

2022-2026

STRATEGIC PLAN



Tropical Hardwood Tree Improvement &
Regeneration Center

A Collaborative Research, Development,
Education, and Extension Center for
Tropical Hardwood Stewardship

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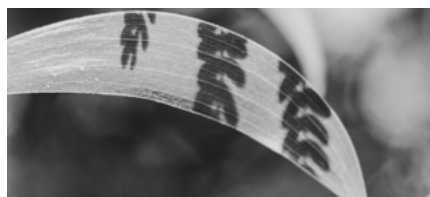


MISSION

The Tropical HTIRC mission is to advance the science and application of tree improvement, management, and protection to improve tropical hardwood forests, with emphasis on the Hawaiian Islands.

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HISTORY OF TROPICAL HTIRC AND OPERATING ENVIRONMENT

Tropical HTIRC was founded in 2011 to address the most important challenges facing tropical hardwoods in Hawai'i and American-affiliated tropical islands. The idea for a Tropical HTIRC was conceived in early 2010 out of a desire to invigorate hardwood tree improvement and restoration research efforts in the tropical region of the USA. The program was developed by a collaboration among Hawai'i state foresters, professional foresters, university scientists, landowner associations, governmental and non-governmental agencies and extension personnel.

The birth of the Tropical HTIRC occurred at the same time that the region was experiencing a renewed interest in afforestation and reforestation of tropical species, such as *Acacia koa*, on lands that had been abandoned from long standing ranching and agricultural production efforts. The hardwood industry was also concerned about the future quantity and quality of the resource for its lumber and secondary wood products sectors. In addition, due to previous land use, tropical forests have seen significant reduction in the volume of tropical hardwood timber that is harvested annually. The hardwood industry was aware that it was not taking advantage of new technologies and research that could improve wood quality, growth, production of merchantable timber, and pest and disease resistance.

The larger community of professional foresters was also concerned about loss of

genetic quality in remaining native forests. They felt that trees that are currently being managed for future timber harvest do not have the same desirable traits for straightness, wood quality, and vigor and that past forest harvest practices of continually taking the "best" trees may have resulted in loss of genetic quality of the remaining germplasm.

In addition, ecologists and land managers throughout the region were becoming increasingly concerned with the ability of native ecosystems to withstand threats from invasive species and climate change. Invasive species, including plants, insect pests and diseases, continue to invade Hawaiian forests. These invaders are changing the ecological dynamics of the forest environment and threatening many native plant and animal species with extinction. The ecology of our tropical forests may be further disturbed by climate change. As a result, regeneration of target native tree species is being inhibited and native forests are being transformed into exotic-dominated forests of reduced conservation and commercial value. To address these global changes, tree improvement efforts aimed at providing improved stock can provide the conservation community with the knowledge of tree genetics and resources for enhanced management of native tropical forests while simultaneously providing the forest industry with material required for enhancing forest-based economic development.





INTERNATIONAL ECONOMIC, SOCIAL, AND CULTURAL ENVIRONMENT

Forests are important across the tropical Pacific for ecological, economic, social and cultural values. Species such as *Acacia koa* are ecological, economic, and cultural keystone species because they play essential roles in the biological functioning of native ecosystems, provide a diverse array of products, and serve as an identity of native Hawaiian culture. In the case of *Acacia koa*, this species is clearly Hawai'i's signature forest industry species. Koa is the largest tree in Hawai'i and one of the most valuable timbers in the world – koa stumpage ranges from \$4,000 to \$5,000 (or more) per 1,000 board feet (mbf) and select koa lumber sells for \$30 per board foot. Koa wood is highly desired for specialty, value-added wood products such as bowls, furniture, picture frames, and flooring, contributing about 75% of the wood for Hawai'i's \$30 million/year forest industry.

For ecological, economic, social, and cultural reasons, there is growing interest in restoring forests to the degraded landscapes of Hawai'i and the Pacific. Water quality has been degraded by conversion of forests to agriculture and ranching. A historic reliance on exotic tree species for planting has degraded ecological values and cultural accessibility of the forest resource. While there have been initial planting efforts with both exotic and native species in Hawai'i and across the Pacific, these efforts have had limited access to improved native species, so exotic species have been and continue

to be selected over native plant species in many circumstances. Thus, the opportunity exists for greatly enhancing the role that quality native hardwood species can play in reforestation efforts in Hawai'i and across the Pacific.

Many of Hawai'i's citizens are concerned about food security, and food production systems have a long and rich history in the region – for example ranching and the paniolo cowboy culture are revered parts of Hawai'i's history. These social and political forces can conflict with those of the conservation community and the forest industry, but there are important mitigating attributes to an enhanced forest sector. Wood security is also an important regional concern as well as an untapped source of economic development. Ranching in Hawai'i has been declining for decades in large part because it is marginally viable as a livelihood. Many consumers assign important aesthetic and spiritual values to forests and even individual trees whether they are in an urban, plantation, or natural forest setting. Critically, an enhanced forest industry would require only a marginal increase in the amount of land set aside and dedicated to reforestation. Further, many ranchers are exploring forest-based solutions to enhancing economic viability of ranch operations, and several creative restoration efforts are seeking to enhance ecological value of a landscape while producing economic value. In addition to ranching, fallow agricultural land is also

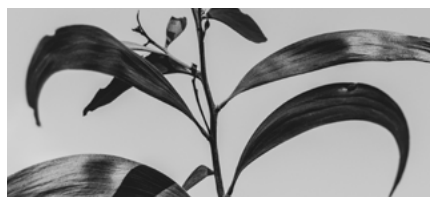
available due to the demise of sugar cane production, and diversified agriculture will be an important part of the future Hawaiian landscape.

In the conservation realm, there are now several funding mechanisms for conservation plantings, including the NRCS-supported Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Environmental Quality Incentives Program (EQIP), and Wetland Reserve Program (WRP). These programs, funded primarily by federal appropriations, plus state-funded programs such as the Forest Stewardship Program, account for the majority of private, conservation, and stewardship forestry focused hardwood tree planting in Hawai'i and across the Pacific. Historically, improved water quality and wildlife habitat, native species restoration, and small-scale forestry have been the focal areas. In some cases, where native species are considered, the genetic characteristics of the trees being planted under these programs are unknown, with important questions regarding growth, form, wood quality and survivorship – especially at elevations or in areas where native seed sources are no longer present.

While the Tropical HTIRC employs tools of modern genetics to understand target tree species, the Center will not support work that directly manipulates plant genomes and leads to creation of genetically modified organisms. We instead will rely on modern genetics to characterize existing, naturally occurring lines, and classical methods for improving these lines – the same methods used by Hawaiians to create 100+ varieties of taro.



Koa dying from wilt at low elevation.



ACCOMPLISHMENTS DURING 2017-2021

During the second five years of Tropical HTIRC and while under the previous 2017-2021 Strategic Plan, Tropical HTIRC continued to maintain important infrastructure, staffing, collaborative networks, and research / extension projects that contributed to its strategic directions and objectives. The Tropical HTIRC advisory (steering) committee met annually (except

2021, due to COVID-19), and most research and extension outcomes were accomplished in direct collaboration with partner agencies. Dedicated office and laboratory space for Tropical HTIRC was maintained at USDA Forest Service Institute of Pacific Islands Forestry and University of Hawai'i Komohana Research and Extension Center.

ADDITIONAL SPECIFIC ACCOMPLISHMENTS INCLUDE

- » Secured funding for Tropical HTIRC work from sources including USDA Forest Service, USDA McIntire-Stennis program, Hawai'i DLNR Division of Forestry and Wildlife, Department of Hawaiian Homelands, van Eck Forest Foundation, Paniolo Tonewoods, Hāloa 'Āina, Kealakekua Mountain Reserve (doTERRA), Purdue University, and the University of Hawai'i.
- » Maintained professional staffing consisting of an extension agent and project coordinator (O. Krauss), project coordinator (B. Kaufmann), senior advisor (R. Masuda), and several Hawai'i-based undergraduate student technicians.
- » Mentored and trained 10 graduate students (6 PhD: A. Ebrahimi, R. Ohara, B. Redfield, K. Rose, K. Roy, E. Thyroff; 4 MS: A. Adhikari, L. Ayala, B. Kaufmann, T. Speetjens) and 4 post-doctoral scientists (I. Paudel, K. Rose, A. Sugiyama, A. Youkhana) in Tropical HTIRC mission-oriented work.
- » Recruited two Native Hawaiian graduate students (K. Roy, T. Speetjens), who were each awarded scholarships from the Sloan Foundation Indigenous Graduate Partnership at Purdue.
- » Established and maintained research projects with *Acacia koa* involving seed scarification, nursery stocktypes and fertilization, clonal nursery propagation, fertilization, ecophysiology, underplanting, thinning, and landscape genomics.
- » Maintained a network of koa progeny tests in collaboration with DOFAW and DHHL on the windward slope of Mauna Kea to serve as a future seed orchard.
- » Installed a koa thinning demonstration trial on the Hawai'i Experimental Tropical Forest (Pu'u Wa'awa'a) and aided partners to implement koa thinning (i.e., TNC).



Measuring stem form of five-year-old koa interplanted among sugi pine (*Cryptomeria japonica*) on Department of Hawaiian Home Lands (left). Measuring koa progeny tests at the Department of Hawaiian Homelands (right).

- » Developed a successful grafting propagation protocol for koa in collaboration with a USDA Forest Service HTIRC tree breeder (J. McKenna).
- » Participated in the Ōhi'a Disease Resistance Program with Tropical HTIRC partners.
- » Developed new research initiatives in 'iliahi with Hāloa 'Āina, Kealakekua Mountain Reserve, and other Tropical HTIRC partners. Published a nursery propagation and field establishment guide for 'iliahi (Speetjens et al. 2021).
- » Published > 10 research articles in international peer-reviewed journals.
- » Renovated a greenhouse facility at the University of Hawai'i Komohana Research and Extension Center to provide dedicated space for Tropical HTIRC nursery and propagation research.
- » Coordinated and sponsored extension workshops and field days to provide forums to share research discoveries among scientists and transfer technology to managers, including the annual Tropical HTIRC advisory committee meeting / field tours and a Hawai'i Native Plants Grower's Meeting in Waimea during January 2018.
- » Developed and launched a new Tropical HTIRC website (www.trophhtirc.org) in collaboration with 'Ākolea Visual.
- » Began production of new Tropical HTIRC annual reports (2018-2021), distributed as hardcopies and available as PDF on our website.



Koa grafting study installation at the John T. Harrington Forestry Research, New Mexico State University (above). Koa populations from different elevations can be tested for frost tolerance by electrolyte leakage (below).



SELECTED TROPICAL HTIRC PUBLICATIONS DURING 2017-2021

- Ayala-Jacobo LM, Woeste KE, Jacobs DF (2021) Cold acclimation increases freeze tolerance in *Acacia koa*, a tropical tree species occurring over a wide elevational gradient. *Forests* 12:1089.
- Idol TW, Diarra G (2017) Mycorrhizal colonization is compatible with exponential fertilization to improve tree seedling quality. *Journal of Plant Nutrition* 40:283-297.
- Jacobs DF, Davis AS, Dumroese RK, Burney OT (2020) Nursery cultural techniques facilitate restoration of *Acacia koa* competing with invasive grass in a dry tropical forest. *Forests* 11:1124.
- Lawson SS, Ebrahimi A (2018) Development and validation of *Acacia koa* and *A. koaia* nuclear SSRs using Illumina sequencing. *Silvae Genetica* 67:20-25.
- Rose KME, Friday JB, Jacobs DF (2019) Establishment and heteroblasty of *Acacia koa* in canopy gaps. *Forest Ecology and Management* 453:117592.
- Rose KME, Friday JB, Oliet JA, Jacobs DF (2020) Canopy openness affects microclimate and performance of underplanted trees in restoration of high-elevation tropical pasturelands. *Agricultural and Forest Meteorology* 292-293:108105.
- Rose KME, Mickelbart MV, Jacobs DF (2019) Plasticity of phenotype and heteroblasty in contrasting populations of *Acacia koa*. *Annals of Botany* 124:399-409.
- Speetjens TM, Thyroff EC, Yeh AKF, Jacobs DF (2021) Propagation of 'iliahi (*Santalum paniculatum* Hook. & Arn.), a valuable endemic Hawaiian sandalwood species. *Tree Planters' Notes* 64:33-49.
- Sugiyama A, Friday JB, Giardina CP, Jacobs DF (2021) Intraspecific variation along an elevational gradient alters seed scarification responses in the polymorphic tree species *Acacia koa*. *Frontiers in Plant Science* 12:716678.

Based on this success and the next phase of challenges, it was deemed important to develop the next five years of work. This 2022-2026 Tropical HTIRC Strategic Plan was revised and updated in direct consultation with the advisory committee and staff of the Center. In addition, the advisory committee will provide annual advice on research priorities and will suggest re-prioritization of objectives as necessary.





STRATEGIC DIRECTIONS AND OBJECTIVES FOR 2022-2026

To meet the above challenges and build on what was learned and accomplished during 2017-2021, Tropical HTIRC has five strategic directions for 2022-2026:

1. Improve the genetic quality of tropical hardwoods, especially *Acacia koa*, through use and refinement of traditional tree improvement methods and novel molecular marker techniques.
2. Develop advanced nursery propagation and seed production technologies to improve the field establishment success of tropical hardwood reforestation / restoration and allow for efficient production of genetically improved trees.
3. Establish a system of native species research and demonstration trials (e.g., on the Hawai'i Experimental Tropical Forest) for education and training of consultant and industrial foresters, nursery practitioners, conservation biologists, and public and private landowners in silviculture and regeneration techniques.
4. Educate future leaders in tree improvement, management, and protection of tropical hardwood forests.
5. Engage our stakeholders and address their needs by communicating research findings and management recommendations.

Tropical HTIRC's strategic objectives will be focused on: (A) research and development, (B) graduate education, (C) extension, and (D) capacity building.

A

Strategic Directions 1-3

RESEARCH AND DEVELOPMENT OBJECTIVES

All of the research and development objectives address issues for tropical hardwood regeneration in Hawai'i. Specific elements include:

CLASSICAL TREE IMPROVEMENT

- » Continue the research program for *Acacia koa* that will increase productivity through improvement of e.g., growth, form, wood quality, precocity, and resistance to abiotic and biotic stressors.
- » Identify genetic sources of disease resistance in 'ōhi'a to Rapid 'Ōhi'a Death (ROD), caused by *Ceratocystis* spp. fungi.

HARDWOOD GENOMICS AND BIOTECHNOLOGIES

- » Develop molecular markers for commercial and adaptive traits of interest.
- » Screen and select through molecular marker techniques.
- » Conduct research that contributes to development of guidelines for seed transfer and breeding.

PROPAGATION TECHNOLOGIES, SEED PRODUCTION AND HANDLING, AND NURSERY MANAGEMENT

- » Develop clonal propagation technologies.
- » Develop advanced seed orchards and seed handling technologies.
- » Develop methods for production of high-quality nursery seedling stock.

HARDWOOD FOREST REGENERATION

- » Develop plantation establishment regimes for tropical hardwoods, including studies of the influence of seedling physiology on early growth.
- » Develop silvicultural systems for mixed tropical hardwoods, including improved understanding of crop tree response to thinning.
- » Develop best management practices for maintaining genetic quality and diversity of tropical hardwood forests.
- » Develop restoration techniques for high-graded tropical hardwood stands.
- » Integrate biocultural values into prescriptions and management of forest restoration.

HARDWOOD PROTECTION

- » Develop novel control and management strategies for major invasive plants and forest pests, especially for introduced exotics.
- » Develop best management practices for managing competing invasive vegetation, such as gorse and kikuyu grass.
- » Determine strategies to mitigate forest decline caused by global climate change.



Koa seeds sorted by families for scarification treatment.

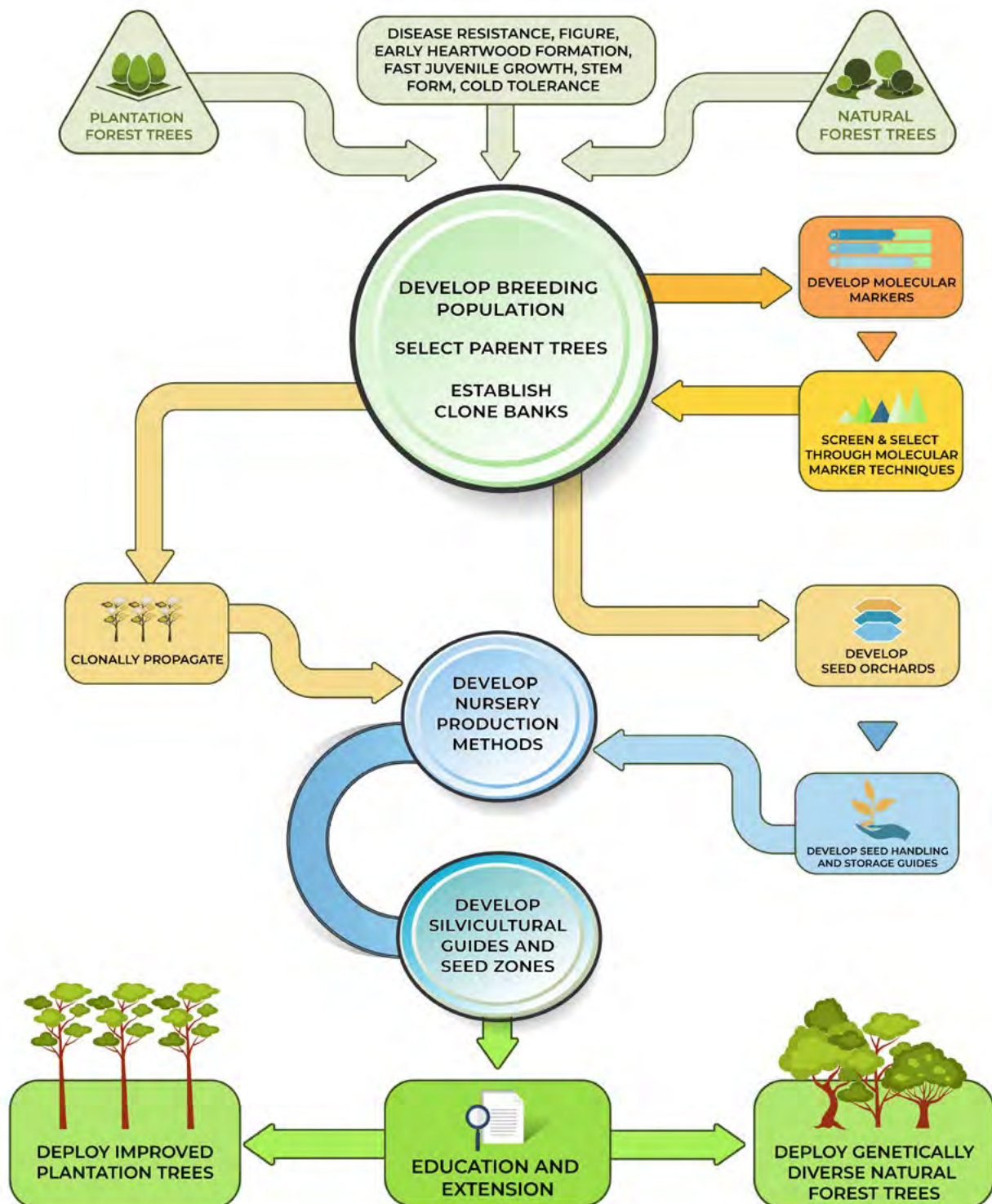
Tropical HTIRC research and development aims to address these themes in an interconnected way for native Hawai'i forest trees including koa, 'ōhi'a, and 'iliihi (see *Tropical HTIRC structure / road map*). For plantation tropical hardwood forests, we will continue a genomics research effort to develop molecular markers for traits of interest. From this basic work and in association with classical tree breeding, traits will be targeted for improvement that will lead to domestication and efficient production of selected tropical hardwood species. Concurrently, seed orchard and tropical hardwood propagation systems will be developed for delivery of this improved germplasm. Modified silvicultural systems will also be established for these domesticated trees. Novel strategies will

be developed for control and management of major forest invasive plants, pests, and pathogens. In addition, research will be conducted, and strategies will be developed to address effects of climate change on forest health. For the identification of research issues, plant materials, and current practices, scientists and research professionals will form partnerships or seek the advice and counsel of consulting foresters, landowners, industry practitioners, and tree improvement and nursery specialists.



Tropical HTIRC

STRUCTURE / ROAD MAP



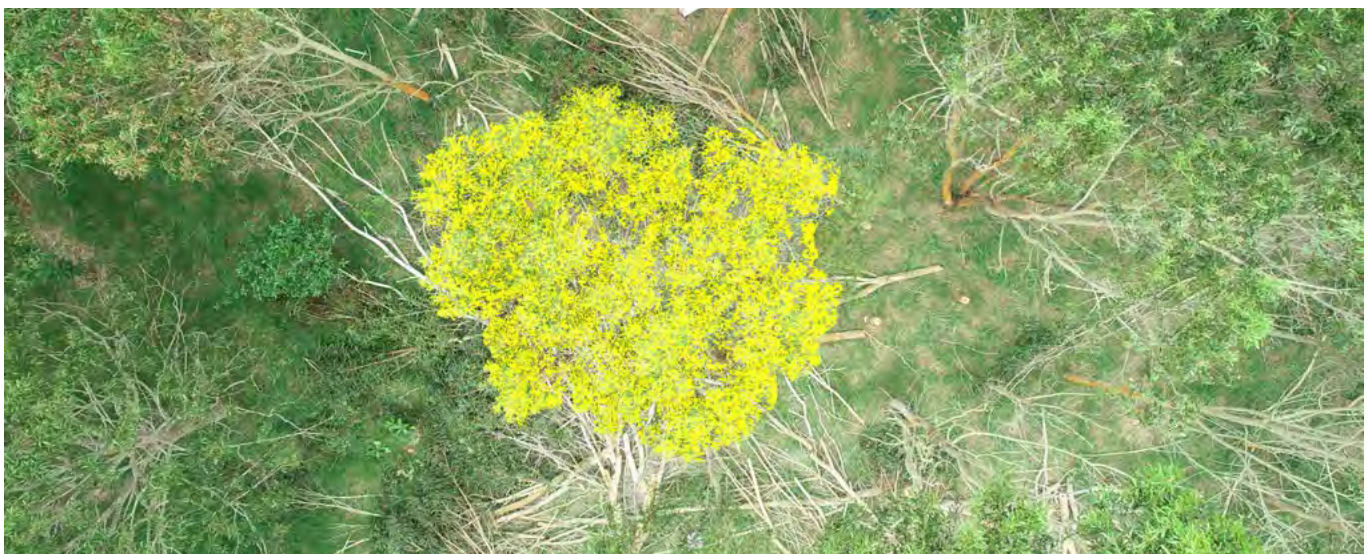
EXPECTED 5-YEAR RESEARCH AND DEVELOPMENT ACTIVITIES AND OUTPUTS*

- » Work collectively to fund, maintain, and expand koa breeding orchards and progeny tests throughout the state (HARC, UH, PU, DOFAW, DHHL, USFS, Forest Solutions).
- » Wilt resistant koa will be screened and selected for new intercrosses and seed orchard establishment (HARC, USFS, UH).
- » Selections will be made for high-elevation koa with improved frost tolerance (PU, UH, DHHL, USFS).
- » A koa seed bank from populations across heterogeneous environments will be expanded upon; this will facilitate studies of koa eco-physiological adaption (e.g., frost or drought tolerance) that may ultimately contribute to guidelines being developed for seed transfer and breeding in Hawai'i (PU, UH, HARC, DHHL, USFS).
- » Intensive silviculture of koa plantations will be improved through identification of the most effective management practices (i.e., site preparation, fertilization, thinning, pruning) under operational settings (Forest Solutions, Paniolo, Kamehameha Schools).
- » Koa responses to interactive factors of light, moisture, and nutrient availability during plantation establishment will be better understood (PU, UH, DHHL, DOFAW, USFS).
- » Clonal propagation technologies (i.e., grafting and rooted cuttings) will be developed for koa (PU, UH, HARC, Paniolo, Maui Native Nursery, Haleakala Ranch).
- » Prescriptions to control invasive vegetation for koa field establishment will be refined (PU, UH, DHHL).
- » Improve upon understanding of koa response to thinning to help guide management prescriptions (UH, PU, USFS, DHHL).
- » Nursery propagation protocols, field establishment prescriptions, and improved understanding of the biology and ecology of 'iliahi will be developed (Hāloa 'Āina, Kealakekua, PU, UH, USFS, DOFAW).
- » Continue to identify disease resistance sources in 'ōhi'a through the 'Ōhi'a Disease Resistance Program (AFTF, USFS, DOFAW, PU, UH).
- » Consideration of cultural values and ecosystem services will be integrated into Tropical HTIRC science and extension programs (AFTF, Kamehameha Schools, USFS, DOFAW, PU, UH).
- » Best Management Practices for forest management will be developed to deter the type of harvesting that leads to high-graded forests, and to ensure maintenance of hardwood genetic diversity (UH, USFS, DOFAW).
- » Maintain the newly revised website to more effectively communicate Tropical HTIRC research discoveries and extension products/events (PU, UH, USFS).

* Expected lead partner agency or agencies are shown, in relative order.



Collecting koa seeds on lands managed by the Department of Hawaiian Home Lands (top-left). Koa used as host species for planting of 'iliahi at the Kealakekua Mountain Reserve (top-right). Thinned koa stand at at Pu'u Wa'awa'a (bottom).





Koa stand established with shelter of sugi pine.

EXPECTED LONG-TERM RESEARCH AND DEVELOPMENT OUTCOMES

- » Tropical hardwood seed production will be more efficient and will significantly increase due to new seed orchard technologies.
- » Advanced nursery practices will be developed to facilitate production of high-quality tropical hardwood nursery seedlings for reforestation and restoration.
- » Integration of cultural values within Tropical HTIRC research will lead to increased local and community engagement.
- » Cold tolerant selections of koa will allow for more cost efficient and effective high-elevation restoration.
- » Genetic gains will be realized through breeding, selection, and clonal propagation technologies; ultimately, selections/families will be deployed through state nurseries and potential private interests.
- » Seed zones for effective transfer of koa for commercial and restoration objectives will be developed.
- » Seedlings with figured grain may become available for commercial production.
- » Effective prescriptions for field establishment of 'iliahi with other Hawai'i native species will be scaled up to promote landscape level forest restoration.
- » Identification of disease resistance in 'ōhi'a will promote restoration to help overcome decline due to Rapid 'Ōhi'a Death.

B**Strategic Direction 4****EDUCATIONAL OBJECTIVES**

The undergraduate, graduate, and post-doctoral education function of the Tropical HTIRC is to develop future hardwood researchers and practitioners with expertise in the science and application of tree improvement, management, and protection of tropical hardwood forests. Students will be trained through a combination of disciplinary coursework, specialized research projects, and opportunities to present their research at scientific conferences and extension meetings. These students will

become the next generation of leaders as forest ecologists, forest geneticists, tree improvement specialists, propagators, nursery managers, silviculturists, forest health specialists, and extension agents. Exposure to interdisciplinary research initiatives and to the broad range of end-goals of tropical hardwood users (i.e., commercial, ecological, and conservation) is a cornerstone of the educational experience at the Tropical HTIRC.

EXPECTED 5-YEAR EDUCATIONAL ACTIVITIES AND OUTPUTS

- » At least ten graduate students, five undergraduate students, and two post-doctoral scientists will be educated and trained by Tropical HTIRC to work on integrated research problems and learn how to perform team-oriented research that affects human populations. These graduates will be available for employment with universities, state and federal agencies, NGOs, and private industry.
- » Successfully recruit and mentor local Hawai'i (born or naturalized) students and staff that are likely to stay in Hawai'i to pursue careers in natural resources. Continue to work with the Sloan Foundation Indigenous Graduate Partnership at Purdue to recruit Native Hawaiians and Pacific Islanders. Apply for grants that will support graduate education and training of local Hawai'i students and staff.

EXPECTED LONG-TERM EDUCATIONAL OUTCOMES

- » Nationally and internationally, students will recognize the Tropical HTIRC (via Purdue University, University of Hawai'i, partners, and collaborators) as a preferred institution to receive education and training in tropical hardwood tree improvement, ecology, regeneration, silviculture, and protection.
- » Graduate students and post-doctoral scientists who were trained at the Tropical HTIRC will continue or establish tropical hardwood research and management programs, thereby increasing the level of research being performed on tropical hardwood trees.
- » Hawai'i forests will benefit from future Hawai'i-based scientists and managers that were trained at the Tropical HTIRC.



C

Strategic Direction 5

ENGAGEMENT AND EXTENSION OBJECTIVES

One function of the Tropical HTIRC will be to communicate: (1) stakeholder needs to the research community and (2) unbiased science-based technology and information to end users through:

- » Extension and communication specialists at the University of Hawai'i and Purdue University.
- » Partnering organizations throughout Hawai'i and the Pacific.
- » Researchers who work with stakeholders to develop technologies.
- » The promotion and maintenance of a revised website (www.trophtirc.org).
- » Continued development of a range of different extension materials tailored to suit different messages and client groups (e.g., traditional extension publications, how-to videos, on-line photo galleries, and social media).
- » Incorporation of online and hybrid extension programming.

We will ensure that information is communicated to clients (landowners, industrial foresters, and consulting foresters) and the scientific community and that newly developed technologies are applied to real-life situations.



Discussing thinning treatments in scarified natural regeneration of koa at Kona Hema on Hawai'i Island.

EXPECTED 5-YEAR ENGAGEMENT AND EXTENSION ACTIVITIES AND OUTPUTS

- » Access and use of Tropical HTIRC science-based information will continue to improve through promotion and maintenance of a revised website designed for ease of use and improved communications with new and existing stakeholders.
- » Current events of interest to hardwood researchers and practitioners will be posted on the Tropical HTIRC website and through social media.
- » Forest landowners and natural resources professionals will receive periodic updates of research and development activities through social media networks.
- » Tropical hardwood silviculture field days, seed conditioning workshops, tree seed collection, native plant seed testing and hardwood nursery workshops will continue to be held on a routine basis.
- » Over 50 landowners and 50 natural resource professionals will be trained in seed handling, tree planting, plantation establishment, and plantation management.
- » Tropical HTIRC will host important regional and international scientific conferences.
- » A new state-wide koa reforestation initiative (i.e., Paniolo Tonewoods, etc.) will be pursued and promoted.

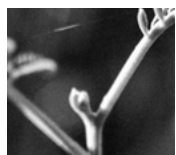


J.B. Friday, Extension Forester at the University of Hawai'i at Mānoa (left). Tropical HTIRC website and annual reports (right).

EXPECTED LONG-TERM ENGAGEMENT AND EXTENSION OUTCOMES

- » Landowners, nursery managers, and consulting foresters will rely on the Tropical HTIRC as a leading source for information on tropical hardwood production and management
- » Landowners, nursery managers, and consulting foresters will increase knowledge of tropical hardwood genetics and heritability of biotic and abiotic stress, wood quality, and tree form.
- » Nursery and land managers will obtain and apply an improved knowledge of best nursery and silvicultural management practices.
- » A wider audience will improve their decision-making in forest management.
- » Local communities will become better connected to forests.
- » Native communities will become re-connected with native forests.
- » Demand for, supply of, and use of genetically selected or improved planting stock that is resistant to pests and diseases will increase, which will lead to production of higher volumes and quality of timber.
- » The land area of high value plantation hardwoods and restored forests in Hawai'i will increase.
- » Tropical hardwood plantations will reduce the harvest pressure on natural forests.
- » Increased habitat for native bird / plant communities and watershed protection will be established through tropical hardwood conservation and restoration.





Tropical HTIRC

LOGIC MODEL

Five Year Vision Statement: Tropical HTIRC is the recognized leader in collaborative research, development, extension and education for sustainable production and conservation of Pacific Island hardwood tree species.

INPUTS	ACTIVITIES	OUTPUTS
<ul style="list-style-type: none"> ✓ Steering committee members ✓ Professional researchers and university faculty ✓ Extension agents ✓ Undergraduate and graduate students ✓ Input from a wide range of experts ✓ Landowners and managers 	<ul style="list-style-type: none"> ✓ Conduct research on tree improvement genetics and silviculture ✓ Organize extension events and create extension products ✓ Coordinate and facilitate research with partners and other groups ✓ Hold regular meetings of steering committee and all partners 	<ul style="list-style-type: none"> ✓ Improved seeds and seedlings ✓ Seed zone maps ✓ Nursery and silvicultural guidelines ✓ Website, newsletter, brochures, reports, presentations and publications ✓ Coordinated research, extension, and management
SHORT-TERM OUTCOMES (knowledge, skills, attitudes)	MEDIUM-TERM OUTCOMES (behaviors)	LONG-TERM OUTCOMES (effects on resource)
<ul style="list-style-type: none"> ✓ Greater recognition of the importance of genetic selection for desired traits ✓ Greater understanding of koa genetics and heritability (abiotic and biotic stress tolerance, form, wood quality) ✓ Better knowledge of the best practices for nursery production and silviculture 	<ul style="list-style-type: none"> ✓ Greater demand for and use of improved varieties ✓ More widespread application of best management practices for nurseries and silviculture 	<ul style="list-style-type: none"> ✓ Increased land area planted with improved trees ✓ More land area managed using scientific techniques ✓ Sustainable production and increased values of forest products ✓ Enhanced cultural connections ✓ More trees produced of improved varieties ✓ Greater survival, growth, wood quality, form and value of planted trees

D**Strategic Direction 5****CAPACITY BUILDING OBJECTIVES**

To meet the challenges associated with tropical hardwoods, it is vital that Tropical HTIRC build its overall research, education, and extension capabilities to address current and longer-term problems. Capacity building is specifically needed in the areas of: (1) research, development, and extension programs, (2) facilities, (3) staffing, and (4) funding. The following objectives and associated actions were prioritized by Tropical HTIRC leadership based on: input from stakeholders; current and anticipated

capabilities and strengths of the staff and regional professionals; priorities of collaborators; and current and anticipated funding.

The needs and priorities established in the Plan will be addressed by hiring, soliciting, and supporting the best scientists and research programs in the tropical hardwood region. The principal investigators will in turn be successful in generating the financial support necessary to implement the Plan.

1. PROGRAMS

- » Develop research and extension programs that provide knowledge for the management and maintenance of sustainable, genetically diverse native forests and highly productive domesticated trees for plantation hardwood crops that contribute a wide array of products.
- » For *Acacia koa*: develop molecular markers, tissue culture technologies, advanced seed orchards, seed handling technologies, breeding orchards, and experimental nurseries for production of elite families and cultivars, identification of superior seed trees, and assessment of genetic quality and diversity in natural stands.
- » Take leadership in documentation of tropical hardwood research discoveries and dispersal of knowledge by hosting scientific conferences, symposia, workshops and field days, and publish manuals, proceedings, and online resources that convey this knowledge to a wide array of end users.
- » Provide for annual evaluation and other periodic review of Tropical HTIRC programs to ensure that the mission and vision remain focused and relevant to stakeholders. Recruit and maintain a Tropical HTIRC advisory committee with members that represent the diversity of landowners managing forests in Hawai'i.

2. FACILITIES

- » Maintain the acquisition of space for research scientists, extension personnel, and staff to house the Tropical HTIRC in the UHM-CTAHR Komohana Research and Extension Center, and USFS IPIF in Hilo, HI.
- » Assess need for acquiring properties and new partners for the future expansion of seed and breeding orchards and progeny tests.
- » Continue to work with forest industry and conservation partners to establish nursery experiments, field trials, progeny tests, and demonstration plots for hardwood genetics and silviculture research.

3. STAFFING

- » At least annually, assess staffing needs to ensure that current staff has appropriate support so that they can be productive and meet the expectations for their level of research outputs.
- » When positions are vacant, pursue national recruitment for the highest qualified staff and do not fill positions unless the candidates meet the highest standards of excellence that are expected of staff at Tropical HTIRC.
- » Evaluate the scientific disciplinary needs of Tropical HTIRC and based on that analysis, prepare a long-range staffing plan that will identify deficiencies and provide for their rectification.
- » Regularly evaluate membership of the Tropical HTIRC advisory committee to ensure that important partners and interest groups are represented.

4. FUNDING

- » Continue to maintain and expand the partnership with Akaka Foundation for Tropical Forests as a separate fundraising arm and collaborate to identify individuals and groups for solicitation of donations.
- » Identify applied research topics and develop proposals that would be appropriate for submission to leading science funding entities such as NSF, USDA AFRI, NRCS CIG, and USFWS.
- » Identify basic research topics and develop proposals with research partners that would be competitive for NSF, NASA, DOE, APHIS and USDA competitive grants.



ORGANIZATION DESCRIPTION AND CHARACTERIZATION

The Tropical Hardwood Tree Improvement and Regeneration Center (Tropical HTIRC) is a collaborative research, development, and extension center for tropical hardwood stewardship. The partnership includes the USDA Forest Service Northern and Pacific Southwest Research Stations, Region 5 and 6 State and Private Forestry, USDA Natural Resource Conservation Service, University of Hawai'i at Mānoa College of Tropical Agriculture and Human Resources (UHM-CTAHR), University of Hawai'i-Hilo College of Agriculture, Forestry and Natural Resource Management (UHH-CAFNRM), Purdue University Department of Forestry and Natural Resources, State of Hawai'i Department of Land and Natural Resources, Department of Hawaiian Home Lands (DHHL), Kamehameha Schools, The Nature Conservancy, Hawai'i Agricultural Research Center (HARC), Forest Solutions Inc., Hawai'i Forest Industry Association (HFIA), Akaka Foundation for Tropical Forests, Paniolo Tonewoods, Haleakala Ranch Company, Maui Native Nursery, Hāloa 'Āina, and Kealahakua Mountain Reserve. In addition, through its affiliation with HTIRC based at Purdue University, it is a member in the National Science Foundation Industry/University Cooperative Research Center (NSF I/UCRC) program titled "Center for Advanced Forestry Systems", a cooperative program among nine universities and industry members. The Tropical HTIRC is unique

and differs from and expands upon the existing HTIRC on the mainland in several key aspects: (1) it has an international focus on tropical (vs. temperate) hardwoods, (2) it is a true partnership of federal, state, university, industry and landowner groups who contribute financial support and leadership, and (3) it generates basic knowledge and technologies for the genetic improvement, utilization, conservation, restoration, and regeneration of tropical hardwood tree species to support tree nurseries, forest industry, public land management agencies, and private and public landowners.



Grafted koa in the laboratory at the University of Hawai'i Komohana Research and Extension Center.



'Ōhi'a disease resistance screening trial at University of Hawai'i Komohana Research and Extension Center. Photo credit: J.B. Friday.

Tropical HTIRC is a virtual Center located at Institute of Pacific Island Forestry (IPIF), University of Hawai'i, and Purdue University (HTIRC). The broad range of collaborators each bring unique experiences and perspectives to the partnership: (1) HTIRC is a national USDA Forest Service Center with expertise in temperate hardwood tree improvement, *Acacia koa* nursery production and plantation establishment, hardwood seed technologies, and integrated government, industry, and university research collaboration, (2) IPIF is a highly respected ecological research and development center with a depth of experience in *Acacia koa* forest management and Hawai'i forest

ecology; (3) UHM-CTAHR has a long-standing *Acacia koa* classical tree improvement effort, research experience in developing new knowledge for plantation establishment, and a well-established extension program for communicating results to landowners and managers; (4) HARC is a leader in disease resistance breeding for *Acacia koa*; (5) DOFAW, DHHL, and other partners are actively restoring Hawai'i forest habitats and (6) HFIA represents numerous entities involved in *Acacia koa* investment, restoration, and utilization.

TROPICAL HTIRC BENEFITS ITS PARTNERS BY:

- » Facilitating exchange of research ideas and results; coordinating research, development, and management activities. The Tropical HTIRC advisory committee, which is comprised of members from each of the partner organizations, communicates regularly and meets annually. This enables partners to develop a collaborative approach in accomplishing needs (e.g., seed orchard maintenance, seed collection) by sharing of staff members, equipment, or lab space, providing access to field sites for projects, coordination of proposal submissions and joint proposal development, and preparation of scientific or extension publications.
- » Providing opportunities for effective dissemination of research results to scientists, managers, and landowners. Tropical HTIRC maintains a website (www.trophtirc.org) with updated information on current research projects and key findings among partners and coordinates a regular research symposium on *Acacia koa*. In addition, through its facilitation with UHM-CTAHR Extension, Tropical HTIRC provides opportunities for extension workshops, field days, and landowner training.
- » Contributing expertise not currently available in Hawai'i through its affiliation with the national center, HTIRC. The HTIRC is a leading research center in temperate hardwoods and provides knowledge in genomics, plant physiology, and propagation that are needed to collaboratively address research priorities in *Acacia koa* and other Hawai'i species.
- » Affording a mechanism through the Tropical HTIRC advisory committee to shape research priorities. By building consensus on specific directions, the advisory committee provides an opportunity for collaborative decision making.



By facilitating communication, sharing and dissemination of knowledge, and combining resources as appropriate, Tropical HTIRC provides a mechanism for partner organizations to collectively achieve more than would be possible individually.



RELATIONSHIP WITH OTHER ORGANIZATIONS

Productive working relationships with scientists from a variety of institutions are necessary for the success of the Tropical HTIRC. To this end, the Tropical HTIRC is vertically integrated with molecular biology and classical geneticists, tree physiologists, silviculturists, entomologists, pathologists, ecologists, and nursery and regeneration specialists from its partners with the USDA Forest Service (NRS, PSW, Region 5 and Region 6), University of Hawai'i, HARC, and Purdue University. Its strength is its ability to perform and communicate the

results of basic, applied, and developmental research so the foundational knowledge that is created will be delivered to industry and private landowners in value-added products. Tropical HTIRC will be one of many institutions performing tropical hardwood research desired by the hardwood industry, nursery operators, government agencies, forest landowners and managers, and the general public. Thus, partnerships with other tropical forestry research institutions in the US and internationally will be developed.

COOPERATORS





ADMINISTRATION AND FUNDING

The Tropical HTIRC Director has responsibility to integrate policy, planning, research, development, extension, education, and management of the Program to ensure an orderly implementation of the Strategic Plan. The Tropical HTIRC Director interacts with USDA Forest Service administrators, the Tropical HTIRC Coordinating and advisory committees, and local, state, regional, and national organizations in planning and implementing activities.

Annual federal funding appropriations and in-kind support are expected from the USDA Forest Service Northern and Pacific Southwest Research Stations. Funding is also provided from Purdue University and the University of Hawai'i for personnel, research, and extension efforts. Because the goals of the Tropical HTIRC require additional support than what can be expected from appropriated funds, program administration will seek to form strategic partnerships with other federal and state agencies and universities and to obtain funding from agencies and associations whose missions support tropical hardwood tree genetics.

Scientists and collaborators within the Tropical HTIRC will apply for federal grants including NSF, NASA, APHIS, DOE, and USDA. In addition, where industry research funds are available, grants and annual funding allocations will be sought from landowner groups, forest industry, and other hardwood

associations. Finally, funding from the private sector, including individual private citizens, and foundations will form an important part of our funding strategy, as has occurred with the Purdue-based HTIRC. These opportunities will be pursued continually as they arise, particularly through the association of Tropical HTIRC with the Akaka Foundation for Tropical Forests.





Mahalo to our photography
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Tropical Hardwood Tree Improvement
& Regeneration Center