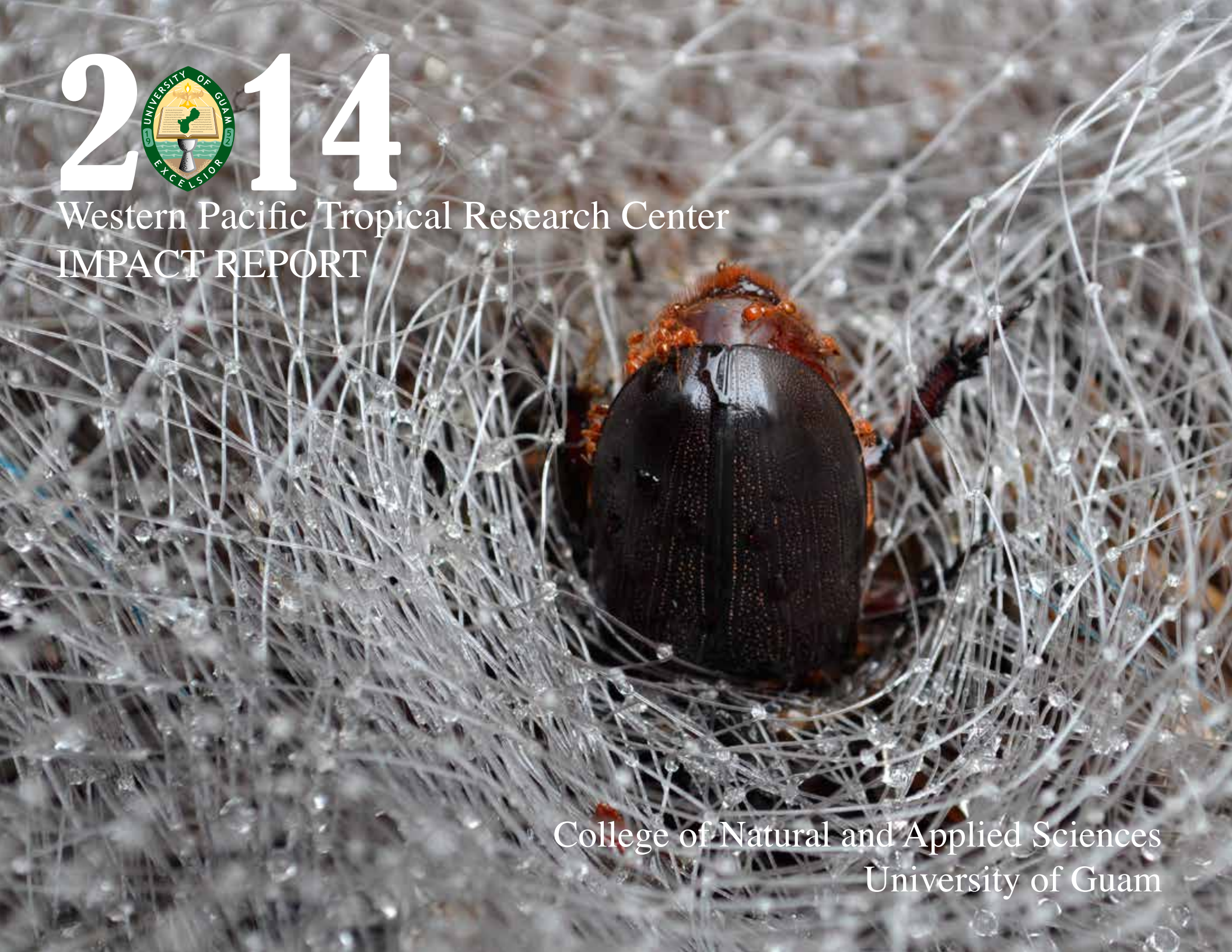
2014

Western Pacific Tropical Research Center
IMPACT REPORT



College of Natural and Applied Sciences
University of Guam

Buenas yan Hafa Adai,

Este na sakkan, ta atbansa'hit. Desde minaolek, para sen'maolek!
This year we move from good to great!

The Western Pacific Tropical Research Center is once again proud to showcase some of our 2014 research, extension and instructional outcomes and the relevance WPTRC plays in the advancement of "Good to Great" within the University of Guam and our island and regional communities.

This year we highlighted projects that exhibit the wide diversity of our center - how Guam's Plant Extinction Prevention program is revitalizing rare plant flora; an update on the invasive little fire ant; how roof gardens play a role in reducing power bills and could put food on one's table; looking at sugar production by Guam's cycads; how invasive species may in fact have a greater impact on flora community than what was previous thought; the relationship between Noni and high levels of aluminum; new methods of controlling the coconut rhino beetle on Guam; a greater understanding of coral beaching problems in Guam's waters; new funds to improve orchid tissue culture by partnering with Guam's Department of Agriculture; and extending applied research into our classrooms. I believe you will find each of these articles not only educational but outcome orientated.

I want to personally thank - researchers, extension personnel, staff and students - who contributed to the 2014 WPTRC impact report. This year's report a true example of what UOG is collectively calling *the road to greatness*. WPTRC is a celebrated investment within UOG and preserves the essential strengths of Guam's natural resources.

Lee S. Yudin
Dean and Director
CNAS/WPTRC

Hafa Adai,

It's been a great year for the Western Pacific Tropical Research Center, and the projects highlighted in this year's Impact Report demonstrate some of the important work happening at the University of Guam.

In 2014, as in previous years, we continue to address the challenge to Guam's tropical agriculture industry, as well as our island's natural resources. We also strive to extend our current capabilities beyond the boundaries of Guam to become an internationally recognized tropical research center. WPTRC may be a small research unit with limited financial, logistical, and human resource support; but we focus on our opportunities, such as: our proximity to Asia, clean ocean water for aquaculture research, partnerships with other entities in Micronesia, commitment by the U.S. government to preserve native species on Guam, and interest by other research entities to collaborate.

The hardworking faculty and staff of WPTRC continue to remain competitive in securing extramural funding. In 2014, the number and diversity of funded grants increased, we collaborated with multiple off-island scientists and institutions, and provided employment to the local community.

WPTRC is here to serve our stakeholders, so please feel free to contact my office if you have any questions or need additional information.

Rachael Taitano Leon Guerrero
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Female rhinoceros beetle, entangled in *tekken*, is attacked by fire ants.

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Table Of Contents

College of Natural & Applied Sciences
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Guam's rare plants receive crucial attention

With increased development on Guam comes an increase in disturbances to the island's natural landscapes. Land clearing directly reduces plant populations. Factor in invasive insects, invasive plants, and invasive animals like deer and pigs there are few surviving seedlings to sustain the remaining plant populations. The Guam Plant Extinction Prevention (GPEPP) program is making a difference for Guam's rarest plants reversing the trend toward extinction by managing wild plants, collecting seeds and establishing new populations. GPEPP conducts surveys to locate founder plants. After monitoring health, vigor and phenological status of individuals, GPEPP staff collects genetic material (seed, cuttings, meristematic tissue, spores, pollen or other form of propagules) from all plants of target species for ex situ propagation and live plant storage, tissue culture or seed storage.

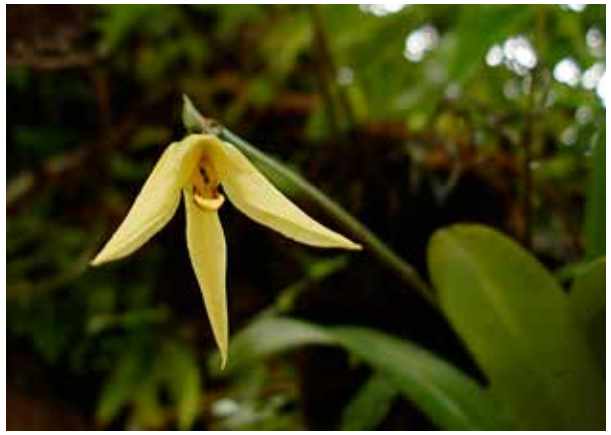
"The seed money for GPEPP came from a two-year US Forest Service grant which was extended for an additional two years to allow our staff to attend training in Hawaii," said James McConnell, co-principal investigator with Justin Santos and Mari Marutani.

Guam Rare Plant Restoration Group is the advisory board for GPEPP that approves what is listed as priority plants as well as specific areas to do the outplantings. "At present, the highest priority plants for GPEPP are *Serianthes nelsonii* and 'to-be-listed' species proposed by US Fish & Wildlife. We have survey teams monitoring the phenology, and other teams working on propagation and outplanting methods for these plants," said project coordinator Else Demeulenaere.

Funding has allowed the GPEPP lab to purchase solar powered refrigerators and freezers to store the seeds collected from rare plant species. This ensures that seeds will be kept at a constant temperature regardless of any power outages experienced at the university. The funding also supported the establishment of a tissue culture lab that will study the micropropagation of these species.

Research on Guam's rarest tree, *Serianthes nelsonii,* has resulted in the propagation of many seedlings. Forty-two trees were recently outplanted in their natural habitat. "Guam currently is home to only one mature *Serianthes* tree. Rota is thought to have fifty or sixty mature trees. Genetic research will determine whether the trees on Guam and Rota are conspecific. The phylogenetic relationship to other species in the region may shed light on the route *Serianthes* took to establish in the Mariana Islands," said Demeulenaere.

GPEPP collaborates with conservation partners to safeguard wild plants as they occur in their natural habitat or are



outplanted in protected areas. Partners include the Guam Department of Agriculture, US Fish & Wildlife, US Forest Service, Micronesian Challenge, US National Park Service, USDA-NRCS, Naval Facilities Engineering Command Marianas (NAVFAC), and the Hawaii Plant Extinction Prevention Program.

Funded by US Forest Service, US Fish & Wildlife, US Navy, McIntire Stennis

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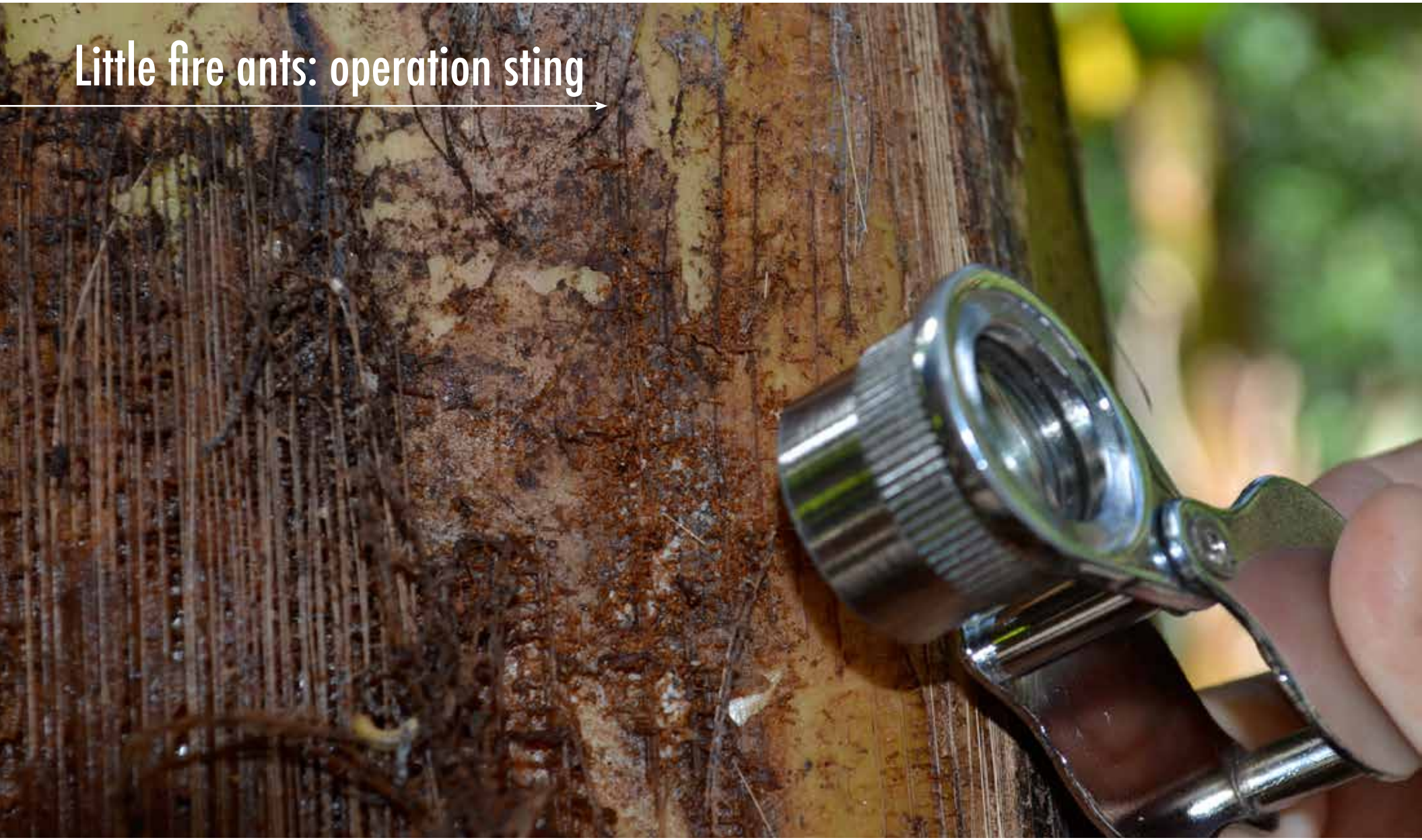
Little fire ants: operation sting



Invasive insects may be small, but they are driving research agendas at WPTRC in a big way. The little fire ant (LFA), *Wasmannia auropunctata*, was first found on Guam in November 2011 and identified by Dr. Ross Miller's Entomology Laboratory, the ant identification center for the region. Since that time LFA have been found in many villages around the island, which may indicate they have been here much longer than previously suspected.

Fire ant is a generic term used for ants that have a very painful sting. Because of its small size, little fire ants swarm over their victims undetected and then sting en masse so that the ants appear to sting simultaneously. The effects of multiple stings can be lethal for small insects and animals that normally constitute the prey of LFA. On humans LFA stings normally leave an irritating rash that dissipates in a few hours, and in rare cases may trigger serious allergic reactions. Animals and birds stung in the eye may experience impaired vision or total blindness.

Miller's lab is collaborating with the Guam Department of Agriculture in LFA control efforts at selected sites around the island. Sites were chosen for their ease of access and the density of LFA colonies. One control site is located next to the animal shelter, GAIN, in Yigo with two control sites in the southern part of the island. "There are several places along the road to Umatac that are heavily infested with LFA. Since the ant population is so large and well established, we believe they have been there for quite a while and were probably transported by people using the area as an illegal garbage dump," said Miller. People have played an important role in helping LFA establish and move throughout the island, which is why LFA populations are found in villages from north to south.

The LFA team at UOG is currently treating six sites to verify techniques adapted for use on Guam from those developed in the Hawaiian Islands for controlling LFA. Detailed surveys are performed at each site to determine the magnitude and range of the infestation. The area is then treated with low toxicity granular bait attractive to LFA called Siesta™. A second insecticide that interrupts the growth cycle of the ants, Tango®, is sprayed on tree trunks and leaves. One week later the team conducts a follow-up survey to check the efficacy of the treatment. Six weeks later both insecticides are reapplied and the site is again surveyed. Each site will receive a total of eight repeat treatments over a period of more than a year.

In a related study, USDA-ARS entomologist Dr. Sanford Porter in Gainesville, Florida is a leading authority on fire ants. Miller and Porter are collaborating to find a biological control agent for another fire ant infesting Guam and most Micronesian islands, the tropical fire ant *Solenopsis geminata*. Miller is sending several thousand live tropical fire ants to Porter who then exposes them to biological control agents collected from the ants' home range in South America. The hope is that he will find an agent that efficiently attacks tropical fire ants under Guam's environmental conditions without harming the few species of indigenous ants found on Guam.

WPTRC scientists in collaboration with local and federal agencies and experts around the globe are working to protect Guam's cultural and natural resources.

Funded by US Forest Service

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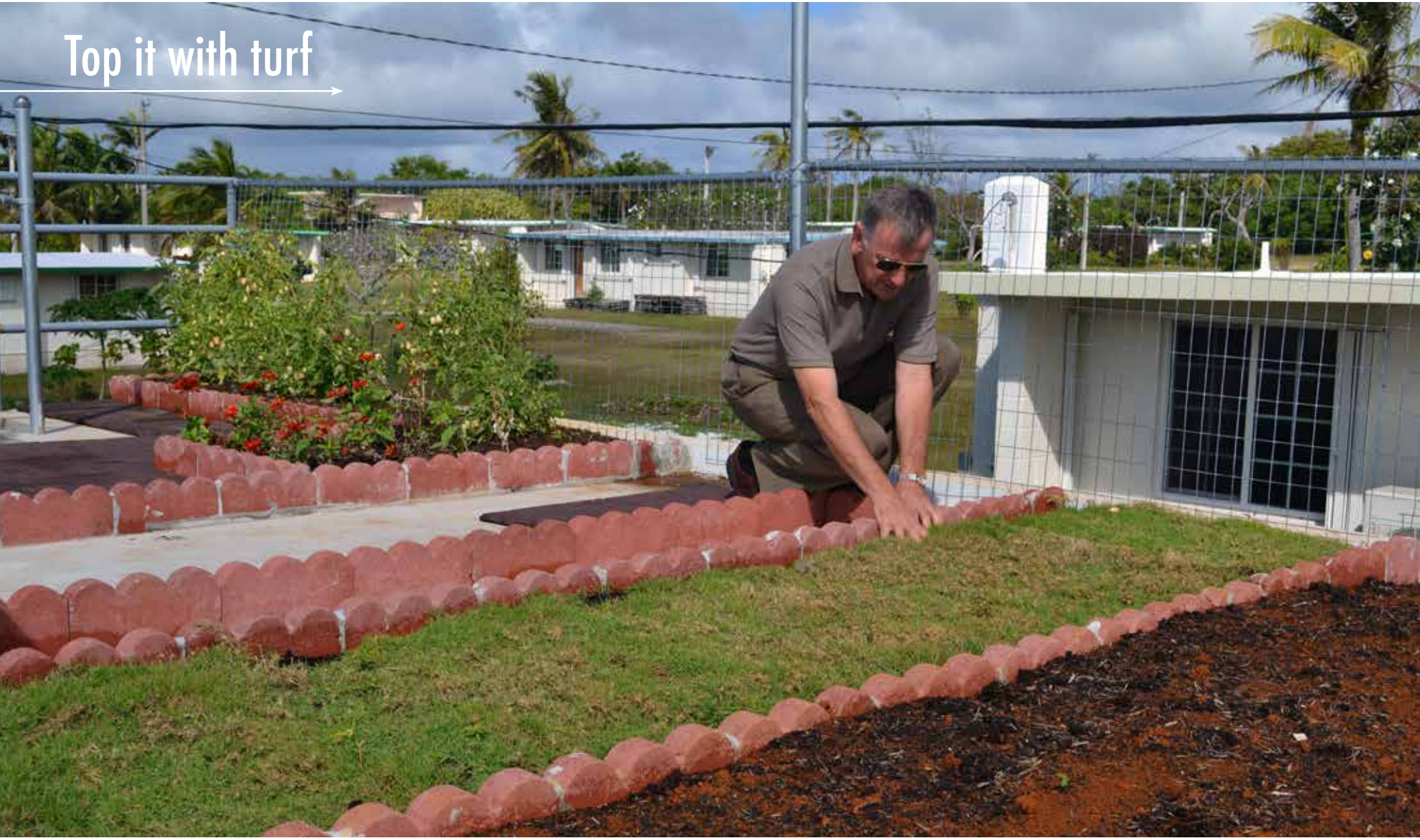
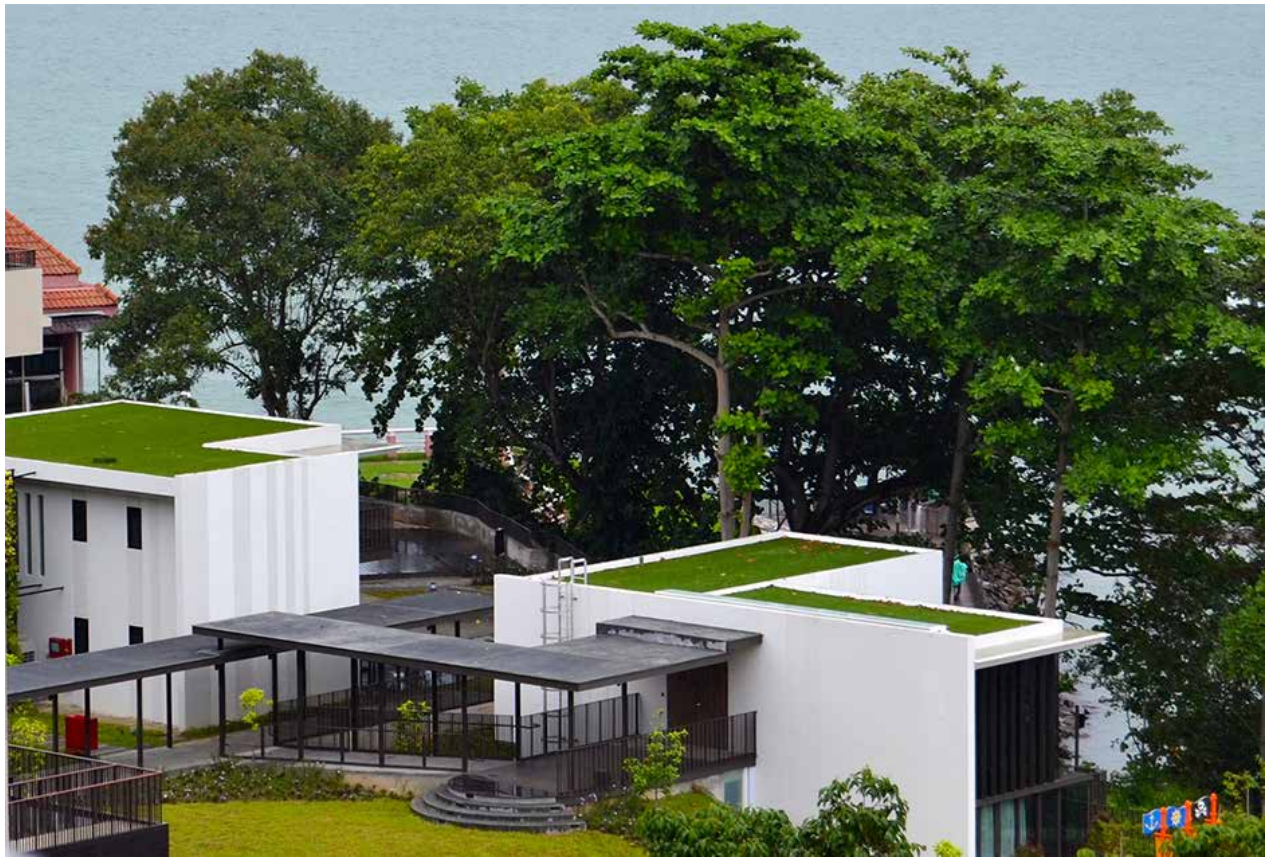
Top it with turf



Rooftops are often unattractive places where heating and cooling equipment, telecommunication towers, and satellite dishes are installed. For many years ecologists, anthropologists, sociologists, and environmentalists have stressed the need for more harmony between lifeless buildings and their occupants. Consequently thousand of acres of rooftop areas in large cities around the world have been converted into gardens, as places of recreation or simply esthetically pleasing components of city skylines. These "green roof gardens" also provide other benefits, most importantly energy conservation.

"Heavy concrete roofs absorb a considerable amount of heat that is removed mainly through air-conditioning systems at an excessive expense of energy. Shielding roofs from the hot sun with vegetation results in substantially lower electric bills," said Dr. Greg Wiecko, WPTRC turf scientist. He believes that Guam is ideally suited for green-roof installations. Residential and commercial buildings constructed from solid concrete are exceptionally strong and can safely carry a heavy load of soil and established vegetation. A protective barrier between the soil and rooftop prevents moisture from affecting the concrete in undesirable ways. In addition, abundant tropical rainfall and the selection of appropriate plant species could eliminate or greatly reduce the need for irrigation, making roof vegetation relatively easy to grow and maintain.



Research conducted by Dr. Wiecko has proven that a residential house may spend at least 50 percent less on its energy bill while maintaining the same indoor temperature when the roof is covered by vegetation. "When Japanese grass *Zoysia tenuifolia* was planted on the rooftop of a concrete dwelling, it showed exceptional resilience to heavy tropical rainfall and most likely would be resistant to damage from typhoons," said Wiecko.

Implementation of existing methods in energy conservation and fine-tuning them for Guam's specific conditions is one of many ways to protect our planet while maintaining a comfortable life.

Funded by Hatch Formula Funds

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A sweet subject

When plants participate in photosynthesis they take carbon dioxide from the air and convert it into compounds called primary metabolites. And what plants do with those initial compounds throughout everyday routine life is a true marvel. The diversity of plant compounds called secondary metabolites is enormous.

Some of these compounds provide plant organs with their color. Others impart aroma or flavor components to the plant parts that humans consume. Some plant metabolites are known to repel animals that may feed on them. Others are known to attract animals that help them, such as pollinators. Yet others are known to attract natural enemies of insects that eat plants.

Among the well-studied plant compounds are the simple sugars, the most common of which are glucose, fructose, and sucrose. These sources of rapidly available energy are anything but simple, as their function for plant life has been shown to be highly multi-faceted.

And equally multi-faceted is the use of these plant sugars by the modern food industry. In 1700 the average person in an affluent country consumed about four pounds of sugar per year, in 1800 that had increased to about 18 pound per year. Since 1900 the annual consumption of processed sugar has been close to 100 pounds per person for many affluent regions. In the United States, the processed food industry alone delivers about 70 pounds of hidden sugar to the average American consumer every year.

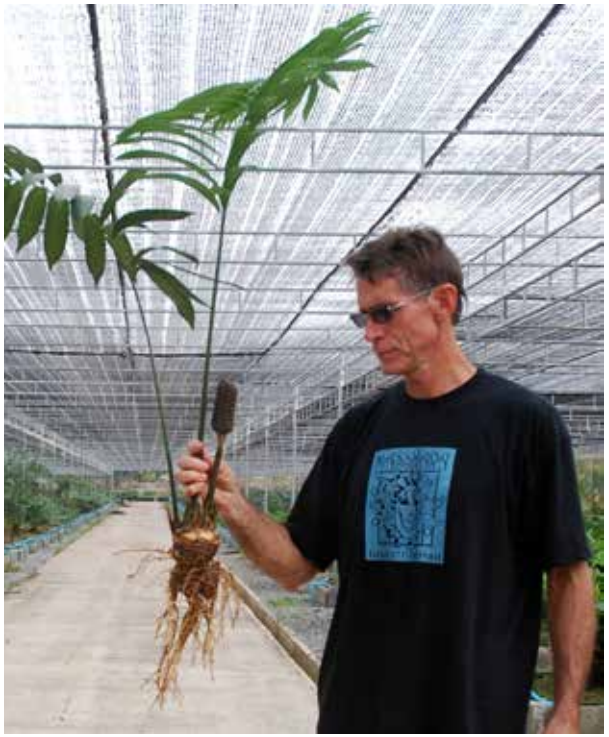
Sugars and the plants that make them are clearly positioned in numerous issues of relevance to everyday life. These issues led researcher Thomas Marler to conduct the first-ever look at sugar production by the ancient group of plants known as cycads. Marler teamed up with scientists at the Nong Nooch Tropical Botanical Garden where representatives of every known genus of cycads are being tended. “This is perhaps the only site worldwide where every known cycad genus is growing under fairly homogeneous conditions,” said Marler. “Controlling for environmental variables like this is the only way to ensure that measured differences are actually due to the genetic factors of interest.”

One of the more informative outcomes of the research was the comparison of sugars among various plant organs. Cycad roots were shown to store great diversity and large quantities of sugars. Contrarily, cycad stems contained the least amount of sugar and sucrose was the only sugar detected. The results indicate the cycad root system likely enables the impressive ability of cycad plants to recover from stresses like typhoon damage by supplying rapidly available sugars for regrowth.

Funded by Hatch Formula Funds

Further Reading:

Marler, T.E. and A.J. Lindström. 2014. Free sugar profile in cycads. *Frontiers in Plant Science* 5:526.



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Alien insect affects more than its host tree

When bad things happen, sometimes the consequences are long-lasting. Guam's recent invasion by the insect pest called *Aulacaspis yasumatsui* would make it on anyone's list as a bad thing. The invasion and its potential devastating consequences were predicted in 2000 by researcher Thomas Marler. So when the 2003 invasion occurred, it should have come as no surprise.

Guam's invasion marked the first time this scale insect invaded a new geographic region that had a native *Cycas* species. At the time of the invasion, *Cycas micronesica* was the most abundant tree on Guam. The *A. yasumatsui* insects, which require *Cycas* trees for food, must have felt like kids in a free candy store, with a smorgasbord at their disposal.

The consequences were acute at first, then relentless as time passed. Plants started dying within months, beginning with the seedlings then progressing to the juvenile plants and finally to the mature trees. The insect jumped to Rota in 2007 and immediately presented scientists with a déjà vu situation in Rota's *Cycas micronesica* population.

The immediate consequences on *Cycas micronesica* plant health and mortality were to be expected. But as the invasion began revealing all of its nuances Marler noticed that forest sites where high density plants had been defoliated or killed were not behaving as a normal forest gap. "Typically the existing seed bank and suite of small seedlings capitalize on a new forest canopy gap with rapid growth to fill the new opening," said Marler. "The gaps created by scale-induced leaf and tree death were remaining barren."

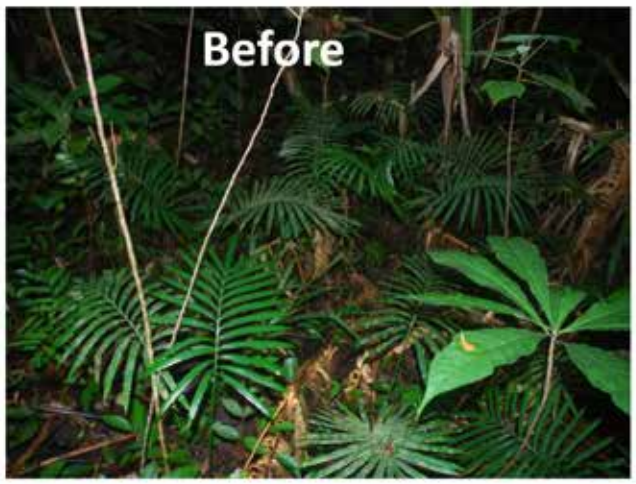
Marler employed the established protocol of using activated carbon to adsorb residual biologically derived compounds that were suspected of lingering in the soils. The soil treatment stimulated plant growth as predicted, and the results pointed to a phenomenon that ecologists call a legacy effect. In this case, organic compounds in the dead *Cycas micronesica* tissue that was killed by *Aulacaspis yasumatsui* were leaving behind a legacy that hindered seed germination and seedling growth of the other forest plant species.

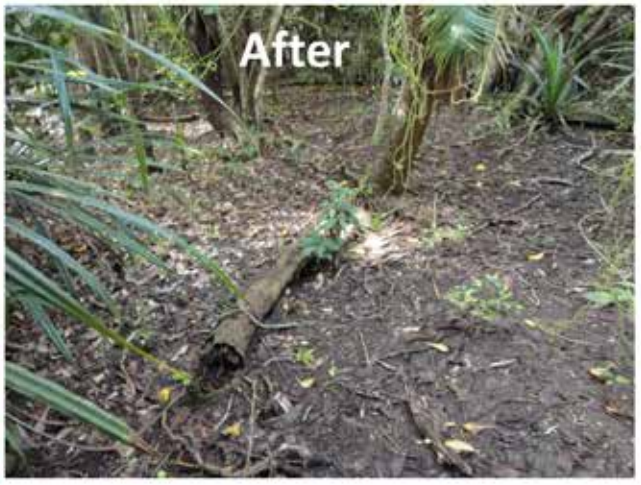
The study revealed an example of how cascading effects of an invasive insect pest can negatively affect species other than the insect's host plant. This case study is an ideal example of how an insect invasion event can lead to unexpected ripple effects that damage the ecosystem in ways that could not be predicted.

Funded by US Forest Service

Further Reading:

Marler, T.E. and N. Dongol. 2013. Do phytotoxic compounds in soils after scale-infested *Cycas micronesica* litter deposits explain reduced plant growth? *HortScience* 48:1571-1573.





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Collateral aluminum exposure in medicinal plant consumption?

The use of herbal products for medicinal or therapeutic purposes is well-established in many cultures. *Morinda citrifolia* is one species employed for medicinal purposes on Guam. The herbal products from this amazing tree have become popular and entered the international market. The tree is called *lada* on Guam, and noni on the international market.

A scientific understanding of the mode of action of the bioactive molecules has progressed for noni and other species. The commercial viability of phytochemicals and herbal extracts has also been heavily studied. Moreover, some research focuses on how environmental factors affect the production of biologically active beneficial compounds in various plant species.

"But a similar look at what influences the production or accumulation of potentially toxic elements or compounds in noni and other medicinal plants has been little studied," said Jian Yang. Yang and fellow researcher Thomas Marler became interested in the possibility of excessive aluminum exposure during consumption of products made from Guam's *lada* trees.

Aluminum is the third most abundant element in the Earth's crust, but it has no known biological function in humans. Exposure in excessive amounts is rarely a concern, primarily because the abundant aluminum is not particularly available to any of the higher animals. This history provides the human body with no inherent protection against aluminum toxicity. Concerns about increases in exposure to aluminum have led to research on aluminum bioaccumulation and its role in chronic diseases in general and neurodegenerative diseases in particular.

"What sparked our interest was an unexpected outcome of our research on how carbon and leaf nutrients cycle in Guam's forests," said Marler. *Lada* was one of the tree species that was included in this research, and the aluminum content of *lada* leaves greatly exceeded that of all other tree species that were studied.

As predicted, the *lada* trees growing in Guam's southern acidic soils produced leaves with elevated levels of aluminum. The research indicated inadvertent ingestion of excessive aluminum may occur when leaves from *lada* trees growing in southern Guam are used for medicinal or therapeutic purposes.

Further reading:

Marler, T.E. and J. Yang. 2013. Risk of aluminum exposure from noni (*Morinda citrifolia* L.) leaf products. *Economic Botany* 67:203-209.

Shaw, C.A. and T.E. Marler. 2013. Aluminum and the human diet revisited. *Communicative & Integrative Biology* 6:e263691-263693.

Funded by USDA Natural Resources Conservation Service

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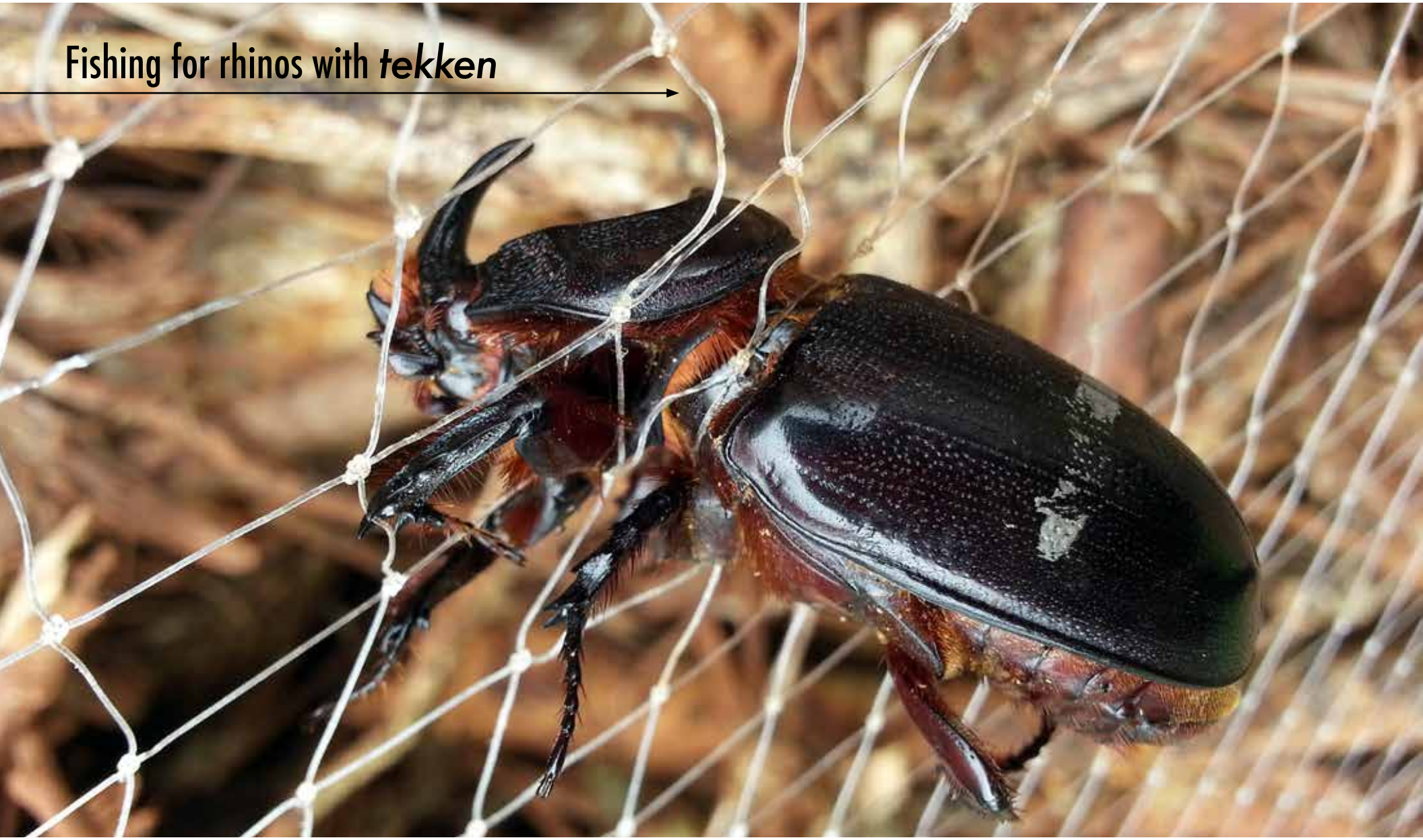
Fishing for rhinos with *tekken*

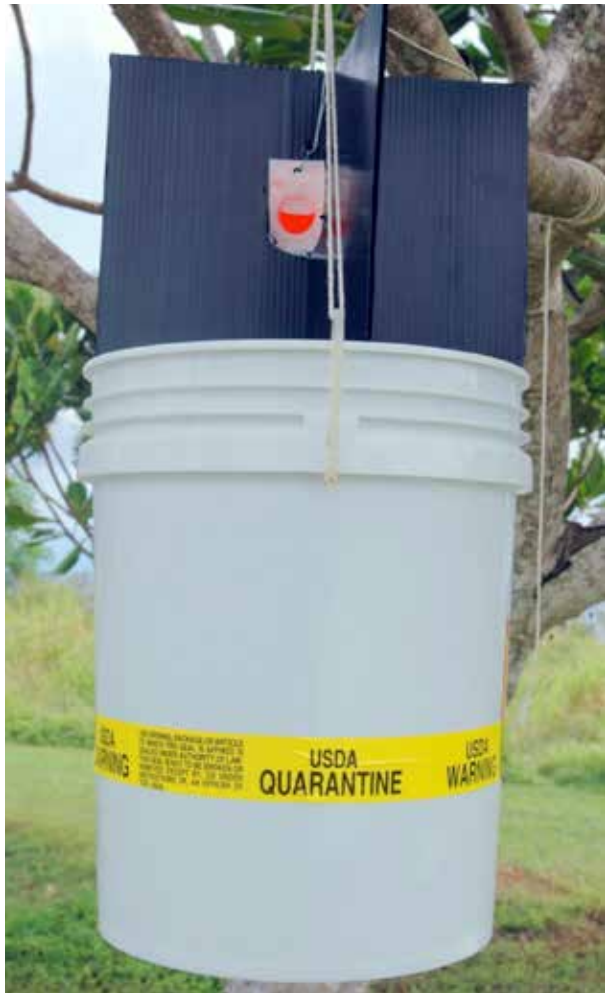


Tekken, a gill net used by Chamorro fishermen for centuries, has proven to be an effective trapping tool for coconut rhinoceros beetles.

The coconut rhinoceros beetle, (CRB) discovered on Guam on September 11, 2007, is a serious pest to coconut and other palms. Trees are damaged and sometimes killed when adult beetles bore into crowns to feed on sap.

Based on a delimiting survey that found CRB only in a small area around Tumon Bay and Faifai Beach areas, it was decided to attempt eradication of the beetle from the island before it spread further. "We were led to believe that we could trap out all beetles using pheromone traps. The standard CRB pheromone trap is a five gallon plastic bucket fitted with plastic vanes and lure. CRB adults fly just after sunset and are attracted to a commercially available aggregation lure hung in a hole near the center of the vanes," said Aubrey Moore, UOG extension entomologist. The Guam CRB Eradication Project built hundreds of pheromone traps and deployed these throughout Tumon and Faifai. Unfortunately, mass trapping was ineffective in preventing the spread of the beetles.

After about a year, the project gave up on using traps for population suppression, but still maintained a network of pheromone traps throughout Guam for detection and monitoring. Control efforts shifted to sanitation: finding and destroying CRB breeding sites where 90 percent of the CRB population is found. CRB breed in piles of decaying organic matter. In an active breeding site one finds adults and large numbers of grubs which do not damage trees, but rather accelerate the decomposition process by feeding on dead plant material.



In December 2013, a rhino beetle infestation on Oahu, Hawaii was detected when a beetle was caught in a pheromone trap on a golf course at Hickam Air Force Base. Subsequently, a very large and active breeding site consisting of coconut green waste was found. This breeding site was discovered by Guam native Wilfred Leon Guerrero, a plant protection quarantine officer with the Hawaii Department of Agriculture. In January 2014 USDA assembled a rapid response team on Oahu and invited Roland Quitugua, UOG extension agent and Moore to participate in an eradication planning meeting as "subject matter experts". In an attempt to prevent adult CRB from leaving the breeding site, the Hawaii Department of Agriculture covered the organic matter pile using bird netting as a physical barrier. Unfortunately, direct observation showed that many beetles were able to pass through the net. The holes in the bird netting were too large.

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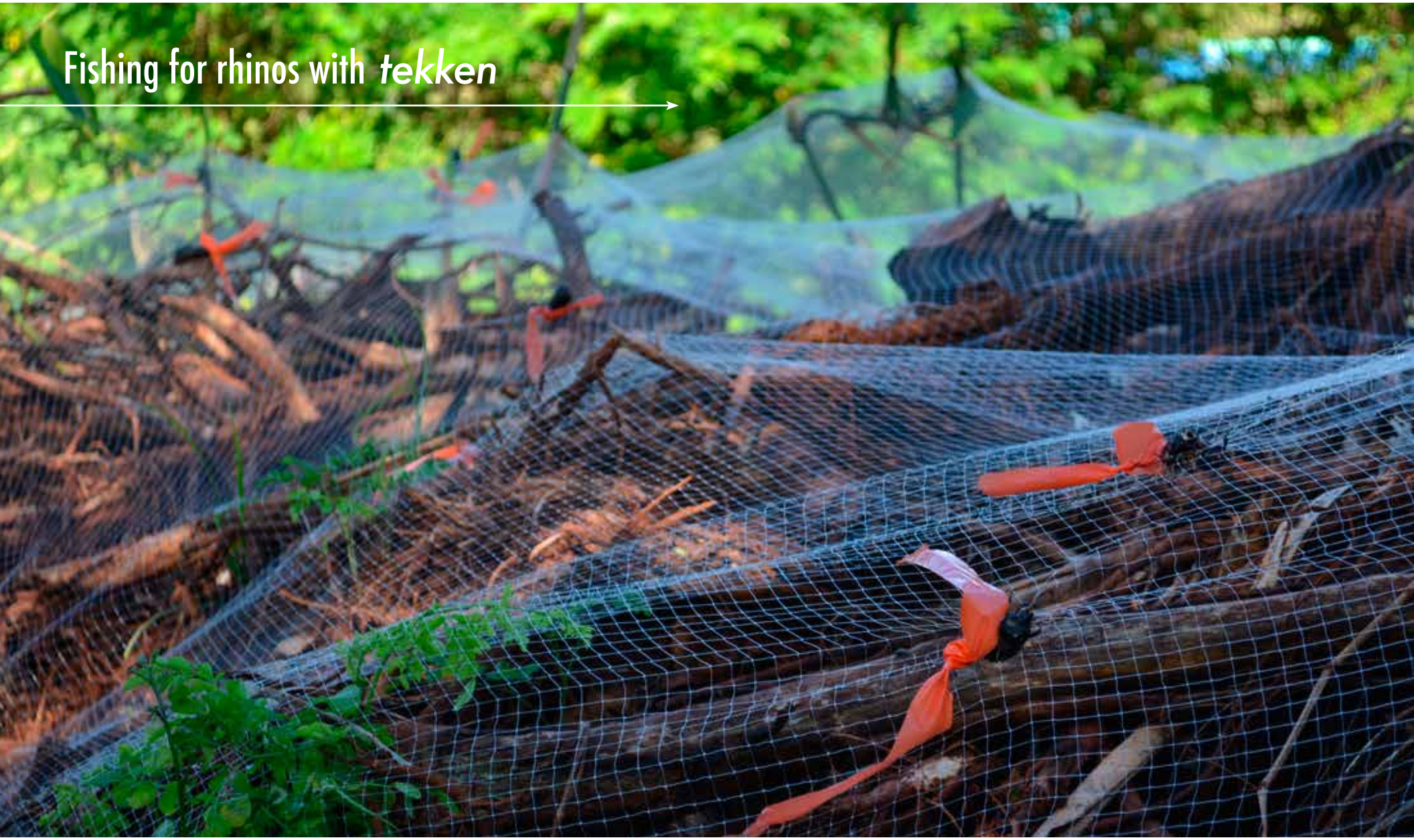
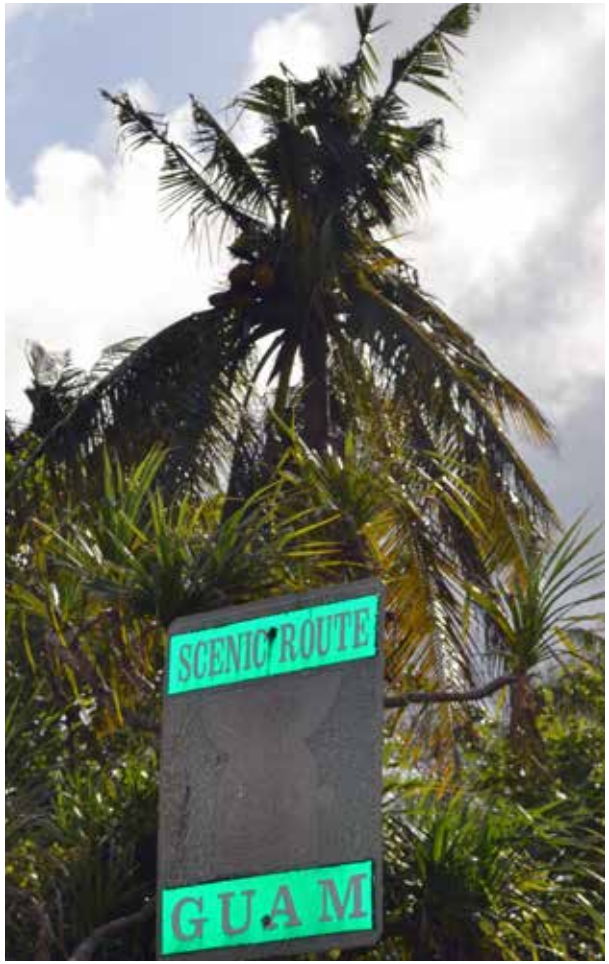
Fishing for rhinos with *tekken*

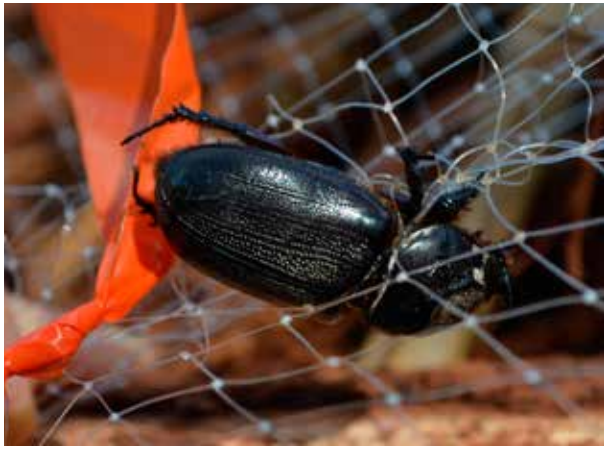


Upon return to Guam, Quitugua and Moore started measuring escape rates through different types of nets. When they asked local fishermen for net samples, they were pleasantly surprised to learn that at least two of them, Johny "Atulai" Taitano and Frank Cushing, were already using pieces of small gill nets known as *tekken* to cover compost piles on their properties in an attempt to prevent CRB from attacking their trees.

Tekken are made from nylon monofilament and designed to catch fish when the monofilament drops into gill slits. Similarly, CRB become caught when the net gets tangled behind the prothorax, hence the name *tekken* trap. CRB escape tests have shown that the size of the hole and monofilament diameter in the right combination catch CRB. These beetles have extremely powerful forelegs equipped with sharp spines, which they use to bore into tree trunks. They readily escape through fine nets or even woven fabrics such as heavy canvas by tearing the material to shreds. If holes are too big or if the monofilament is too thin, these beetles can force their way through the holes in the net and escape. According to Moore and Quitugua, the *tekken* trap has about a 75 percent catch rate for CRB as they attempt to leave or enter infested breeding sites. The CRB eradication team is working to improve the capture rate.

Quitugua and Moore are currently developing the *tekken* trap as a novel, cost-effective tool for monitoring and managing rhino beetle populations. "As a barrier for potential or active breeding sites, the *tekken* trap is an affordable and easy to use method of reducing rhino beetle populations in residential areas," said Quitugua. The original idea was to cover compost piles being used as breeding sites to suppress the emergence of adults, which damage nearby palms.





Current research shows that compost piles are highly attractive to the beetles, functioning as a trap in a given area. Large piles of organic matter have been covered with *tekken* at the UOG Agriculture Experiment Station in Yigo and on the UOG campus in Mangilao catching 25 times as many beetles as standard pheromone traps. It should be possible to cover even very large breeding sites efficiently and relatively affordably with little effort.

Funded by USDA-APHIS, US Forest Service, government of Guam

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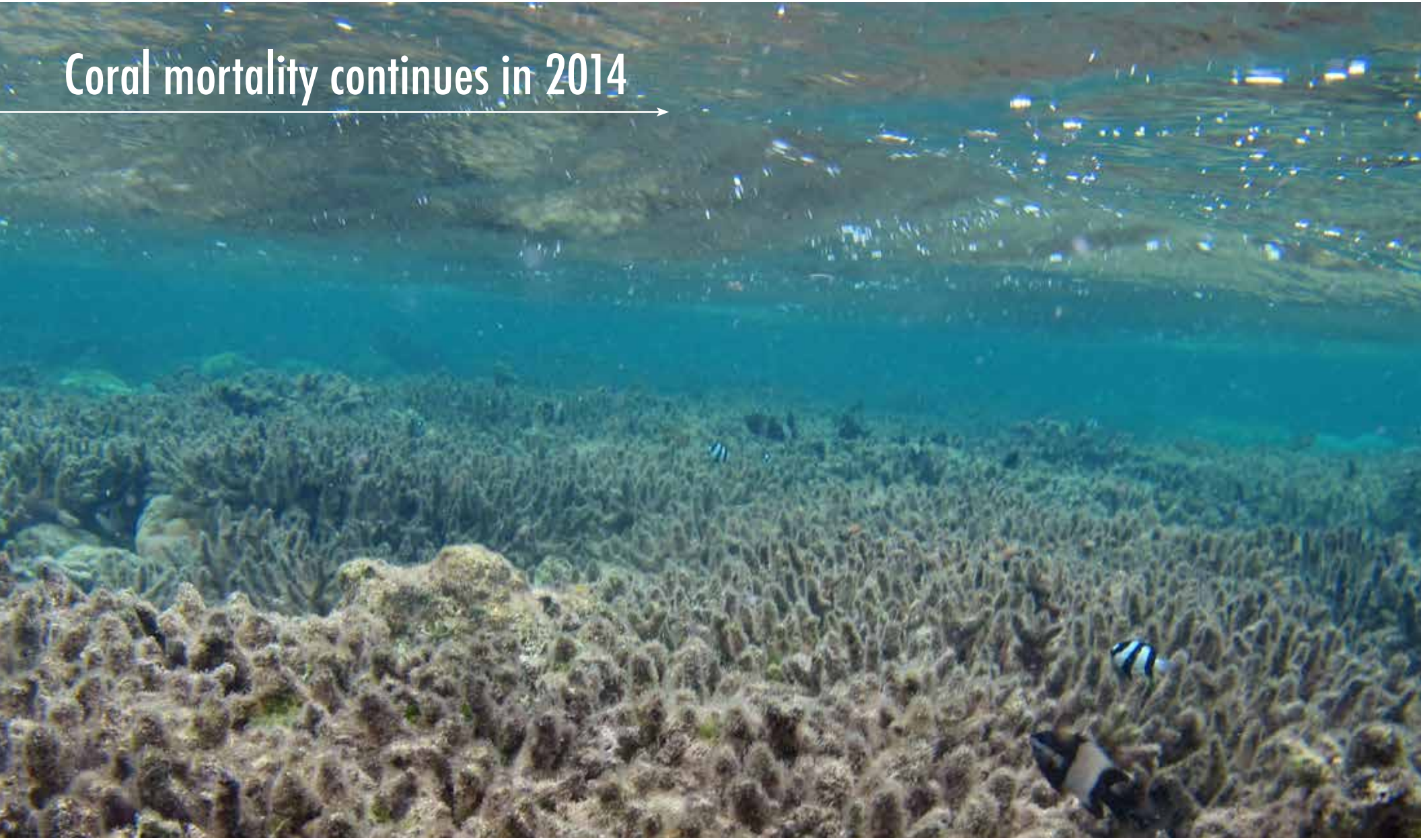
Coral mortality continues in 2014



The very hot August of 2013 had a detrimental effect on several species of coral on Guam's reefs. Stress from high water temperatures that lasted through December caused the corals to exhibit signs of coral bleaching as deep as twenty meters (sixty feet), especially in the species *Acropora* also known as staghorn coral. *Acropora* are a bit like the canary in the coalmine whose vulnerability to toxic gases warned humans of the danger. These sentinel corals are very sensitive to temperature stress and disease-causing microbes. Several major populations of *Acropora* survived the 2013 bleaching event, but the 2014 summer saw intense water temperatures for a second time, and many of those surviving populations perished.

"Some types of staghorn corals are perplexing. We do not know when they spawn or even if they do, or what effect yearly bleaching episodes would have on their ability to reproduce," said Marine Lab coral scientist Dr. Laurie Raymundo. "Graduate student Val Lapacek is devoting her time and expertise attempting to solve this spawning mystery."

Raymundo is a member of the local Bleaching Response team, a collaborative effort that includes Val Brown from National Oceanic Administration Agency (NOAA); Dave Burdick, Costal Management; and other individuals from Guam EPA; UOG Marine Lab; US National Parks Service. Burdick is currently updating his ten-year-old records of coral mapping from around the island. This is important in that there has been significant damage to coral stands over the years.

As a possible measure for rehabilitating rare coral populations, outplanting of *Acropora* using coral nurseries around the island is scheduled to begin in January 2015. "The scale of mortality is enormous and daunting. Once we can get pockets of these corals growing, we are predicting that they will spread and repopulate reef areas," said Raymundo. "We have the technology and we know what to do."

The permitting process has been approved to fragment small pieces from live coral and grow them in a safer, protected environment. Once the corals reach a suitable size they will be attached to a substrate and outplanted. "Dr. Dan Lindstrom is helping graduate student Val Lapacek figure out how many staghorn species we have on Guam, based on their genetics. This will be important in figuring out more effective management strategies," said Raymundo.

Daunting as the task may be, Raymundo and other concerned scientists are submitting grants to fund recovery efforts for this sensitive coral. Their work will keep Guam waters alive with reefs and the creatures that inhabit them.

Funded by US National Park Service

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Orchids in tissue culture

Western Pacific Tropical Research Center in partnership with the Guam Department of Agriculture has been propagating tissue-cultured plants since 2011. Now they are adding tissue-cultured orchids to their range of disease-free plants available to local farmers and back-yard gardeners.

Worldwide there are about 700 genera and 35,000 species of orchids and Guam has perfect climate to grow most of them. Their presence is highly desired by Guam's residents and by the tourists who come to the island to enjoy beautiful tropical vegetation including colorful exotic flowers.

On Guam there is little commercial production of orchids or other ornamental flowers and nearly all potted orchids are imported from Thailand, Taiwan, the Philippines, Hawaii and California. Unfortunately, with the importation of flowers also comes a host of orchid diseases including viral infections. Recent island-wide surveys conducted by the WPTRC Plant Pathology Laboratory show that many of Guam's orchids are infected with viruses. A viable solution to this problem is to introduce an immense influx of inexpensive healthy orchids and eliminate (by burning) infected plants.

In 2014, the Tissue Culture Laboratory started in vitro propagation of *Dendrobium and Phalaenopsis* orchids. In vitro means "in glass" and involves a massive propagation of plants from just a tiny piece of plant tissue that grows on artificial media in special laboratory conditions and then transferred to an outside nursery. Within the year local nurseries and the general public will be able to purchase inexpensive and healthy orchids by the hundreds and possibly thousands.

"The goal of this project is not just orchid production, this grant allows for the training of local resident workers in developing the unique skills of tissue culture propagation. The ultimate goal of this project is that interested nurseries on Guam would start their own tissue culture labs, employ skilled workers and develop successful orchid and other floriculture businesses," said principal investigator Alicja Wiecko.

In Hawaii where the economy, just like Guam, depends on tourism, the orchid industry is one of the fastest growing horticultural sectors. Guam has similar needs and now a unique opportunity to develop orchid businesses that would supply local nurseries and flower shops. Orchids are considered ideal for decorations and cut flower bouquets.

The success of the joint venture Tissue Culture Lab depends on the continued collaboration of the university and government of Guam as well as local growers and gardeners taking advantage of this excellent resource.

Funded by USDA Agriculture Marketing Service

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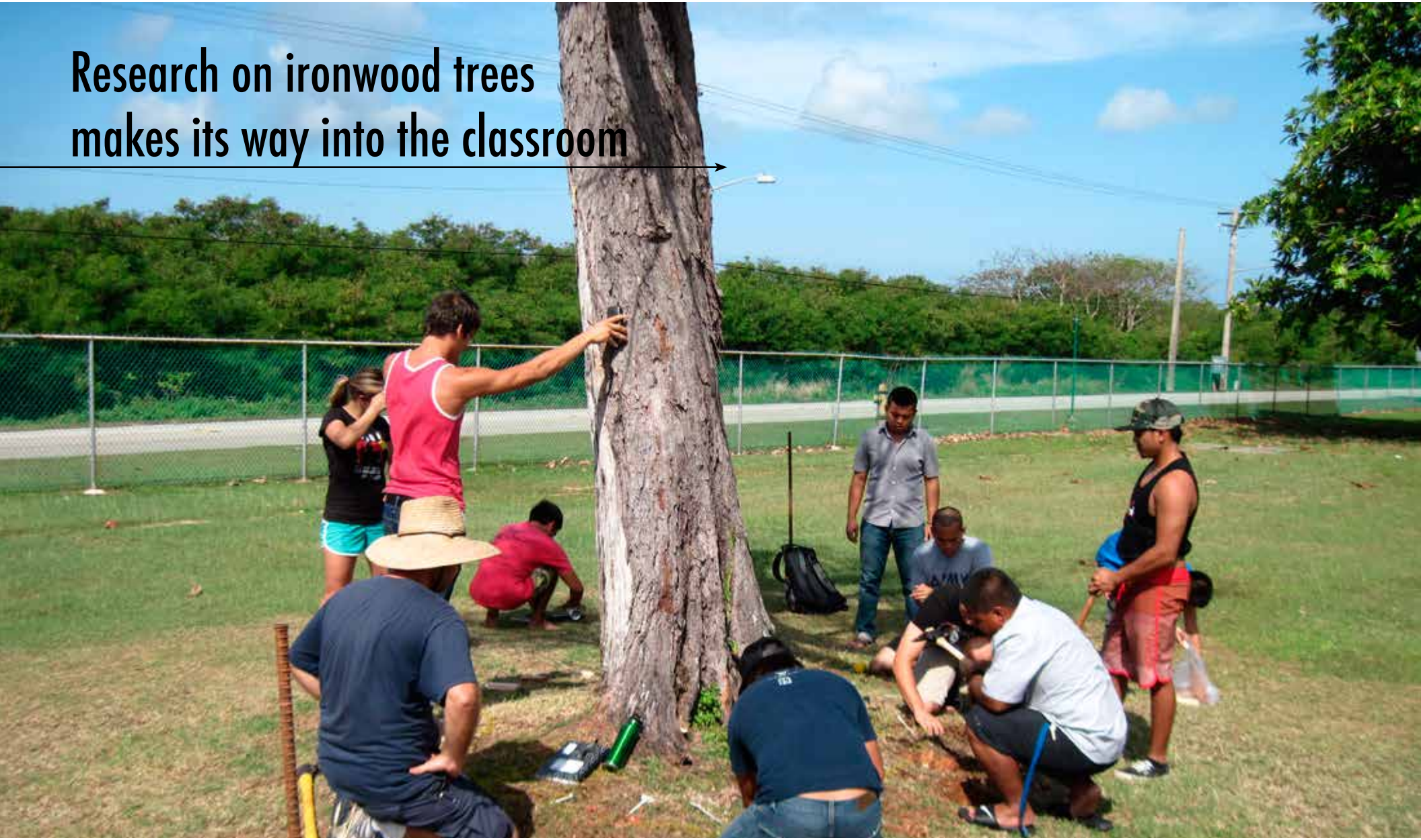
Research on ironwood trees makes its way into the classroom



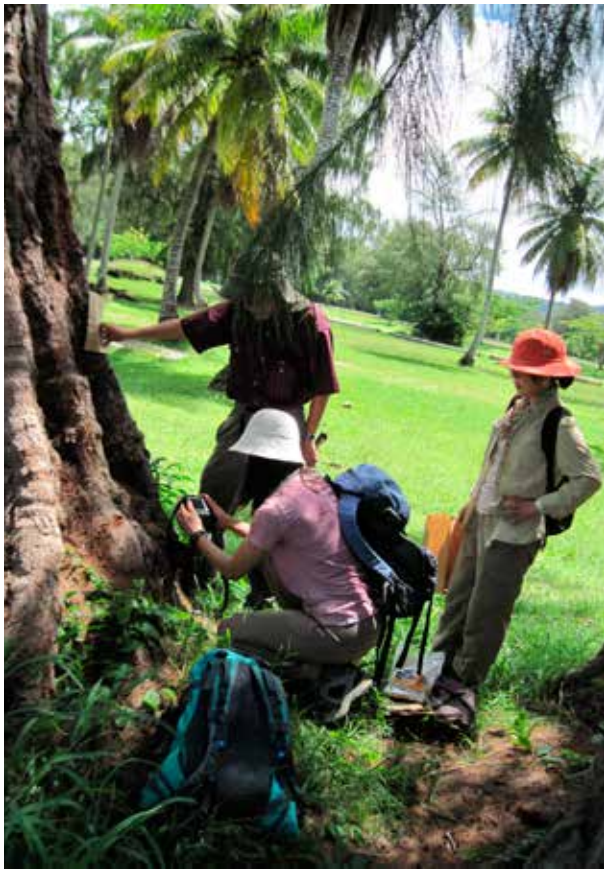
Beginning in 2002, Dr. Robert Schlub began researching the cause or causes of Guam's "sick" ironwood trees. Since this time, researchers and tree specialists from the states of Hawaii, Louisiana, Ohio, Oregon, George, Florida, and the counties of Australia, Japan, and Korea have traveled to Guam and lent their expertise. When ever possible Dr. Schlub has provided opportunities for his students to learn from these individuals.

In the fall of 2014, Dr. Phil Cannon, US Forestry Region 5 forest pathologist, lead an international team of forest pathologists on a tree survey of Guam. Dr. Cannon presented a lecture to Dr. Schlub's Plant Pathology students on butt-rot pathogens and their mode of action. The following day, some of the same students joined the international team in their survey.

Pathology students continued their study of tree pathology, by repeating an experiment conducted by Dr. Schlub's spring 2012 Pest Management students. Using isolates obtained by Dr. Anne Alvarez, while on a visit to Guam, the students were able to demonstrate systemic movement of the pathogenic bacterium *Ralstonia solanacearum* in ironwood seedlings and the lack there of for *Klebsiella* spp. Their results confirmed the findings of Dr. Alvarez's graduate student, Caleb Ayin. In addition, Mr. Ayin found that *Ralstonia* alone was sufficient to cause wilt in tomato and ironwood seedlings and that there were no differences in pathogenicity between *Ralstonia* strains from Guam and Hawaii. These strains also have similar BOX-PCR phylotypes.

"Though termite activity was linked to ironwood decline in 2010, it wasn't until spring 2014 that experiments began to test this hypothesis," said Schlub. As part of his Pest Management course, entomologist Dr. Lee Yudin provided a short lecture on termites and assisted students with a termite experiment. The class successfully baited for subterranean termites on ironwood tree roots, which may contribute to the understanding of the complex factors behind ironwood decline on Guam.

Sources of funding for ironwood decline extension and research activities include various United States government programs (NIFA, RREA, US Forest Service), and Smith-Lever Formula Funds.



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Cyathea lunulata, a tree fern indigenous to Micronesia is one of Guam's rare plants deserving protection.