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tropical

The Bulletin of the National Tropical Botanical Garden



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ON THE COVER

Talia Schmidt, Breadfruit Institute horticultural technician, holds a just-harvested fruit in the Regenerative Organic Breadfruit Agroforest on Kaua'i. Read about how the institute is collaborating with partners across the Pacific on page 14. Photo by Matthew Parent.

Tropical: The Bulletin of the National Tropical Botanical Garden is a publication for supporters of the National Tropical Botanical Garden, a not-for-profit institution dedicated to tropical plant conservation, scientific research, and education.

We encourage you to share this publication with your family and friends. If your household is receiving more than one copy and you wish to receive only one, please inform our Development Office at our national headquarters at: members@ntbg.org.

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National Tropical Botanical Garden

Allerton Garden | Kahanu Garden & Preserve | Limahuli Garden & Preserve | McBryde Garden | The Kampong

We work across five botanical gardens and throughout the tropics to grow a brighter tomorrow for plants and all they sustain. We do so through a biocultural approach, where Indigenous knowledge, community priorities, and scientific research guide our path forward. Together, we will restore flourishing relationships between plants, people, and places.

National Tropical Botanical Garden is chartered by Congress as a not-for-profit, non-governmental institution.







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Message from the President and CEO



Just as we were preparing to go to press, on September 7, Hurricane Lowell passed 60 miles west of Kaua'i which is home to NTBG's McBryde Garden, Allerton Garden, and Limahuli Garden and Preserve, as well as our national headquarters. The category 2 tropical cyclone brought wind gusts up to 92 mph, relentless coastal inundation, and torrential rainfall and flooding, causing widespread damage to our community and the Garden.

Lowell struck just four days before the 34th anniversary of Hurricane 'Iniki which devastated Kaua'i in 1992. These storms, like so many others, including spring storms on Maui, are vivid reminders of the power of nature, the fragility and value of life, and the need to cherish and care for our environment and each other.

Even as we continue to assess damage to the Garden, I am thankful that all of our NTBG 'ohana (family) is safe. I am deeply moved by their commitment to the Garden and their eagerness to jump in and help as we begin another long recovery. I am equally grateful for you — our members and supporters — for sticking with us in good times and hard times. Your unwavering commitment and belief in our mission, allow us to keep our staff employed and continue our vital work.

On a more positive note, we hope you will notice our members' magazine has a new look and a new name. We are pleased to reintroduce this publication in a way that reflects our core identity: *Tropical*.

Volume 1, Number 1 of *The Bulletin of the Pacific Tropical Botanical Garden* was published in 1971. For over five decades The Bulletin has documented the Garden's accomplishments and aspirations. But with many organizations publishing their own "Bulletin," we decided it was time to announce who we are front and center. With four gardens in Hawai'i and one in Florida, it was clear that "tropical" was a timeless and unifying quality. No matter how much we evolve and grow, no matter what challenges we face, NTBG will always be *Tropical*.

As you read this issue of *Tropical: The Bulletin of the National Tropical Botanical Garden*, we hope you will be as inspired as I am by stories of new growth, collaboration, and rediscovery, and by the dedication of longtime employees and the new members of our staff who bring fresh energy and talent to the Garden.

As steadfast members of our NTBG 'ohana, you make all of this possible. Your ongoing support and engagement, and the enthusiasm for our work which we share, are deeply valued and welcome, especially on the hardest days, infusing us with strength and renewing our sense of purpose.

Mahalo nui loa,

Janet Mayfield
President and CEO

garden impacts

For more than six decades, NTBG has been a leader in plant science, conservation, and education. Through our extensive living collections, exploration, discovery, and research, NTBG works tirelessly to preserve and protect tropical plants. You play a vital role in our impact.

NTBG's ongoing botanical research, conservation, and education programs are benefiting people around the world from students and educators to farmers, scientists, artists, and plant enthusiasts of every stripe. We are working to conserve the rarest of rare species even as we celebrate commonly grown plants, raising awareness and appreciation of plants among visitors from afar to members of our local communities.

Our mission is rooted in the biocultural conservation that recognizes the vital ties that bind people and plants to the places where they thrive. Our work is both urgent and inspiring and the impact we are having is made possible thanks to your support. Let's continue to flourish forward together.

You can explore more of your impact in our 2025-2026 Impact Report: ntbg.org/impact


MATTHEW PARENT

OVER 1.4 MILLION SEEDS
added to our conservation seed bank

MORE THAN 4,300 LBS
of produce harvested from the Regenerative Organic Breadfruit Agroforest and donated to food banks and staff

OVER 1,300 STUDENTS from pre-K through 12th grade welcomed into McBryde Garden through the 'Ike Māla summer program

SIX ENDANGERED FERN SPECIES
propagated in our Fern Lab, representing thousands of individual gametophytes

THREE NEW PLANT SPECIES
described, including *Peperomia kauaiana*, *Geniostoma imadae*, and *Lysimachia barcae*


MATTHEW PARENT


ERICA TANIGUCHI

"Over the past year, Limahuli's horticultural team strengthened our role in biocultural conservation by expanding native Hawaiian plant collections, refining propagation techniques, and improving planting protocols."

– Randi Umetsu, Senior Horticulture Specialist

Allerton Garden is named for Robert and John Gregg Allerton who built their garden and a life together on Kaua'i. Robert, the elder Allerton, was a founding Trustee and was instrumental in establishing the congressionally chartered organization that is today NTBG. The story of how Robert, a philanthropist and heir of the First National Bank of Chicago, and architecture student John Gregg, met and built their garden can be found on NTBG's website. Their legacy, as a couple dedicated to each other and as designers committed to preserving plant life, is a story worth celebrating.

Kahanu Garden and Preserve strengthened our 'awa (kava) collection through a comprehensive replanting effort, establishing two duplicate sets of 14 recognized Hawaiian varieties. Beyond the plants growing at Kahanu Garden, we propagated additional sets with community collaborators Mahele Farm and Ala Kukui cultural retreat. At a time when local stewards and agriculturalists crave verified varieties for ceremonial and commercial use, East Maui now holds four duplicate sets of this Hawaiian 'awa collection. By sharing these plants, we hope to encourage a renaissance of 'awa use and cultural reintegration across Hawai'i.

Limahuli Garden and Preserve, recognized as a prime example of biocultural conservation, is bisected by the Limahuli Stream. In the adjacent riparian area we have launched an intensive, three-year restoration project along a vital tributary of the stream. By clearing aggressive invasive plants and establishing resilient native species like māmaki and neke fern, our team is successfully stabilizing the watershed and breathing new life into this critical freshwater habitat. This effort not only accelerates the recovery of rare biodiversity but ensures a healthier, flowing ecosystem that supports plants and animals that are central to Hawaiian culture.

McBryde Garden is home to the world's largest and most diverse collection of loulu (*Pritchardia*), Hawai'i's only native palms, with nearly all species represented, numbering more than 700 trees. This living collection is a vital seed bank, research library, and source of material for outplanting and institutional sharing, including more than 600 seeds sent to partner institutions last year. When the destructive coconut rhinoceros beetle arrived in the Lāwa'i Valley in early 2024, our staff quickly mobilized to deploy detection traps, protective netting, conservation dogs, and drone-applied treatments in order to protect this irreplaceable collection.

The Kampong is recognized as a tropical botanical oasis in Miami's Coconut Grove neighborhood. Increasingly, The Kampong is also home to art exhibitions that are sparking thought and discussions about plant conservation and the environment. These exhibitions have included *Revenant Florida*: Landscapes as Living Memory; *Blue in our Veins*: a poetic journey between past and present guided by the hues of sky and sea; and *Rootwork*: a solo exhibition featuring Naomi Fisher and her 25-year practice of botanically inspired art-making and community organizing. The fusion of nature and art continues at The Kampong.

READ MORE ABOUT OUR IMPACT

https://ntbg.org/impact

Notes from the Field:

On geological time, evolution, and the rediscovery of *Cyanea kolekoleensis*

BY KENNETH R. WOOD, RESEARCH BIOLOGIST

The origins of the Hawaiian flora and fauna is an 80-million-year-old tale, an odyssey written through evolutionary history as each consecutive volcano formed and rose from the hot spot where the Big Island of Hawai'i is active today. It is an unfathomable tale, one of the greatest, where each island formed and reached its ultimate size, slowly eroded, and subsided while drifting to the northwest on the Pacific Plate a few inches each year.

Meanwhile, during this great expanse of space and time, while isolated smack in the middle of the northern Pacific Ocean, these massive volcanoes were slowly colonized by a fantastic diversification of plants and animals crossing great ocean barriers from far distant continents. Seeds of plants and little hitch-hiking pūpū (snails) mostly arrived with manu (birds), while fern spores, nananana (spiders) and other small insects arrived via stratospheric winds and storms.

Over time the plants and animals continued to disperse, colonize, and speciate into many more fabulous life forms, hopping from older to newer islands, and becoming further isolated into highly eroded and unique habitats in a magic cauldron of island evolution and biogeography.

Today Kaua'i is around 5 million years old and stands 5,243 ft. above the sea, but I often wonder about the majesty of a younger Kaua'i, several million years ago when she towered more than 8,500 ft. in elevation. During that period Kaua'i would not only have had the dry, mesic, and wet forest habitats that exist today, but was also home to alpine conditions that are inherently dryer after breaching into higher elevations above the cloud inversion layer.

In the distant past, there may have existed an even more diverse suite of bizarre insects, plants, and mysterious creatures evolving in isolation. One can now only imagine the long-lost ancestors of ʻāhinahina (Hawaiian silverswords), ʻōhā wai and hāhā (lobeliads), and other families of plants scattered across the vast landscape, back in the times when sublime flightless Hawaiian moa nalo (ducks), and nā manu nahele (forest birds) lived peacefully and in balance, without all the threats and invaders that drive extinction today. Past is the cacophony of their twilight songs, and now, like the old nursery rhyme, all the king's horses and all the king's men may never put what has broken, back together again.

COEVOLUTION AND DIVERSITY

Here and now, the biological conditions of oceanic islands are changing quickly, and yes, we are losing species to habitat loss, invasive non-native species, and loss of pollinators and seed dispersers. Although we can only guess about the floristic diversity of the Hawaiian chain during the pre-human contact period, we do know that the documented Hawaiian flora currently contains around 1,386 native flowering plant and fern taxa, with around 130 of those species considered extinct.

Many of us are also burdened to know that there were at least 84 endemic Hawaiian forest bird species, yet today around 58 (70%) of those magnificent creatures are gone forever. As we witness the decline of Hawaiian forest birds, particularly the honeycreepers, we also witness a decline in their co-evolutionary services as native plant pollinators and seed dispersers. One predominantly bird-pollinated plant lineage, the Hawaiian lobeliads (Campanulaceae family), has been particularly affected by the ongoing extinction of Hawaiian birds. This plant lineage is considered one of the oldest and most diverse in the Hawaiian archipelago, having numerous endemic genera (*Brighamia, Clermontia, Cyanea, Delissea,* and *Trematolobelia*) that include around 143 species.

Many of the Hawaiian lobeliads have had an intimate and ancient relationship with the Hawaiian honeycreepers, so much so that the down-curved bills of these birds co-evolved to fit perfectly inside their arched tubular flowers. This divine mutualism is like nature's *quid pro quo* (something for something) whereby the flowers present sweet nectar which the honeycreepers search for and drink from by inserting their long arcuate



CYANEA KOLEKOLEENSIS RECENTLY LOCATED USING DRONE TECHNOLOGY. PHOTO BY BEN NYBERG (PG. 6-7). PENDENT INFLORESCENCE OF *CYANEA KOLEKOLEENSIS* CULTIVATED AT THE HAWAI'I STATE DIVISION OF FORESTRY AND WILDLIFE MID-ELEVATION NURSERY, KŌKE'E, KAUA'I. PHOTO BY KEN WOOD (PG. 9)



CYANEA KOLEKOLEENSIS HABITAT AROUND RUGGED WINDWARD HEADWATER DRAINAGES AND SLOPES OF KAUA'I. PHOTO BY KEN WOOD

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(curved) bills and bizarre tube-like tongues. In so doing, their feathered heads are dusted with pollen as they nod against the flowers protruding pollen-filled anther sacs, thereby pollinating each flower during visitations. Furthermore, when the fruit ripen, nā manu nahele return to eat the berries and spread the seed progeny across adjacent forests.

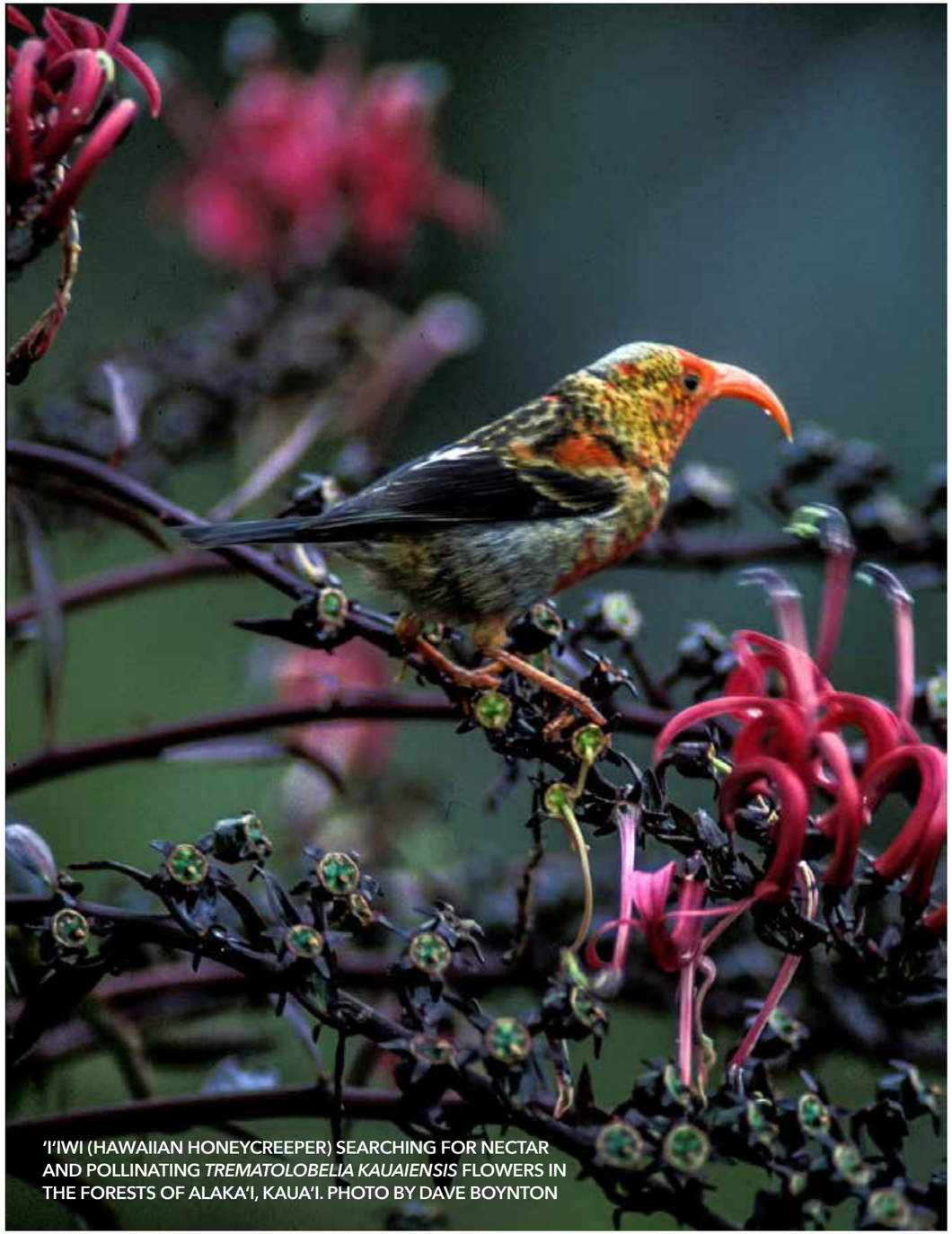
Research botanists now estimate that 42 Hawaiian lobeliad species have possibly gone extinct, with no wild individuals known and the loss of Hawaiian forest bird pollinators and seed dispersers being one of the major causes. Yet grim as that number sounds, presumed Hawaiian extinctions in the lobeliad lineage was even greater when the Manual of the Flowering Plants of Hawai'i was first published in 1990. Since then, forest research by NTBG, the Plant Extinction Prevention Program (PEPP), and the State of Hawai'i's Division of Forestry and Wildlife (DOFAW) have rediscovered ten previously presumed extinct Hawaiian lobeliads and have followed up with decades of conservation monitoring and seed collections.

LOST AND FOUND

In the spirit of hope and renewal, I'd like to share the story of one of those recently re-discovered lobeliad species, hāhā (*Cyanea kolekoleensis*) which was originally discovered by longtime NTBG botanist Steve Perlman in 1979. Steve spent much of his life in the wao akua (sacred forest uplands) of Kaua'i, and, for that matter, throughout the Pacific, becoming intimately familiar with the many unique life forms that dwelled therein.

During his far-reaching explorations, Steve took the time to document with herbarium vouchers the unusual plant species he encountered, and as such, he discovered and made the original holotype[1] voucher of *C. kolekoleensis*. Suffice it to say that it was of exquisite design, with an eight-flowered pendent inflorescence, long white-purple corollas and large dark purple anther tubes. After its discovery it was botanically described by Steve's mentor and friend, the great 20th century botanist Harold St. John who worked out of Bishop Museum on O'ahu. Although the small colony was closely monitored for many years,

[1] The primary specimen that serves as the best source material of what makes a species distinct from others.



'I'IWI (HAWAIIAN HONEYCREEPER) SEARCHING FOR NECTAR AND POLLINATING *TREMATOLOBELIA KAUAIENSIS* FLOWERS IN THE FORESTS OF ALAKA'I, KAUA'I. PHOTO BY DAVE BOYNTON

horticulturalists were unable to establish successful long-term cultivation of *C. kolekoleensis* and the only known wild individuals died after last being observed in 1998.

And so it goes, the pendulum swings, and populations of plants naturally fluctuate up and down, but when plants are rare there is little room to climb back up if the downward swings to zero. Here in this story a spark of hope rises like a phoenix and exemplifies our thesis that information concerning endangered organisms opens a direct pathway to their preservation. Now, after not being documented for over a quarter of a century, *Cyanea kolekoleensis* was recently rediscovered by PEPP botanists Scott Heintzman and Susan Deans in partnership with NTBG, in a remote wao akua headwater along windward Kaua'i.

This re-discovery opened the opportunity to return several times to monitor, cross-pollinate flowers, and bag developing fruit to protect against rat predation. Ultimately, many thousands of seeds have been collected for short and long-term storage, and healthy plants are being cultivated at DOFAW's mid-elevation nursery in Kōke'e, Kaua'i.

Remarkably, not long after the initial re-discovery, NTBG research associate Dr. Ben Nyberg joined us on one of our research forays and found yet another small colony of *C. kolekoleensis* utilizing drone technology. While flying his exploratory drone, Ben captured close-up, high-resolution images of this new colony along with geographic coordinates. Subsequently, we returned to the new colony in July 2026 whereby NTBG and PEPP teamed-up to monitor the new location.

This example of partnership included Ben taking to the air and using his drone to guide Scott, who successfully navigated on foot through the steep slopes and drainage to access the new individuals of *C. kolekoleensis*. We now have a safe helicopter landing zone and overland route to the new second colony for future monitoring and seed collections. This successful rediscovery underscores the need to increase support and funding for such conservation efforts.

The story of *Cyanea kolekoleensis's* rediscovery, along with these photo images, puts a well-needed face on this endangered evolutionary lineage and its biologically rich habitat. The plants need these forests, and the forests need our immediate focus and protection. The loss of endemic island plants and animals, after all, is also a loss to the Hawaiian culture itself. Fortunately, there is a whole new generation of highly trained conservation biologists and horticulturalists poised to continue this work. What more will be rediscovered and what can be saved remains to be seen and depends on future conservation support.



PLANT EXTINCTION PREVENTION PROGRAM BOTANIST SCOTT HEINTZMAN POLLINATING FLOWERS AND BAGGING POTENTIAL FRUIT OF *CYANEA KOLEKOLEENSIS* AT THE SITE OF RE-DISCOVERY. PHOTO BY KEN WOOD

READ AND SHARE ONLINE

Rooted in Community:

Breadfruit Conservation Brings the Pacific Together

BY NOEL DICKINSON, BREADFRUIT INSTITUTE PROGRAM MANAGER AND DR. TIFFANY KNIGHT, DIRECTOR OF SCIENCE AND CONSERVATION

When 26 farmers, researchers, and conservation professionals from nine Pacific Island countries[1] gathered for a breadfruit workshop on Fiji's lush Taveuni island in April, they shared a common purpose: strengthening the conservation of breadfruit diversity through collaboration, practical documentation, and knowledge exchange.

Nestled among the bountiful agroforests stretching from the slopes of Mount Uluigalau to the coast, the Tutu Rural Training Centre demonstrates the spirit of Fiji's "Garden Island." Its breadfruit collection, nursery, farmer training programs, and food processing facilities provided an ideal setting to experience breadfruit biocultural conservation in practice.

While on Taveuni, the group enjoyed the warm hospitality of the center's staff in classrooms, agroforests, and nurseries. Group meals reflected a distinctly Pacific approach to knowledge exchange. Staff generously shared their experience establishing a breadfruit living collection, propagating

[1] Papua New Guinea, Solomon Islands, Fiji, New Caledonia, Tonga, Cook Islands, Marshall Islands, Kiribati, Hawai'i (USA)

ROOTED IN COMMUNITY

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NOEL DICKINSON WITH PARTICIPANTS AT AN INTERNATIONAL BREADFRUIT WORKSHOP ON FIJI'S TAVEUNI ISLAND. PHOTO BY MEREWALESI ROKOSAWA





ABOVE: THE AUTHORS WITH PIFON'S MEREWALESI ROKOSAWA (CENTER). PHOTO BY NOEL DICKINSON. BELOW: FROM LEFT: PIFON'S KYLE STICE, HON. TAKAIBURE RABAUA AND KINAAI KAIRO FROM KIRIBATI'S MINISTER FOR ENVIRONMENT, LANDS AND AGRICULTURAL DEVELOPMENT, WITH NBTG'S NOEL DICKINSON IN MCBRYDE GARDEN. PHOTO BY JON LETMAN

traditional varieties, and training farmers. They showcased innovative breadfruit products, demonstrating how conservation and community can strengthen one another.

Facilitated by NTBG's Breadfruit Institute in partnership with the Pacific Islands Farmer Organisations Network (PIFON), the workshop centered on the developing methods to document traditional knowledge, drawing on the collective decades of experience represented across the group in conserving, cultivating, and stewarding breadfruit diversity. Although organized by the Breadfruit Institute and PIFON, the workshop was designed as a collaborative exchange in which every participant contributed knowledge, experience, and perspectives from their own communities.

For more than three decades, NTBG has curated one of the world's most comprehensive breadfruit collections. As interest in breadfruit's potential to contribute to food security, climate resilience, and cultural perpetuation has grown, institutions and farming communities across the Pacific are establishing living collections of their own. The Breadfruit Institute strengthens regional capacity and support efforts to document what is conserved, identifies gaps, and coordinates priorities for safeguarding diversity.

Collaborating closely with PIFON, Breadfruit Institute program manager Noel Dickinson and Science and Conservation director Dr. Tiffany Knight co-designed the Taveuni workshop program, drawing on NTBG's experience. The practical methods shared during the workshop built upon the institute's long-standing work, including the development of internationally recognized breadfruit descriptors by founder Dr. Diane Ragone and photographer Jim Wiseman. Rooted in that legacy, the group refined approaches that could be applied by researchers and community practitioners while respecting local knowledge systems and governance.



TUTU RURAL TRAINING CENTER ON TAVEUNI ISLAND, FIJI. PHOTO BY NOEL DICKINSON

Over three days, participants moved between the classroom and the field, working together to document breadfruit varieties through standardized photography, mapping, and data collection. The group also practiced conducting ethical and respectful interviews with knowledge holders and explored ways to record the biological and cultural diversity associated with each variety. Rather than introducing entirely new concepts, the workshop created opportunities for participants to compare approaches, align methods, and discuss how record-keeping can better support breadfruit conservation.

At the heart of the workshop was the concept of biocultural conservation — the recognition that the diversity of breadfruit cannot be separated from the people who have cultivated, named, shared, and cared for the trees over countless generations. Biocultural conservation is about more than collecting and saving trees but acknowledging and including Indigenous people's inextricable connections to the tree itself through cultivation, cooking practices, oral histories, and traditional variety names.

Despite differences in language, geography, and culture, participants discovered that they shared challenges and values that guide their stewardship of breadfruit. As conversations unfolded, they found common ground in traditions surrounding harvests, cooking, and community celebrations. Many also reflected that these traditions, and the passing of knowledge from elders to younger generations, are becoming increasingly rare, much like some breadfruit varieties themselves.

Tours of Tutu Rural Training Centre's breadfruit nursery, living collection and food development facilities illustrated how conservation, education, and processing can strengthen livelihoods. Participants explored propagation techniques, nursery management, and breadfruit processing — from flour and chips to a variety of baked goods — highlighting how conserving and utilizing traditional varieties can create new economic opportunities.

The workshop was not about teaching communities how to conserve breadfruit — it was about recognizing the important work already taking place and creating a

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TUTU RURAL TRAINING CENTRE STAFF AND WORKSHOP PARTICIPANTS GATHER FOR WELCOMING FESTIVITIES, INTRODUCTIONS, SONGS, AND A TRADITIONAL KAVA CEREMONY. PHOTO BY MEREWALESI ROKOSAWA



PHOTO BY MEREWALESI ROKOSAWA



PHOTO BY NOEL DICKINSON

"I never felt like it was my place to use these scientific methods… now I know I can." – Waisea Turaga

space where participants could learn from one another. Through the workshop's WhatsApp group, participants will continue to ask and answer questions, share observations, and support and celebrate their successes.

Expanding on the Breadfruit Institute's system of record keeping, discussions focused on how shared characterization methods could strengthen the understanding of breadfruit while respecting cultural practices and governance across Oceania.

Participants emphasized that any regional framework must be guided by the principles of Free, Prior and Informed Consent, ensuring that traditional knowledge remains under the ownership and direction of the Indigenous peoples.

Discussions also highlighted challenges facing breadfruit conservation efforts such as limited capacity and funding, transportation issues, and the need for greater government recognition. Still, the mood of the workshop was positive and focused on the resilience shared by people throughout the Pacific.

"This workshop showed what is possible when farmers, researchers, and institutions come together as partners," said Kyle Stice, PIFON's executive director. "Every participant brought valuable experience and knowledge from their own country. By connecting knowledge holders through shared methods and ongoing collaboration, we're building something that is much stronger than any one organization could achieve alone."

Identifying future collaborations, the group was eager to continue exchanging ideas and strengthening this budding regional network. The conversations continued at the Global Breadfruit Summit on Hawai'i Island in September.

One of the workshop's most meaningful outcomes emerged during the closing reflections. "I've been doing this work already, but I never felt like it was my place to use these scientific methods," said Waisea Turaga, breadfruit project officer at the Tutu Rural Training Centre, "Now, I know I can."

His reflection resonated with others who recognized that they too had been carrying out this work for years, but rarely had the opportunity to compare methods, share experiences, and engage with their peers.

For the Breadfruit Institute, the workshop represents an evolving vision for collaborative conservation where botanical gardens, research institutions, farmer organizations, and Indigenous communities will steward this vital crop. The workshop also reflected the legacy of Dr. Diane Ragone, whose decades of global breadfruit exploration, collection, conservation, research, and advocacy helped establish the Breadfruit Institute as an international center for biocultural conservation.

Breadfruit is more than a staple crop – it is part of the shared heritage of Pacific peoples, carried across the ocean by voyagers and woven into the origins, identities, and food systems of the communities of Oceania. For one week in Taveuni, it was a catalyst to renew and strengthen those connections and the shared commitment to conserve the extraordinary biocultural diversity of breadfruit for generations to come.

READ AND SHARE ONLINE

plant people

EXPLORING PEOPLE'S RELATIONSHIPS WITH PLANTS


DUSTIN WOLKIS

MAKOA ELGIN

Growing up beneath the slate grey skies cast over Puget Sound, as a kid in Seattle Makoa Elgin loved conifers, cedar, and sage. He enjoyed picking blackberries and blueberries and his first job was growing organic produce on an urban farm. From his father, he learned about his Muckleshoot heritage and grew to appreciate the ties between Coast Salish tribes and their tradition of weaving cedar bark into mats, hats, and baskets, and carving trees into canoes. Yet Makoa knew very little about his mother's Hawaiian cultural traditions and her extended family who still lived on O'ahu.

That changed when, encouraged by his parents, he enrolled at the University of Hawai'i. Makoa initially planned to study marine biology but after taking an oceanography class, he realized he was more comfortable with his feet on the ground and hands in the dirt. Makoa began studying botany and was soon immersed in the connections he found between Hawaiian plants and culture and Coast Salish traditions.

Today, Makoa works at Lyon Arboretum at the University of Hawai'i at Mānoa. He spoke with Tropical about his relationship with plants.

When you earned a masters degree in botany what was your focus?

My masters project was focused on the loulu (*Pritchardia* palm)'s floral biology and conducting hand pollination experiments with three loulu species. Throughout my studies, I was deepening my relationship with loulu as well as with my Native Hawaiian roots. In doing so, I established a connection with a plant my ancestors lived deeply, intimately with. Doing that research into cultural uses and their ecological roles was very enriching.

There are approximately 24 species of *Pritchardia* that are endemic to the Hawaiian Islands and over half of them are considered endangered. They're also the only genus of palm tree that is native to Hawai'i. There are many reasons why these palms are so important to learn about. One reason is that loulu's floral biology is not well-documented. I felt like learning about their flowers and ability to hybridize would be a valuable contribution to science and local communities.

How did you first connect with NTBG?

My advisor professor Don Drake connected me with NTBG staff. Dustin Wolkis and Seana Walsh came to O'ahu to give a lecture in one of my seminars. I asked them if they would be on my committee and that was how I got connected with NTBG's beautiful loulu collection. It's one of the most amazing loulu groves I've ever seen.

What kind of work are you doing now?

I work in the horticulture department at Lyon Arboretum in the Mānoa Valley, we grow and care for a myriad of plants, mostly focused on Native Hawaiian plant conservation but we are also growing [Polynesian introduced] canoe plants and other tropical ornamentals. We also have a loulu collection we are maintaining and trying to prevent from being taken out by coconut rhinoceros beetles.


KEN WOOD

You mentioned that you're interested in traditional plant-based medicine, yes?

There are plant-based medicines that relate to Muckleshoot traditional medicine that involve healing drums and using sage as a smoke cleanse. In the Hawaiian culture 'awa (*Piper methysticum*) can be spiritual and physical. I've always been intrigued by the medicinal benefits of plants.

What drew you to making lei?

It's a great way to fuse botanical and cultural knowledge. When you make lei, you can give them to people for birthdays, graduations, and weddings. I like how you can keep a lei and let it dry to serve as a memory of an event of the love that somebody gave you. It's more than just a one-time thing. It's picking and having that intentional relationship with the plants. It's making sure that you're picking in a responsible manner – not over picking. There's so much that goes into lei making that shows respect for the plants, for yourself, and for the people around you. It's a process that brings me a lot of fulfillment and joy.

What are your favorite lei plants?

Tī leaf (*Cordyline terminalis*) is a classic because you can make a tī leaf lei with the Hilo-style twist and you can add different flowers or plant material after you make it. When you make lei poʻo (garland worn on the head), palapalai fern is beautiful and adds nice depth. Color-wise, I like blue jade flowers which are not native to Hawai'i but they're really beautiful.

Does the Muckleshoot culture use plants for clothing or ornamentation?

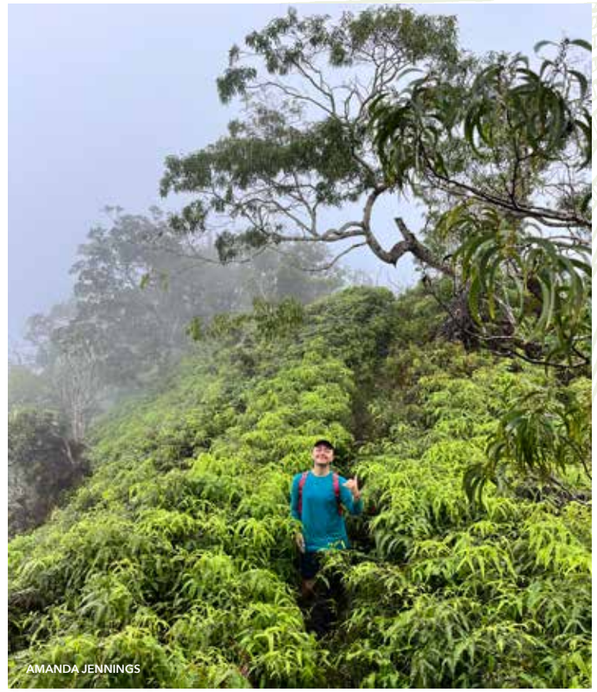
Cedar hats are made entirely out of plants, woven with bark from cedar trees. While it's not unique to Muckleshoot specifically, it's a tradition shared by tribes in the Coast Salish region. It's worth noting that the Muckleshoot tribe is the combination of two different tribes. That's important context.

You mentioned having a personal connection to Hawaiian plants. What is that connection?

My mom's name is Lehua. I always knew it meant a beautiful flower (of the 'ōhi'a) but I'd never seen one before. Then, when I moved to Hawai'i, I saw them everywhere. I learned about the crucial role they play in maintaining a healthy ecosystem. One of the first times I went to the rim of the Kalalau Valley on Kaua'i, I saw a forest full of 'ōhi'a lehua (*Metrosideros* sp.) and koa trees. My mom didn't grow up in Hawai'i so I don't think she knew that koa is a really valuable tree culturally, economically, and ecologically.

After I moved to Hawai'i, I found this out about two of the most important trees in our Hawaiian forest canopy. So my name and my mom's name both stem from these trees. I just think there's something beautiful about that.

This interview was edited for length and clarity.


AMANDA JENNINGS

garden notes

News from around the Garden


DIANE RAGONE


DIANE RAGONE

BREADFRUIT INSTITUTE FOUNDER DIANE RAGONE RETIRES

Concluding a 37-year career with NTBG, Dr. Diane Ragone retired in July. Born and raised in Virginia, Diane studied horticulture at the University of Hawai'i in the 1980s during which time her association with NTBG began. In 1985, while working towards a PhD in Horticulture (1991) from the University of Hawai'i, she received seed grant funding from NTBG, allowing her to begin breadfruit field research in Samoa, Tonga, the Cook Islands, and Tokelau.


JIM WISEMAN

This early field work led to a career focused on breadfruit exploration, conservation, ethnobotany, and research throughout the Pacific and beyond. Over nearly four decades, Diane traveled to Pacific islands and atolls in at least 50 countries and territories. On expeditions everywhere from Micronesia and the Marquesas to the Solomon Islands, Kiribati, Fiji and elsewhere, Diane spent countless hours visiting remote forests, conducting interviews, and documenting historically and culturally important biocultural knowledge. Diane's has collected more than 600 individual trees representing over 150 Pacific breadfruit and breadnut varieties, many of which are today rare or endangered.

Diane joined NTBG in 1989 as program director for the Hawai'i Plant Conservation Center before serving as manager of Kahanu Garden on Maui. During her tenure at NTBG, Diane has also served as NTBG's acting director, chair of the plant science department, director of science, horticulture, conservation, and other positions.

In 2003, Diane established the Breadfruit Institute, an NTBG program which continues to curate and preserve the world's largest and most diverse collection of *Artocarpus* sp. (breadfruit and breadnut) on Maui and Kaua'i.

The Breadfruit Institute has played a vital role in advancing the understanding, conservation, and use of breadfruit around the world. Under Diane's direction, NTBG has become a leader in breadfruit-related genetic research, nutritional, horticultural, and biocultural studies, while helping establish dozens of pilot programs, farmer and community collaborations, and local efforts to improve food security in the Pacific, Central America, the Caribbean, Africa, and Asia.

Today the Breadfruit Institute continues its vital work under NTBG science and conservation director Dr. Tiffany Knight and Noel Dickinson who coordinates programs and activities.

In retirement, Diane continues her affiliation with NTBG as a research associate as she works on a forthcoming comprehensive breadfruit book. The fruits of Diane's labor continue to thrive and grow in Hawai'i and around the world. Learn more about the Breadfruit Institute at: https://ntbg.org/breadfruit/.

KAHANU GARDEN RECOVERS FROM KONA LOW STORMS

In March, Hawai'i experienced back-to-back Kona low storms which caused extreme rainfall and flash flooding. East Maui and Kahanu Garden and Preserve were hit especially hard, with some parts of the island receiving 30 to 49 inches of rainfall. Winds surpassed 70 mph. Subsequent smaller storms and episodic bouts of wet, windy weather throughout the spring compounded damage to Kahanu Garden's living collections.

Five important breadfruit trees were toppled with roughly the same number of introduced (non-native) trees downed in the garden, as well as a modest number of Polynesian-introduced trees (kukui and hala) near Pi'ilanihale Heiau which was fortunately not damaged. Neighboring Mahele Farms lost six large, mature macadamia nut trees.

Post-storm assessments were followed by weeks of hard labor as staff cleared downed trees, shredded branches, and other debris. Access trails in the Kahanu Preserve's coastal hala (*Pandanus*) forest were ravaged but fortunately most garden infrastructure was not greatly affected. The nursery, however, sustained significant damage which will require new corrugated panels and other repairs. With contractors already busy in the wake of other storm damage and ongoing post-Lahaina wildfire recovery, it may be a while before all garden repairs can be made.


MIKE OPGENORTH

Recovery in the breadfruit collection began with raising felled trees when possible; collecting cuttings from exposed healthy roots for future propagation; and sending root collections to NTBG's Conservation and Horticulture Center on Kaua'i for back up duplication.

Over the summer, trails and roads were cleared and refinished, much of the damaged infrastructure has been repaired, and other tree maintenance has been ongoing. Breadfruit Institute staff continue to monitor trees for late-presenting storm impacts and initiate protocols for root collection from trees that have demonstrated resistance to storm stress.

Facing future destructive storms and a very active 2026 Pacific hurricane season, we continue to make backups of targeted collections, implement horticulture plans appropriate for future disruptions, and advocate for additional improvements to garden roads and stream crossings to ensure safer and more reliable access into and out of the garden, especially when rough weather hits.


DAVID BRYANT

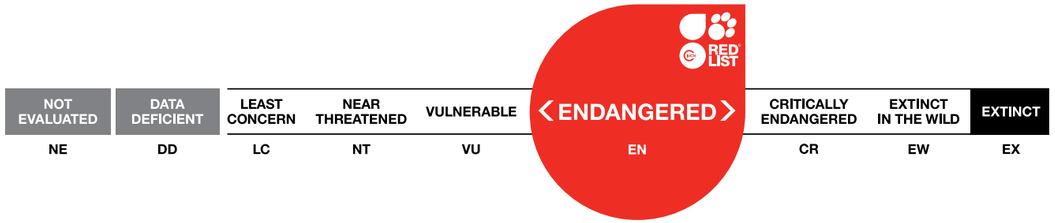
HURRICANE LOWELL RECOVERY UPDATES ONLINE

In the wake of Hurricane Lowell, NTBG's three Kaua'i gardens will require months of repairs. The Allerton house was inundated with sand and water, trees were downed, and roofing torn off. In the Limahuli Preserve, fencing and the weatherport shelter were badly damaged. Fortunately, previous efforts to harden infrastructure helped mitigate greater damage. Garden members, supporters, and volunteers play an instrumental role in our recovery. As these efforts continue, the most impactful way to help is to donate, which keeps staff – many who face their own personal and home recoveries – employed and advancing garden cleanup, repairs, and plant restoration efforts for a safe reopening. For the latest updates and to learn how you can support the recovery, visit: ntbg.org/lowell

red listed

The International Union for Conservation of Nature (IUCN) publishes the online resource, The IUCN Red List of Threatened Species, ranking taxa (species, subspecies, or varieties) in one of nine categories from 'Not Evaluated' to 'Extinct'. The Red List is an invaluable tool for not only scientists, educators and policy makers, but for anyone seeking a better understanding of the conservation status of plants, animals and fungi around the world.

In recent years, conservation agencies, institutions, and organizations including NTBG have increased efforts to assess the nearly 1,400 native plant taxa in Hawai'i. To date, over half have been assessed, reviewed, and published on the Red List, adding to the more than 76,000 plant taxa published through the latest update of the Red List worldwide. In 2021, NTBG scientists completed assessments of all Kaua'i single-island endemic vascular plants (currently at least 256 species) and even more recently, collaborated with conservation partners to complete assessments for all of Hawai'i's native trees.



Species: Loulu *(Pritchardia flynnii)* Arecaceae

IUCN RED LIST CATEGORY: ENDANGERED (EN)


KEN WOOD

Pritchardia is a genus of fan palms comprising approximately 27 species native to tropical Pacific islands, with around 23 species endemic to Hawai'i. Known as loulu in Hawaiian, they are Hawai'i's only native palms and hold deep cultural, ecological, and economic significance. Loulu face a wide range of threats, but today the most urgent is the Coconut Rhinoceros Beetle (CRB), a highly destructive invasive pest first detected on O'ahu in 2013 that spread to Kaua'i in 2023.

Pritchardia flynnii is a Kaua'i endemic found between 660 and 975 m elevation in wet forests. The species was described by NTBG staff and colleagues and named after NTBG's herbarium curator Timothy Flynn. Only about 400 plants remain in the wild. NTBG assessed the species in 2015 using the IUCN Red List criteria as Endangered. It is not federally listed under the U.S. Endangered Species Act.

Because loulu seeds are not amenable to conventional seed banking, the genus is conserved primarily as living collections. In 2025, following the establishment of CRB on Kaua'i, NTBG evaluated global ex situ holdings of loulu and found that *P. flynnii* was represented by just three plants, all cultivated within NTBG's Lāwa'i Gardens. Funding was immediately secured through the APGA-USFS Tree Gene Conservation Partnership to expand its conservation collection. A total of 11 field expeditions yielded 1,152 seeds from 13 wild individuals, enabling propagation and distribution to multiple conservation partners.

–Dr. Seana Walsh, Conservation Scientist and Curator of Living Collections



National Tropical Botanical Garden
The Garden Club of America

SCHOLARSHIPS

The National Tropical Botanical Garden and The Garden Club of America are collaborating to offer two scholarships related to tropical botany. The Garden Club of America Fellowship in Tropical Botany will award $5,500 to PhD students. A second scholarship, The Loy McCandless Marks Scholarship (an International Scholarship in Tropical Horticulture or Landscape Architecture), will award $5,000 to graduate or undergraduate students.

The deadline for both scholarships is January 15, 2027. Learn more at: https://www.gcamerica.org/scholarships

THE GARDEN CLUB of AMERICA

wish list

Make a difference today! Your purchased Wish List item will directly meet immediate program needs. Donate online at ntbg.org/support/donate or call Chelsey Aki at (808) 332-7324 Ext. 209. Mahalo for your support!

BREADFRUIT INSTITUTE
Safety duplication tools and supplies - $1,500
Breadfruit documentation supplies kit - $500

EDUCATION
White board for Education Center - $1,500

FINANCE DEPARTMENT
New office chairs - $400

KAHANU GARDEN
Irrigation parts for greenhouse sprayers - $1,200
New office chairs - $800

THE KAMPONG
Garden entryways and kiosk landscaping - $1,500
Student field trip sponsorships - $1,500

LIMAHULI GARDEN
Sets of two-way Motorola radios - $1,500

NURSERY
New hardware for mist house - $1,000

SCIENCE AND CONSERVATION
Lightweight backpacking tent for field work - $500
Propagation chamber for cuttings - $700

VOLUNTEER PROGRAM
Kraft tool road rakes - $540

To see the complete Wish List, please visit: https://ntbg.org/support/wishlist/

The Science of Seedlings, Sprouts, and other Small Plants

BY JON LETMAN, EDITOR

NTBG'S FERN LAB MANAGER NATALIE BLUM STUDIES NEW LIFE UNDER A MICROSCOPE. PHOTO BY MATTHEW PARENT

In the earliest stages of a plant's life, when it transforms from a seed to a sprout or a spore to a sporeling, it holds its greatest potential but is also in its most vulnerable state. A new plant's primary function is to establish roots and leaves so that it can manufacture chlorophyll that captures sunlight enabling it to produce glucose (basic sugar). Whether in soil, on a tree, a rock, or other surface, young plants must capture sunlight and moisture in order to grow. They are what NTBG's senior research botanist Dr. David Lorence calls "little growth machines."

Under favorable conditions, a seed's embryo will produce an initial root called a radicle which anchors the seed to the earth where it seeks nutrients and water. As the radicle burrows deeper into the ground, a shoot apex rises toward the sunlight to produce false leaves called cotyledon which are followed by the first true leaves. During this early phase of plant life, the seed's endosperm contains nutrients to nourish the emerging plant until it can photosynthesize light to make its own food.

But young plants face peril in the form of predators (insects, snails, rodents) and pathogens, competition for space and resources from other plants, and environmental factors such as too much or too little moisture, or the risk of being trampled or crushed. The likelihood of a young plant's survival, Dave Lorence says, is often quite small.

BLOWING IN THE WIND

Not all plants start as seeds in the ground. Bananas, gingers, and heliconia spread underground as rhizomes while orchids and tillandsias, for example, produce wispy, light-weight seeds that float like feathers, dispersed by wind which carries them onto the surface of trees, rocks, and manmade objects where they germinate.

In south Florida, where bromeliads are common, Dr. Brian Sidoti, director of The Kampong, along with colleagues and interns[1] are studying the reproduction and growth rate of native bromeliads like the giant airplant (*Tillandsia utriculata*) which grows on tree branches and trunks.

Today, in Florida some native bromeliads are threatened by a weevil (*Metamasius callizona*) which can destroy giant airplants that can grow up to two meters from its base to the tip of the inflorescence over the course of 15 to 20 years. This species is known to produce as many as 33,000 seeds from a single mother plant before it dies. Interns working with NTBG, are conducting viability and germination trials to better understand survivability and the pressure posed by weevils and other threats.

"If a weevil were to attack the bromeliad before it reaches reproductive maturity, then that plant dies and tens of thousands of potential new individual plants would be lost," says Brian.

Weevils and other insects, along with habitat loss and changing climate conditions continue to threaten these distinctive plants that are an integral part of Florida's natural landscape.

[1] Colleagues from Colorado College, Rhodes College, New York Botanical Garden, University of Connecticut and Florida International University interns





ABOVE: KAMPONG DIRECTOR BRIAN SIDOTI HOLDS A YOUNG GIANT AIRPLANT (*TILLANDSIA UTRICULATA*) ON THE GROUNDS OF THE KAMPONG. RIGHT: A MATURE AIRPLANT GROWING ON A PALM TRUNK. PHOTOS BY JON LETMAN

THE SCIENCE OF SEEDLINGS, SPROUTS, AND OTHER SMALL PLANTS TROPICAL | FALL 2026



TIME AS A THREAT

Another challenge young plants face is time. Some plants – *Melicopes*, for example – may take a year or more to germinate. Other seeds take even longer and when seedlings finally emerge, they face predators, larger, aggressive plants, and the struggle to get sunlight and water. Because young plants lack biomass, they are more vulnerable, says NTBG seed laboratory manager Jena Osmani. With fewer leaves and branches to draw energy from, small plants are more susceptible to drought whereas larger, more mature plants have greater capacity to store moisture and energy in their more developed stems, leaves, and root systems.

Jena says that unlike common domesticated food crops, many native Hawaiian plants possess a specialized dormancy mechanism meaning they may take longer to sprout and rely on environmental cues such as temperature or moisture level or even chemicals released in a fire before they germinate.

NTBG's seed lab staff conduct ongoing seed germination tests that produce thousands of tiny native Hawaiian plants. Because many of these are rare or endangered, the seedlings are not discarded but instead painstakingly transferred from a petri dish to soil and then moved to NTBG's horticulture and conservation center where they can be grown out


JENA OSMANI


JON LETMAN


NATALIE BLUM


JENA OSMANI

NATALIE AND RUTH IN THE FIELD (UPPER LEFT). A TRAY OF GAMETOPHYTES IN THE FERN LAB (UPPER RIGHT). YOUNG FERNS IN THE FOREST (LOWER LEFT). NATALIE FINDS A TINY FERN (LOWER RIGHT).

THE SCIENCE OF SEEDLINGS, SPROUTS, AND OTHER SMALL PLANTS TROPICAL | FALL 2026

and eventually used for our living collections and restoration projects.

Seed bank and laboratory technician Amme Kekuna spends much of her time meticulously conducting this work, transplanting seedlings, providing species-specific care based on the conditions of their wild habitat. This determines if they should go into the greenhouse or be temporarily put under grow lights inside the fern lab for greater protection. For seedlings accustomed to cooler, higher elevation habitats, it can be more difficult to survive in a hotter environment like the Lāwa'i Valley.

When Amme sees an adult plant she knew as a sprout she thinks, "It's so fun to see what they look like in their mature version. It's like, I saw you when you were an inch high. It's weird to see you now twelve feet tall!"

Jena's work with seeds has changed her perspective on the natural world. She now takes more time to observe the quality and composition of forests, noticing the balance between native, introduced, and invasive species. Expressing her greater appreciation for healthy native forests, Jena recalls one recent visit to the Lower Limahuli Preserve where she encountered four large hōlei (*Ochrosia kauaiensis*) mother trees that had produced a healthy population of more than a hundred saplings. Seeing all those tiny plants filled her with joy and excitement.

HEALTHY FOREST FAMILIES

Dr. Uma Nagendra, Limahuli Garden and Preserve's conservation and operations manager, finds the early stage of plant life fascinating because every plant experiences it in some form. She notes how young plants must develop adaptations to counter threats and disturbances and how their appearance can change with age — not only size — but certain attributes, for example leaf color. A young plant which is more vulnerable to solar radiation or predation by herbivores may change colors. For example, ferns which are red or crimson when young will turn green with age. Some plants produce larger leaves when they are young as an adaptation to survive in dense forest canopy but later grow proportionately smaller leaves as the plant matures.

Leading a team that does native forest restoration in the Lower Limahuli Preserve, Uma says they try to create conditions most favorable for seedling survival. Ideally this means a protective canopy without too much sun or impenetrable shade and a forest floor conducive to growth. Seedlings have the best chance of survival in soil that doesn't bake in the sun or wash away in the rain. A good native understory can help protect soil and an abundance of moss allows for better moisture infiltration, slowing down water flow and creating micro-habitats and protective pockets that collect seeds and nutrients.

Depending on the species, surrounding mature plants can benefit or hinder a seedling's growth. Uma explains that if a young plant can tap into the mycorrhizae or microbiome of another plant, it can help them survive but if pathogens are present, the impact can be detrimental. For many plants, she says, they need to be in the "Goldilocks zone" where they are not too close or too far from mature trees. Once a plant passes that early stage and has developed root stock or rhizomes to draw from, it's more likely to withstand stress or damage. Uma adds that while it is generally better to get plants from the nursery into the wild sooner than later, if they are outplanted too soon, disturbing the roots can cause shock.

Whenever Uma finds herself beneath a canopy of adult trees, she searches the ground for seedlings or saplings which will eventually fill the space of older trees. "If there's not a younger population to replace them, there's a time limit on the forest." Finding baby plants is so heartening, Uma says, "because regeneration is not something we want to take for granted ever."

TINY GREEN WORLDS

One of the most important non-seed-bearing plant groups are ferns which produce spores that grow into tiny structures called gametophytes which in turn produce the egg and sperm that, when fertilized, develop a tiny sporophyte that eventually grows into what is recognizable as a fern.

Speaking from inside NTBG's fern laboratory on Kaua'i, fern lab manager Natalie Blum explains that the process of a spore becoming a sporophyte and reaching maturity can take months or even years and keeping the gametophyte moist is key to their survival. Holding a translucent plastic tray the size of a tofu container, Natalie shows off a tiny hāpu'u (*Cibotium glaucum*) — a native tree fern which can grow to ten feet tall. Collected as spores in the Limahuli Valley, these gametophytes are only five millimeters wide.





YOUNG PLANTS IN THE HORTICULTURE CENTER. PHOTO BY JON LETMAN (ABOVE)
AMME KEKUNA DOING MICROSCOPE WORK IN THE SEED LAB. PHOTO BY MATTHEW PARENT (BELOW)

Because gametophytes are easily contaminated by algae, fungi, microbes, and weedy spores, fern lab staff must remain vigilant to minimize the threat of contamination. Natalie says that because gametophyte fertilization generally takes longer to see results, she has gained a deep sense of appreciation for the process required to produce even a single sporophyte.

Working closely with Natalie is long-time NTBG research associate Dr. Ruth Aguraiuja who specializes in native Hawaiian ferns. Ruth says people may see them inside the fern lab hunched over small trays for hours on end and wonder what they are doing, but insists working in this "microworld" is very rewarding.

"There's so much beauty in how ferns grow with different structures. Connecting microscope surveys to field surveys in a natural habitat provides a lot more information and a better understanding of fern life," Ruth said.



NURSERY MANAGER ANUHEA BRAUN LOADING TRAYS OF YOUNG PLANTS. PHOTO BY MATTHEW PARENT

Whenever you walk in a forest, she says, every patch of moist earth or fallen log may hold countless ferns in early-stage development. Under the right conditions, the fern life cycle will continue to produce new ferns to carpet the forest, benefiting other plants, fostering growth and creating healthier, more diverse habitats.

For humans, busy with our daily lives, even if we are surrounded by plants, it's easy to forget just how miraculous and unlikely it is that so many plants defy the odds, overcome the obstacles, and grow from tiny green specks into forests, grasslands, and countless plant-filled habitats that support other forms of life, providing much of what sustains us and makes our planet a home.

READ AND SHARE ONLINE

an eye on plants

SELECT SPECIES IN FOCUS

Mosses in Hawai'i

Searching for moss in a swamp seems like a simple task, but if you're looking for a very specific moss – *Trachypodopsis auriculata* – it takes persistence. NTBG herbarium curatorial assistant Amanda Vernon and curator of the herbarium Tim Flynn learned this while collecting specimens for their new field guide *Common Mosses of the Hawaiian Islands*.

They had already collected many other mosses, but even the fiery reddish-orange *Trachypodopsis*, an indigenous moss that forms tangled mats, was difficult to locate until they finally found it deep in Kaua'i's Alaka'i Swamp.

They also collected *Racomitrium lanuginosum*, a dense grey moss that covers the swamp in cushion-like patches. Greenish-grey and soft, when dry it turns brittle. Magnified, its leaves resemble animal fur. Although it's indigenous to Hawai'i, it's also found in Arctic tundra.

In Hawaiian, moss is called limu, the same word for seaweed or marine algae. Other names like limu kele and limu ahi indicate where it grows. There are roughly 300 moss taxa (species, subspecies, varieties, and forms) in Hawai'i. Reproducing by spores or vegetative parts, moss easily spreads by wind and birds.

Sponge-like with a structure that captures fog, mist or rain, mosses allow moisture to slowly percolate into the earth. Moss also supports arthropods and offers a protective environment for seeds or spores to germinate. Moss also provides bird nesting material and acts as a carbon sink, absorbing CO^2 from the atmosphere.

Over two dozen collecting trips Tim and Amanda hiked and slogged through bogs, sometimes collecting 15 moss species at a time. When they encountered a new moss, they photographed it extensively and if there was enough plant material, made duplicate collections to share with other gardens, museums, and universities.

Reciprocal exchanges help safeguard collections in multiple locations, providing more access to researchers and students. If plant material is limited, a collector might make only one specimen.

When identifying moss, Amanda says, "you really have to look at the leaves under a microscope because so much depends on the cell shape and size... You can't just pick up a moss and be certain what it is." It's essential to observe subtle morphological variations under a microscope.

Tim and Amanda sought help with identifications from moss specialists at the California Academy of Sciences and Missouri Botanical Garden. Although different botanists may reach different conclusions about identification, those discrepancies are noted with each herbarium specimen.

Understanding and properly identifying mosses can shed light on possible threats or potential conservation strategies for specific ecosystems. For example, if a certain species of moss is well-adapted to an environment, its establishment may encourage the growth of other species.

One of NTBG's Hawaiian moss project goals was to ensure that every image in the field guide was associated with a herbarium collection. Tim and Amanda recognize the value of connecting field collecting to new technologies that help more people access NTBG's database.

Although most people focus on flowering trees and shrubs, Tim and Amanda hope interest in mosses, lichens, and other bryophytes will grow. At a time when science and education face so many challenges, they say moss allows more people to play a role in scientific observation.

Tim suggests the next time you find yourself admiring big, beautiful trees, take notice of the mosses and lichens growing on the trunks and branches. Even an inexpensive hand lens can reveal the stunning world of moss.

Amanda encourages people to stop, look, and observe the differences. "In general, mosses in Hawai'i have been so understudied," she says. "It's becoming more popular but there's so much still to discover."



TRACHYPODOPSIS AURICULATA.
PHOTO BY AMANDA VERNON

National Tropical Botanical Garden
3530 Papalina Road
Kalāheo, Hawai'i 96741 USA

REDUCE
REUSE
RECYCLE



KAMPONG DIRECTOR BRIAN SIDOTI CONDUCTS A GERMINATION EXPERIMENT WITH THE SEEDS OF *TILLANDSIA UTRICULATA* (GIANT AIRPLANT) IN THE KAMPONG'S KENAN LAB. READ MORE ABOUT THE EARLY STAGES OF PLANT LIFE ON PAGE 28. PHOTO BY JON LETMAN