

SERDP FY25 Preproposal: Remote Sensing for Detection and Monitoring of Coconut Rhinoceros Beetle Damage

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December 18, 2023

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Note to reader: Paragraphs in italics will be removed when the proposal is complete.

Proposal Number: *Generated by SEMS when proposal details are entered and saved in the system.*

Proposal Title: Remote Sensing for Detection and Monitoring of Coconut Rhinoceros Beetle Damage

Lead Principal Investigator: Roland Quitugua

Lead Organization: University of Guam, College of Natural and Applied Sciences, Mangilao, Guam

1. Objective

The proposed objectives and how the project is responsive to the objectives articulated in the SON.

Our objective is to develop an automated remote sensing system that detects and monitors coconut rhinoceros beetle (CRB) damage on isolated Pacific islands.

This proposal addresses the SON entitled **Advancing Non-Indigenous Invasive Species Surveillance, Mitigation, or Biosecurity Measures Affecting Military Readiness in the Indo-Pacific Region.**
MORE??

2. Background

Sufficient technical background to demonstrate a thorough understanding of the problem and frame the proposed research in the context of the current state of the science or technology.

The proposed project builds on an existing system which maps CRB damage using automated analysis of ground-based imagery which uses a smart phone mounted on a road vehicle for data acquisition. Currently, images are taken at a rate of one per second by a free cell phone app named OpenCamera. Each image is 1920 x 1080 pixels in size and GPS coordinates are embedded within the image file. Note that the phone does not require a SIM card or internet connection during data acquisition.

After transferring image files to a laptop computer, each is examined by a pair of object detectors trained by an artificial intelligence technique called deep learning. One detector puts a bounding box around all coconut palms within each image and assigns a standardized 5-scale damage index to each palm [REF]. The damage index is based on a standard methodology developed by CRB experts working on islands in the south Pacific [REF]. A second object detector counts v-shaped cuts to coconut palm in fronds which are distinctive signs of CRB feeding damage. Results are visualized using interactive web maps. This ground-based system has been used for routine roadside surveys on Guam and has also been used for early detection of CRB damage on Rota in the Commonwealth of the Northern Mariana Islands and on Majuro in the Republic of the Marshall Islands [REFS].

For details on this ground-based CRB damage survey methodology see the attached file roadside.pdf.

We will improve the existing ground-based system and adapt this system to use aerial drone imagery to facilitate:

- CRB damage detection over large areas of remote, otherwise inaccessible, terrain
- early detection and delimiting surveys in rapid response projects on islands where CRB has not yet established, increasing chances of eradication
- monitoring temporal and spatial changes in CRB damage on islands where CRB has established
- measuring changes in CRB damage in response to biological control, sanitation, and other mitigation tactics

3. Approach

The technical approach and methods, preferably structured in hypothesis-driven tasks that clearly identify how the objectives of the proposed project will be addressed. This section should be the primary focus of the pre-proposal.

- improve ground-based system
 - improve code to minimize false positive s and false negatives
 - evaluate performance using standard metrics
 - provide technical documentation
 - provide user manual
 - develop and test a cell phone app which does real-time object detection. This can be done by embedding the two object detectors in the app. This app would work in much the same way as a license plate reader: sending out an alert whenever CRB damage is detected. Images to be saved for eventual upload and further analysis. IF THIS APP IS MADE AVAILABLE PUBLICLY, IT COULD BE USED FOR CROWD SOURCED DATA SIMILAR TO INAT.
- develop aerial-based system
 - train object detectors to detect CRB damage from aerial images using the existing VDC ortho-mosaic
 - evaluate performance using standard metrics
 - provide technical documentation
 - provide user manual
- operational testing
 - initial operational testing of the ground-based system during routine island-wide CRB damage surveys on Guam
 - initial operational testing of the aerial-based system using new imagery from VDC
 - remote operational testing on Majuro: ground-based system for roadside survey; aerial-based survey for islets in the northern part of the atoll
 - detection survey on Kiribati using both ground-based and aerial-based methods

4. Schedule

The duration of the project, along with a milestone chart that delineates the timeline for each task and major deliverables.

The duration of this project component will be 4 years. A schedule with milestones is provided as Fig. 1.

5. Cost

The estimated total costs, including labor, materials, travel, burdens, and profit (fixed fee, if any, for eligible organizations) by year. A detailed breakout of costs is not required or desired in the pre-proposal.

Estimated total costs for this project component are provided in Table D.

6. Research Team

Identify the Principal Investigator(s), the key co-performers, and their respective organizations. If multiple co-performers are proposed, indicate their responsibilities within the project.

The members of the research team for this project component and their roles are listed in Table 2.

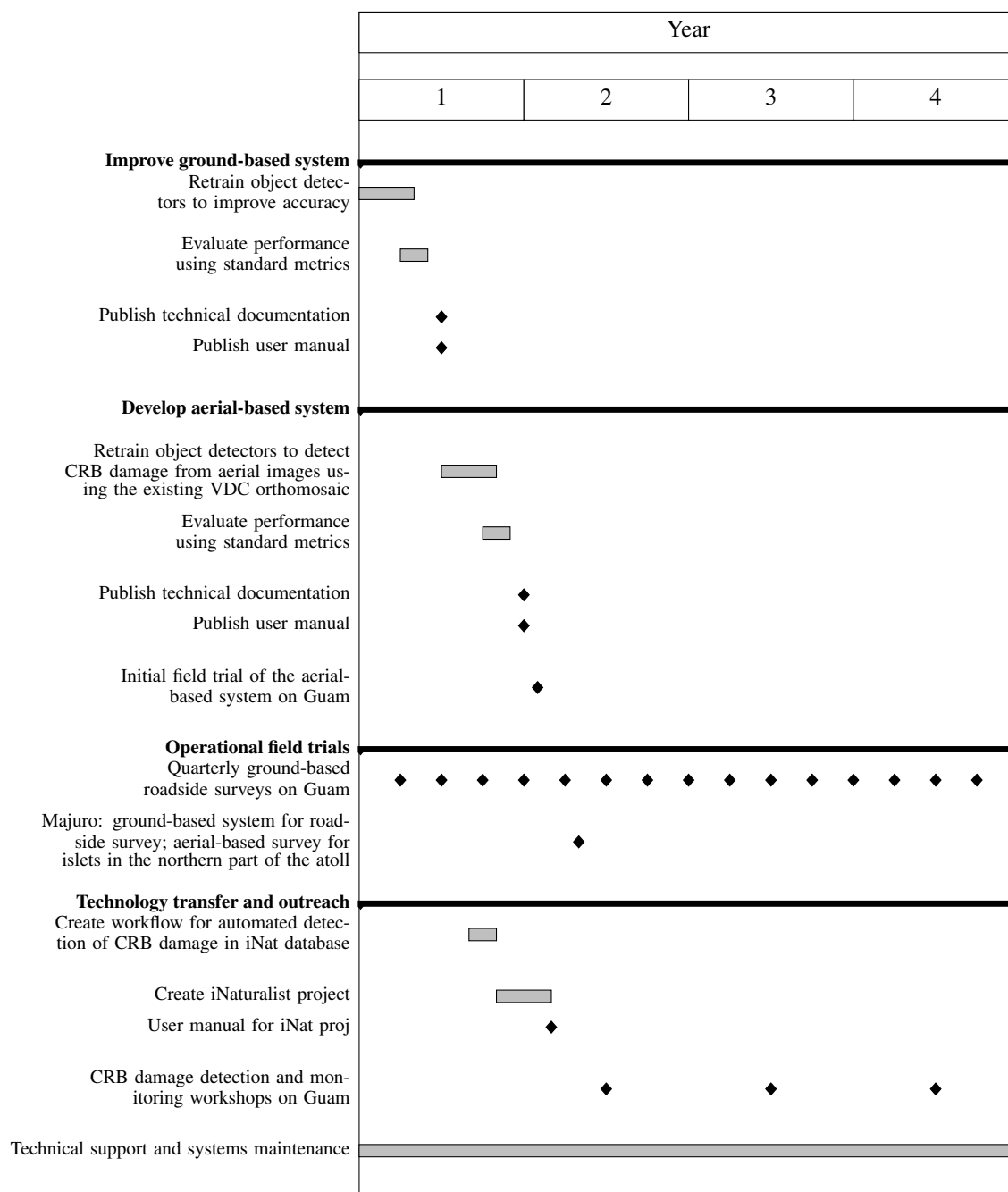


Figure 1: Project schedule.

Table 1: Summary of project cost estimates. Indirect rates are 26% for CEMML, 27.6% for NCSU, and 15% for UOG. These rates are applied to Labor + Materials + Travel. In addition, NCSU charges 27.6% on the first \$25k of each subcontract awarded to CEMML and UOG. For details see Appendix D.

Year	Institution	Labor	Materials	Travel	Rent	Indirects	Year total
1	CEMML	\$145,618	\$29,102	\$11,817	\$12,000	\$48,499	\$247,036
1	NCSU	\$33,959	\$0	\$37,000	\$1,000	\$33,384	\$105,343
1	UOG	\$378,980	\$96,250	\$0	\$0	\$71,284	\$546,514
1	All	\$558,557	\$125,352	\$48,817	\$13,000	\$153,167	\$898,893
2	CEMML	\$149,985	\$28,102	\$0	\$12,000	\$46,302	\$236,389
2	NCSU	\$44,677	\$0	\$50,000	\$1,000	\$39,930	\$135,607
2	UOG	\$397,041	\$56,250	\$0	\$0	\$67,993	\$521,284
2	All	\$591,703	\$84,352	\$50,000	\$13,000	\$154,225	\$893,280
3	CEMML	\$154,484	\$26,102	\$0	\$12,000	\$46,952	\$239,538
3	NCSU	\$36,432	\$0	\$50,000	\$1,000	\$37,655	\$125,087
3	UOG	\$408,952	\$56,250	\$0	\$0	\$69,780	\$534,982
3	All	\$599,868	\$82,352	\$50,000	\$13,000	\$154,387	\$899,607
4	CEMML	\$158,921	\$26,102	\$0	\$12,000	\$48,105	\$245,128
4	NCSU	\$43,853	\$0	\$36,000	\$1,000	\$35,839	\$116,692
4	UOG	\$408,033	\$56,250	\$0	\$0	\$69,642	\$533,925
4	All	\$610,807	\$82,352	\$36,000	\$13,000	\$153,586	\$895,745

Table 2: Research team. A list of additional collaborators, not directly funded by this proposed project, is presented in Table 16.

Collaborator(s)	Roles
Dr. Godshen Pallippambil (PI), NSF Center for Integrated Pest Management, North Carolina State University	Overall project management, coordination and communication; organization of annual meetings in coordination with the CRB-G Action Group
Dr. Aubrey Moore (co-PI), Dr. James Grasela and Roland Quitugua, University of Guam	Applied research leading to implementation of biological control of CRB-G using OrNV; in vivo propagation of OrNV; field release of OrNV via autodissemination, CRB trapping surveys, and CRB damage surveys on non-DOD lands in Guam
Dr. Ken Puliafico, Center for Environmental Management of Military Lands, Colorado State University	Liaison with DOD; Field release of OrNV via autodissemination, CRB trapping surveys, and CRB damage surveys on DOD lands in Guam.

A. Abbreviated Curriculum Vitae

A.1. Dr. Godshen R. Pallipparambil

Please see next page.

GODSHEN ROBERT PALLIPPARAMBIL

Senior Researcher, NSF Center for Integrated Pest Management, NC State University
1730 Varsity Dr., STE 110, Raleigh, NC; Ph: +1 919-855-7527 | Email: grpallip@ncsu.edu

EDUCATION

2010	Ph.D. Entomology. University of Arkansas, Fayetteville, AR.
2006	M.S. Entomology. Montana State University, Bozeman, MT
2002	B.S. Agriculture. Kerala Agricultural University, India

EMPLOYMENT

2014-Pres.	Senior Researcher. NSF Center for Integrated Pest Management, North Carolina State University, Raleigh, NC, USA. Plant Biosecurity & New Pest Response.
2011-2013	Postdoctoral Research Associate. Energy Biosciences Institute, University of Illinois, Urbana Champaign, IL, USA. Pests of Biofuel Crops.
2010-2011	Postdoctoral Research Associate. University of Arkansas, Fayetteville, AR, USA. Systems Thinking and Modeling.
2006-2010	Graduate Research Assistant. University of Arkansas, Fayetteville, AR, USA. Plant-insect interactions & Host Plant Resistance.
2004-2006	Graduate Research Assistant. Montana State University, Bozeman, MT, USA. Biological Control.
2003	Research Assistant. All India Coordinated Research Project, Kerala Agriculture University, India. Biological control of crop pests and weeds.

RELEVANT PUBLICATION

Pallipparambil, G. R. 2015. New Pest Response Guidelines for the **Coconut Rhinoceros Beetle**, *Oryctes rhinoceros*. U.S. Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine. Washington, D.C.: Government Printing Office

SELECTED GRANTS (awarded grants only)

2015-Pres.	Lead P.I. Objective Prioritization of Exotic Pests. Multiple Farm Bill grants	\$1,761,980
2019	Lead P.I. Pest and Disease Databases and Applications. Cooperative Agreement USDA APHIS	\$1,357,226
2019-2020	Lead P.I. New Pest Response Guidelines. Farm Bill	\$311,850
2018-2019	Lead P.I. Pest Exclusion Analysis. Cooperative Agreement USDA APHIS	\$273,029
2017-2019	Co-PI. East Africa Invasive Groundnut Leafminer DNA Sequencing Project. United States Agency for International Development	\$41,918

A.2. Dr. Aubrey Moore

Please see next page.

Aubrey Moore Ph.D.

College of Natural and Applied Sciences, University of Guam

Rm. 105, Agriculture and Life Sciences Bldg., 303 Campus Dr., Mangilao, Guam 96923, USA

Email: [aubreyymoore@triton.uog.edu](mailto:aubreymoore@triton.uog.edu) Cell phone: +1 671 686-5664

Education

Ph.D. 1988 Entomology; University of Hawaii, Honolulu, HI
M.S. 1984 Entomology; Michigan State University, East Lansing, MI
B.Sc. 1979 Integrated Science Studies; Carleton University, Ottawa, Canada

Employment

2008-Pres. Professor of Entomology, University of Guam, Guam
2003-2008 Research Associate, College of Natural & Applied Sciences, University of Guam, Guam
1999-2003 Pesticide Evaluator, Pest Management Regulatory Agency, Health Canada, Ottawa, ON
1998-1999 Entomologist, Land Grant Program, Northern Marianas College, Saipan
1992-1997 Research Director, Land Grant Program, Northern Marianas College, Saipan
1991-1992 Entomologist, Northern Mariana Islands Department of Natural Resources, Saipan
1990-1991 Entomologist, Ag. Development in the American Pacific Project, Guam & Maui
1989-1990 Research Associate, University of Hawaii Ag. Expt. Stn., Maui, Hawaii
1988 Post-doctoral Fellow, Hawaiian Evolutionary Biology Program, Honolulu, Hawaii
1985-1988 Graduate Assistant, Department of Entomology, University of Hawaii, Honolulu, Hawaii
1985-1986 Programmer/consultant, University of Hawaii Computing Center, Honolulu, Hawaii
1984 Research Associate, Dept. of Entomology, Michigan State University, East Lansing, MI
1984 Entomologist, Insect and Rodent Control Sect., MI Dept. of Public Health, Lansing, MI
1981-1984 Graduate Assistant, Dept. of Entomology, Michigan State University, East Lansing, MI
1979-1981 Res. Tech., Forest Pest Management Inst., Environment Canada, Sault Ste. Marie, ON
1975-1979 Res. Tech., Chemical Control Research Institute, Environment Canada, Ottawa, ON

Relevant Publications

- [1] Sean D. G. Marshall, Aubrey Moore, Maclean Vaqalo, Alasdair Noble, and Trevor A. Jackson(2017). **A new haplotype of the coconut rhinoceros beetle, *Oryctes rhinoceros*, has escaped biological control by *Oryctes rhinoceros* nudivirus and is invading Pacific islands.** Journal of Invertebrate Pathology 149, p. 127-134. <http://www.sciencedirect.com/science/article/pii/S0022201117300289>
- [2] Aubrey Moore(2018). **The Guam Coconut Rhinoceros Beetle Problem: Past, Present and Future.** Zenodo. <https://zenodo.org/record/1185371#.W4Dolh9fhE>
- [3] Aubrey Moore, Roland Quitugua, Ian Iriarte, Michael Melzer, Shizu Watanabe, Zhiqiang Cheng, and Jathan Muna Barnes(2016). **Movement of Packaged Soil Products as a Dispersal Pathway for Coconut Rhinoceros Beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) and Other Invasive Species.** Proceedings of the Hawaiian Entomological Society 48: pp. 21-22. <http://scholarspace.manoa.hawaii.edu/handle/10125/42743>
- [4] Aubrey Moore, Diego C. Barahona, Katherine A. Lehman, Dominick A. Skabeikis, Ian R. Iriarte, Eric B. Jang, and Matthew S. Siderhurst(2017). **Judas Beetles: Discovering Cryptic Breeding Sites by Radio-Tracking Coconut Rhinoceros Beetles, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae).** Journal of Environmental Entomology 46(1), pp. 92-99. <https://doi.org/10.1093/ee/nvw152>
- [5] Aubrey Moore, Trevor Jackson, Roland Quitugua, Paul Bassler, and Russell Campbell(2015). **Coconut Rhinoceros Beetles (Coleoptera : Scarabaeidae) Develop in Arboreal Breeding Sites in Guam.** Florida Entomologist 98(3), pp. 1012-1014. <http://journals.fcla.edu/flaent/article/download/84794/84044>
- [6] R W Mankin and Aubrey Moore(2010). **Acoustic Detection of *Oryctes rhinoceros* (Coleoptera: Scarabaeidae: Dynastinae) and *Nasutitermes luzonicus* (Isoptera: Termitidae) in Palm Trees in Urban Guam.** Journal of Economic Entomology 103(4) pp. 1135-1143. <http://www.ingentaconnect.com/content/esa/jee/2010/00000103/00000004/art00014>

Relevant Grants

USDA-APHIS Farm Bill 2013 through 2019: Biological Control of Coconut Rhinoceros Beetle

DOI, Office of Insular Affairs: 2018-2019: Funding to Hire an Insect Pathologist Post-Doc

CESU 2013 Federal Candidate Species Surveys on Guam

NAVFAC Pacific 2011 Peer Review of the Micronesia Biosecurity Plan and Development of a Strategic Implementation Plan

A.3. Dr. Kenneth Puliafico

Please see next page.

Kenneth Puliafico, Ph.D.
Entomologist

Center for Environmental Management of Military Lands
PO Box 3226, Hagatna GU 96932
671-929-7510
ken.puliafico@colostate.edu

Doctor of Philosophy, Entomology (2008)

Plant Soils & Entomological Science, University of Idaho. Moscow, ID 83843.

Master of Science, Entomology (2003)

Entomology Department, Montana State University. Bozeman, MT 59717

Bachelor of Science, Biological Science, with honors (1992)

Biology Department, Montana State University. Bozeman, MT 59717

2018 – present **Supervisory Entomologist –Center for Environmental Management of Military Lands, Colorado State University, based in Asan, Guam, USA**

- Organized monitoring program for Coconut Rhinoceros Beetle (CRB) populations and assessed damage across Andersen Air Force Base and Naval Base Guam
- Supervised baseline and long term monitoring for terrestrial arthropods for improved biosecurity in transport networks and training areas
- Implemented treatment program for invasive Little Fire Ants on military lands
- Scientific and taxonomic support of vehicle and cargo inspections for military exercises in Guam, Commonwealth of the Northern Marianas and partner nations

2018 **Research Entomologist** – Research Corporation of the University of Hawaii, Pacific Cooperative Studies Unit UH-Manoa, Institute of Pacific Islands Forestry, Hilo, Hawaii

2017 – 2018 **Volunteer Research Entomologist** – USDA Forest Service, Institute of Pacific Islands Forestry, Pacific Southwest Research Station, Hilo, Hawaii

2012 – 2017 **Research Entomologist – Postdoctoral Researcher** – USDA Forest Service, Institute of Pacific Islands Forestry, Pacific Southwest Research Station, Volcano, Hawaii

2010 – 2012 **Research Associate: Entomology** – Natural History Museum of Denmark, Zoological Museum, Copenhagen, Denmark

2010 **Contract Entomologist** – Landcare Research – Biosystematics Team, Auckland, New Zealand

2009 – 2010 **Volunteer Curator** – Entomology Auckland War Memorial Museum, Entomology Department, Auckland, New Zealand

2009 **Entomologist** – Montana Department of Agriculture – Pest Management Bureau, Helena, MT, USA

1994 – 1996 **U.S. Peace Corps Volunteer** – National University of Samoa, Apia, Samoa

Publications and Presentations available on request

A.4. Dr. James Grasele

COMING SOON.

A.5. Roland Quitugua

COMING SOON.

B. List of Acronyms

Provide a complete list of acronyms used in your preproposal and their definitions. List the proposal number at the top of the page.

Proposal Number: *Proposal Number: Generated by the SERDP and ESTCP Management System (SEMS) when the proposal details are entered and saved in the system.*

CEMML Center for Environmental Management of Military Lands, Colorado State University

CRB Coconut rhinoceros beetle, *Oryctes rhinoceros*

CRB-G Coconut rhinoceros beetle, Guam biotype

CRB-S Coconut rhinoceros beetle, not Guam biotype

DOD United States Department of Defense

IATS Invasive, alien terrestrial species

LD50 Dose which causes 50% mortality

LT50 For a fixed dose, this is time between treatment and 50% mortality

NCSU North Carolina State University

OrNV *Oryctes rhinoceros* nudivirus, a biological control agent for coconut rhinoceros beetle

SON Statement of need

USDA-APHIS United States Department of Agriculture, Animal & Plant Health Inspection Service

C. Literature Citations

- [1] Bedford G. O. (1986). Biological control of the rhinoceros beetle (*Oryctes rhinoceros*) in the South Pacific by baculovirus. *Agriculture, Ecosystems and Environment*. 15:141-7.
- [2] Bedford, G. O.(2013). Long-term reduction in damage by rhinoceros beetle *Oryctes rhinoceros* (L.) (Coleoptera: Scarabaeidae: Dynastinae) to coconut palms at *Oryctes* nudivirus release sites on Viti Levu, Fiji. *African J Agricultural Research*. 8(49):6422-5.
- [3] Marshall SDG, Moore A, Vaqalo M, Noble A, Jackson TA (2017). A new haplotype of the coconut rhinoceros beetle, *Oryctes rhinoceros*, has escaped biological control by *Oryctes rhinoceros* nudivirus and is invading Pacific Islands. *Journal of Invertebrate Pathology* 149:127-34. <http://www.sciencedirect.com/science/article/pii/S0022201117300289>
- [4] Pallipparambil G. (2015). New Pest Response Guidelines: *Oryctes rhinoceros* (L.) Coleoptera:Scarabaeidae Coconut Rhinoceros Beetle [Internet]. United States Department of Agriculture - Animal and Plant Health Inspection Service - Plant Protection and Quarantine; 2015 p. 180.
- [5] Vander Meer RK, Ghatak UR, Alam SK, Chakraborti PC, Alam KS, Chakraborti PC (1979). (+-)-Des-N-Morphinan: a unique bridged hydrocarbon attractant for the rhinoceros beetle, *Oryctes rhinoceros*, and development of an olfactometer. *Environmental Entomology*. 8(1):6-10.
- [6] Huger AM (2005). The *Oryctes* virus: Its detection, identification, and implementation in biological control of the coconut palm rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaeidae). *Journal of Invertebrate Pathology*. 89(1):78-84.

D. Cost Breakdown Narrative

Required, Cost Breakdown Narrative: Provide a 1-2 page narrative discussing each cost element in sufficient detail to explain why the cost proposed is considered fair and reasonable, including the techniques used to determine subcontractor costs fair and reasonable.

D.1. CEMML

D.1.1. Labor

1 entomologist 5% of \$135,810
1 field admin support 20% of \$90,540
2 survey techs 100% of \$60,360
labor is increased by 3% each year

D.1.2. Materials

Office Materials and Supplies: printer paper, printer cartridges: \$1,500.00
Field Materials and Supplies: field supplies, ropes, ties, collection vials: \$5,000.00
Computer and Laptop (Hardware and Software) 2 Laptops: \$2,000.00 each; one purchased y1, other y2
GPS unit: \$1,000.00
cell phone service for 3 technicians: \$1440/year
internet access: \$1362/year
vehicle lease: \$1440 per year
vehicle lincensing: \$50 per year
electrical service: \$2400 per year
water service: \$360 per year
building rental: \$12000 per year

D.2. Rent

\$12,000 per year

D.2.1. Travel

Off-island recruitment of field ops manager and monitoring trip to Tinian: \$11,817

Table 3: CEMML year 1

cost_item	cost_type	qty_or_fte	unit_cost	units	total
CEMML Field Admin Support	labor	0.20	\$90,540.00	\$/year (inc. benefits)	\$18,108
CEMML survey tech 1	labor	1.00	\$60,360.00	\$/year (inc. benefits)	\$60,360
CEMML survey tech 2	labor	1.00	\$60,360.00	\$/year (inc. benefits)	\$60,360
CEMML entomologist	labor	0.05	\$135,810.00	\$/year (inc. benefits)	\$6,790
Vehicle lease (incl.fuel and maintenance)	materials	12.00	\$1,200.00	\$/month	\$14,400
Office Materials and Supplies	materials	1.00	\$1,500.00	\$/year	\$1,500
Field Materials and Supplies	materials	1.00	\$5,000.00	\$/year	\$5,000
cell phone service for 3 technicians	materials	1.00	\$1,440.00	\$/year	\$1,440
vehicle lincensing	materials	1.00	\$1,362.00	\$/year	\$1,362
electrical service	materials	1.00	\$2,400.00	\$/year	\$2,400
Laptop computers	materials	1.00	\$2,000.00	\$/each	\$2,000
GPS Unit	materials	1.00	\$1,000.00	\$/each	\$1,000
building rental	rent	1.00	\$12,000.00	\$/year	\$12,000
Off-island travel (Denver and Tinian)	travel	1.00	\$11,817.00	\$/year	\$11,817

Table 4: CEMML year 2

cost_item	cost_type	qty_or_fte	unit_cost	units	total
CEMML Field Admin Support	labor	0.20	\$93,256.00	\$/year (inc. benefits)	\$18,651
CEMML survey tech 1	labor	1.00	\$62,170.00	\$/year (inc. benefits)	\$62,170
CEMML survey tech 2	labor	1.00	\$62,170.00	\$/year (inc. benefits)	\$62,170
CEMML entomologist	labor	0.05	\$139,884.00	\$/year (inc. benefits)	\$6,994
Laptop computers	materials	1.00	\$2,000.00	\$/each	\$2,000
Vehicle lease (incl.fuel and maintenance)	materials	12.00	\$1,200.00	\$/month	\$14,400
Office Materials and Supplies	materials	1.00	\$1,500.00	\$/year	\$1,500
Field Materials and Supplies	materials	1.00	\$5,000.00	\$/year	\$5,000
cell phone service for 3 technicians	materials	1.00	\$1,440.00	\$/year	\$1,440
vehicle lincensing	materials	1.00	\$1,362.00	\$/year	\$1,362
electrical service	materials	1.00	\$2,400.00	\$/year	\$2,400
building rental	rent	1.00	\$12,000.00	\$/year	\$12,000

Table 5: CEMML year 3

cost_item	cost_type	qty_or_fte	unit_cost	units	total
CEMML Field Admin Support	labor	0.20	\$96,053.00	\$/year (inc. benefits)	\$19,211
CEMML survey tech 1	labor	1.00	\$64,035.00	\$/year (inc. benefits)	\$64,035
CEMML survey tech 2	labor	1.00	\$64,035.00	\$/year (inc. benefits)	\$64,035
CEMML entomologist	labor	0.05	\$144,081.00	\$/year (inc. benefits)	\$7,204
Vehicle lease (incl.fuel and maintenance)	materials	12.00	\$1,200.00	\$/month	\$14,400
Office Materials and Supplies	materials	1.00	\$1,500.00	\$/year	\$1,500
Field Materials and Supplies	materials	1.00	\$5,000.00	\$/year	\$5,000
cell phone service for 3 technicians	materials	1.00	\$1,440.00	\$/year	\$1,440
vehicle lincensing	materials	1.00	\$1,362.00	\$/year	\$1,362
electrical service	materials	1.00	\$2,400.00	\$/year	\$2,400
building rental	rent	1.00	\$12,000.00	\$/year	\$12,000

Table 6: CEMML year 4

cost_item	cost_type	qty_or_fte	unit_cost	units	total
CEMML Field Admin Support	labor	0.20	\$98,935.00	\$/year (inc. benefits)	\$19,787
CEMML survey tech 1	labor	1.00	\$65,857.00	\$/year (inc. benefits)	\$65,857
CEMML survey tech 2	labor	1.00	\$65,857.00	\$/year (inc. benefits)	\$65,857
CEMML entomologist	labor	0.05	\$148,403.00	\$/year (inc. benefits)	\$7,420
Vehicle lease (incl.fuel and maintenance)	materials	12.00	\$1,200.00	\$/month	\$14,400
Office Materials and Supplies	materials	1.00	\$1,500.00	\$/year	\$1,500
Field Materials and Supplies	materials	1.00	\$5,000.00	\$/year	\$5,000
cell phone service for 3 technicians	materials	1.00	\$1,440.00	\$/year	\$1,440
vehicle lincensing	materials	1.00	\$1,362.00	\$/year	\$1,362
electrical service	materials	1.00	\$2,400.00	\$/year	\$2,400
building rental	rent	1.00	\$12,000.00	\$/year	\$12,000

D.3. NCSU

D.3.1. Staffing

Godshen 5% (Total salary 83k, so 5% of that)

Subject matter specialist (or working committee coordinator) 50% @36.5\$/hour

D.3.2. Indirect costs for NC State

27.6% of the staffing costs for CIPM (so not the entire amount) + 27.6% of the first 25k for each subcontract (i.e. if two subcontracts larger than 25k goes out from CIPM, then 27.6% of 50k)

D.3.3. Rent

Rent \$1,000 per year)

Table 7: NCSU year 1

cost_item	cost_type	qty_or_fte	unit_cost	units	total
SME	labor	0.35	\$75,920.00	\$/year	\$26,572
P.I.	labor	0.05	\$75,265.00	\$/year	\$3,763
SME fringe benefits	labor	1.00	\$2,285.00	\$/year	\$2,285
P.I. fringe benefits	labor	1.00	\$1,339.00	\$/year	\$1,339
rent	rent	1.00	\$1,000.00	\$/per year	\$1,000
Domestic travel	travel	1.00	\$18,500.00	\$/year	\$18,500
International travel	travel	1.00	\$18,500.00	\$/year	\$18,500

Table 8: NCSU year 2

cost_item	cost_type	qty_or_fte	unit_cost	units	total
P.I.	labor	0.05	\$75,265.00	\$/per year	\$3,763
SME	labor	0.48	\$75,920.00	\$/per year	\$36,442
SME fringe benefits	labor	1.00	\$3,134.00	\$/per year	\$3,134
P.I. fringe benefits	labor	1.00	\$1,339.00	\$/per year	\$1,339
rent	rent	1.00	\$1,000.00	\$/per year	\$1,000
Domestic travel	travel	1.00	\$25,000.00	\$/per year	\$25,000
International travel	travel	1.00	\$25,000.00	\$/per year	\$25,000

Table 9: NCSU year 3

cost_item	cost_type	qty_or_fte	unit_cost	units	total
P.I.	labor	0.05	\$75,265.00	\$/per year	\$3,763
SME	labor	0.38	\$75,920.00	\$/per year	\$28,850
SME fringe benefits	labor	1.00	\$2,481.00	\$/per year	\$2,481
P.I. fringe benefits	labor	1.00	\$1,339.00	\$/per year	\$1,339
rent	rent	1.00	\$1,000.00	\$/per year	\$1,000
Domestic travel	travel	1.00	\$25,000.00	\$/per year	\$25,000
International travel	travel	1.00	\$25,000.00	\$/per year	\$25,000

Table 10: NCSU year 4

cost_item	cost_type	qty_or_fte	unit_cost	units	total
P.I.	labor	0.05	\$75,265.00	\$/per year	\$3,763
SME	labor	0.47	\$75,920.00	\$/per year	\$35,682
P.I. fringe benefits	labor	1.00	\$1,339.00	\$/per year	\$1,339
SME fringe benefits	labor	1.00	\$3,069.00	\$/per year	\$3,069
rent	rent	1.00	\$1,000.00	\$/per year	\$1,000
Domestic travel	travel	1.00	\$18,000.00	\$/per year	\$18,000
International travel	travel	1.00	\$18,000.00	\$/per year	\$18,000

D.4. UOG

D.4.1. Labor

2 lab techs @ \$60,360 gross 2 survey techs @ \$60,360 gross 1 field ops manager 50% @ \$95,680 gross
1 insect pathologist @ \$83,200 gross 1 entomologist 5% @ \$130,000 gross
labor is increased by 3% each year

D.4.2. Materials

UOG will procure pheromone traps and lures for both UOG (1000 traps) and CEMML (500 traps). Replacement rate estimated at 500 traps per year.

Lab and insect rearing supplies \$3,000 per year

Table 11: UOG year 1

cost_item	cost_type	qty_or_fte	unit_cost	units	total
UOG lab tech 1	labor	1.00	\$60,360.00	\$/per year (inc. benefits)	\$60,360
UOG lab tech 2	labor	1.00	\$60,360.00	\$/per year (inc. benefits)	\$60,360
UOG survey tech 1	labor	1.00	\$60,360.00	\$/per year (inc. benefits)	\$60,360
UOG survey tech 2	labor	1.00	\$60,360.00	\$/per year (inc. benefits)	\$60,360
UOG Field Ops Mgr	labor	0.50	\$95,680.00	\$/per year (inc. benefits)	\$47,840
UOG entomologist	labor	0.05	\$130,000.00	\$/per year (inc. benefits)	\$6,500
UOG insect pathologist	labor	1.00	\$83,200.00	\$/per year (inc. benefits)	\$83,200
Panel traps	materials	1,500.00	\$40.00	\$/each	\$60,000
Pheromone lures	materials	7,800.00	\$3.75	\$/each	\$29,250
Vehicle maintenance	materials	1.00	\$2,000.00	\$/per year	\$2,000
Vehicle fuel	materials	1.00	\$2,000.00	\$/per year	\$2,000
Lab and insect rearing supplies	materials	1.00	\$3,000.00	\$/per year	\$3,000

Table 12: UOG year 2

cost_item	cost_type	qty_or_fte	unit_cost	units	total
UOG lab tech 1	labor	1.00	\$62,170.00	\$/per year (inc. benefits)	\$62,170
UOG lab tech 2	labor	1.00	\$62,170.00	\$/per year (inc. benefits)	\$62,170
UOG survey tech 1	labor	1.00	\$62,170.00	\$/per year (inc. benefits)	\$62,170
UOG survey tech 2	labor	1.00	\$62,170.00	\$/per year (inc. benefits)	\$62,170
UOG Field Ops Mgr	labor	0.50	\$98,550.00	\$/per year (inc. benefits)	\$49,275
UOG entomologist	labor	0.10	\$133,900.00	\$/per year (inc. benefits)	\$13,390
UOG insect pathologist	labor	1.00	\$85,696.00	\$/per year (inc. benefits)	\$85,696
Panel traps	materials	500.00	\$40.00	\$/each	\$20,000
Pheromone lures	materials	7,800.00	\$3.75	\$/each	\$29,250
Vehicle maintenance	materials	1.00	\$2,000.00	\$/per year	\$2,000
Vehicle fuel	materials	1.00	\$2,000.00	\$/per year	\$2,000
Lab and insect rearing supplies	materials	1.00	\$3,000.00	\$/per year	\$3,000

Table 13: UOG year 3

cost_item	cost_type	qty_or_fte	unit_cost	units	total
UOG lab tech 1	labor	1.00	\$64,035.00	\$/per year (inc. benefits)	\$64,035
UOG lab tech 2	labor	1.00	\$64,035.00	\$/per year (inc. benefits)	\$64,035
UOG survey tech 1	labor	1.00	\$64,035.00	\$/per year (inc. benefits)	\$64,035
UOG survey tech 2	labor	1.00	\$64,035.00	\$/per year (inc. benefits)	\$64,035
UOG Field Ops Mgr	labor	0.50	\$101,507.00	\$/per year (inc. benefits)	\$50,754
UOG entomologist	labor	0.10	\$137,917.00	\$/per year (inc. benefits)	\$13,792
UOG insect pathologist	labor	1.00	\$88,267.00	\$/per year (inc. benefits)	\$88,267
Panel traps	materials	500.00	\$40.00	\$/each	\$20,000
Pheromone lures	materials	7,800.00	\$3.75	\$/each	\$29,250
Vehicle maintenance	materials	1.00	\$2,000.00	\$/per year	\$2,000
Vehicle fuel	materials	1.00	\$2,000.00	\$/per year	\$2,000
Lab and insect rearing supplies	materials	1.00	\$3,000.00	\$/per year	\$3,000

Table 14: UOG year 4

cost_item	cost_type	qty_or_fte	unit_cost	units	total
UOG lab tech 1	labor	0.95	\$65,957.00	\$/per year (inc. benefits)	\$62,659
UOG lab tech 2	labor	0.95	\$65,957.00	\$/per year (inc. benefits)	\$62,659
UOG survey tech 1	labor	0.95	\$65,957.00	\$/per year (inc. benefits)	\$62,659
UOG survey tech 2	labor	0.95	\$65,957.00	\$/per year (inc. benefits)	\$62,659
UOG Field Ops Mgr	labor	0.50	\$104,552.00	\$/per year (inc. benefits)	\$52,276
UOG entomologist	labor	0.10	\$142,055.00	\$/per year (inc. benefits)	\$14,206
UOG insect pathologist	labor	1.00	\$90,915.00	\$/per year (inc. benefits)	\$90,915
Panel traps	materials	500.00	\$40.00	\$/each	\$20,000
Pheromone lures	materials	7,800.00	\$3.75	\$/each	\$29,250
Vehicle maintenance	materials	1.00	\$2,000.00	\$/per year	\$2,000
Vehicle fuel	materials	1.00	\$2,000.00	\$/per year	\$2,000
Lab and insect rearing supplies	materials	1.00	\$3,000.00	\$/per year	\$3,000

E. Supporting Technical Data

Table 15: Meetings of the CRB-G Action Group

2015 Pacific Entomology Conference, Honolulu, HI, USA
2016 International Congress of Entomology, Orlando, USA
2017 Japanese Society for Insect Pathology, Tokyo, Japan
2018 Society for Invertebrate Pathology, Gold Coast, Australia
2019 XIX International Plant Protection Congress, Hyderabad, India
2020 (tentative): Pacific Plant Protection Organization, Guam

Table 16: A list of additional collaborators, not directly funded by this project.

Collaborator(s)	Roles
Dr. Matthew Siderhurst, Eastern Mennonite University, Pennsylvania	Collaboration on CRB chemical ecology, detection and tracking technology
Dr. Ross H. Miller, University of Guam	Research into mechanism of virus resistance in CRB
Dr. Chris Kitalong, Palau Community College, Republic of Palau	Field release of OrNV in the Republic of Palau
Dr. Mark Schmaedick, American Samoa Community College, American Samoa	CRB collection survey to test for presence of CRB-G in American Samoa and incidence of OrNV; Collection of virus-susceptible beetles (CRB-S) for comparative bioassays
Dr. Sean Marshall, Dr. Trevor Jackson, AgResearch New Zealand	Collaboration (organization of annual meetings); Insect pathology; Establishment and maintenance of cell culture for OrNV isolates
Dr. Mike Orr and Leilani Sablan, University of Guam	CRB chemical ecology; Research on responses to pheromones and other chemicals
Dr. Keith Stokes, Northern Marianas Community College, Commonwealth of the Northern Mariana Islands	Early detection and management of CRB in the Commonwealth of the Northern Mariana Islands
Dr. Madoka Nakai, Tokyo University of Science and Technology, Japan	Insect pathology; Research into mechanism of virus resistance in CRB

F. Existing Support

Optional: Existing Support: If the Principal Investigator is funded by other programs to conduct research that overlaps or parallels the current proposal, provide a brief description of that support (1-2 page per relevant effort).