Service will help managers better understand the impacts caused by this native species.

Figure 7. Wiliwili tree with recovered crown at Waikoloa, Hawaii.

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 were developed over 2014 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 new detections beyond the island of Hawai'i.

Monitoring of the lobate lac scale (*Paratachardina pseudolobata*) continued on the island of Oahu in 2014. 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 Hawaii in 2014 found the scale to be present in forests on both native and non-native species although causing less damage than in urban settings. So far the scale has only been detected on Oahu.

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 has begun searching in SE Asia for biological control agents to control this pest.

Figure 8. Hala scale damages leaves of Pandanus spp. which were used to weave the sails of ancient Hawaiian voyaging canoes.

Asian gypsy moth (AGM) This pest is a major problem with a wide range of hosts in forests, natural areas and on fruits, vegetables and ornamentals. Multiple AGM detections occurred on ships at many US mainland ports in 2014 as AGM populations have been on the rise in Japan and Russia since 2012. On 8 October 2014, eleven AGM egg masses were detected on board a Taiwanese ship in Honolulu Harbor; on 25 September 2014 an additional 3 egg masses were detected on a Taiwanese ship (APHIS). This pest could be ecologically devastating if it became established in Hawaii or anywhere on the mainland.

Invasive Plants

Albizia
Falcataria moluccana

Albizia, a large, fast growing tree from SE 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 serious hazards for residents living in areas invaded by albizia.

Figure 9. Damage from downed albizia after Tropical Storm Iselle hit Hawaii in 2014

Since the storm hit, the Big Island Invasive Species Committee with funding from the state, county, and the US Forest Service Forest Health Protection has coordinated strategic albizia removal. Funds were applied to rapidly assemble a dedicated 5-person albizia control team. The team partnered with the local electric utility to achieve complete removal of albizia from the first of 18 miles of primary electrical transmission lines running through albizia forest. This first section supplies power to the Hilo Medical Center and residents in both Hilo and the Hamakua Coast. The team also finished the 200 acre albizia demonstration project in Keauohana Forest Reserve, begun in 2013 with seed money from the Hawaii Invasive Species Council. Finally, with the assistance of BIISC's new communications director, a formal community engagement program was launched. With BIISC assistance, interested community leaders can organize Albizia Control Teams to "ACT!" on albizia in their neighborhoods. Averaging two per month, training sessions teach participants how to recognize and report hazard trees; connect with a certified arborist and get a reasonable estimate; treat non-hazard trees safely and appropriately; organize work days to hand pull seedlings along privately managed subdivision roads; and find additional information and assistance. In addition, the USDA Forest Service, Pacific Southwest Research Station's Institute for Pacific Islands Forestry received FHP and U&CF funds to monitor ecological response to the treatment regime so that success of the program can be evaluated.

Hawaii-Pacific Weed Risk Assessment (HPWRA)

The Coordinating Group on Alien Pest Species (CGAPS) continued conducting outreach to the plant industry about making good planting decisions. Surveys and interactions in 2013 found that although many in the industry had heard of the HPWRA, there was still a lack of understanding about the tool and how it works. Further, personnel who were considered plant "experts" were not likely to request that a plant be screened. CGAPS staff organized a series of workshops taught by a HPWRA evaluator in October. Two were for "lay-people" which provided a non-technical overview of the HPWRA and focused on traits that make a plant likely to become invasive. Nearly 30 people attended the workshops, with representatives from forestry, the Hawaii Farm Bureau, nursery and landscaping, master gardeners, and others involved in horticulture. The third workshop focused on the technical elements of assessments, and invited participants included six plant experts who had a strong botanical background. Additional workshops will be planned in coordination with island-based invasive species committees on each island in 2015.

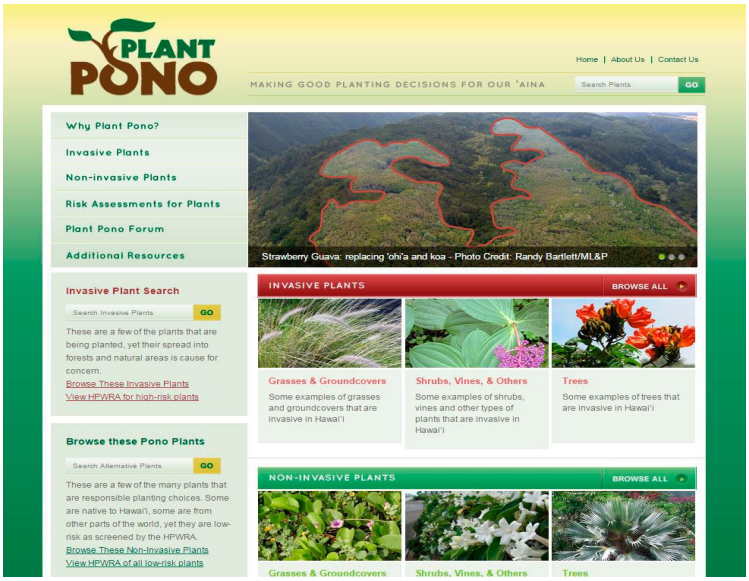


Figure 10. plantpono.org screenshot.

The website Plant Pono (www.plantpono.org) which provides information from HPWRA to both the plant industry and the general public continued to be improved. One change allows plant enthusiasts to fill out an online form with proposed plants and planting information for the "pono" plant database. CGAPS staff also engaged Master Gardeners in the program by creating a volunteer job description and training volunteers to increase the database of pono plants. A re-launch of the Plant Pono website (www.plantpono.org) is planned for July 2015.

Welcome

Through an agreement between the Hawaii Agriculture Research Center (HARC) and US Forest Service, State and Private Forestry program, HARC was able to hire a NAVY combat veteran as part of the USFS 21st Century Conservation Service Corps Program in July 2014. The veteran, Michael Kaufmann, received training and mentoring in a wide range of forestry topics including tree seed collection, processing and germination, tree seedling production, forest tree seed orchard management, basic principles of tree improvement, applications of GIS mapping to forestry and natural resource management, principles of plant pathology and pest management in native forest restoration and reforestation projects. This partnership has contributed directly to the goals of the 21st Century Conservation Service Crops through employing a veteran to directly address several critical needs such as improving forest and watershed health as identified in Hawaii's Forest Action Plan.

Figure 11. US Navy Veteran, Michael Kaufmann, inspecting Acacia koa seedlings for pests and pathogens at the HARC Maunawili Station. (Photo: T. Jones)

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), Hawaii 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).

References

Hodges, C. T., K. T. Adee, J. D. Stein, H. B. Wood, and R. D. Doty. 1986. Decline of ‘ōhi’a (*Metrosideros polymorphy*) in Hawaii. General Technical Report PSW-86. Pacific Southwest Forest and Range Research Station, USDA Forest Service, Berkeley, CA. 22 pp.

Keith, L. M., R. F. Hughes, L. S. Sugiyama, W. P. Heller, B. C. Bushe, and J. B. Friday. 2015. First Report of *Ceratocystis* wilt on ‘Ōhi‘a. Plant Disease. http://dx.doi.org/10.1094/PDIS-12-14-1293-PDN

Mortenson, L., J. B. Friday, R. F. Hughes, N. Friday, Z. Liu, L. Keith, and C. Fettig. October 2014. Rapid ‘ōhi’a Death (ROD), Island of Hawaii. Society of American Foresters Poster, Salt Lake, Utah.

Mueller-Dombois, D. and H. J. Boehmer. 2013. Origin of the Hawaiian rainforest and its transition states in long-term primary succession. Biogeosciences, 10: 5171-5182.

da Silva, A.C., P.M. de Andrade, A.C. Alfenas, R.N. Graca, P. Cannon, R. Hauff, D.C. Ferreira, and S. Mori. 2014. Virulence and impact of Brazilian strains of *Puccinia psidii* on Hawaiian ’Ōhi’a (*Metrosideros polymorpha*). Pacific Science 68; no. 1:47-56.

Graça, R. N., A. C. Alfenas, A. L. Ross-Davis, N. B. Klopfenstein, M. S. Kim, T. L. Peever, P. G. Cannon, J. Y. Uchida, C. Y. Kadooka, and R. D. Hauff. 2011. Multilocus genotypes indicate differentiation between *Puccinia psidii* populations from South America and Hawaii. In: M.L. Fairweather, compiler, Proceedings of the 58th Western International Forest Disease Work Conference. 4-8 Oct., 2010. Valemount, B.C., Canada. US Forest Service, AZ Zone Forest Health, Flagstaff, AZ.

Hughes, R. F., T. Sowards, L. K. K. Tango, S. Yelenick, S. L. Smith, and R. Hauff. 2014. Ecosystem function and health: effects of *Scotorythra paludicola* on Acacia koa forests poster.

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

United States Department of Agriculture