



RESEARCH

AT THE UNIVERSITY OF GUAM

2021





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**OFFICE OF RESEARCH &
SPONSORED PROGRAMS**
UNIVERSITY OF GUAM

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JULY 2021

TABLE OF CONTENTS

- 2 Welcome Messages
- 4 Research at UOG:
Rising Above Expectations
- 6 Financial Information
- 9 Key Research Focuses
- 40 Research Units
- 46 Hawaii-Pacific Islands Cooperative
Ecosystem Studies Unit
- 48 Research Faculty

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Tel: (671) 735-2989 Website: www.uog.edu/research

MESSAGE FROM THE VICE PROVOST OF RESEARCH & SPONSORED PROGRAMS



Buenas yan Håfa Adai!

As a USDA land-grant university, the University of Guam has research embedded in its mission and has a long and prestigious history of research based in Guam and the Western Pacific region. UOG's Marine Lab and Water Environmental Research Institute (WERI) are among the world's best centers of their kind.

Last year, UOG completed a strategic planning process and published the Para Hulo' Strategic Plan of 2019-2024. The first strategic initiative – "Being recognized as a RESEARCH UNIVERSITY centered in island wisdom" – sets the stage for research to become an even more prominent activity at the university. As stated within Strategic Initiative #1, the goal is for the University of Guam to become a nationally and internationally recognized research university as a Doctoral Professional University (DP/U) under the Carnegie Foundation for the Advancement of Teaching. Currently, the UOG is classified as Master's Colleges and Universities I. This new Carnegie (DP/U) classification will earn University of Guam a respected voice in the global conversation on topics intimately familiar to and of concern to its region and its cultures, such as marine science, climate change, and indigenous languages and cultures.

We are pleased to report that significant progress has been made in the realization of the above-mentioned goals, and despite the daunting challenges caused by the COVID-19 pandemic, this has been an outstanding year for research and scholarly achievements here at the University of Guam.

In FY2020, UOG received a new five-year \$20 million National Science Foundation-funded Established Program to Stimulate Competitive Research (EPSCoR) grant and its third five-year cycle of funding of \$7.3 million for the National Cancer Institute-funded Pacific Island Partnership for Cancer Health Equity (U54-PIPCHE) grant. These and many other projects were accomplished by the hardworking faculty and staff of UOG who continue to remain competitive in securing extramural funding.

In FY2020, we collaborated with multiple off-island scientists and institutions, provided employment to the local community, and offered students the opportunity to gain valuable research experience.

We hope that the information presented here will highlight the many facets of UOG's research activities and will help you gain a greater understanding of what UOG has to offer. Please feel free to contact my office at (671) 735-2170 or email rachaeltlg@triton.uog.edu if you have any questions or need additional information.

Si Yu'os Ma'åse'

A handwritten signature in black ink that reads "Rachael T. Leon Guerrero".

Rachael T. Leon Guerrero, Ph.D.
Vice Provost for Research & Sponsored Programs
Professor of Nutrition

MESSAGE FROM THE PRESIDENT

Håfa Adai!

Wherever there is a question or curiosity about how something works or came to be, research is the process that delivers answers, informs decisions, and advances society. As with universities worldwide, research and innovation are at the core of what we do at the University of Guam as we seek to find and disseminate knowledge, wisdom, and truth.

As one of 106 institutions designated with federal land-grant status and, later, sea-grant and space-grant status, the University of Guam has a specific role in conducting and disseminating research with pragmatic, hands-on value to the people of Micronesia and the Western Pacific. The land-grant designation originally built UOG's research foundation on agriculture, although our research now spans many more disciplines, which we are pleased to share in this publication.

UOG has built an increasingly efficient structure in the past two decades for research that has led to annual grant funding of \$14 million over the past 10 years.

We hope this booklet will not only inform our local community and those with similar questions and research interests abroad, but that it will inspire partnerships and collaborations with other researchers, institutions, and agencies to combine our strengths toward even more impactful outcomes.

Si Yu'os Ma'åse'



Thomas W. President, Ph.D.
President and Professor of English



MESSAGE FROM THE SENIOR VICE PRESIDENT & PROVOST

Buenas yan Håfa Adai!

It is my great pleasure, on behalf of the research faculty and staff at the University of Guam, to present the exciting discoveries taking place here in the Western Pacific.

Our research agenda is fueled by our unique geographic location and status – a U.S. territory in a tropical climate on the opposite hemisphere – along with our well-managed research centers and highly motivated faculty. With \$14.8 million spent in 2020, our small regional university ranks in the 35th percentile nationwide for research and development expenditures.

Our water research institute is rated top 12 in nation. Our Marine Laboratory, one of the world's first coral research facilities, has been the source of multiple marine research firsts and discoveries. And our Micronesian Area Research Center houses the largest collection in the world of documents specific to Micronesia.

We are leading the way in research on endangered cycads, invasive species, and the health impacts of betel nut. We are also building momentum in new areas with the addition of the NASA Guam Space Grant program and our growing Regional Center for Public Policy.

From our remote part of the Pacific, we are proud to be part of the global network of scholars that is advancing communities and look forward to continuing to evolve our capacity to do so.

Si Yu'os Ma'åse'



Anita Borja Enriquez, DBA
Senior Vice President and Provost



RESEARCH

AT THE UNIVERSITY OF GUAM

RISING ABOVE EXPECTATIONS

For an institution of its size – 3,000 students and 180 full-time faculty with a \$95 million annual budget – the University of Guam rivals larger universities in the dollar amount spent every year for research. In 2019, the latest available year for the data, UOG ranked in the 35th percentile of universities with \$12.2 million in federal funds expended for research and development, according to the National Science Foundation’s Higher Education Research & Development Survey.

In the past 10 years, UOG has conducted research through federal and non-federal grants totaling \$157 million that has led to annual grant funding of \$14 million over the past 10 years.

WHAT DRIVES OUR RESEARCH

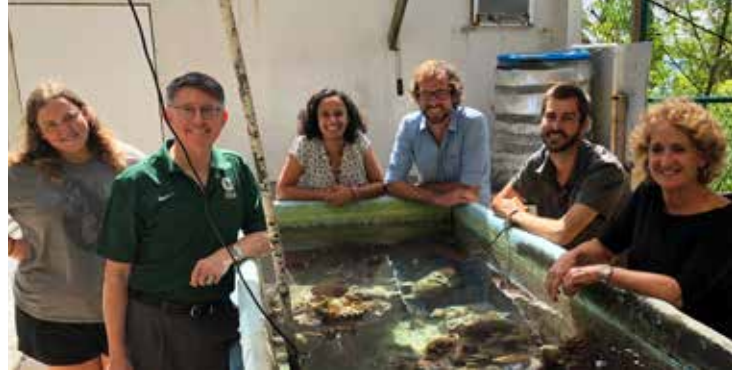
So what contributes to this large portfolio? First and foremost, it’s the faculty. Nearly half of UOG’s full-time faculty are actively engaged in research. They are driven to advance regional and global knowledge, many coming to UOG with specific research goals related to the Western Pacific in mind.

Secondly, there is a significant need for research in the region. The populations of the Western Pacific, though under U.S. jurisdiction, are largely underrepresented in national studies, and the region itself, which is lesser known and visited due to its geographical isolation, is ripe for exploration.

Thirdly, faculty are supported by the university’s Office of Research & Sponsored Programs and the Research Corporation of the University of Guam, which work to find, compete for, and manage external funding and to support faculty members and university personnel in conducting their projects.

The research being done at UOG – driven by faculty interest, local need, and federal need in managing and protecting natural resources – largely falls under the subject areas of marine biology, terrestrial biology, agriculture, groundwater, Micronesian history and culture, health and welfare of Pacific Islanders, and regional public policy.





OUR RESEARCH EXPERTISE

Research projects at UOG explore and advance knowledge on topics ranging from cancer prevalence and risk factors among Pacific Islanders to the resilience of corals in the face of climate change to controlling the spread of non-native species. In fact, these are the focus areas of UOG's largest ongoing research projects.

The University of Guam, located on U.S. soil but some 7,000 miles from the continental United States, is a particularly unique place for research on less common, niche subjects, but also on subjects that apply to islands and tropical environments as a whole.

UOG is one of few U.S. universities in a tropical climate and the only one near the Coral Triangle, the global center of marine diversity. The island and region also have a diverse population of ethnicities that are underrepresented in national data. Additionally, as a host to U.S. military bases and a hub for U.S. shipping, Guam has unfortunately become home to a number of non-native pests, making it a prime place to study the impact of invasive species on agriculture and the local ecosystem.

OUR RESEARCH FUTURE

With major grants underway and more being sought, research and research collaborations will remain a focal point at the University of Guam going forward.

In fact, one of UOG's goals in its strategic plan is to elevate its status in the Carnegie Classification system from a regional comprehensive university to a research-level university – a Doctoral Professional University – among the ranks of Indiana State University, University of North Florida, and Middle Tennessee State University.

Though UOG already triples the DPU classification's requirement of securing \$5 million in federal research funding, pursuing the classification is a key indicator that UOG will remain committed to the quantity and breadth of research detailed in this publication.

FINANCIAL INFORMATION

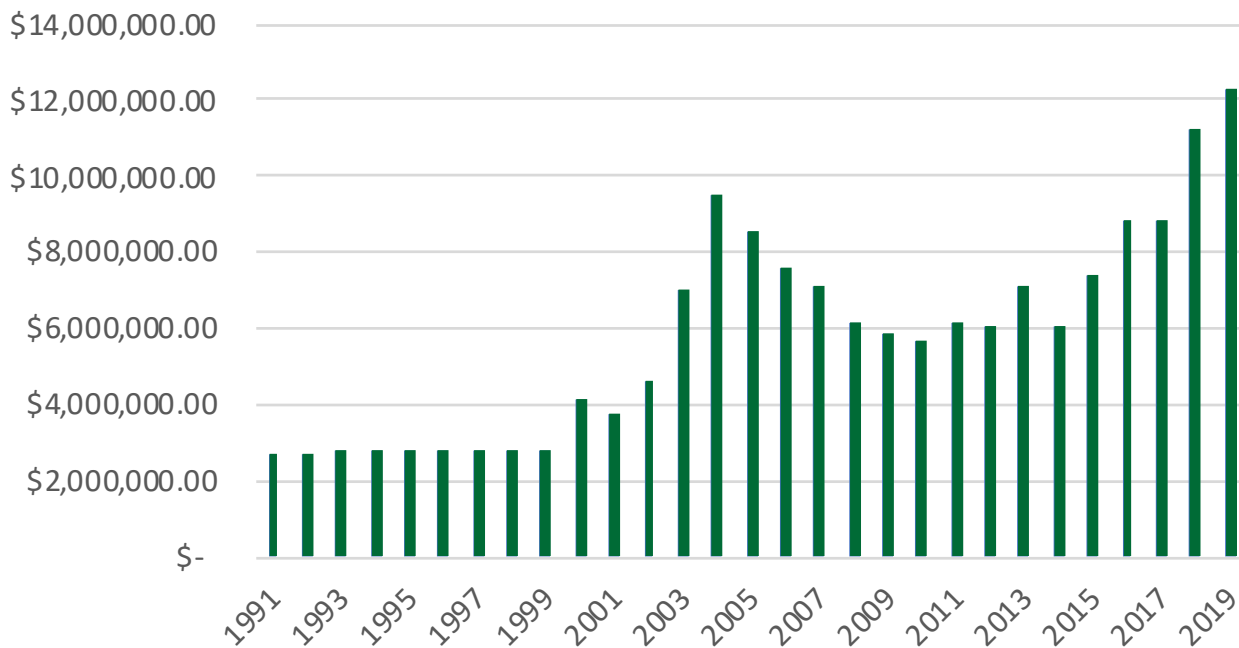
Through six schools and colleges and eight research centers, the University of Guam, as of 2021, is managing a portfolio of active grant funding totaling \$43 million. This covers 140 individual projects – the majority of which are federally funded.

In 2019, the university expended \$12.2 million in research funding, placing it in the top 35% of universities nationwide, according to the National Science Foundation’s Higher Education Research & Development Survey.

This amount has steadily increased over the years with an average increase of 15% every year since 2016.

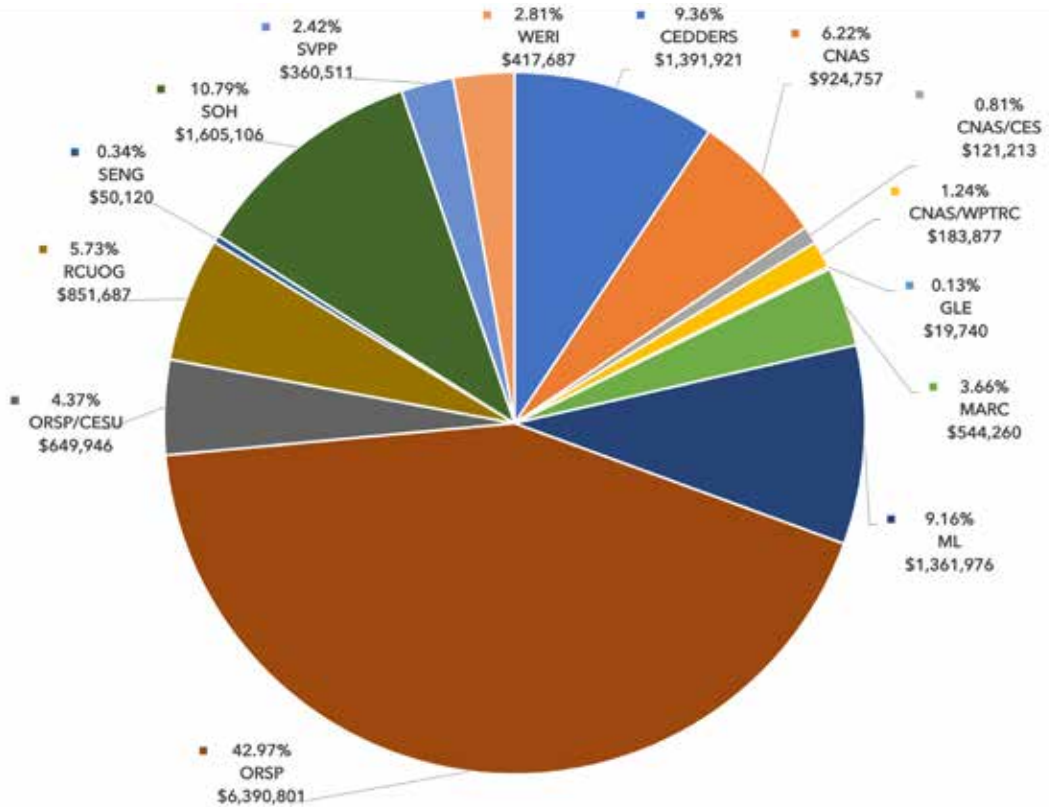
The three dominant funding agencies for UOG’s research portfolio are the U.S. Department of Agriculture’s National Institute of Food & Agriculture, the National Science Foundation, and the Department of Defense through the Cooperative Ecosystem Studies Units network, while the largest recipients of research grant funding at UOG are its Office of Research & Sponsored Programs, followed by the School of Health and the Center for Excellence in Development Disabilities Education, Research & Service.

Total Federal Research Expenditures at UOG 1991 to 2019



Source: Higher Education Research & Development Survey, National Science Foundation

Sum of Grant Awards by Unit in 2020



DEPT. / PROGRAM KEY

CEDDERS
Center for Excellence in Developmental Disabilities Education, Research & Service

CNAS
College of Natural & Applied Sciences

CNAS/CES
Cooperative Extension Service

CNAS/WPTRC
Western Pacific Tropical Research Center

GLE
Global Learning & Engagement

MARC
Micronesia Area Research Center

ML
Marine Laboratory

ORSP
Office of Research & Sponsored Programs

ORSP/CESU
Hawaii-Pacific Islands Cooperative Ecosystem Studies Unit

RCUOG
Research Corporation of the University of Guam

SENG
School of Engineering

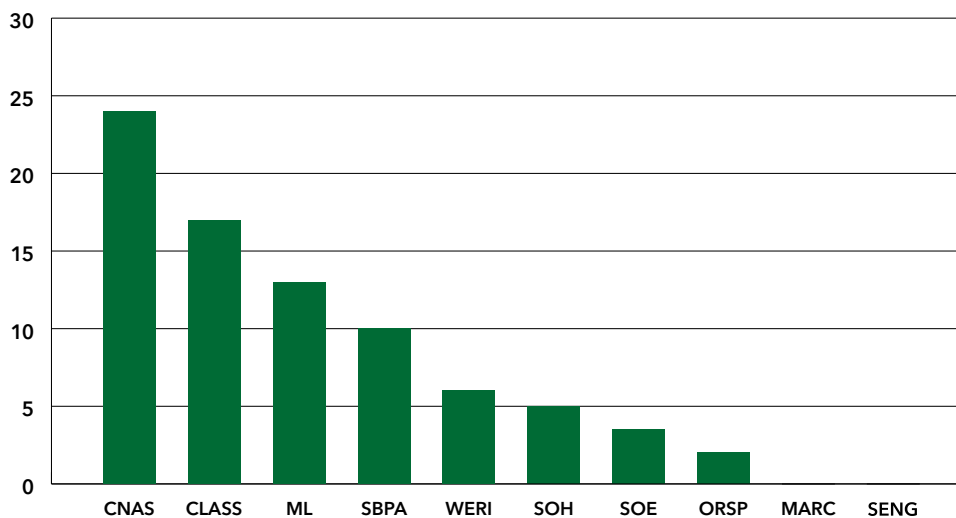
SOH
School of Health

SVPP
Office of the Senior Vice President and Provost

WERI
Water & Environmental Research Institute

UOG Research and Scholarly Publications for 2020

PUBLICATIONS BY COLLEGE/UNIT



OFFICE OF RESEARCH AND SPONSORED PROGRAMS

The Office of Research & Sponsored Programs is the central point of support and management for all research and sponsored projects at the university.

The office seeks available external funding related to the missions and goals of the university, supports faculty in their personal research endeavors, and coordinates studies with public and private agencies locally, nationally, and internationally.

The office consists of a small core team as well as the sub-units indicated here that manage some of the university's primary sponsored and grant-funded programs.



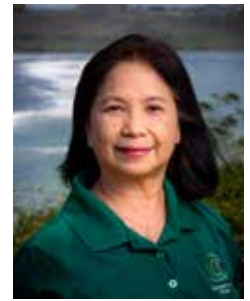
Rachael T. Leon Guerrero, Ph.D.
Vice Provost of Research and Sponsored Programs



Pamela Peralta Taitano, Ed.D.
Director of Contracts and Grants



Luke Duenas
Program Coordinator II



Zenaida Valencia
Accountant I



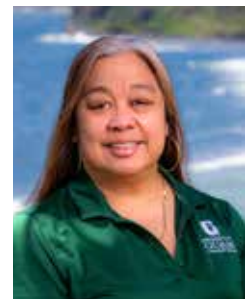
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U54/PIPCHÉ



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Research Associate I
U54/PIPCHÉ



Rachel Naguit
Grant Assistant III
U54/PIPCHÉ



KEY FOCUS AREAS

The University of Guam offers a unique environment to explore topics less studied globally as well as nationally. Guam – being U.S. soil but some 7,000 miles from the continental United States – is one of few places in the nation suitable for exploring a tropical environment, both on land and underwater, as well as the Pacific Islander populations that live within U.S. territories and associated states in the Western Pacific yet are largely underrepresented in national data. Moreover, research conducted at UOG often is informative and useful for tropical environments and island communities outside of Guam and the Micronesian region as well.

Driven by faculty interest, local need, and federal need in managing and protecting natural resources, the research endeavors at the University of Guam cover an array of topics and disciplines. While UOG has decades of experience in some disciplines, such as marine biology, agriculture, and Micronesian history and culture, other subjects of exploration are more recent in interest and need, such as studies on public policy and economics in the Micronesian region. This section highlights six of the University of Guam's most specialized areas of research and what UOG is uniquely able to bring to each.

Lorenzo Stephan holds one of many coral-eating crown-of-thorns starfish found while monitoring coral reefs during the El Niño-Southern Oscillation event of 2015-2017 in Chuuk, Federated States of Micronesia.



RESEARCH FOCUS: MARINE SCIENCE

THE NEED: Guam's biodiverse marine systems are faced with complex human-derived environmental issues that are common to island systems around the world. In this era of rapid climate change, it is essential that coastal and small island communities that rely heavily on healthy, functional marine systems understand the nature and consequences of this change. Governments and organizations cannot hope to plan for or assist communities in adapting to these changes if they don't understand the systems themselves.

OUR ABILITIES: The University of Guam is unique in that it is located just outside the global center of marine diversity, the Coral Triangle. Further, it has a fully equipped marine station – the UOG Marine Laboratory – situated adjacent to coral reef ecosystems. This combination of factors is quite rare among universities and gives UOG researchers the advantage of being able to access the local marine environments year-round.

OUR IMPACT: The impact of the work at the UOG Marine Lab is evident in a growing public awareness of the value of reefs, the threat that humans pose on them from unregulated use and destruction, and the importance of marine conservation. What is learned about Guam's marine systems is readily shared in conferences, presentations, and publications so it can be applied to similar environments around the world.

\$9.0M
RESEARCH GRANT AWARDS

14
RESEARCH
PROJECTS

10
FACULTY

FIGURES ARE BASED ON FY20



ONGOING RESEARCH IN MARINE SCIENCE

Coral reef restoration in an era of climate change

Since devastating coral reef bleaching events between 2013 and 2017, the lab of Dr. Laurie Raymundo has worked to study and document the impact of the events and restore decimated populations via coral nurseries and novel transplantation techniques.

One study revealed that four bleaching events, repeated extreme low tides, and disease outbreaks associated with a prolonged El Niño killed more than 50% of staghorn *Acropora* communities on Guam and more than one-third of all corals around the island in the span of five years.

With an “assisted evolution” approach, researchers are outplanting fragments of resilient staghorn *Acropora* coral species, cultured in the UOG Marine Lab’s ocean nurseries, into waters around Guam. Today, coral nurseries in the Piti Marine Preserve and Cocos Lagoon house more than 2,000 juvenile colonies of the species.

This has resulted in a two- to five-fold increase in fish compared to an adjacent unplanted area.

An expanded project in the Asan-Piti Marine Preserve area introduced two staghorn species – one of which, *Acropora aspera*, had been reduced to a single population and was in danger of local extinction. This 2.8-acre project has seen 90% survival in one year.

Raymundo’s findings are informing a reef restoration strategy for the island, helping to ensure reef ecosystem sustainability, and protecting economic, environmental, and human health interests in the face of climate change.

Project: Restoring Staghorn Corals and Ecosystem Services on Reef Flats in Guam, Micronesia

Funded by: National Park Service, the National Oceanic & Atmospheric Administration, and the National Fish and Wildlife Foundation

Above Photo: (From left) Mike Gawel, formerly with the National Park Service, UOG graduate biology student Grace McDermott, and Farron Taijeron of The Nature Conservancy prepare to outplant corals in the Piti Marine Preserve in February 2021.

Next Page Top Photo: David R. Burdick, a research associate at the UOG Marine Laboratory, looks through the online database of the UOG Biorepository.


Next Page Middle Photo: Cara Lin from the Department of Aquatic and Wildlife Resources works with the UOG Marine Laboratory to outplant corals in the Piti Marine Preserve in February 2021.

Next Page Bottom Photo: (From left) UOG Research Associate David R. Burdick; UOG Marine Laboratory Director Laurie J. Raymundo; and Whitney C. Hoot, a biologist with the Guam Bureau of Statistics & Plans, present to media in July 2019 newly published research about the extent of coral bleaching in Guam.



Other ongoing research in MARINE SCIENCE:

- **Guam Ecosystems Collaboratorium for Corals and Oceans**
(Drs. Terry Donaldson, Bastian Bentlage, Austin Shelton, Rachael Leon Guerrero)
- **Building Staghorn Coral Community Resilience and Facilitating Post-Bleaching Recovery**
(Dr. Laurie Raymundo)
- **Identifying Key Reef Sites for the Management and Conservation of Coral Genetic Diversity and Resilience**
(Dr. David Combosch)
- **Fisheries Development and Utilization**
(Dr. Brett Taylor)
- **Sea Turtle Survey of Farallon de Medinilla Island**
(Dr. Austin Shelton)
- **Mapping of Guam's Priority Coral Reefs**
(Dr. Romina King)
- **Comprehensive Coral Reef Monitoring at Long-Term Sites on Guam**
(David Burdick)
- **Developing a Genetics Toolkit to Assess and Predict Stress Levels in Corals**
(Dr. Sarah Lemer)
- **Restoring Staghorn Corals and Ecosystem Services on Reef Flats in Guam, Micronesia**
(Dr. Laurie Raymundo)
- **Characterizing Fate and Transport of Nitrate and Sediments to Coral Reefs on Guam**
(Dr. Chris Yeo)



Former UOG Marine Laboratory graduate student David Benavente conducts coral and fish surveys in July 2016 on the outer reefs of Chuuk Lagoon. The surveys were conducted to support ongoing climate change research and local fisheries policy development.

An underwater photograph of a diver in a black wetsuit and mask, holding a clipboard and pen, standing on a coral reef. Bubbles rise from the diver's equipment. The background is a deep blue ocean.

Using big-data analysis to see the big picture

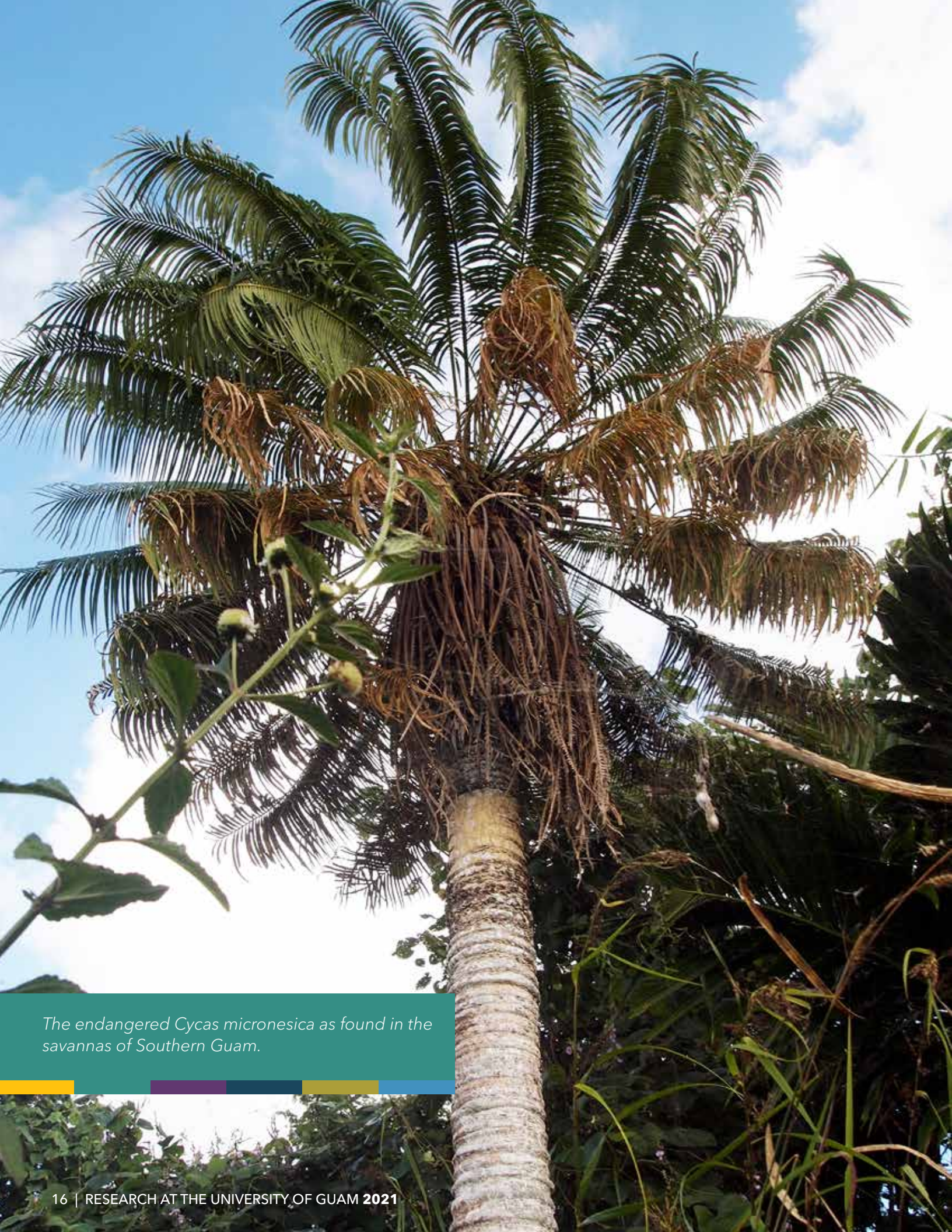
Under a significant \$20 million grant from the National Science Foundation's Established Program to Stimulate Competitive Research (EPSCoR), the University of Guam is increasing the collection, documentation, integration, and analyses of complex genetic and oceanographic data from reefs within the region. These research activities are necessary to understand the evolutionary and ecological processes that drive resilience during climate change and other factors and could provide valuable insight into the development of viable management strategies.

Led by Dr. Bastian Bentlage, the research team is collecting genetic, genomic, oceanographic,

and ecological datasets. Using mathematical models and a high-performance computer cluster, they will then analyze the data to better predict changes in the reef ecosystems. Additionally, specimens and field collection data are being digitized and posted in the UOG Biorepository's online-accessible database, providing the scientific community with an invaluable resource for marine biodiversity research.

Project: Guam Ecosystems Collaboratorium for Corals and Oceans

Funded by: National Science Foundation



The endangered *Cycas micronesica* as found in the savannas of Southern Guam.

RESEARCH FOCUS: TERRESTRIAL BIOLOGY

THE NEED: Organisms brought by purpose or chance to environments where they did not evolve are causing massive ecological and socio-economic impacts on Guam. Invasive species and degradation of terrestrial ecosystems are critical issues on national and global scales as well. Intrinsic negative processes, such as soil erosion, loss of habitat, and chaotic urban encroachment interact with invasive species to greatly expand the harm. It is imperative to learn more about human and biophysical causes of ecological degradation and to develop sound restoration practices.

OUR ABILITIES: Few places on Earth have suffered the devastating effects of invasive species like Guam has. These impacts have been fast, pronounced, and unabated. Simultaneously, the island itself is an outdoor laboratory for conducting research, making the University of Guam a prime place to understand species' competitive advantages, human and biophysical interactions, and restoration techniques in a tropical insular environment.

OUR IMPACT: Widely communicated in the media, scientific conferences, and local councils, like the Guam Invasive Species Council, UOG's research in terrestrial biology is helping to broaden the world's foundation of conservation knowledge. A regional authority on invasive species, plant pathology, soils, and the ecological relationships among them, UOG researchers provide expert advice to local and federal agencies and assist in efforts to create community awareness.

\$741K
RESEARCH GRANT AWARDS

13
RESEARCH
PROJECTS

15
FACULTY

FIGURES ARE BASED ON FY20



ONGOING RESEARCH IN TERRESTRIAL BIOLOGY

Controlling invasive insects, new and old

Because of its status as a military and transportation hub in the Western Pacific, Guam is subject to many exotic and potentially harmful insect species – with about two insects per month gaining a foothold in Guam, up from two per year 20 years ago. Invasive insects are a biosecurity concern that threatens Guam’s natural resources, plant life, agricultural crops, other populations of insects, and human health.

Dr. Ross Miller, along with invasive species specialist Roland Quitugua and extension entomologist Dr. Aubrey Moore, is working to identify new pests in a timely fashion and to formulate mitigation procedures to prevent their spread.

Ongoing efforts involve:

- *the little fire ant* – a tropical stinging ant discovered on Guam

in 2011, which they’ve found has spread to more than 30 sites in Guam

- *the greater banded hornet* – an aggressive wasp discovered on Guam in 2016, which they’ve found destroys honeybee colonies and the nests of other wasps
- *varroa mites* – a parasite UOG researchers discovered has been attacking bees on Guam and Saipan
- *aphids* – sap-sucking insects that have caused serious damage to a variety of crops as well as ornamental plants in Guam and Saipan.

In the island’s only USDA Bio-Control Quarantine Laboratory at UOG, Miller studies the use of beneficial organisms to fight these invasive pests

threatening crops and trees. Miller also trains farmers and agency officials on Guam and other Micronesian Islands facing the same threats to educate them on identification and effective control tactics.

Project: Identifying, Assessing, and Managing Invasive Insects on Guam

Funded by: U.S. Department of Agriculture, Animal & Plant Health Inspection Service; U.S. Department of Agriculture, U.S. Forest Service; and the U.S. Department of Defense

In this photo: Fire ants, an invasive species in Guam, investigate a newly set trap for another invasive species in Guam, the brown tree snake, in Piti, Guam. Photo taken by G. Curt Fiedler

The hunt for a virus to control Guam's rhino beetle

The coconut rhinoceros beetle, discovered in Guam in 2007, is expected to destroy more than 50% of Guam's coconut palms and continue to spread to other locations. Beyond its cultural and economic impacts, this beetle remains a threat to islands that have an active coconut palm industry or that rely on the tree for survival.

Experts have experimented with different control techniques with limited success. Among them, a virus known to suppress the beetle failed to reduce Guam's populations, and pheromone traps only capture a very small percentage of adults.

Dr. Aubrey Moore and Dr. James Grasela, a post-doctoral insect pathologist, have found that Guam's beetle, known as biotype CRB-G, is genetically different than known types and resistant to the *Oryctes rhinoceros nudivirus* (OrNV).

They are now investigating different isolates of that original virus and others to determine their ability to affect Guam's beetle type. So far, they've tested about 10 viruses. Analyses of their effectiveness in the population on Guam are underway at UOG and AgResearch New Zealand.

Project: Biological Control of Coconut Rhinoceros Beetle Biotpe G on Guam

Funded by USDA's Animal & Plant Health Inspection Service and the Department of Interior's Office of Island Affairs

Strengthening ironwood tree populations on Guam

More than 18 years ago, the ironwood tree – a hearty, salt-resistant species important for soil erosion control and a protector of vegetation from the wind – unexpectedly began dying in Guam. It would take another six years to find the culprit: a bacterial wilt known as *Ralstonia solanacearum*.

Since then, under a longstanding effort, UOG's Dr. Robert L. Schlub has worked to better understand and stop bacterial attacks through monitoring and surveying, plantings of bacteria-resistant species, and more recently, studies to pinpoint spreaders of the wilt.

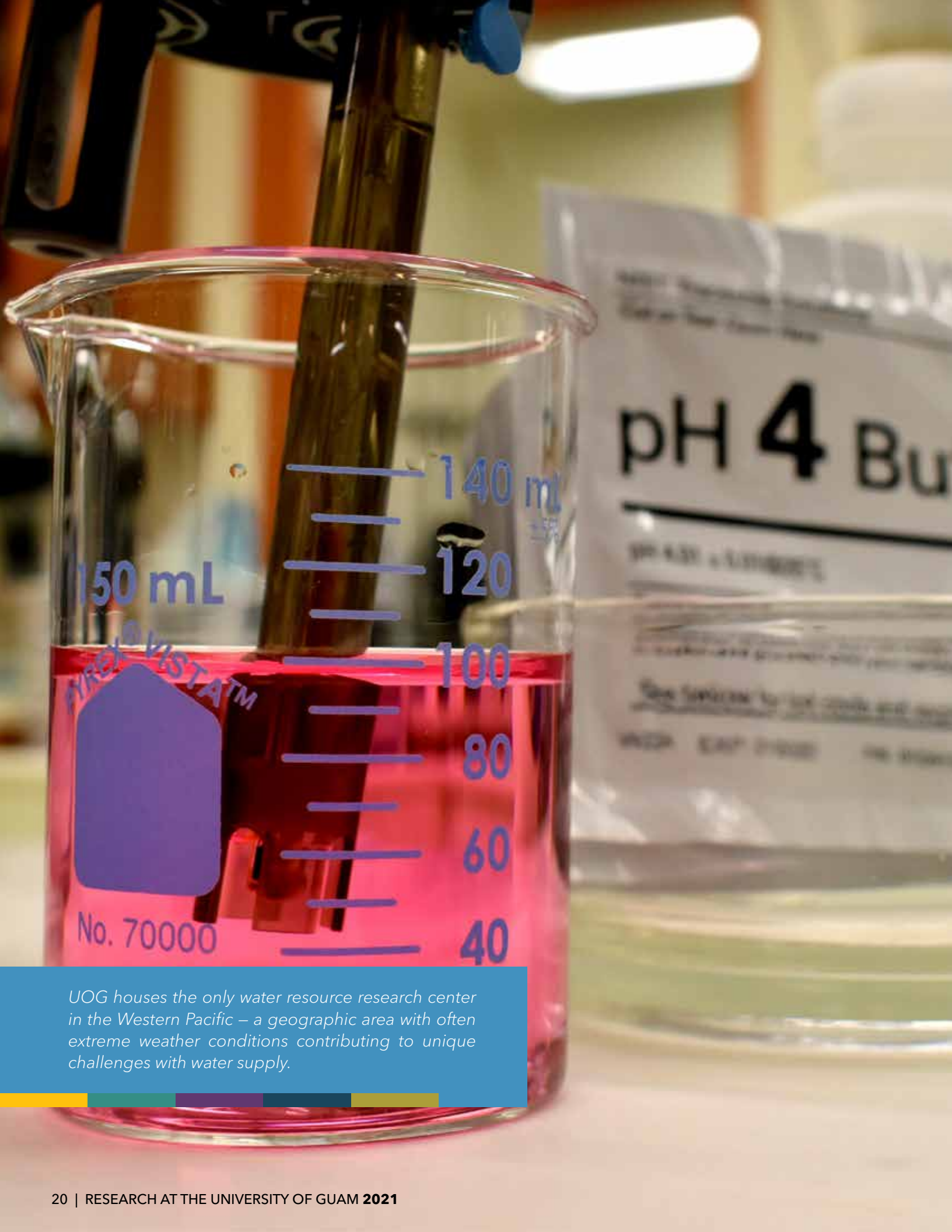
Recent evidence points to the *Nasutitermes takasagoensis* termite, which has a taste for the ironwood, *Casuarina equisetifolia*. Researchers from UOG are analyzing the guts of the termite to assess its role as a vector of the soil-borne bacteria, which today infects more than 20% of the island's ironwood trees.

Project: Reducing Tree Decline of Casuarina Equisetifolia in Guam Through Replacement of Bacterial Wilt Infected Trees and Research into the Bacterial Microbiomes of Trees and Associated Termites

Funded by: U.S. Department of Agriculture's Western Region Sustainable Agriculture Research and Education Program and McIntire-Stennis Cooperative Forestry Research Program

Other ongoing research in TERRESTRIAL BIOLOGY

- **Enhancing Local Knowledge to Sustain a Forest Inventory and Monitoring Program Throughout the Pacific Islands**
(Dr. James McConnell)
- **Reducing Tree Decline of Casuarina Equisetifolia in Guam**
(Dr. Robert Schlub)
- **Micropropagation of Guam's Native Trees**
(Dr. James McConnell)
- **Guam Forest Biodiversity Inventory**
(Dr. Aubrey Moore)
- **Establishment of Self-Sustaining Biological Control of Coconut Rhinoceros Beetle Biotpe G in Micronesia**
(Dr. Aubrey Moore)
- **Enhancing Awareness of Coconut Rhinoceros Beetle and Little Fire Ant in Micronesia**
(Dr. Ross Miller)
- **Continued Monitoring of Reduction in Brown Tree Snake Abundance During Eradication Activities in the Habitat Management Unit**
(Dr. Aubrey Moore)
- **Captive Breeding of Eight-Spot Butterfly**
(Dr. Aubrey Moore)
- **Forest Bird Monitoring and Assessment on Tinian Joint Region Marianas-Leased Lands**
(John Gourley, Micronesia Environmental Services)
- **Plant and Invertebrate Surveys: Snail Surveys**
(Dr. Curt Fiedler)



UOG houses the only water resource research center in the Western Pacific – a geographic area with often extreme weather conditions contributing to unique challenges with water supply.

RESEARCH FOCUS: WATER RESOURCES

THE NEED: Understanding storm and drought cycles is crucial to freshwater supply, quality, and management in the tropical Western Pacific. Although most islands in this region receive 100 or more inches in annual rainfall, the erratic timing and intensity of rainfall, affected by El Niño and La Niña cycles, pose unique challenges. Sudden, intense storms can disable municipal water systems and household rain catchments for weeks. Following a strong El Niño, surface reservoirs can dry up and groundwater reserves can turn saline.

OUR ABILITIES: The University of Guam is home to one of the 54 water research institutes established at land-grant institutions by U.S. Congress. The portfolio of core expertise at UOG's Water & Environmental Research Institute of the Western Pacific spans the natural water cycle from meteorology to surface and groundwater hydrology as well as essential water-use activities.

The institute's facilities include a well-equipped Water Quality Laboratory capable of microbiological, chemical, and physical tests as well as a Hydrogeological and Meteorological Laboratory, and a Bioreactor Laboratory.

OUR IMPACT: Throughout the region, WERI actively collaborates with the U.S. Geological Survey, the local water and environmental authorities, the military, and other agencies to provide reliable and honest scientific research, advice, and training on water-related interests. Consistent with the regional role of the University, the institute devotes part of its program effort to Western Pacific islands other than Guam. UOG and WERI also train new environmental scientists through the University's master's level environmental science program, fostering continued integrity in research and application of environmental science.

\$1.3M
RESEARCH GRANT AWARDS

25
RESEARCH
PROJECTS

6
FACULTY

FIGURES ARE BASED ON FY20

RECENT RESEARCH IN WATER RESOURCES

Decades of data give clarity to Guam's primary water source

In the first research project to take advantage of nearly 40 years' worth of data collected from deep observation wells in Guam, University of Guam graduate student Bekah Dougher and WERI faculty Dr. Nathan C. Habana, Dr. John W. Jenson, and Dr. Mark A. Lander were able to conduct the most comprehensive hydrographic analysis to date of Guam's aquifer, which provides 90% of drinking water for the island.

Freshwater lenses in unconfined island karst aquifers have a dynamic response to contributing hydrologic processes. A significant process is rainfall that infiltrates to recharge the freshwater lens.

The researchers conducted a hydrographic analysis of the observation wells to determine the types of hydrologic and climate factors that contribute to the thinning or thickening of the lens and began to answer some of the most frequently asked questions about the aquifer, including how do big storms and droughts affect the water supply, and how is recharge distributed between the dry seasons and wet seasons?

The analysis showed the actual thickening of the lens during the rainy season and a thinning of the lens during a prolonged drought, with the lag time for thinning being twice as long as the lag time for thickening. The magnitude of these changes and the rate at which they occur was previously unknown.

The lens dynamics for the entire aquifer can now be measured long-term and the data used for sustainable management. The techniques may also be applicable for determining capacities in similar aquifers.

Project: Dynamic Response of a Freshwater Lens to Natural Variations in Recharge

Funded by: Guam Hydrologic Survey and Comprehensive Water Monitoring Program and the U.S. Geological Survey's Pacific Islands Water Science Center (Hawaii)

In this photo: Dr. John Jenson, director of UOG's Water & Environmental Research Institute, stands on Mount Santa Rosa looking south over the Northern Guam Lens Aquifer.





In this photo: Graduate student Paul Bourke uses a portable well-drilling rig for his thesis project, a hydrogeologic survey of Santa Rita Spring in Guam.

More for less: Money saved on water production through effective engineering

A natural spring in the village of Santa Rita in Guam has long produced freshwater for inhabitants of the island. It is captured in a concrete reservoir built by the U.S. Navy Corps of Engineers in 1929, where it is then supplemented with water from the Navy's water system and injected in the municipal water distribution system. Collection capacity has been limited to a single 8-inch diameter pipe, creating a substantial loss of additional water and contributing to a higher cost for water since the Navy's supplemental water comes at a cost of three times more to the Guam Waterworks Authority than the authority's production cost at the spring.

In conducting a hydrogeologic survey of the spring, WERI senior hydrologist Dr. John Jenson and groundwater hydrologist Dr. Nathan Habana along with graduate student Paul Bourke were able to understand the geology of the spring and the failures of the current system and recommend engineering and design modifications to capture additional springwater, resulting in substantial cost savings for GWA.

These engineering modifications were presented to the local water authority as a solution that could increase the production of the spring from 80-500 gallons per minute to an average of 735 gallons per minute with a possible maximum of 1,220 gallons per minute.

Project: A Hydrogeologic Survey of Santa Rita Spring, Guam: Engineering and Design Recommendations for Rehabilitation

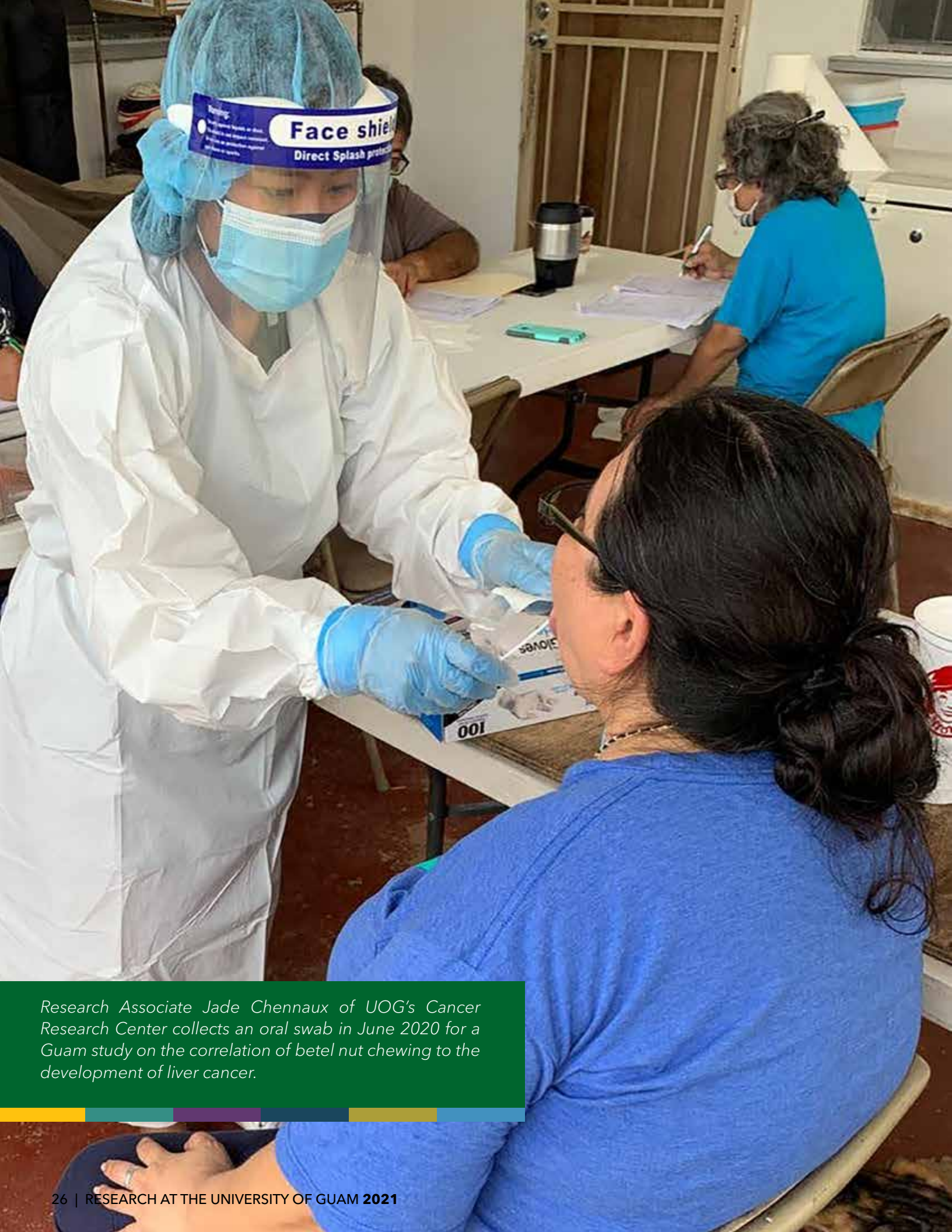
Funded by: Guam Waterworks Authority



In this photo: Environmental science graduate student C.J. Paulino at a field site in Ipan, Guam

Other ongoing research in WATER RESOURCES

- **Ecological Contribution of Groundwater Discharge to the Coastal Ecosystem in Tumon Bay, Guam**
(Dr. Chris Yeo)
- **A Sustainable Plan for Stormwater Management and Flooding at Garapan, Saipan**
(Dr. Chris Yeo)
- **Comprehensive Hydrological Database for Secure Water Resources in Tofol Watershed, Kosrae Island**
(Dr. Chris Yeo)
- **Sustainable Planning for Floods with Context of Climate Change for Tumon Bay**
(Dr. Chris Yeo)
- **PFOS Trend Monitoring in Saipan Production Wells**
(Dr. Barry Kim)
- **Geospatial-Temporal Analysis of Patterns and Trends of Salinity in Finegayan**
(Dr. Yuming Wen)
- **Establishing Groundwater Protection Zones in Guam**
(Dr. Yuming Wen)
- **Development of the Groundwater Model of the Yigo-Tumon Basin, Northern Guam Lens Aquifer**
(Dr. Nathan Habana)
- **Production Well Nitrate-N Trends in the Northern Guam Lens Aquifer**
(Dr. Nathan Habana)
- **Hydrologic Spatial Analysis of Basins and Suspect Sinkholes on the Northern Guam Lens Aquifer**
(Dr. Nathan Habana)
- **Hydrogeologic Assessment for Closed-Contour Depressions Identified in Finegayan Marine Corps Activity Site**
(Dr. John Jenson)



Research Associate Jade Chennaux of UOG's Cancer Research Center collects an oral swab in June 2020 for a Guam study on the correlation of betel nut chewing to the development of liver cancer.

RESEARCH FOCUS: HEALTH AND WELFARE



THE NEED: Pacific Islanders suffer some of the highest mortality rates from non-communicable diseases (NCDs) in the world. These NCDs – deemed an epidemic in the region by the Pacific Island Health Officers’ Association in 2010 – are linked, in part, to poor lifestyle choices. Challenges to healthy living that face the Pacific Islands are complex and related to the social determinants of health and geographic isolation, such as a high reliance on imported foods, climate change, and transitions away from cultural subsistence. Cultural practices and local resources, which may support health, are eroded and undergoing a renaissance.

OUR ABILITIES: With faculty expertise in public health, nutrition, nursing, and geriatrics and an established Cancer Research Center in partnership with the University of Hawaii, the University of Guam is well-suited to study health among Pacific Islanders, particularly those living within the Micronesian region. The diverse population of the region has also allowed UOG to develop cultural competence in research activities and strengths in minority health and cultural determinants. The university is a long-established and trusted entity in the region familiar with developing partnerships to assist research activities and educational outreach.

THE IMPACT: With a focus on outreach and education, the University of Guam has seen notable impacts and improvements on islanders’ health and welfare – in particular a reduced prevalence of childhood obesity and an increased awareness about the negative health effects of chewing areca (betel) nut – a common cultural practice in the Pacific and Southeast Asia. Research on cancer health disparities in the populations of Guam and Hawaii is also advancing awareness and influencing public policy.

\$4.6M
RESEARCH GRANT AWARDS

9
RESEARCH
PROJECTS

16
FACULTY

FIGURES ARE BASED ON FY20



ONGOING RESEARCH IN HEALTH AND WELFARE

Uncovering the link between betel nut chewing and cancer

Approximately 600 million people across the globe chew areca nut, or betel nut – many living in the Pacific region. While usage has declined over the last century, it remains a public health concern due to its strong link to oral and liver cancers, which disproportionately affect Pacific Islanders. But the mechanisms driving these diseases are poorly understood.

Dr. Yvette Paulino and colleagues have evaluated the saliva in chewers and non-chewers with oral premalignant lesions looking for differences in the microbiome – a collection of microorganisms, including bacteria and viruses, in the mouth – and if those differences coincide with an increased risk in cancer. A 2017 study of 122 adults found chewers with premalignant lesions had elevated levels of various harmful bacteria.

The most recent study is investigating Cyanobacteria in the mouth known to be toxic to the liver. The researchers identified Cyanobacteria in the areca nut and betel leaves often chewed with the nut, which supports the hypothesis that exposure to betel nut is the source of oral Cyanobacteria in users.

The studies are offshoots of the Betel Nut Intervention Trial, a first-of-its-kind study, in collaboration with the University of Hawaii, to help people quit. The intervention, which is ongoing, has shown success with cessation rates.

Project: Betel Nut Chewing, Oral Premalignant Lesions, and the Oral Microbiome

Funded by: National Cancer Institute



Tackling childhood obesity on Guam

Pacific Islanders experience high rates of obesity and diabetes, with childhood obesity also becoming prevalent. Children who are overweight have a higher risk of being overweight or obese as adults with an increased risk of chronic diseases later in life, including diabetes. Yet limited data on health and nutrition exists in the region to help inform programs.

UOG researchers, in conjunction with 10 other partners throughout U.S.-Affiliated Pacific Islands in the Children’s Healthy Living Program network, are developing, implementing, and testing multiple approaches to decrease obesity rates – which the research team found to be 27% among children ages 2 to 8 in Guam – by targeting healthy behaviors.

Using data collected, the teams have advocated for better parks, access to clean water, placement of healthier foods in stores, and school to gardens and physical activity programs.

Researchers also coordinated training for teachers, parents, and care providers. The program launched the “Early Start, Fit for Life” program to promote physical activity in public schools and the “Food Friends Fun with New Foods” and “Get Movin’ with Mighty Moves” program in preschools to address food phobias, which is now sustained by the Supplemental Nutrition Assistance Program – Education (SNAP-Ed) in 26 schools and growing.

The ongoing program has shown positive outcomes, with significantly decreased overweight and obesity prevalence and a decrease in cases of acanthosis nigricans, a skin condition that can indicate type 2 diabetes, among Pacific Island children. Targeted behaviors that improved as a result of CHL was water intake (increased) and screen time (decreased).

Project: Children’s Healthy Living Program

Funded by: U.S. Department of Agriculture, National Institute of Food & Agriculture

Improving geriatric and dementia care in the Western Pacific

Adults over 65 years of age are the fastest growing population in Guam, with a 20% increase from 2013-2017, and separate data from the World Health Organization has identified sensory organ diseases and diseases such as Alzheimer’s and related dementias among the major causes of disease burden in the Western Pacific region. These circumstances contribute to a crisis facing the region of critical shortages of health care workers, including nursing assistants, to care for the elderly.

The University of Guam is addressing the issue through the Guam/Micronesia Geriatrics Workforce Enhancement Program. The program’s vision is to transform the health systems serving the elderly and those with Alzheimer’s Disease and Related Dementias (ADRD) through workforce development and engaged community networks, resulting in improved health outcomes and an improved quality of life for elderly in Guam and the Micronesian region. Workforce development includes training more Certified Nursing Assistants and caregivers and educating families and caregivers how to care for the elderly and those with ADRD. The G/M GWEP acts as a resource for patients, families, and health professionals in Guam and Micronesia and serves as a model for the Western Pacific.

Project: Geriatrics Workforce Enhancement Program

Funded by: U.S. Department of Health & Human Services, Health Resources & Services Administration

Other ongoing research in HEALTH AND WELFARE

- **Pacific Island Partnership for Cancer Health Equity**
(Dr. Rachael Leon Guerrero)
- **Geriatrics Workforce Enhancement Program**
(Dr. Margaret Hattori-Uchima)
- **Children’s Healthy Living Center of Excellence**
(Dr. Rachael Leon Guerrero)
- **Pacific Islands Cohort on Cardiometabolic Health**
(Dr. Margaret Hattori-Uchima)
- **SNAP-Ed (Supplemental Nutrition Assistance Program)**
(Dr. Tanisha Aflague)
- **State Grant for Assistive Technology**
(Dr. Heidi San Nicolas)
- **Educating Pacific Island Clinicians in Speech-Language Pathology**
(Dr. Heidi San Nicolas)
- **Guam Child Link Early Hearing Detection Intervention**
(Dr. Heidi San Nicolas)
- **Development of a School-Based Curriculum and a Social Media-Based Social Marketing Campaign for Tobacco and Betel Nut Use Prevention Among Middle School Students in Guam**
(Dr. Francis Dalisay)

RESEARCH FOCUS: PUBLIC POLICY AND ECONOMICS

THE NEED: Guam and its surrounding region have seen an increasing demand for objective research on a range of social and humanitarian issues and the potential impact of proposed legislation to address them.

Additionally, the region also needs reliable information upon which to build a more resilient economy. The prosperity of regional islands has been dependent upon imports – for basic necessities, but also for assistance from other governments and imported labor. This collective dependence frames a fundamental vulnerability. For true prosperity, research is needed on the effects of such dependence, how to build a sustainable regional economy without it, and the impacts that regional cooperation and trade could have.

OUR RESPONSIBILITY: As a land-grant university with more than 70 years of influence in the Western Pacific, the University of Guam is an honest knowledge broker intent on communicating comprehensive, unbiased research to policymakers, government leaders, and business managers. Social issues in Guam and its surrounding region are complex – influenced by culture, economics, public citizenry, social interactions, formation, and other factors. UOG is uniquely positioned to explore best practices while taking both a multidisciplinary and indigenously relevant approach – two aspects that are highly important in the region for community buy-in.

THE IMPACT: The University of Guam has produced and contributed to several key economics and public policy reports and projects with meaningful outcomes for the community. In the process of these projects -- which have included studies on the economy, minimum wage, school meals, health center fees, the cost/benefit of migration, and the effectiveness of buying locally – the researchers, students, and resource partners involved are actively engaged in thinking about ways to make lasting advancements for the community. The final research products then provide unbiased and reliable data to inform local stakeholders in personal, business, and policy decisions.



The University of Guam is strategically positioned to communicate high-quality, unbiased research to policymakers, government leaders, and business managers.

RECENT RESEARCH IN PUBLIC POLICY AND ECONOMICS

How bad is corruption in Guam from the public's perception?

Like other small island economies, Guam is highly susceptible to corruption incidences that prevent the economy from reaching its full growth potential. These incidences can be countered or minimized by an intensive effort and authentic leadership that increase transparency, encourage reporting, and establish and implement effective accountability mechanisms.

The University of Guam's Regional Center for Public Policy, under lead author Dr. Maria Claret Ruane, published in 2019 a first-of-its-kind Guam Corruption Perception Report, modeled after the Global Corruption Barometer surveys by Transparency International. Based on the results of a survey of island residents, the report provided a deeper understanding of the loss of public trust in government, started a dialogue on the complicated and sensitive issue, and empowered citizens to report corruption incidences and hold the government accountable for addressing them.

The study found that two-thirds of respondents believed corruption was a very serious problem in Guam and that it has increased in the last two years. Political parties were viewed as most corrupt, while religious and military institutions were viewed as least corrupt. Respondents saw personal contacts as very important when dealing with agencies and entities of the local government but less important when dealing with the federal government.

Project: Guam Corruption Perception Report

Other ongoing research in PUBLIC POLICY AND ECONOMICS

- **2019 Democracy and the Informed Citizen Initiative**
(Dr. Francis Dalisay)
- **Compact of Free Association Subsample Survey**
(Pete Barcinas)
- **Household Income & Expenditure Survey**
(Pete Barcinas)
- **Socio-Economic Opportunities for Sustainable Agriculture in the Genetically Modified Food System**
(Dr. Kuan-ju Chen)
- **Guam Self-Determination Study**
(Dr. John Rivera)
- **Refining the Cessation Approach in the Betel Nut Intervention Trial**
(Dr. Gena Rojas)
- **Sustainable Tourism by Producing Locally and Reducing Imports: Implications for Guam**
(Dr. Maria Claret Ruane)
- **Market Forces vs. Government Promotion: What Drives Tourism in Guam?**
(Dr. Maria Claret Ruane)



The University of Guam's Micronesian Area Research Center houses the largest collection in the world of historical documents, photographs, maps, and manuscripts related to Micronesia.

RESEARCH FOCUS: MICRONESIAN HISTORY AND CULTURE

THE NEED: The history of the remote islands within Micronesia has been defined over several eras – from their first seafaring settlers several millennia ago to centuries of colonization by foreign powers. Unique and comparatively unstudied, this region’s history and culture intrigues scholars and Micronesian descendants not only from a discovery standpoint but in that it also holds wisdom applicable today.

OUR ABILITIES: Home to the Micronesian Area Research Center, the largest research center in the world dedicated to Micronesia, the University of Guam has become an authority on the region’s history. The center includes growing collections of academic publications as well as historic news clips, Spanish documents, family genealogies, photographs, maps, and manuscripts.

By 2022, the campus will also host the Guam Cultural Repository, which will house and display various artifacts found in Guam, paving the way for a deeper and more widespread knowledge of Micronesia’s heritage and contemporary realities.

THE IMPACT: The University of Guam has given the history of the Micronesian region a centralized home to be documented and explored. Researchers through MARC have been able to answer fundamental and long-standing questions about Micronesian peoples throughout time – from their origins to the experiences that influenced their modern practices, struggles, successes, and viewpoints.

This knowledge is available to more people than ever through a partnership with Guampedia, a well-known and commonly used online research tool for the public.



FIGURES ARE BASED ON FY20



RECENT RESEARCH IN MICRONESIAN HISTORY AND CULTURE

Ancient DNA sheds light on the origins of Mariana Islanders

The settlement of the Mariana Islands in the Western Pacific, which happened around 3,500 years ago, has received little attention as compared to the peopling of Polynesia. Researchers from the University of Guam joined the Max Planck Institute for Evolutionary Anthropology and the Australian National University to obtain answers to long-debated questions regarding the origin of the first colonizers of the Marianas and their relationship to the people who initially settled in Polynesia.

The researchers obtained ancient DNA data from two skeletons from the Ritidian Beach Cave site in Northern Guam, dating to around 2,200 years ago, about 1,400 years after the first human settlement in Guam. Their findings strengthen the picture that has emerged from linguistic and archaeological studies, linking some of the first settlers of the Marianas to the Philippines.

The ancient Guam skeletons share a close link with the early Lapita individuals from Vanuatu and Tonga in the Western Pacific region, suggesting the Marianas and Polynesia may have been colonized from the same source population and that the Marianas possibly played a role in the eventual settlement of Polynesia.

Project: Ancient DNA from Guam and the Peopling of the Pacific

Funded by: Chiang Ching-kuo Foundation for International Scholarly Exchange, the Australian Research Council, and the Max Planck Society



Top photo: Archaeologist Mike T. Carson uncovers a 2,200-year-old skeleton outside Ritidian Beach Cave in Northern Guam.

© Hsiao-chun Hung, "Ancient DNA from Guam and the peopling of the Pacific," Jan. 5, 2021, Proceedings of the National Academy of Sciences of the United States of America

Bottom Photo: The Latte Stone is a Chamoru term that refers to stone pillars which were used as house supports by the people of the Mariana Islands.

Teaching the tools for underwater cultural heritage preservation

The world-renown shipwrecks in Chuuk Lagoon of the Federated States of Micronesia are under threat from corrosion, oil pollution, and tourism. Key to the preservation of these historically and economically important pieces of underwater cultural heritage was the development of expertise and skills among the local government authorities to do so.

With funding from the UNESCO Participation Programme, the University of Guam organized a field school in June 2019 in Chuuk to train employees from the Historic Preservation Offices in the four island states of the FSM as well as from the Marshall Islands and Palau. Instructors from Japan, Australia, Hong Kong, and Guam taught a number of core activities to implement including site management, surveying and documentation, 3D photogrammetry, and interpretation.

With 12 newly trained historic preservation officers and newly formed connections to underwater cultural heritage experts, the FSM is now working with a consultant to develop a management plan. The field school also introduced the Marshall Islands and Palau representatives to the requirements of ratifying, as 60 nations including the FSM have done, UNESCO's 2001 Convention on the Protection of the Underwater Cultural Heritage.

Project: Underwater Cultural Heritage Field School in FSM (Chuuk 2019)

Funded by: United Nations Educational, Scientific, and Cultural Organization (UNESCO)

Using modern technology to preserve the endangered CHamoru language

The University of Guam is working to preserve the CHamoru language before the last of its remaining speakers have passed on. Through a \$275,000 grant to document endangered languages from the National Science Foundation, the University is working with 10 first-language CHamoru speakers to formally document traditional terms and cultural practices as well as audio recordings of them speaking. The collected data will be stored in a new repository in UOG's Micronesian Area Research Center.

The project will ensure the language is accurately documented and researchable for linguists, the CHamoru community, and academics studying endangered languages for generations to come.

Project: Developing CHamoru Language Infrastructure: Goggue Yan Chachalani Mo'na I Fino'-ta (Embrace and Make a Way Forward for Our Language)

Funded by: National Science Foundation



The bow of the 7,000-ton Fujikawa Maru shipwreck in Chuuk Lagoon, Federated States of Micronesia. Photo by Greg Adams

Other ongoing research in MICRONESIAN HISTORY AND CULTURE

- **Developing Chamoru Language Infrastructure: Goggue Yan Chachalani Mo'na I Fino'-ta**
(Dr. Robert Underwood and Dr. David Ruskin)
- **Spanish Shipwrecks in the Marianas**
(Dr. William Jeffery and Dr. David Atienza)
- **Islas Marianas - History of Guam and the Marianas during the 1800s**
(Dr. Carlos Madrid)
- **CHamoru Oral Folklore**
(Dr. Carlos Madrid and Ray Barcinas)



Guam is one of the few places in the United States with a tropical climate, providing the University of Guam a unique opportunity to study farming systems in this environment.

RESEARCH FOCUS: AGRICULTURE

THE NEED: In addition to crop yields, aspects such as food security and human nutrition are critically important to remote islands like Guam, where more than 90% of the food is imported, making the island highly vulnerable in the case of typhoons or other events that disrupt food shipments.

The island has potential to increase agricultural inputs to improve income and quality of life for local farmers, but farmers face immense difficulties with the presence of numerous harmful insects, diseases, and abiotic constraints. Other limitations include soil erosion and depleted soil nutrient pools, high labor costs, reduced land availability, and difficulties in accessing local and outside markets.

OUR ABILITY: Guam is one of the few places in the United States with a tropical climate, providing a unique opportunity to study the potential and challenges of farming systems in this environment. The university's College of Natural & Applied Sciences operates three experiment stations, which provide ample land for field trials, well-equipped laboratories that are continuously upgraded, and farms for research and demonstrations.

THE IMPACT: UOG research on agriculture is communicated locally and internationally at meetings, in technical reports, and in peer-reviewed articles. Additionally, the information is conveyed by UOG's extension and outreach professionals to farmers and other stakeholders in Guam and Micronesia to assist them on crop variety selection, human nutrition, integrated pest management, soil conservation practices, and other topics.

Breakthrough research on disease-free shrimp conducted at UOG informs the global aquaculture industry – the fastest growing animal production sector in the world. UOG researchers also aid the USDA Animal and Plant Health Inspection Service to identify new diseases and insects that arrive to Guam and threaten agricultural production.

\$735K
RESEARCH GRANT AWARDS

7
RESEARCH
PROJECTS

8
FACULTY

FIGURES ARE BASED ON FY20

ONGOING RESEARCH IN AGRICULTURE



Promoting sustainable aquaculture practices in Guam

With an established five-acre, 14-pond Guam Aquaculture Development & Training Center, a suitable climate, and close proximity to Asia – the center of global aquaculture – Guam has an economic opportunity to develop fish and shrimp farming as a new industry for the island. As an island largely reliant on imports, Guam could greatly benefit from aquaculture in terms of food security. Additionally, demand for high-health seafood and seed stocks throughout Asia positions Guam to be successful as an exporter as well.

However, the aquaculture industry on Guam hasn't made substantial progress in the past three decades, though interest from the community remains.

Under a five-year Hatch Act grant from the USDA's National Institute of Food and Agriculture, the University

is working to expand and diversify the industry on Guam, with the aim of producing a safe and nutritious food supply, long-term sustainability, and increased aquaculture competitiveness in the global market.

UOG researchers have introduced high-quality, clean-seed stocks of shrimp, tilapia, and freshwater prawn. They have achieved significant accomplishments in terms of breeding, determining feeding regimens that best support larval development and survivability.

And as infectious disease outbreaks are the most catastrophic threats to aquaculture everywhere, the Guam Aquaculture Development & Training Center has evolved to become a biosecure facility, keeping both shrimp and prawn stocks under strict health surveillance to remain specific pathogen-free.

Project: Promoting Sustainable Aquaculture Practices on Guam

Funded by: Hatch Act grants from the U.S. Department of Agriculture, National Institute of Food & Agriculture



Top photo: Chasy Cayton, a biologist with UOG's Western Pacific Tropical Research Center, marks tilapia by gender in order to breed the fish at UOG's aquaculture facility.

Above photo: UOG researchers have introduced high-quality, clean-seed stocks of shrimp, tilapia, and freshwater prawn.



Four different breeding lines of papaya that were evaluated for fruit traits and resistance to common diseases found in Guam's environment.

Developing disease-resistant papaya of USDA quality

Plant pathologists at the university's Western Pacific Tropical Research Center carried out a papaya breeding program to develop new varieties tailored to Guam's environment and consumer market and resistant to common diseases, such as papaya ringspot and Erwinia rot. Some hybrid breeding lines they developed were suitable for commercial development, and two of them were released in 2019 with favorable reception from extension agents and local growers.

These new varieties are expected to reach the standards for USDA Plant Variety Protection status to make these lines a saleable product for UOG.

Project: Evaluation and Improvement of Papaya Genetic Resources for Fresh Market Production in Guam

Funded by: Hatch Act grant from the U.S. Department of Agriculture National Institute of Food and Agriculture.

Trial and error: What grows best in the environment

One of the most cost-effective and environmentally friendly ways to improve yields and deter plant pests is to select crop varieties that respond well to the local climate and soils and are resistant to native and introduced pests.

Working on private farms and local research stations, Joseph E. Tuquero, Extension Agent and Dr. Mari Marutani, Professor of Horticulture, have relentlessly tested germplasm. These efforts involve multi-year, multi-location experiments to address inter-annual climatic variations and the diverse site conditions in the island.

Crops included in these trials were bok choy, bell pepper, edamame, hot pepper, kale, winged bean, and zucchini. The findings for each crop – including planting, plant care, and harvesting instructions and information on common pests and diseases – are published for public use in papers on UOG's Western Pacific Tropical Research Center webpage.

Project: Evaluation of Important Vegetable Varieties Grown in a Local Soil Type in the Tropical Environment of Guam

Funded by: Hatch Act grant from the U.S. Department of Agriculture National Institute of Food and Agriculture.

Other ongoing research in AGRICULTURE

- Evaluation of Production and Costs for Commercial Aquaponics System for Guam
(Dr. Kuan-Ju Chen)
- Promoting Sustainable and Local Food Systems in Guam
(Dr. Kuan-Ju Chen)
- Improvement of Seed Distribution System of Heirloom Eggplants and Chili Peppers for Sustainable Agriculture of Guam
(Dr. Mari Marutani)
- Improvement of Tropical Agriculture and Food Science Research at UOG
(Dr. Bulan Wu)
- NASA Autonomous Control Technology for Unmanned Aerial Systems with Agricultural and Environmental Applications in Central Pacific Islands
(Dr. John Jenson)
- Western Sustainable Agriculture Research Education Implementation 2020
(Dr. Leroy Barber)
- Promoting Beginning Farmer Training at the University of Guam
(Dr. Adrian Ares)
- The Impact of Integrated Management Practices on Soil Carbon Dynamics and Related Agroecosystems Services in Southern Guam
(Dr. Mohommad Golabi)
- Improving Soil Quality for a Sustainable Agriculture While Reducing Greenhouse Gas Emissions by Increasing Carbon Sequestration Potential of the Porous Soils of Northern Guam
(Dr. Mohommad Golabi)
- Real-time Optimization of Irrigation Scheduling in the Kula Agricultural Park in Maui and Farmers' Farms in Guam
(Dr. Mohommad Golabi)
- Forecasting Daily Reference Evapotranspiration and Rainfall for Irrigation
(Dr. Mohammad Golabi)



RESEARCH CENTERS

With nine dedicated research centers, the University of Guam is able to conduct projects that advance regional and global knowledge in a breadth of subjects, in particular the unique needs and topics of relevance to the Western Pacific region. Each of the units highlighted here has a team of faculty and staff who work to manage grant funding, carry out lab and field work, analyze the results, and bring the results to scholarly and public audiences.

RESEARCH CENTERS

Cancer Research Center

The **University of Guam Cancer Research Center**, established in 2009, is the only U.S. cancer research infrastructure established west of Hawaii. It houses the:

- Pacific Island Partnership for Cancer Health Equity (PIPCHÉ)
- Guam Cancer Trust Fund
- Guam Cancer Registry
- Pacific Regional Center Cancer Registry

The Pacific Island Partnership for Cancer Health Equity (PIPCHÉ) between the University of Guam and the University of Hawaii Cancer Center is the only U54-supported, Pacific-based cancer research partnership that addresses the substantial cancer health and education disparities in the peoples of Guam, Hawaii, and the U.S.-Affiliated Pacific Islands through research.

PIPCHÉ is one of 14 partnerships established through the National Cancer Institute's Partnerships to Advance Cancer Health Equity grant program to support cancer research capacity building at minority-serving institutions and to address the impact of research disparities on underserved and socioeconomically disadvantaged populations.

With two principal investigators and eight faculty and administrators and \$14 million in funding through 2025, PIPCHÉ supports research on cancers of significance in the Hawaii-Pacific region, in particular to the underserved



populations of CHamorus, Chuukese, and Marshallese. Its recent projects have focused on:

- betel nut use, cessation, and its links to oral cancer;
- increasing cervical cancer screenings among Chuukese women;
- incidence rates of breast cancer in Filipinos and Chamorros;
- substance use and obesity-related risk factors among college students;
- the impact of territorial status on indigenous health.

The Cancer Research Center also houses the Guam Cancer Registry, the Guam Office of the Pacific Regional Center Cancer Registry (PRCCR), and the Guam Cancer Trust Fund. The Guam Cancer Registry and PRCCR track cancer incidence and mortality in the region by ethnicity, age, and gender. The data have since informed important legislation, including an increased tax on tobacco products, and has provided data to cancer researchers.

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Center for Excellence in Developmental Disabilities Education, Research & Service

The **Center for Excellence in Developmental Disabilities Education, Research & Service (CEDDERS)** at the University of Guam exists to create pathways that enhance and support the quality of life of individuals with developmental disabilities and their families. It is one of 67 federally funded university centers of its kind found in every U.S. state and territory.

From its inception in 1993, CEDDERS has evolved into a dynamic organization. With a team of 19 staff members the center implements a host of training and support services, community programs, and care capacity-building efforts under three major initiative areas:

- quality assurance
- early intervention/education
- assistive technology

One key program at CEDDERS is the Guam System for Assistive Technology (GSAT), which seeks to enhance the independence and productivity of individuals with

disabilities by providing them with information and training on assistive technology. Another program is Guam Early Hearing Detection & Intervention, which has conducted newborn hearing screening for more than 43,000 babies over 15 years at Guam's birthing facilities.



Acting Director:
June De Leon, M.Ed.
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Website: www.guamcedders.org

Center for Island Sustainability

The **UOG Center for Island Sustainability (CIS)** was established in 2009 to lead and support the transition of island communities toward a sustainable future. It has since become a focal institute in the Western Pacific region for sustainability-related research and community outreach to help meet island needs in the areas of education, human society, natural environment, and the economy.

CIS and its team of researchers are the stewards of more than \$9.5 million in active federal and external funding, which it uses to implement sustainability research, policy, and education projects. CIS facilitates the Guam Green Growth (G3) initiative, the island's most comprehensive public-private partnership ever created to achieve a sustainable future. In partnership with the Office of the Governor of Guam and more than 97 working group members from all sectors of society, CIS facilitates the implementation of the G3 Action Framework.

CIS oversees UOG Sea Grant, one of 34 university-based programs in the National Sea Grant College Program network. UOG Sea Grant applies research, extension, and educational activities that sustain and develop island environments while integrating the knowledge and culture of island people. The Guam Restoration of Watersheds Initiative is a notable Sea Grant project as well as the



UNIVERSITY OF GUAM CENTER FOR ISLAND SUSTAINABILITY

INCLUDES: SEAS Island Alliance, which provides research and mentorship support for hundreds of students from Guam, Puerto Rico, and the U.S. Virgin Islands.

CIS, via the University of Hawaii at Hilo, is also one of UOG's key players in the Cooperative Ecosystem Studies Units Network, through which UOG conducts research for federal land management, environmental, and research agencies to inform the stewardship of natural and heritage resources and needs for sustainability science. Research projects include sea turtle nesting and protection, wetlands protection, restoration of native vegetation and forest habitats, and monitoring of threatened and endangered species.

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Established Program to Stimulate Competitive Research (GUAM EPSCoR)

In a time when modern research on reef ecosystems is urgent, **Guam EPSCoR** is providing understanding of the processes that drive coral reef resilience under stress from climate change. Guam EPSCoR is a \$20 million National Science Foundation grant that the University of Guam is utilizing to implement the Guam Ecosystems Collaboratorium for Corals and Oceans.

The National Science Foundation's EPSCoR program is meant to strengthen STEM capacity and capabilities in part by catalyzing research capabilities.

At the University of Guam, the collaboratorium will focus on increasing the collection, documentation, integration, and analyses of complex genetic and oceanographic data from coral reefs within the region – some of the most diverse ecosystems in the world.

The project is using innovative techniques and technologies, including hyperspectral scanning to automate mapping of reef communities, DNA barcoding to facilitate the identification of reef organisms, and micro CT scanning within a biorepository to further understand



the morphology of marine organisms and their taxonomic diversity.

The new collections of marine biodiversity from the region are curated, imaged, and mapped, and the specimens are stored in UOG's biorepository, adding to its historical collections dating back more than 50 years. The biorepository includes an online-accessible database, providing the scientific community with an invaluable resource for marine biodiversity research.

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Marine Laboratory

The **Marine Laboratory** at the University of Guam plays an important role in regional as well as national marine research. It facilitates research on tropical coral reef and marine organisms with an emphasis on conservation, adaptation to climate change, and development of marine resources in Guam and Micronesia.

Established in 1970, it was one of the world's first research facilities to specialize in the study of coral reefs and remains the only U.S. university adjacent to what is commonly considered the global epicenter of marine diversity: the Coral Triangle, encompassing the Philippines, Malaysia, Indonesia, and Papua New Guinea. The lab has contributed many firsts in coral reef research, including the discovery and description of numerous new species and novel chemical compounds and studies on outbreaks of the predatory sea star, the crown-of-thorns, and reef recovery after major disturbances.

Operating under grant funding totaling \$1.4 million in 2020, the Marine Lab's team of faculty and postdoctoral research associates focus on a variety of research topics, which include:

- coral genetic connectivity
- fisheries health
- sea turtle nesting behavior
- coral diseases
- endolithic algae
- coral nurseries
- diver effects on coral reefs
- shark genetic connectivity

Research projects are concentrated on Guam but extend throughout the Northern Mariana Islands, Palau, the Federated States of Micronesia, the Marshall Islands, the Philippines, Japan, and other locations of the Indo-Pacific region.



Coral reefs are easily accessible from the backyard of the Marine Lab – the shoreline of Guam's Pago Bay – or by one of the laboratory's three research boats. The two-story Marine Lab facility includes two outdoor wet labs with a flowing seawater system; a biorepository; and ecology, genetics, molecular, microbiology, and biochemistry laboratories.

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Micronesian Area Research Center (MARC)

The **Richard Flores Taitano Micronesian Area Research Center (MARC)** at the University of Guam was established in 1967 to serve as an educational institution that acquires, preserves, and provides access to unique collections about the Micronesian region.

The center houses the largest collection in the world of historical documents related to Micronesia. These collections have paved the way for a deeper knowledge of Micronesia, its peoples, and their cultures as well as the region's contemporary realities.

MARC's Guam and Micronesia Reference Collection collects books, manuscripts, periodicals and serials, government documents, reprints, maps, and other documents that were either written about or produced within the region. The Spanish Documents Collection is comprised of original documents as well as full-size and microfilm reproductions that reflect the lengthy presence of Spain in Micronesia. The Manuscripts Collection has extensive documentation reflecting the American presence in Guam.

MARC adds new information about the region through its faculty research projects, publications, transcriptions and translations programs, and analytic bibliographic listings of important Spanish,

German, French, Japanese, and other foreign language documents. MARC faculty have introduced new understandings about the region through archival, historical, and empirical research in the fields of anthropology, archaeology, history, education, political science, economics, and sociology.



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Regional Center for Public Policy

The **Regional Center for Public Policy** under the University of Guam's School of Business & Public Administration was launched in 2016 to innovate and improve governance, leadership, and public policy for the people and institutions of Guam, the Asia-Pacific region, and the world. The center aims to become the premier policy research nexus in the region, where leaders converge to address, collaborate, and solve crucial issues.

As a land-grant institution, the University of Guam fosters the movement to conduct research that is interdisciplinary – understanding that the issues that society grapples with are not drawn in distinct lines but, rather, influenced by a multitude of factors.

The center seeks to address topics that include:

- government structure
- public finance
- environment
- sustainability and economic development
- water resources
- education
- health care
- human services
- technology
- urban growth
- quality of life

The Regional Center for Public Policy has facilitated the production of events including the Great Gubernatorial Debates, an Enhanced Collaborative Model to Combat Human Trafficking, and Project Foresight – an anti-sexting campaign resulting in the establishment of a nonprofit organization and winner of the FBI Director's Community Leadership Award.



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Water & Environmental Research Institute of the Western Pacific

The **Water & Environmental Research Institute (WERI) of the Western Pacific** at the University of Guam works to provide trustworthy and timely research to support the scientifically informed development and effective management of freshwater resources in Guam, the Northern Mariana Islands, and the Federated States of Micronesia.

WERI is one of 54 institutes nationwide – one at each of the land-grant universities – established by the federal Water Resources Research Act. Of the 54 institutes, WERI is one of 12 to achieve the highest rating in its most recent five-year performance review by the U.S. Geological Survey.

Supported by \$375,000 in funding primarily from the U.S. Geological Survey but also from other federal and local sources as well as contracts with private companies, WERI addresses local and regional water problems and expands understanding of water and water-related phenomena.



Its research projects cover topics related to:

- weather and climate
- surface water and watersheds
- groundwater and aquifers
- water quality production and distribution
- water resource management and GIS

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Western Pacific Tropical Research Center

The **Western Pacific Tropical Research Center**, the research arm of the College of Natural & Applied Sciences at the University of Guam, explores topics that are germane to the well-being of the environment and people throughout the region. This includes research encompassing tropical agriculture, aquaculture, invasive species, plant pathology, protecting native plants, soil health and more.

With federal and local grants, the Western Pacific Tropical Research Center concentrates on applied research that directly impacts agriculture in Guam, Micronesia, the Western Pacific, and the tropics in general. This includes topics related to:

- tropical agriculture
- aquaculture
- invasive species
- plant pathology
- protecting native plants
- soil health

Agricultural research stations

The WPTRC operates three research and education centers that are each located within one of Guam's major soil types. The stations allow agricultural experiments to ensure a safe, nutritious, and affordable food supply and support the preservation and protection of the island's natural resources. The stations have been improved not only for research purposes, but to host teaching and extension activities.

Visitors to the Yigo station can see well-tended research experiments and collections of Cycas and tropical fruit tree species. At the Inarajan station, there are experiments and demonstrations on papaya variety selection, bananas, intercropping, and beehives. Windbreaks with native tree species are an excellent alternative and a planting of binãlo trees was recently established. The Ija station

contains studies to test practices to control soil erosion, resistance of ironwood varieties to dieback, and collections of Cycas and mango varieties.

Triton Farm

Located on the northern research station in Guam, the five-acre Triton Farm provides research and instruction opportunities in sustainable agriculture practices for the whole community. The farm demonstrates an excellent example of an integrated farming system that includes aquaponics, egg production, and fruit orchards.

It promotes agricultural production, sustainable environmental management, food security, economic development, and enhanced quality of life incorporating Micronesian and global agricultural wisdom and culturally appropriate techniques.

Aquaculture Development & Training Center

The Guam Aquaculture Development & Training Center is the largest and oldest aquaculture center in the Western Pacific. It was transferred by the government of Guam to the University of Guam in 2001.

A bio-secure facility on a five-acre site, it has 14 concrete ponds with both a fresh and saltwater supply. It conducts research on shrimp, prawns, and tilapia, working to develop improved strains. It also farms post-larvae and broodstock shrimp and saltwater-tolerant tilapia to sell locally and to export.

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Research Corporation of the University of Guam

As a public corporation rather than a government entity, RCUOG made it possible for UOG to hire externally funded personnel more quickly. This has not only supported the timeliness of scholarly research to advance the local and regional communities, but it has also opened job opportunities for the local community.

The corporation has more than doubled its hiring actions over the past five years. It now has about 160 employees who gain valuable experience working in the field, analyzing data, performing outreach duties, and monitoring budgets, among other tasks.

RCUOG accepted management of its first grant in October 2014 and today supports 125 different grants – a 7% increase from the prior year – which total more than \$10.3 million in federal funding.



RESEARCH CORPORATION
OF THE UNIVERSITY OF GUAM

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HAWAII-PACIFIC ISLANDS COOPERATIVE ECOSYSTEM STUDIES UNIT (HPI-CESU)

ENVIRONMENTAL STEWARDSHIP THROUGH COLLABORATION

Together with its federal and community partners, the University of Guam works to manage and protect the region's natural resources, from land to sea, under a longstanding support and funding network known as Cooperative Ecosystem Studies Units (CESU).

These units link federal agencies with more than 300 university and non-federal partners around the United States for projects designed to preserve natural and cultural heritage and strengthen environmental management and sustainability practices.

Among the 17 CESUs operating throughout the United States, UOG is part of the Hawaii-Pacific Islands Cooperative Ecosystem Studies Unit, hosted by the University of Hawaii at Hilo, which was established in 2004. UOG started gaining momentum and receiving CESU awards around 2010 and has since been awarded funding for more than 30 projects amounting to more than \$13 million from Naval Facilities Engineering Systems Command (NAVFAC) and the U.S. Army Corps of Engineers - Alaska District.

Guam and the Northern Mariana Islands, including federally controlled lands, face a series of issues – climate change, globalization, and development – that impact ecosystems. The driving belief is that CESU partners are stronger together to manage such issues through combined research, technical assistance, and education expertise.

In 2020, UOG maintained more than 20 active projects that amounted to more than \$8.5 million, each led by UOG faculty members across different research units and in partnership with experts from NAVFAC and other entities.

TERRESTRIAL PROJECTS

Fruit bat population recovery: The population of the Mariana fruit bat, or fanihi in the native CHamoru language, on Andersen Air Force Base in Northern Guam has significantly declined from more than 1,000 in the 1980s to less than 50 in 2015, when this collaborative project began.

Dr. Tammy Mildestein, a former adjunct professor of UOG, leads survey and monitoring efforts at Andersen Air Force Base in collaboration with their environmental team. Over the last six years, the team has studied the fanihi to generate population size estimates to understand the bats' population trend better and examine the effect aircrafts have on their behavior.

A \$605,000 project is also studying fanihi habitat needs to inform the U.S. Fish & Wildlife Service's fruit bat recovery plan. Outreach materials are also being created for greater awareness on Guam about this majestic native species.

Protection of Guam's rarest trees: Dr. James McConnell, a professor of ornamental horticulture, leads two plant conservation efforts, including a project to protect and propagate Guam's rarest tree, the *Serianthes nelsonii*, and another project to monitor and manage another rare tree, the cycad (*Cycas micronesica*), on Andersen Air Force Base. A total of \$1.3 million has been awarded for the projects since 2015.

Protecting endangered plants and invertebrates: An effort that began in 2019, with funds totaling more than \$1.7 million and led by Dr. James McConnell, includes plant and invertebrate surveys within the military's "areas of responsibility" and other forested areas. The purpose of the surveys is to inform management techniques that provide a conservation benefit to protected, threatened, and endangered species on Guam and the Northern Mariana Islands.

Restoring native limestone forest: Forest restoration research and the promotion of endemic species is one of the main pillars of UOG's Center for Island Sustainability natural resources unit. Led by Else Demeulenaere, CIS associate director for natural resources, an ongoing habitat management project at Andersen Air Force Base aims to restore the native limestone forest habitat. The goal is to support the introduction of Guam Micronesian kingfishers and Guam rails and expand the recovery efforts for the eight-spot butterflies, fruit bat, and native tree snails.

Since 2017, more than \$750,000 has been awarded to research and piloting sustainable restoration methods to control invasive species and enhance the native vegetation by broadcasting native seeds and outplanting nursery grown plants, such as *Procris pendunculata*, *Ochrosia mariannensis* (langiti), *Melanolepis multiglandulosa* (alom), and *Intsia bijuga* (ifit). Demeulenaere and her team of biologists hope their research can be used by local communities island-wide.

MARINE PROJECTS

Sea turtle monitoring: The waters off the Northern point of Guam at Andersen Air Force Base serve as a habitat for the endangered green sea turtle, or "haggan." As part of ongoing conservation and management activities, a project led by Dr. Austin Shelton, director of UOG Sea Grant, monitors the turtles and their nests and conducts educational outreach to ensure their protection and success.

Led by Fran Castro, associate director for the Sea Grant program, sea turtle aerial surveys are also being conducted in the nearshore waters of Farallon de Medinilla within the Northern Mariana Islands chain. Combined, the projects represent more than \$560,000 in funding since 2018.



Detection of hammerhead sharks: Marine Lab Professor Dr. Tom Schils and students have partnered with researchers from James Cook University to develop a non-invasive assay for the detection of elusive and critically endangered scalloped hammerhead sharks in Apra Harbor and adjacent waters. Environmental DNA (eDNA) from filtered seawater samples was used to successfully validate the sharks' presence in Apra Harbor. The developed techniques can be used for the spatial and temporal monitoring of scalloped hammerheads to guide management and conservation strategies in the busy harbor area. Awards for this project total nearly \$360,000.

INVASIVE SPECIES

Eradicating the invasive fire ant: Researchers spotted the little fire ant more than 10 years ago and have been working to control its presence ever since. In a project nearing \$570,000, Dr. Ross Miller, a professor of entomology, spearheads monitoring and management efforts at the Andersen South and Naval Magazine based in Guam, including eradication of the ant, which is considered to be the greatest invasive ant threat to the region.

Removing invasive ironwoods: While ironwood (*Casuarina equisetifolia*) is tightly integrated into the Guam's environment and culture and is propagated for windbreaks, erosion control, and urban landscapes, it is not so for this tree on Wake Island. On Wake Island it is considered an invasive species. Its encroachment on the island's runway is contributing to a high risk of bird strikes. As principal investigator, Dr. Robert Schlub, a professor of plant pathology, is providing advice on actions to remove unwanted trees, to improve habitat for native plant species, and to ensure safe flight operations in the future. The project totals more than \$740,000 and was awarded through the U.S. Army Corps of Engineers – Alaska District.

OTHER CESU PROJECTS INCLUDE:

- Forest Bird Monitoring and Assessment on Tinian (Dr. Rachael Leon Guerrero and John Gourley)
- Cetti Bay Watershed Monitoring (Dr. Austin Shelton)
- Water Quality Monitoring, Naval Base Guam Submerged Lands (Dr. Tom Schils)

For more information on CESU projects at the University of Guam, contact Jerica B. Santos, Office of Research & Sponsored Programs, at (671) 735-2169 or blasj8288@triton.uog.edu.

Photos clockwise: Mariana fruit bats, known in Guam's native CHamoru language as fanihi, at a roost site on Andersen Air Force Base. Photo by Dr. Tammy Mildenstein during field work under Cooperative Agreement #: N40192-15-2-8001, Monitoring Mariana Fruit Bats on Andersen Air Force Base, funded by the U.S. Department of the Navy

Samoana fragilis, a fragile tree snail native to Guam and Rota. Photo by Dr. Curt Fiedler

Else Demeulenaere, associate director of UOG's Center for Island Sustainability, collects an herbarium specimen of the endangered *Serianthes nelsonii* tree on the island of Rota in the Northern Mariana Islands.

Environmental DNA surveys in Apra Harbor conducted by doctoral candidate Matthew Mills of the UOG Marine Laboratory. Photo taken during field work under Cooperative Agreement#: N40192-18-2-8001, Water Quality Monitoring at Naval Base Guam Submerged Lands, funded by the U.S. Department of the Navy

A tree fern native to Guam called the *Cyathea lunulate*, or *Tsatsa* in Guam's native CHamoru language, in UOG's Guam Plant Extinction Prevention Program nursery.

A water quality multiprobe on a coral-dominated reef in Apra Harbor. Photo taken during field work under Cooperative Agreement#: N40192-18-2-8001, Water Quality Monitoring at Naval Base Guam Submerged Lands, funded by the U.S. Department of the Navy

RESEARCH FACULTY

University of Guam faculty come from all around the globe with a breadth of research interests. Of 180+ faculty members at UOG, about 25 are full-time research faculty with many more actively engaged in research. Those listed here carry out research projects in their respective fields.

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