Western Pacific Tropical Research Center

2018 IMPACT REPORT

College of Natural & Applied Sciences
University of Guam

Buenas yan Hafa Adai,

Simon Sinek once stated, "A team is not a group of people who work together. A team is a group of people who trust each other."

One unique characteristic that makes Western Pacific Tropical Research Center (WPTRC) such an integrated part of our island is that our mission as a land-grant entity requires us to take agriculture research-based studies and refine them so that the public can benefit from its usefulness. I think this year's impact report demonstrates this central theme extremely well. WPTRC is proud to showcase its 2018 research and how it relates to the community that we are honored to serve.

This year we have highlighted projects that portray the diversity of what WPTRC is engaged in not only on Guam but in our Pacific region. Inside you will find articles related to protecting our endangered native plants, rooting out brown rot disease in our limestone forest, and research that contributes to the field of biogeochemistry. We continue to discuss our efforts to control the coconut rhino beetle and keeping freshwater prawns disease free. We are all well aware that the honey bee is essential as a food crop pollinator and yet with the introduction of the greater banded hornet, great concern is taking place among our beekeepers on Guam. With regards to crops growing on Guam, we added articles that deal with improving papaya varieties, kale production and use of biochar in soil fertility. WPTRC, showcases its cycad garden and current studies on Guam's mother tree, *Serianthes nelsonii*. Lastly, but impactful for people who trust each other is the new fitness center constructed with the belief that people's physical health is important for their mental vitality.

I want to personally thank all those individuals who have contributed to the 2018 WPTRC impact report and especially to my administrative staff who set true examples of leadership. Collectively, we are making a difference in the lives and welfare of our community. As a land-grant institution this is a major goal of our team as described by Simon Sinek.

Si Yu'os ma'åse',

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Dean/Director
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Hafa Adai,

In 2018, the Western Pacific and Tropical Research Center (WPTRC) continued to relentlessly address relevant research themes to generate novel scientific knowledge and benefit the environment and the people of Guam and the Western Pacific region.

Research at WPTRC is aimed to 1) sustain, protect, and restore the natural environment, 2) stimulate economic development through sustainable use of resources, and 3) improve quality of life in the Western Pacific. Some noteworthy research to preserve Guam's unique environment includes the Guam Plant Extinction Prevention Program, forest health studies on biotic and abiotic threats to native and introduced tree species, the Guam Forest Inventory Analysis, and extensive work on "geo-health" to reduce chemical pollution, curtail sedimentation in coastal environments, conserve threatened taxa, and improve water quality by reducing the application of synthetic fertilizers and the proper disposal of animal waste. Research on socio-economic alternatives focuses on aquaculture, integrated small-scale farming systems involving simultaneous production of compost, fish, fruits, poultry, and vegetables; disease-free plant propagation, and widened availability of crop genetic resources. Projects emphasizing the enhancement of quality of life in the Western Pacific concentrate on human nutrition and child obesity, food safety and quality, and green roofs (vegetated surfaces on top of buildings).

We thank the American people for funding research at WPTRC through the Hatch, Multistate Hatch, and McIntire Stennis programs administered by the USDA National Institute of Food and Agriculture. Additional funding comes from the National Science Foundation, USDA Animal and Plant Health Inspection Service, USDA Forest Service, U.S. Military, and the private sector. Researchers at WPTRC also teach classes, participate in multiple service efforts, and provide students opportunities to gain research experience.

Faculty, staff, and administrators at WTPRC build upon valuable lessons from the past and an optimistic attitude to the future based on the core values of hard-work, integrity, excellence, and collaboration to develop new initiatives in collaboration with UOG's Cooperative Extension and Outreach, also housed at CNAS, other units of the university, the Guam and U.S. governments, and several entities in Micronesia and beyond. We are proud of being part of WTPRC. We are not an island within an island, and are always open to learn and share knowledge to strengthen local, regional, and global partnerships.

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The beautiful flower of the rare *Serianthes nelsonii* tree, which is called håyun lågu in CHamoru.

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GPEPP keeps endangered native plants safe

The endangered orchid *Bulbophyllum guamense* is found only on the islands of Guam and the northern Marianas.

As the military continues its plans to move 5,000 marines to Guam, the Guam Plant Extinction Prevention Program (GPEPP) is working to relocate and protect numerous native species.

October 2015 saw a number of plant species from Guam placed on the U.S. Endangered Species list. They include five plants known only to Guam: *Eugenia bryanii, Hedyotis megalantha, Phyllanthis saffordii, Psychotria malaspinae*, and *Tinospora homosepala*. Also listed were eight plants, including several orchid species, known only from Guam and the Commonwealth of the Northern Marianas: *Bulbophyllum guamense, Dendrobium guamense, Heritiera longipetiolata, Maesa walkeri, Nervilia jacksoniae, Solanum guamense, Tuberolabium guamense,* and *Tabernaemontana rotensis*.

Close-up view of *Tuberolabium guamense* flowers. This orchid is found in higher elevations in southern Guam and older limestone forests in northern Guam.

One cycad species was also listed, *Cycas micronesica*, which is found only in the Mariana Islands, Yap, and Palau.

To accommodate the influx of military personnel, numerous development projects are occurring in areas where these endangered plants are present. Through mitigation efforts, the Guam Plant Extinction Prevention Program, in collaboration with the Department of the Navy (DON) and a local company, Landscape Management Systems (LMS), have engaged in surveying lands designated for DON development.

GPEPP trained LMS personnel on identifying Guam's U.S. Endangered Species listed plants. They surveyed over five acres of DON land and found three species of endangered plants, *Tuberolabium guamense, Bulbophyllum guamense,* and *Dendrobium guamense*. These orchids live primarily on host trees.

GPEPP and LMS carefully extracted, translocated, and out-planted over 2,000 *Tuberolabium guamense* and all of the *Bulbophyllum guamense* and *Dendrobium guamense* that were discovered. As the project continues, the remaining *T. guamense* still within the extraction site will be removed and out-planted. The out-plant sites were determined by GPEPP and DON as appropriate and protected habitats for the relocation of the endangered plants.

Dendrobium guamense blooms last for only one day. These orchids flower simultaneously several times a year on Guam.

Research on Guam's native plants and ecosystems is one way WPTRC makes a difference for the people and ecosystems on the island.

Funded by the Department of the Navy

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The many branches of recovery

The only mature håyun lågu on Guam is located in a northern limestone forest on Andersen Air Force base property.

Serianthes nelsonii is currently represented on Guam by one lone mother tree. On the island of Rota, located north of Guam, fewer than 50 mature trees can be found in the wild. *S. nelsonii* has long been considered rare on both islands, and was placed on the U.S. Endangered Species list in 1987.

This large tree is believed to be endemic to the Marianas on the islands of Guam, where it is known as håyun lågu, and Rota, where it is called tronkon guåfi in the CHamoru language. Håyun lågu is often translated as "northern tree", which may indicate the tree was rare or more common in the northern part of the island. Tronkon guåfi means "fire tree", perhaps because the forest canopy looks like it is on fire when the bright pink flowers are in bloom.

On Rota, beautiful tronkon guåfi flowers turn the forest canopy into a fiery blaze when they bloom.

The good news for *S. nelsonii* is that the WPTRC, through the Guam Plant Extinction Prevention Program (GPEPP) and other research, has been instrumental in ongoing recovery efforts. Working in collaboration with the Guam Department of Agriculture, USDA, US Fish and Wildlife Service, Department of Land and Natural Resources (CNMI), US Forest Service, and US Department of Defense Cooperative Ecosystems Studies Unit, seeds are collected, stored, and sprouted. Seedlings are cared for in the GPEPP nursery before outplanting.

About 200 håyun lågu plants have been planted in the field and are individually protected by a netting system to deter damage by the caterpillars of three-spot grass yellow butterfly, *Eurema blanda*. These small butterflies lay their eggs on *S. nelsonii* plant parts and the gregarious larvae feed on the leaves, seriously defoliating the plants.

All plants have been geographically marked and documented by Global Positioning Systems (GPS). Their health is monitored and pests and diseases are identified and treated with approved methods. Plants are also fertilized and receive supplemental watering as needed in the dry season. GPEPP personnel monitor the outplantings monthly.

Hopefully, the end result will be more mature *Serianthes nelsonii* flourishing on Guam in the future.

The butterfly *Eurema blanda* is laying its eggs on the leaves of håyun lågu. The voracious caterpillars defoliate the endangered trees.

Funded by Department of the Navy

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Beekeepers are keeping watch

Originally from Asia, the greater banded hornet, *Vespa tropica*, is causing great concern among Guam beekeepers. First recorded on Guam by the University of Guam Entomology Lab on July 12, 2016, it is unclear how the hornet came to the island or exactly when it arrived.

UOG graduate student and president of the Guam Beekeepers Association, Chris Rosario, meets regularly with beekeepers around the island and many have reported seeing the greater banded hornet kill bees, and in several instances, wipe out entire hives.

"When Master Beekeeper Paul Packbier opened a hive under attack by the hornet, he found over 30 hornets inside the hive. All the bees were dead," said Rosario, "We have been experimenting with our own trap designs, which not only exclude the hornet but also trap them while allowing bees to enter the hive." Rosario is currently developing a grant proposal to fund the management of *Vespa tropica*.

Packbier is on the warpath. He keeps a yellow fly swatter by the door of his office, where a beehive sits just outside his window. When he sees a hornet checking out the bees he grabs the swatter, runs outside and dispatches it. Although it does feel good to swat the hornet, he knows this is not very effective. He has designed and is experimenting with a prototype hornet trap. "After doing some research I found that beekeepers in Europe have issues with hornets as an invasive species and have been working on effective traps. Unfortunately, a company that has developed a promising design does not ship to Guam, so I am in the process of designing a trap for use here. The most heartbreaking evidence of the greater banded hornet's destructive impact is seeing the mostly empty combs of feral (wild) beehives around the island. Without the relative protection of the wooden hives we beekeepers provide, the bees are defenseless and the hornets can wipe out a colony in a matter of days," lamented Packbier.

Beekeepers on Guam are bringing attention to what happens when an alien species enters an island ecosystem. Without much notice by most people, it appears that the hornet has been busy preying on the small paper wasps called "boonie bees" on Guam and also the feral bees. Now the hornets are attacking local beehives. "We really do not know much about native bee populations on the island, so it is difficult to know the effect this hornet is having on the environment," noted UOG entomologist Ross Miller. He feels strongly about the need to study and catalog native bee populations.

One thing is certain, it is much cheaper to keep invasive insects and plants from entering the island's ecosystems than it is to control them once they have arrived.

Greater banded hornet experimental trap designed on Guam by Master Beekeeper Paul Packbier.

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CRB research has gone global

Jim Grasela

University of Guam entomologist, Aubrey Moore, continues to look for a solution to the coconut rhinoceros beetle (CRB) that is killing Guam's palm trees. He believes the best way to control the beetle population is through infecting them with a virus called *Orcytes rhinoceros nudivirus (OrNV)*, which attacks only rhino beetles.

Years ago, *OrNV* was introduced into rhino beetle populations on many Pacific islands, which had been invaded by CRB and the damage they caused disappeared. Unfortunately, the CRB population, which is rapidly killing coconut palms on Guam and elsewhere in the Pacific is resistant to *OrNV* strains that worked in the past.

Finding a viable virus effective for the beetle biotype on Guam is imperative. To that end, he recently hosted two research entomologists from Japan who are virology experts. Professors Madoka Nakai and Shin-ichiro Asano were returning to Japan from a CRB fact-finding trip to Palau and stopped in Guam for four days to have a better understanding of the issue on Guam.

"While in Palau, we did detect the virus in beetle DNA, but we found no indication of infection," said Nakai. This was disappointing news to Moore, but the good news is that these scientists will be collaborating to find a solution to control the destructive beetle on Guam.

Left: Collaborating entomologists pose in front of coconut trees damaged by CRB. L to R Aubrey Moore, Madoka Nakai, Jim Grasela, Shin-Ichiro Asano.

Nakai is excited by the possibilities of this research, "We are asking important questions, such as what size a beetle population must be to cause the devastating damage we see on Guam? How are the beetles resisting the virus? What are the differences between the Guam biotype (CRB-G) and other biotypes?" With funding from the Japan Society for the Promotion of Science (JSPS), Nakai proposes to import CRB-G from Guam as well as beetles not of the Guam biotype and breed them in the lab to undertake basic biology studies and possible crossbreeding to understand what the mechanism is that helps them resist viral infection.

"We are working with a Pacific-wide collaboration of scientists trying to solve this problem that is critical for Pacific Islanders. Researchers from Guam, New Zealand, Malaysia, Japan, Papua New Guinea, and the Solomon Islands are united in their efforts to find a virus that can be used to control be lethal to the coconut rhinoceros beetle beetles before we lose most of our palms and to stop it spreading to more islands," stated Moore.

Funded by USDA-APHIS and Department of the Interior-Office of Insular Affairs

Painting of a third-instar coconut rhinoceros beetle larva by Guam artist Nina Peck.

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Looking for signs of the perfect virus

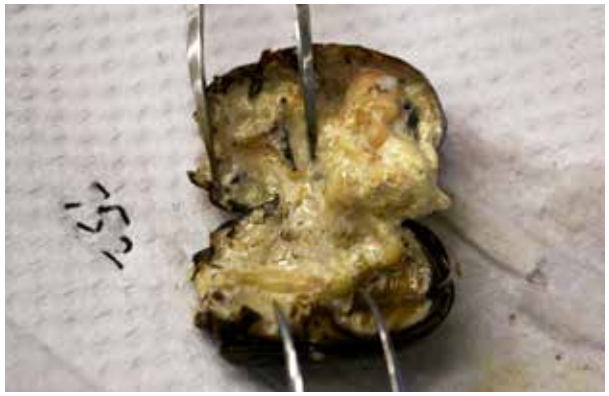
The *Orcytes rhinoceros nudivirus (OrNv)* was first found in Malaysia. Currently, A, B, and C strains are known there, of which the B strain is the most deadly for coconut rhinoceros beetles (CRB) and their larvae. Researchers in Malaysia are conducting studies to replicate the B strain as an integrated pest management solution for palm oil growers who are losing a substantial percentage of young palms to the voracious beetle.

To find the *Orcytes rhinoceros nudivirus* in an infected rhinoceros beetle, the process is tedious and can be an assault on the olfactory system. Since the virus duplicates in the midgut of the adult beetle, the beetle must be dissected and the midgut removed and examined, hence the unpleasant odor.

At the WPTRC CRB laboratory, post-doctoral Research Associate Jim Grasela is dissecting beetles daily. The process involves first finding a dead beetle or waiting for one to die. The dead beetle is decapitated and dismembered. Once the legs are removed, the exoskeleton is cut open to expose the digestive system and other organs. Shifting through the exposed tissue Grasela locates the gut and carefully removes it.

"Infected gut tissue looks swollen and white in color as opposed to healthy tissue, which appears brown and thin," said Grasela. He pops the gut tissue into a tube with formalin

The exoskeleton is cut open to expose the digestive system and other organs.



The midgut is carefully removed and sent for study to AgResearch, New Zealand.

to be sent to AgResearch, New Zealand, where scientists study the virus. They will run PCR tests to see whether the virus is present and determine the virus strain.

This search for the virus is vitally important. It is necessary to find a beetle that has died from infection by the virus in order to have the appropriate virus strain that will be lethal for the Guam biotype of CRB.

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Orchid team makes Guam more beautiful

"In an orchid workshop I found out that of seven orchids in my garden, only one is virus free. This is sad news, but the good news is that I can trade out my sick plants for healthy, virus-free orchids," said local Guam resident Vera De Oro. She recently completed an orchid tissue culture class at the Guam Department of Agriculture (DOA).

"I'm impressed with the fine work DOA is doing with its orchid tissue cell propagation project. Kamile Wang is opening my eyes to the hidden world of orchids," enthused De Oro.

The tissue culture laboratory and nursery is indeed a very unique place. The public can bring their sickly-looking orchids and exchange them, free of charge, for healthy *Phalaenopsis* or *Dendrobium* seedlings or mature plants.

The tissue culture team has one full time employee, Alexander Chingyan, and a part time tissue culture assistant Kamile Wang. They are both experienced in growing orchids and bananas in vitro and in the nursery. The lab also hires and trains several students every year. Presently, Alyanna Del Rosario and Jaena Taitagua work part time at the lab. Edwina Chiroo joined the team recently, and she has a lot of enthusiasm for working with orchids.

Left: Tissue culture lab team L to R: Kamile Wang, Ricardo Lizama, Alicja Wiecko, Jaena Taitagua, Alexander Chingyan, Alyanna Del Rosario, and Edwina Chiroo.

Ricardo Lizama from DOA and Alicja Wiecko from the University of Guam started this project, "Growing disease-free orchids on Guam", in 2013. Their work has been presented at many conferences including the American Society for Horticultural Sciences and last year at the 22nd World Orchid Conference in Guayaquil, Ecuador.

At the DOA laboratory, new orchids are propagated from disease-free orchids previously tested for two common viruses, *Cymbidium* mosaic virus and *Odontoglossum* ringspot virus. These viruses infect more than 60% of local orchids and 30% of imported orchids.

When visitors come to the nursery they will find thousands of orchid seedlings planted in small pots and hundreds of medium-size and mature orchids growing in larger pots. Some orchids have already produced seedpods, which are ready to propagate on a special medium where they will eventually germinate.

In the laboratory growth room shelves are crammed with hundreds of containers holding miniature *Phalaenopsis* and *Dendrobium* seedlings growing on agar. The tiny plants produced by the tissue culture team are free of viruses. WPTRC is doing its part to make Guam beautiful.

Funded by USDA Agriculture Marketing Service

Tissue-cultured orchid plantlets in the lab before planting in the nursery.

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Partulid populations in Guam and Rota

Professor G. Curt Fiedler's lab continues to focus on the conservation of native tree snails on Guam and in the Commonwealth of the Northern Marianas Islands. Biology graduate student, Megan Volsteadt, is investigating population level differences in the fragile tree snail, *Samoana fragilis*. Her research is supported by a McIntire-Stennis grant.

There are five known populations of this endangered snail species on Guam. They can be found at Hilaan, Pugua Point, Sella Bay, Marbo Cave, and San Carlos Falls. These populations are distant from each other and small, ranging in size from 30 to 140 individuals. The fragile tree snail is also reported from Rota, and is still found at a single location on the mountain slope of southern Talakhaya.

Small populations are likely to diverge genetically over time, particularly when they are isolated. Both Fiedler and Volsteadt predicted that the genetic divergence of Guam *Samoana fragilis* would be small, compared to differences between any Guam population and the lone Rota population.

They collected DNA samples from snail slime from all six populations and Megan later amplified sequences of COI, a mitochondrial gene, for molecular comparisons. Megan's preliminary data indicates few differences, if any, between populations.

The Rota snails COI differed slightly from most populations of Guam snails, but were nearly identical to the San Carlos Falls population.

Pictured above and left are *Samoana fragilis* snails on the island of Rota. The snails on Rota tend to grow larger than their Guam counterparts, but research shows the genetic differences are minimal.

This was a surprise, as Rota *S. fragilis* reach larger sizes (>2mm difference) than their Guam counterparts. Furthermore, Rota has its own endemic partulid snail, suggesting the possibility of genetic isolation for *S. fragilis*.

The conservation implications of these results are, that despite isolation, populations of these snails are evolving very slowly. Their ability to adjust to changing environmental conditions (*e.g.,* climate change or non-native predators) may be constrained. These factors must be evaluated for the proper management of this species and development of a recovery plan to ensure their long-term survival.

Funded by USDA NIFA McIntire-Stennis

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Rooting out brown root rot disease in Guam's limestone forests

Fungi are not always nice guys. Take *Phellinus noxius,* an aggressive pathogen known to cause a disease referred to as brown root rot. This disease has been detected in over 200 species of trees across 59 families throughout the Asia-Pacific region and as far west as the Arabian Sea. Brown root rot has been known to exist on Guam for at least the past 25 years but rarely seen. This changed after a group of forester surveyors attended a UOG seminar about *P. noxius* in 2013 and then began looking for it in Guam's limestone forests. Within a few weeks three trees species were found infected at several locations, the most common species being the local Paipai or *Meiongyne cylindrocarpa* (formerly known as *Guamia mariannae*).

The characteristic brown or black sock at the base of the tree is distinctive of brown root rot, but this symptom may present differently in various tree species. Many trees will exhibit this distinctive symptom while some exhibit patches of brown, crusty rot all along the trunk and roots. This pattern can be seen on banyan trees.

Phellinus noxius begins its growth on the outer surface of roots and stems then invades and rots the wood beneath. The most common way for *P. noxius* to spread is when the roots of healthy trees contact roots, stems, or stumps of infected trees. Less common, but can result in spread over large distances, is when spores produced by the fungus are carried by air currents. Brown root rot is expected to increase this year as a result of tree woundings from recent storms that passed near Guam: Tropical Storm Maria, Typhoon Mangkhut, and Typhoon Yutu.

One of the main pathways of infection *by Phellinus noxius*, as well as other fungi, is by entering via wounds or tree injuries. Damage caused by typhoons, and even tropical storms can leave trees susceptible to attack by fungal pathogens such as *P. noxius*. Wounds on trunks and branches expose tissue to infectious spores while wounds at the tree base or below ground expose tissue to infection through contact with roots of diseased trees. Even a diseased tree knocked over in a storm poses a threat to neighboring trees as the fungus grows out of the rotting tree into the soil in search of live, healthy trees to infect.

Since 2013, there has been a concerted effort by researchers to gain a deeper understanding of brown rot root in the Pacific region. Preliminary conclusions from an on-going genetic diversity study identified three distinctive groups of *P. noxius*: (1) American Samoa, (2) Eastern Asia (Hong Kong, Malaysia, Taiwan, Japan), (3) Australia and Pacific islands (Guam, Saipan, Palau, Yap, Pohnpei, Kosrae, Japan, Taiwan). Extension assistants working with Dr. Schlub will be collecting soil samples from healthy and infected tree in the Anao limestone forest in northern Guam for an on-going soil metagenomic study at the University of Colorado.

Funded by US Forest Service

On this Guam tree, signs of *Phellinus noxius* can be seen as a characteristic brown sock, which begins at the base of the trunk and extends upwards.

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Biochar traps carbon in soil

Biochar is an organic material that is rich in carbon. It is created through a process called pyrolysis, which involves heating biomass in a special oven that eliminates oxygen. Studies have shown that using biochar as a soil amendment can trap carbon dioxide and keep it in the ground. This carbon storage capacity is known as carbon sequestration.

Greenhouse gases (GHG) including carbon dioxide, which result from the burning of fossil fuels, contribute to climate change and the resulting extreme weather events that come with a warming planet. Attention to carbon sequestration is significant, as a major source of carbon dioxide emissions into the atmosphere comes from soil.

The two chief sources of carbon dioxide in soil are organic carbon that results from the decomposition of plant material and carbon dioxide that results from microbial activity. Microbes living in soil break down dead plants and animals and release carbon dioxide through respiration. Once the soil surface is disturbed, carbon dioxide is released into the atmosphere.

"We have been experimenting with comparing the carbon storing capacity of biochar with compost as soil amendments," explained soil scientist Mohammad Golabi. He and graduate student Chieriel Desamito conducted trials to identify ways to maximize carbon sequestration in Guam soil types. Using three different treatments to amend the soil in experiment plots, biochar, compost and a mixture of biochar with compost, measurements were made of carbon dioxide released from the soil for each treatment. Preliminary results have shown that only the pure biochar treatment resulted in preventing the release of carbon dioxide.

In experimental plots at the Ija Research and Education Center, Dr. Golabi installs a gas capture chamber where sodium hydroxide is used to capture carbon dioxide from the soil.

Graduate student Chieriel Desamito places a beaker filled with sodium hydroxide into to pipe to capture carbon dioxide emissions from experimental plots.

Biochar has the added benefit of improving soil quality. Plots treated with biochar and compost produced healthy crops with higher yields compared with plots amended with only compost or biochar treatments. Biochar also succeeded in maintaining and preserving soil quality.

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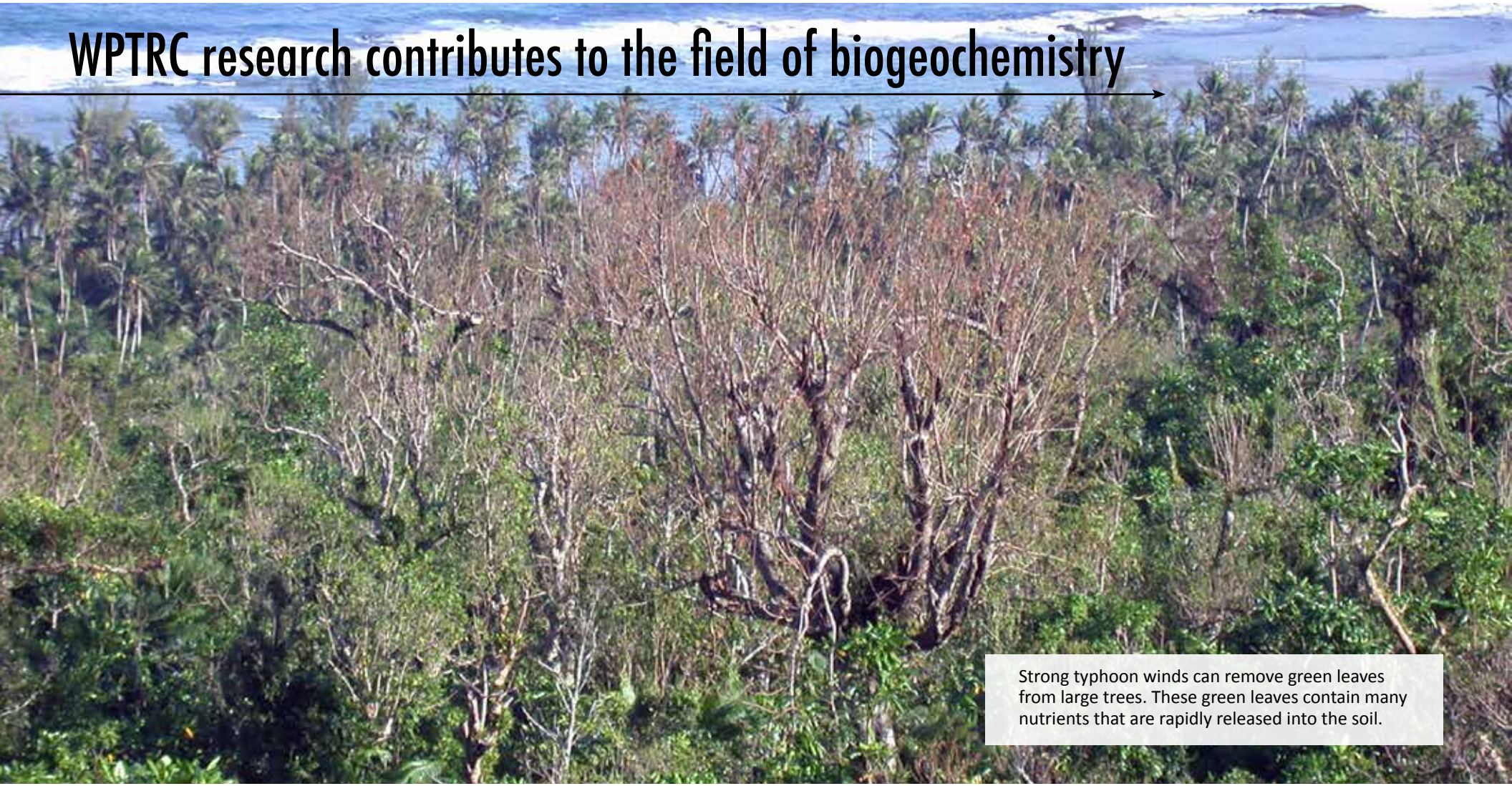
WPTRC research contributes to the field of biogeochemistry



Strong typhoon winds can remove green leaves from large trees. These green leaves contain many nutrients that are rapidly released into the soil.

Research programs at the University of Guam are designed to increase knowledge concerning local issues. At times these issues are unique to our island, but sometimes opportunities arise where local research contributes to a global agenda. Dr. Thomas Marler's laboratory has been actively studying how plants fit into ecosystem cycles in an effort to contribute to the global biogeochemistry agenda.

"Biogeochemistry is a discipline that looks at living and non-living processes that govern the chemical composition of the natural environment," said Marler. His research has been based in Guam, Commonwealth of the Northern Mariana Islands, and Philippines, and has focused on the role of native trees in the cycling of chemical elements through space and time.

The concepts of biogeochemistry can be visualized in three spheres of diminishing size, with each smaller sphere imbedded within the larger spheres. The largest sphere is comprised of all the material and energy processes of the world. The second sphere is the biosphere and contains all living processes within the world. The smallest sphere is the human sphere, where decisions made by the human element of the biosphere modify the processes within the larger spheres.

"I have been delving into how background biogeochemical cycles are disrupted by human-induced perturbations," said Marler. "I believe it is incumbent on us to learn as much as possible about how our decisions and behaviors are modifying the living and non-living processes of Guam and the region." Human influence has never been as profound as it is today. The WPTRC research has focused on how typhoons and invasive insect pests modify the contributions of trees to the chemical cycling that occur in the surface layers of the soil. Human decisions are

A female cycad blue butterfly arches her body to deposit an egg on a cycad leaf. This butterfly invaded Guam in 2005 and immediately began damaging Guam's native *Cycas micronesica* trees. The chemistry of partially eaten leaves is changed, which leads to more rapid nutrient turnover in the forest.

responsible for the many damaging insects that invade regional islands every year. Human activity is changing the climate, and one of the predictions is more of the regional typhoons will be intense in the future.

A common thread through all of Marler's research is that the natural turnover of carbon and minerals will become more rapid as invasive insects continue to damage native trees and as typhoons defoliate the forests on a more frequent basis. These changes are poised to modify numerous aspects of ecosystem function, such as species interactions and contributions of regional forests to atmospheric carbon dioxide concentrations. Research groups in many universities around the world are actively studying biogeochemistry, and Guam is contributing to this global agenda through Marler's WPTRC research.

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FURTHER READING

Marler. 2018. *International Journal of Insect Science* 10:1. DOI:10.1177/1179543318797329.

Marler. 2018. *Horticulturae* 4: 9. DOI:10.3390horticulturae4020009.

Marler & Krishnapillai. 2018. *Forests* 9:565. DOI:10.3390/f9090565.

Marler & Dongol. 2016. *Communicative & Integrative Biology* e1208324. DOI:10.1080/0889.2016.1208324.

Marler & Ferreras. 2015. *Journal of Geography & Natural Disasters* 5:1421-1427. DOI:10.4172/2167-0587.1000142.

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UOG's new cycad garden

Botanic gardens serve a variety of functions around the world. Not only are they aesthetically pleasing, but they also participate in conservation, education, and outreach. Visiting public gardens also boosts health and well-being, especially for people who live in cities. Guam does not have an official botanic garden. With the number of invasive insect species entering the island annually, and the number of rare endemic and indigenous plants that have been the victims of these insects, a botanical garden could serve as a platform for education and conservation. The WPTRC has addressed these issues with the recent construction of a cycad garden.

The goal of the project was to create an aesthetically pleasing garden on the campus of the University of Guam highlighting the world's major cycad groups while at the same time raising awareness of their ongoing threats. Although under-utilized in Guam's landscapes, many cycad species have displayed robust growth in 15-year-old specimens planted at WPTRC's research and education centers. The UOG garden project started two years ago with the layout designed by Research Associate Benjamin Deloso and Professor Thomas Marler.

Cycads in the wild are mainly distributed near the equator, with centers of diversity in Australia, Southeast Asia, Africa, the Caribbean, and Central and South America.

Benjamin Deloso and Frankie Matanane care for a *Microcycas calocoma* planted in UOG's cycad garden. This species is endemic to the island of Cuba and is one of the most threatened cycads globally.

Through a visit to UOG's cycad garden, one can "travel" around the world and back in time and see the major cycad groups, starting with Australia and ending up in the Americas.

Cycads comprise the world's most threatened plant group, with over 60% of all species threatened with extinction. They are a resilient group of plants that have been on Earth for over 250 million years, living alongside dinosaurs and surviving global mass extinctions. Due to their unique place among the living plants, they are of great interest to botanists and horticulturists alike. Certain cycad species are so rare, they are completely extinct in the wild. Some of the causes of their current decline include habitat destruction, deforestation, and poaching.

Since humans are primarily to blame for the contemporary decline of cycads, this means that the responsibility of preserving these special plants also falls on humans. Guam's native cycad, locally known as the fadang, was once the most abundant tree on the island. The accidental introductions of several insect pests were caused by human activity, and now this species is threatened with extinction. Marler's research over the last 15 years has focused on various aspects of cycad trees in Guam, Philippines and in Thailand.

"The real treat was including a rescued plant of the native cycad, *Cycas micronesica*, in the garden," said Deloso. "The garden is showcasing the beauty of a native tree species while at the same time raising awareness of its ongoing threats."

Funded by USDA NIFA Hatch

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Focus on kale

Nutrition Facts

Serving Size: 100 g

Amount Per Serving	
Calories 50	Calories from Fat 6
	% Daily Values*
Total Fat 0.7g	1%
Saturated Fat 0.091g	0%
Polyunsaturated Fat 0.338g	
Monounsaturated Fat 0.052g	
Cholesterol 0mg	0%
Sodium 43mg	2%
Potassium 447mg	
Total Carbohydrate 10.01g	3%
Dietary Fiber 2g	8%
Sugars -	
Protein 3.3g	
Vitamin A 308%	Vitamin C 200%
Calcium 14%	Iron 9%

* Percent Daily Values are based on a 2000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

Originally from the Mediterranean region, kale, *Brassica oleracea*, is currently grown worldwide for its high vitamin content and eaten both raw and cooked. Growing green leafy plants in the tropics can be problematic, as insect pests abound in the warm environment.

Extension Horticulturist Joe Tuquero, with agriculture student Tanielle Terlaje, conducted experimental trials on four varieties of kale, which included Beira (F1 Hybrid), Redbor (F1 Hybrid), Scarlet, and Starbor (F1 Hybrid). After growing in plant trays for 22 days, seedlings were transplanted into the Guam cobbly clay loam soil in fields located at the WPTRC Yigo Research and Education Center in northern Guam.

A major insect pest that attacked all the varieties in this study was the larvae of *Hullula undalis*, the cabbage webworm. This pest is detrimental to crop yields as it feeds on all parts of kale plants. According to Extension Associate Jesse Bamba, surrounding the kale fields with trap crops like mustard and collard may reduce the infestation of cabbage webworm larvae. In the trials, Tuquero applied a biological pesticide with the active ingredient *Bacillus thuringiensis v kurstaki* twice weekly to control the cabbage webworm. In the end, this aggressive pest severely hindered the growth of 17% of total plants in the field.

A cabbage webworm larva feeds on the kale variety Starbor.

The results of the field trials found the variety Beira grew more vigorously than all other varieties. Starbor and Redbor cultivars performed fairly well with Scarlet showing the poorest average growth. Due to the damage caused by the cabbage webworm, only 50% of the total harvested plants were labeled as marketable.

Kale is potentially a good choice for backyard growers and commercial farmers on Guam. In choosing seeds, it is important to look for varieties that are heat tolerant. Common cabbage family pests like the cabbage webworm will likely require intense control measures to reduce pest damage and maintain quality marketable yields.

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Cultivar	Mean weight per plant (g)	Percentage of marketability
Scarlet	62	25
Beira	466	25
Redbor	189	100
Starbor	240	50

Yield data of kale cultivars grown in Guam cobbly clay loam soil April 25 to June 7, 2018.

Field plot of kale varieties used in this study.

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Keeping freshwater prawns disease free

Macrobrachium rosenbergii (de Man), the giant freshwater prawn, is the largest and most popular palaemonid freshwater prawn cultured worldwide, even though its origins are the tropical and subtropical rivers and estuaries of the Indo-Pacific region. Global production of cultured *M. rosenbergii* reached 230,000 metric tons in 2016, which was valued at 1.9 billion US dollars according to a 2018 FAO report.

Disease outbreaks caused by various infectious pathogens have been the most significant threat to global prawn farming and will remain a major constraint in the near future. Currently, there is no effective cure available once animals become infected. Therefore, emphasis on biosecurity and the utilization of specific-pathogen-free (SPF) seed stock are of the utmost importance in order to overcome this limitation and expand the freshwater prawn aquaculture industry. Dr. Hui Gong Jiang and her team are closely monitoring and keeping the prawn stock at the UOG hatchery free of major shrimp/ prawn diseases.

Several viral diseases have originated from *M. rosenbergii.* A few of the most catastrophic prawn diseases are white tail disease (WTD) caused by *M. rosenbergii nodavirus* (MrNV) and extra small virus (XSV). Other aetiological agents include macrobrachium muscle virus (MMV) resulting in muscle necrosis, hepatopancreatic parvovirus (MrHPV) affecting the digestive tract, and recently *M. rosenbergii* Taihu virus (MrTV).

There are also pathogens that have originated from other domestic aquatic species and have been transmitted to freshwater prawns and lead to disease outbreaks. These emerging prawn diseases include penaeid shrimp pathogens such as infectious hypodermal and hematopoietic necrosis virus (IHHNV), white spot syndrome (WSSV), shrimp hemocyte iridescent virus (SHIV), covert mortality nodavirus (CMNV) and enterocytozoon hepatopenaei (EHP). Moreover, *Spiroplasma eriocheiris*, the causative pathogen for trembling disease in Chinese mitten crabs was recently found in *M. rosenbergii*. In addition, *Cherax quadricarinatus* iridovirus (CQIV), a crayfish virus, was added to the disease watch list for freshwater prawns. Specific information regarding prawn viruses can be found in the table below.

Virus	Virion Size	Nucleic Acid	Type	Infected Tissues
MrNV	26 nm	ssRNA	Nodavirus	Muscle
XSV	15 nm	ssRNA	Unknown	Muscle
MMV	23 nm	ssDNA	Parvovirus or Picornavirus	Muscle
MrHPV	25-30 nm	ssDNA	Parvovirus	Hepatopancreas
MrTV	25-29 nm	ssRNA	Dicistrovirus	Cuticle epithelium, collective tissue, ganglion
MnRV	60 nm	dsRNA	Reovirus	Hepatopancreas
CQIV	150 nm	dsDNA	Iridovirus	Connective tissues, Gills
SHIV	159 nm	dsDNA	Iridovirus	Hematopoietic tissue
WSSV	130 x 350 nm	dsDNA	Nimavirus	Cuticular epidermis, connective tissue and lymphoid organ
IHHNV	20nm	ssDNA	Parvovirus	Hepatopancreas
CMNV	32nm	ssRNA	Nodavirus	Hepatopancreas

Funded by USDA NIFA Hatch

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Improving papaya varieties for Guam's fresh markets

UOG undergraduate Tristan V. Paulino learns how to produce directed out-crosses and self-crosses in papaya for breeding and seed production programs.

Papaya is a popular fruit in Guam and can be found in many residential gardens and roadside scrub forests. Papaya fruit is highly nutritious, and the trees can start producing fruits in as little as nine months given optimal conditions. Many nutrition education and sustainable agriculture programs in Guam include papaya for these reasons. Therefore, the number of local residents who want to grow their own papayas is increasing. Almost all backyard growers purchase seeds or seedlings from local nurseries and hardware stores, but these are papaya varieties imported from Taiwan and are not specifically adapted to Guam's environment and consumer preferences. As a result, many of these young papaya trees soon succumb to diseases such as papaya ringspot and Erwinia rot, reducing the tree's fruit production, fruit quality, and eventually killing the tree.

Above left, a papaya crown killed by an infection of Erwinia rot. At right, a developing stem canker from Erwinia rot. This papaya tree may survive the initial infection but the integrity of the tree in strong winds is compromised.

Dr. Andrea L. Blas has re-started Dr. George Wall's (WPTRC, retired) program to create improved varieties of papaya targeted for Guam's environment and consumer preferences. Erwinia rot and papaya ringspot diseases are endemic in Guam, meaning they are always present at low levels but some years their incidence increases when environmental conditions are optimal for disease development or spread. These are two diseases for which the Taiwanese papaya varieties do not have genetic resistance or tolerance, however, our local Guam landraces of papaya do. Landraces are varieties of domesticated animal or plant species that have adapted to their local, natural environment over a long period of time. But the local landraces lack the fruit quality traits that the Taiwanese papaya varieties offer. Since 2016, Dr. Blas has produced directed crosses resulting in about a dozen new hybrid lines that are now under evaluation for uniformity, disease tolerance, and fruit quality. These hybrids between local landraces and imported varieties from Malaysia, Indonesia, Thailand and Hawaii will eventually lead to new commercial varieties that possess the fruit quality traits preferred by our local papaya consumers, the disease tolerance/resistance needed for our local environment, and true-to-seed reproduction for sustainable agriculture.

The first of these hybrid papaya trees is planned for release at the 2019 University of Guam Charter Day. Dr. Blas is now planning with the Research Corporation of UOG and the Small Business Development Center to create a student-run, seed-production company to allow UOG Agriculture & Life Sciences students to produce, market and distribute seeds for these new hybrids and varieties.

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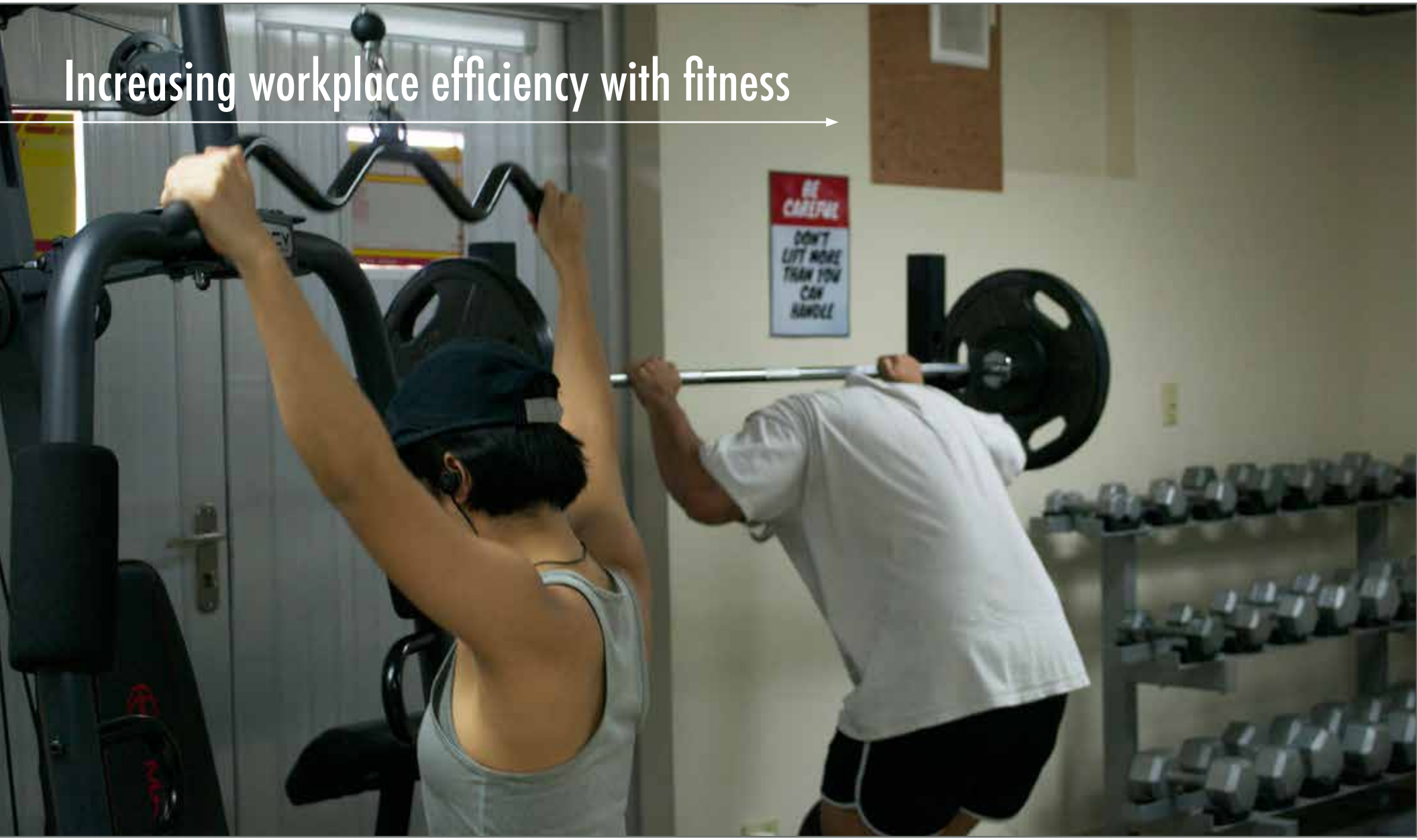
Increasing workplace efficiency with fitness



In his valedictorian speech in May 2017, mathematics major Russell Lee said, "Just keep learning. Just keep moving forward. That's how life works." Lee's drive to move forward was a factor in his success in losing weight while working as an adjunct mathematics instructor. "When I first started going to the gym, it wasn't to lose weight, it was just to be active to live healthier. As I started to go to the gym more and more, I changed my diet as well and saw a lot of progress. If it weren't for the Dean putting the mini gym together, I probably would have never started to change my lifestyle. It was one of the best decisions I've made."

Dean Yudin repurposed a small, under utilized classroom to make it easier for staff and faculty to find time to exercise. His idea was to encourage people to exercise by eliminating drive time to a private gym or the need to use the main campus fitness center where faculty may find themselves working out next to young students, a potentially daunting undertaking for those middle aged and above.

Administrative Assistant Julie Pangelinan lost 16 pounds from exercising in the CNAS fitness room. More importantly, with regular exercise she no longer needed to take four types of medication she had been on to manage high blood pressure, diabetes and high cholesterol. Annie Santos, administrative secretary to the dean, has lost 15 pounds. "I really noticed with regular exercise how much more energy I had and how much better I felt overall after

CNAS staff members Julie Pangelinan and Annie Santos work out regularly together. Pangelinan was able to come off of four medications after she began her exercise program at the fitness center.

exercising. It has become my Friday afternoon ritual before going home," said Santos. Adjunct math instructors Charlotte Mercado and Rodney Teria (at left) enjoy working out together and with other instructors. "It has been a bonding experience to work out in this room. CNAS has been our home through our undergraduate years and now as instructors. We have fun and do much more exercise than if we went to a gym alone," said Teria.

"Never in my wildest expectations could I have imagined what has taken place for CNAS faculty and staff after 12 months of the fitness center becoming operational. Personally, I run on the treadmill 20 kilometers a week, I am 22 pounds lighter, and down from a size 36 to a size 32 pants," enthused Yudin, the man that made fitness a priority for himself and his employees.

Funded by TLC

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2018 Selected Publicat

Ansari, A., M.H. Golabi. 2018. Prediction of special land use changes based on LCM in a GIS environment for Desert Wetland – a case study: Meighan Wetland, Iran. International Soil and Water Conservation Research Journal. DOI.org/10.1016/j.iswcr.2018.10.001.

Butel, J., C.R. Nigg, C.J. Boushey, K.L. Braun, J. Davis, R.T. Leon Guerrero, A. Bersamin, P. Coleman, T. Fleming, R. Novotny. 2018. What Supports and Hinders Community Intervention Success? A Cross-Case Study of the Children's Healthy Living (CHL) Program. *Journal of Nutrition Education and Behavior*. DOI:10.1016/j.jneb.2018.04.165.

Dongol, N. and T.E. Marler. 2018. Season and frequency of *Cycas micronesica* leaf and reproductive events. *Memoirs New York Botanical Garden*. 117:497-503. DOI:10.21135/893275389.031.

Freedman, M.G., R.H. Miller, H.S. Rogers. 2018. Landscape-level bird loss increases the prevalence of honey-dew-producing insects and non-native ants. *Oecologia* OECO-D-18-00198R1.

Gawel, A.M., H.S. Rogers, R.H. Miller, A.M. Kerr. 2018. Contrasting ecological roles of non-native ungulates in a novel ecosystem. *Royal Society Open Science*. DOI: 10.1098/rsos.170151.

Golabi, M.H., S. Manibusan, T. Righetti, D. Okano. 2018. Using vetiver grass technology for mitigating sediment loads in the Talakhaya Watershed in Rota, CNMI. *International Soil and Water Conservation Research Journal 6:2.* DOI.org/10.1016/j.iswcr.2018.03.001.

Marler, T.E. 2018. Leaf damage by phytophagous beetles alters Terminalia catappa green and senesced leaf chemistry. *International Journal of Insect Science* 10:1-5. DOI:10.1177/1179543318797329.

Marler, T.E. 2018. Stem carbohydrates and adventitious root formation of *Cycas micronesica* following *Aulacaspis yasumatsui* infestation. *HortScience* 53:1125-1128. DOI:10.21273/HORTSCI13170-18.

Marler, T.E. 2018. Axial and radial spatial patterns of non-structural carbohydrates in *Cycas micronesica* stems. *Plants* 7:49. DOI: 10.3390/plants7030049.

Marler, T.E. 2018. Coconut leaf age and coconut rhinoceros beetle herbivory influence leaflet nutrients, metals, and lignin. *Horticulturae* 4:9. DOI:10.3390/horticulturae4020009.

Marler, T.E. 2018. Host tree identity influences leaf nutrient relations of the epiphyte *Dendrobium guamense* Ames. *Horticulturae* 4:43. DOI:10.3390/horticulturae4040043.

Marler, T.E. 2018. Bi-directional acclimation of *Cycas micronesica* leaves to abrupt changes in incident light in understory and open habitats. *Photosynthetica* 56:776-785. DOI:10.1007/s11099-017-0730-3.

Marler, T.E. 2018. Elemental profiles in *Cycas micronesica* stems. *Plants* 7:94. DOI:10.3390/plants7040094.

Marler, T.E. and A.N.J. Cascasan. 2018. Carbohydrate depletion during lethal infestation of *Aulacaspis yasumatsui* on *Cycas revoluta*. *International Journal of Plant Science* 179:497-504.

Marler, T.E. and A.J. Lindström. 2018. Scouting the Philippines for Cycas. *Memoirs New York Botanical Garden* 117:519-528. DOI:10.21135/893275389.033.

ions

Marler, T.E. and A.J. Lindström. 2018. Inserting cycads into global nutrient relations data sets. *Plant Signaling & Behavior* 13:e1547578. DOI:10.1080/15592324.2018.1547578.

Marler, T.E., A.J. Lindström, W. Field. 2018. Range, density, and threatened status of *Cycas nongnoochiae*. *Memoirs New York Botanical Garden*. 117:86-94. DOI:10.21135/893275389.008.

Marler, T.E. and M.V. Krishnapillai. 2018. Does plant size influence leaf elements in an arborescent cycad? *Biology* 7:51. DOI:10.3390/biology7040051.

Marler, T.E. and M.V. Krishnapillai. 2018. *Cycas micronesica* trees alter local soil traits. *Forests* 9:565. DOI:10.3390/f9090565.

Marler, T.E. and P.N. Marler. 2018. *Rhyzobius lophanthae* behavior is influenced by cycad plant age providing odor samples in Y-tube olfactometer. *Insects* 9:194. DOI:10.3390/insects9040194.

Marler, T.E. and R. del Moral. 2018. Increasing topographic influence on vegetation structure during primary succession. *Plant Ecology* 219:1009-1020. DOI:10.1007/s11258-018-0853-z.

Martinez, M., M. Marutani, J.A. Soria. 2018. Characterization of crude and biodiesel oils of *Jatropha curcas* and *Calophyllum inophyllum* in Guam. *Micronesica* 1: 1-15.

Marutani, M. 2018. Calamansi (× *Citrofortunella microcarpa*) for potential citrus fruit production for the island of Guam. *Acta Horticulturae*. DOI:10.17660/ActaHortic.2018.1205.49.

Moore, A. (2018). The Guam coconut rhinoceros beetle problem: Past, Present And Future. Zenodo. DOI:org/10.5281/ZENODO.1185370.

Novotny, R., J. Davis, J. Butel, C. J. Boushey, M.K. Fialkowski, C.R. Nigg, K. L. Braun, R.T. Leon Guerrero, P. Coleman, A. Bersamin, A.A.R. Areta, L.R. Barber, Jr., et al. 2018. Effect of the Children's Healthy Living Program on young child overweight, obesity, and *Acanthosis nigricans* in the US-Affiliated Pacific Region. *JAMA Network Open*. 1(6):e183896. DOI: 10.1001/jamanetworkopen.2018.3896.

Palafox, N., R.T. Leon Guerrero, H. Robinett, J. Peterson, D. Ward, C.W. Vogel, C. 2018. Advancing Cancer Health Equity in Pacific Islanders: A 15-Year Investment in Cancer Research, Training and Outreach in Guam, Hawaii and the U.S. Associated Pacific Islands. *Journal of Global Oncology* 4:17. DOI:10.1200/jgo.18.32100.

Terry, I., C. Calonje, M.S. Calonje, and T.E. Marler. 2018. Thermogenesis patterns in selected *Cycas* species. *Memoirs New York Botanical Garden*. 117:410-432. DOI:10.21135/893275389.027.

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