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The value of research to selling the conservation of threatened species: the case of *Cycas micronesica* (Cycadopsida: Cycadales: Cycadaceae)

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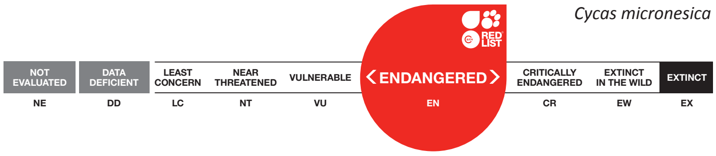
Abstract: A case study is described wherein strong focus on research during the developing threats that caused the elevation of *Cycas micronesica* from Near Threatened to Endangered status illustrates how targeted research results may be used to aid in conservation education. We argue that the devotion of a portion of conservation funds to research in addition to mitigation efforts may improve ultimate conservation success.

Keywords. *Aulacaspis yasumatsui, Chilades pandava*, cycad, invasion biology, plant-arthropod interactions.



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Author Contribution: The authors have studied cycads together in natural habitats and managed garden settings since 2005. Together they developed the framework for the article. TEM wrote the first draft. Both authors worked on subsequent versions.

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Conservation of biodiversity is not straightforward, and no recipe applies to every threatened species. Effective conservation programs balance ecological, economic, political and jurisdictional issues. Discontinuities and conflicts are inevitable, and long-term planning would benefit from bringing such issues into public discussion of conservation measures. Ecologists fulfill a crucial role in conserving threatened species by providing the sound science that conservation practitioners require to fulfil their responsibilities. While biologists in general value the conservation of threatened species, non-biologists are sometimes apathetic about potential extinctions. What can ecologists do to address such indifference or opposition from stake-holders while attempting to establish formal conservation programs or recovery plans?

Cycas micronesica K.D. Hill is a cycad with an endemic range from Palau to the Mariana Islands in the western Pacific Ocean (Hill 1994). The armored scale coccid *Aulacaspis yasumatsui* (Images 1–3) (Hemiptera: Diaspididae) and several other non-native specialist insects have invaded this endemic range in recent years, and the resulting plant mortality led to a change in status of *C. micronesica* from Near Threatened to Endangered in 2006 (IUCN Red List: Marler et al. 2010). The United States Fish & Wildlife Service recently proposed this species for federal listing (Ashe 2014). Based on recent occurrences, the justification for this listing may be met with apathy and misconceptions from some members of the general public. Moreover, the proposed listing may be met with outright opposition by the United States Department of Defense because of the prominence of *C. micronesica* on federal lands.

Scientists have traditionally used outlets such as newspapers or magazines to convey the importance of conservation to stakeholders. Additionally, field trips for members of the general public or more affluent individuals such as politicians or policy makers may be facilitated to venues where endangered species can be observed and discussed. Lectures in classroom settings, or at garden clubs and civic organizations, have also been employed by scientists as vehicles for marketing conservation ethics. Web-based information dissemination approaches may also reach target audiences. Here we do not attempt to expand this list of venues or stakeholder audiences as a means of improving conservation education, rather we outline how a compilation and communication of empirical evidence about the importance of a threatened taxon may improve the efforts to sell the need for conservation when scientists enact any of these traditional communication formats and attempt to influence any of these audiences.

Convey local importance

(a) An extensive forest inventory conducted in 2002 portrayed *C. micronesica* as the most abundant tree on Guam (Donnegan et al. 2004). The first arthropod invasions that initiated plant mortality were documented in 2003 and 2005 (Moore et al. 2005; Marler & Muniappan 2006; Marler 2012b). Plant mortality was so rapid and voluminous (Marler & Lawrence 2012) that the species was Red Listed as Endangered in 2006, only three years after the devastating invasions began (Marler et al. 2010). These facts demonstrate that this cycad species was not just a common tree on Guam, it was the most abundant tree prior to the arrival of the invasive species that initiated the threats. They also illuminate an unprecedented case where the decline in a plant population progressed from most abundant to endangered status in only three years after the arrival of a biological threat to an insular habitat.

(b) Cycads are gymnosperms (Norstog & Nicholls 1997). *Cycas micronesica* is not on a short list of native gymnosperm species, it is in fact the only native gymnosperm on the island of Guam. Therefore, the loss of this single taxon would lead to the loss of every native gymnosperm in the region.

(c) Cycads are exploited by indigenous peoples in many regions for food, spiritual, and medicinal uses (Norstog & Nicholls 1997; IUCN 2010). In Guam, seed gametophyte tissue has been exploited as an important source of starch in the traditional diet (Whiting 1963). Reliance on this food source was especially important at times when tropical cyclones destroyed other crops (Edwards 1918). Recent threats to the *C. micronesica* population also threaten the traditional knowledge that enables preparation of this traditional food.

(d) Litterfall and litter decomposition dynamics control biogeochemical cycling in forested habitats. We have determined litter decomposition speed for 11 common forest species in Guam, including *C. micronesica*. The results indicate that *C. micronesica* litter was the only litter that retarded decomposition speed of the litter from other species, and that its presence resulted in 23% slower decomposition of co-mingled litter than the presence of litter from the other species (unpublished data). Preferential removal of the *C. micronesica* population from Guam's forests would therefore alter natural decomposition and carbon sequestration traits more so than preferential removal of any one of the other species.

Image 1. Healthy *Cycas micronesica* trees (left) were the most abundant tree on the island of Guam prior to the invasion of several exotic specialist pests. *Aulacaspis yasumatsui* invaded Guam in 2003, and heavy infestations rapidly began to kill trees (right).

Image 2. *Cycas micronesica* male strobili are borne terminally on stems (left), and are susceptible to direct attack by *Aulacaspis yasumatsui* (right).

Image 3. *Cycas micronesica* female strobili bear naked seeds as with all gymnosperms (left), and direct attack by *Aulacaspis yasumatsui* (right) reduces germination percentage and seedling vigor.

Describe phylogenetic importance

(a) Of the world's described cycad species, 62% are threatened with extinction, making cycads the most threatened group of plant species on Earth (IUCN 2010). Therefore, conservation of Guam's cycad species results in conservation of the most threatened group of plants worldwide.

(b) Cycads are the most ancient of contemporary spermatophytes (Donaldson 2003), forming 20% of the world's flora during the Jurassic period (IUCN 2010). As such, empirical research on today's cycad taxa has the potential to provide a window to the past (Brenner et al. 2003), and illuminate the traits that may have enabled persistence of cycads as myriad other sequential sympatric species appeared then disappeared from the Earth. For example, conservation of *C. micronesica* would enable sustained research on the role of thalassochory (oceanic dispersal) in cycad evolution.

(c) A coalition of alien specialist insects has imposed the acute threats to *C. micronesica*. In contrast, the remainder of threatened cycad species faces the primary threats of habitat loss and poaching (Donaldson 2003). Therefore, the greatest threats to *C. micronesica* are unique among contemporary threatened cycads. Biological invasions will likely increase as global change ensues, so the Guam case study is positioned to inform future cases where invasive species begin to threaten other cycad populations.

Communicate importance to science

(a) Environmental toxins inadvertently enter the human food chain and cycads have been the focus of myriad research programs on this subject (Whiting 1963). The role of consumption of *C. micronesica* seed tissue on the extremely high incidence of neurodegenerative disease on Guam has received decades of attention (Kurland 1988; Mabry 2001; Marler et al. 2005). Despite very clear correlative explanations about the relationship, no clear causal mechanism has been confirmed. Epidemic loss of the plant population is threatening sustainability of this ongoing research that is of international importance to human health.

(b) Islands have been vital for the study of evolution and many other scientific disciplines. Island ecology is of crucial interest to contemporary biologists, ecologists, and conservationists. One of the first authoritative writings that informed island ecology emphasized how oceanic island research has application to all "insular" habitats (MacArthur & Wilson 1967). For example, anthropogenic forest fragmentation is creating disjointed communities that are islands in many respects (Laurence & Bierregaard 1977). Therefore, research in oceanic islands directly informs many questions pertinent to other global agendas. The endemic range of *C. micronesica* has its southern limits in the Rock Islands of Palau, and its northern limits in the island of Rota (Hill 1994). The islands of Yap, Guam, and Rota supported extremely high densities of *C. micronesica* prior to the recent pest invasions. In 2014, Yap remains pest-free and the cycad population is showing no signs of decline, Guam has an established scale predator (Moore et al. 2005) and recent fortuitous additional parasitoid scale control and is exhibiting a clear decline in plant mortality, and Rota has the predator control only with no augmentation of the parasitoid control. Rota continues to exhibit epidemic, sustained plant mortality. These three disjunct *C. micronesica* populations are ideally positioned to use the distinct islands as "living laboratories" (Garcia-Verdugo & Fay 2014) to study how the differing tritrophic relations drive the ongoing threats to the plant population. Seizing the opportunity to conduct "natural experiments" such as this provides unique insights about system perturbations, as they incorporate the capacity of the entire system to shift in response to the treatment in a manner that is not achievable in controlled experiments (Sagarin & Pauchard 2009).

(c) The ecological concept of a 'foundation species' was introduced to describe particular species that exert a disproportionate effect on the rest of the community (Dayton 1972). Foundation species exert their influence largely by abundance, and focusing on foundation species may enable a simplified approach to more rapidly understand how a community may react to disturbances. In previous areas of occupancy, *C. micronesica* exhibited densities greater than 12,000 plants per hectare (Marler & Terry 2013). Only three species emerged as exhibiting more than one million mature individuals in a 2002 forestry survey of Guam's forests (Donnegan et al. 2004), and of those three only *C. micronesica* exhibits a relationship with a nitrogen-fixing endosymbiont. All cycad species utilize a relationship with cyanobacteria to access fixed nitrogen within specialized root structures (Norstog & Nicholls 1997). Grove et al. (1980) estimated up to 8.5kg ha^{-1} yr^{-1} of nitrogen was fixed in *Macrozamia riedlei* Australian habitats, verifying a substantial input of nitrogen into the forest ecosystem as a result of the cycad population. For *C. micronesica*, the high plant density undoubtedly combined with its role as a nitrogen source for the terrestrial system to signify that this taxon could be exploited to study the foundation species concept.

(d) The concept of 'keystone species' was introduced to describe those species that exert their effect on the community by way of other organisms depending on them (Paine 1995). The clearest examples result from mutualisms where the loss of one species would have a great impact upon other components of the ecosystem. Two native arthropods on Guam depend on *C. micronesica* tissues as food for their larval stage. The stem borer *Dihammus marianarum* feeds on stem tissue and the pollinator *Anatrachyntis* sp. feeds on male cone tissue after pollen dispersal (Marler & Muniappan 2006; Marler 2010, 2013b). Conservationists must approach case studies such as this by resisting the tendency to elevate the importance of conserving the plant host above that of the native insect herbivores. Wu et al. (2010) discussed a similar case in Taiwan where the *Cycas*-specific herbivore *Chilades pandava* is native, and mitigating the arthropod threats to the endemic *Cycas taitungensis* population warrants acknowledgement of the need to also conserve the native butterfly. How does a conservationist balance the need to conserve the insect and its host plant, when these two goals seem to be at odds? Guam's *C. micronesica* exemplifies an ideal insular system to study these phenomena.

Communicate importance to global agenda

(a) We have used Guam's *C. micronesica* population to demonstrate how arthropod pest invasions can compromise resilience of a native tree species to large scale natural disturbances, by focusing on tropical cyclone (TC) activity. We have accomplished this using a before-after approach. Prior to the invasions, 12% of the cycad population failed mechanically by stem snapping during an intense TC (Marler & Hirsh 1998) and 100% of these trees recovered (Hirsh & Marler 2002). After the invasions, however, 18% of the cycad population exhibited stem snapping during a moderate TC and 100% of these trees subsequently died (Marler & Lawrence 2013). We also employed experimental winching techniques within a "chronosequence" approach to demonstrate that chronic pest infestations compromised biomechanical integrity of the cycad stems (Marler 2013a). Climate change predictions indicate severity of TCs will increase in the coming decades (Elsner et al. 2008; Knutson et al. 2010). The scientific community has studied climate change predictions on natural systems by focusing on temperature and moisture changes, but the effects of disturbances caused by climate change have largely been ignored (Dale et al. 2001). Seizing every opportunity to learn from today's frequent severe Pacific TCs will uniquely prepare the global community for this future. As alien invasions are also of global concern, the Guam case study using *C. micronesica* demonstrates how these two global change issues may interact.

(b) The *C. micronesica* case study also emerges as an informative example of a threat created by an 'invasional meltdown' (Simberloff & von Holle 1999) within insular habitats. While the armored scale *Aulacaspis yasumatsui* was the primary catalyst for the epidemic mortality of the plant population (Marler 2012b), the realistic threat is actually a result of a coalition of invasive species. The specialist leaf miner *Erechthias* sp. and blue butterfly *Chilades pandava* are exotic arthropod herbivores that compete directly with the scale, feral pigs (*Sus scrofa*) also damage Guam's cycad trees as plants decline in health, and numerous exotic ant species are facilitators of the blue butterfly damage. As cycad trees decline and begin to exhibit dead tissues, exotic termites begin to infest the live trees and add to the assault (Marler et al. 2011). We have addressed this meltdown with long-term monitoring of pest incidence within permanent plots, which enabled us to retrospectively understand how three of the most severe biological threats interacted with the scale (Marler 2013b). Other examples of invasional meltdowns would benefit from implementing a similar approach.

(c) The risk of 'coextinction' (Koh et al. 2004) in biodiversity conservation is a phenomenon that magnifies the consequences of species losses. Extirpation of the *C. micronesica* population from Guam would consequently lead to extirpation of the native stem borer and pollinator species, magnifying the loss of biodiversity.

(d) Employing biological control to counteract biological invasions provides unparalleled benefits for conserving plant taxa threatened by invasive herbivores. Ecologists can learn from previous case studies where attempts at biological control were not effective. In that regard, our introduction of the predator *Rhyzobius lophanthae* (Moore et al. 2005) to Guam has been plagued with limitations. Following several years of observing the plant, scale herbivore and beetle predator populations interact, a spatial pattern emerged whereby scale infestations were frequently abundant on leaves near the forest floor. Experimental parsing of this phenomenon confirmed that the predator tends to avoid lower strata in the forest canopy, thereby allowing sustained scale infestations on small plants or leaves of low side stems of mature trees (Marler et al. 2013). Direct observations of the foraging behaviors of the predator also revealed a structural limitation where the scale insects could find and exploit plant surface microsites that structurally protected them from the predator (Marler & Moore 2010; Marler 2012a). Understanding these and other phenomena may directly inform future cases where attempts at biological control are not successful.

Selling the need for conservation

We have conveyed various issues that demonstrate the value of *C. micronesica* within local, regional, and global perspectives. When met with the attitude of indifference concerning the threats to *C. micronesica* from members of the general public, we believe these specifics can be used to address the indifference and thereby build capacity for implementing conservation. We suggest that ecologists could reach greater success in selling their conservation efforts to the general public by reducing the approach of arguing the virtues of biodiversity conservation in a generic sense, and amplifying the approach of clearly communicating the benefits of the singular target species that is threatened. These efforts may require a portion of limited funding to be earmarked for empirical research on a newly threatened taxon in order to generate the required specific knowledge, rather than devoting all available funding for direct mitigation or conservation efforts.

References

Ashe, D.M. (2014). Proposed endangered status for 21 species and proposed threatened status for 2 species in Guam and the Commonwealth of the Northern Mariana Islands. *Federal Register* 79(190): 59364–59413.

Brenner, E.D., D.W. Stevenson & R.W. Twigg (2003). Cycads: evolutionary innovations and the role of plant-derived neurotoxins. *Trends in Plant Science* 8: 446–452; http://dx.doi.org/10.1016/S1360-1385(03)00190-0

Dale, V.H., L.A. Joyce, S. McNulty, R.P. Neilson, M.P. Ayres, M.D. Flannigan, P.J. Hanson, L.C. Irland, A.E. Lugo, C.J. Peterson, D. Simberloff, F.J. Swanson, B.J. Stocks & B.M. Wotton (2001). Climate change and forest disturbances. *Bioscience* 51: 723–734; http://dx.doi.org/10.1641/0006-3568(2001)051[0723:CCAFD]2.0.CO;2

Dayton, P.K. (1972). Toward an understanding of community resilience and the potential effects of enrichments to the benthos at McMurdo Sound, Antarctica. pp. 81–96. In: Parker, B.C. (ed.). Proceedings of the Colloquium on Conservation Problems. Allen Press, Lawrence, Kansas. U.S.A.

Donaldson, J.S. (ed.). (2003). *Cycads. Status Survey and Conservation Action Plan*. IUCN/SSC Cycad Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK, ix+86pp.

Donnegan, J.A., S.L. Butler, W. Grabowiecki, B.A. Hiserote & D. Limtiaco (2004). *Guam's forest resources, 2002.* Resour. Bull. PNW-RB-243. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. U.S.A., 32pp.

Edwards, C.W. (1918). *Report of the Guam Agricultural Experiment Station*. Government Printing Office, Washington, U.S.A. 62pp.

Elsner, J.B., J.P. Kossin & T.H. Jagger (2008). The increasing intensity of the strongest tropical cyclones. *Nature* 455: 92–95; http://dx.doi.org/10.1038/nature07234

Garcia-Verdugo, C. & M.F. Fay (2014). Ecology and evolution on oceanic islands: broadening the botanical perspective. *Botanical Journal of the Linnean Society* 174: 271–275; http://dx.doi.org/10.1111/boj.12154

Grove, T.S., A.M. O'Connell & N. Malajczuk (1980). Effects of fire on the growth, nutrient content and rate of nitrogen fixation of the cycad *Macrozamia riedlei*. *Australian Journal of Botany* 28: 271–281; http://dx.doi.org/10.1071/BT9800271

Hill, K.D. (1994). The *Cycas rumphii* complex (Cycadaceae) in New Guinea and the Western Pacific. *Australian Systematic Botany* 7: 543–567; http://dx.doi.org/10.1071/SB9940543

Hirsh, H. & T. Marler (2002). Damage and recovery of *Cycas micronesica* after Typhoon Paka. *Biotropica* 34: 598-602; http://dx.doi.org/10.1111/j.1744-7429.2002.tb00579.x

International Union for Conservation of Nature (2010). *IUCN Red List of Threatened Species. Cycad Facts*. < cmsdata.iucn.org/downloads/cycad_factsheet_final.pdf >. Downloaded on 1 November 2014.

Knutson, T.R., J.L. McBride, J. Chan, K. Emanuel, G. Holland, C. Langsea, I. Held, J.P. Kossin, A.K. Srivastava & M. Sugi (2010). Tropical cyclones and climate change. *Nature Geoscience* 3: 157–163; http://dx.doi.org/10.1038/ngeo779

Koh, L.P., R.R. Dunn, N.S. Sodhi, R.K. Colwell, H.C. Proctor & V.S. Smith (2004). Species coextinctions and the biodiversity crisis. *Science* 305:1632-1634; http://dx.doi.org/10.1126/science.1101101

Kurland, L.T. (1988). Amyotrophic lateral sclerosis and Parkinson's disease complex on Guam linked to an environmental toxin. *Trends in Neuroscience* 11: 51–53; http://dx.doi.org/10.1016/0166-2236(88)90163-4

Laurence, W.F. & R.O. Bierregaard Jr. (eds.) (1977). *Tropical Forest Remnants*. University of Chicago Press, Chicago, 632pp.

Mabry, T.J. (2001). Selected topics from forty years of natural products research: betalains to flavonoids, antiviral proteins, and neurotoxic nonprotein amino acids. *Journal of Natural Products* 64: 1596–1604; http://dx.doi.org/10.1021/np010524s

MacArthur, R.H. & E.O. Wilson (1967). *The Theory of Island Biogeography*. Princeton University Press, Princeton, New Jersey, U.S.A., 224pp.

Marler, T.E. (2010). Cycad mutualist offers more than pollen transport. *American Journal of Botany* 97: 841–845; http://dx.doi.org/10.3732/ajb.0900251

Marler, T.E. (2012a). Boomeranging in structural defense: Phytophagous insect uses cycad trichomes to defend against entomophagy. *Plant Signaling & Behavior* 7: 1484–1487; http://dx.doi.org/10.4161/psb.22013

Marler, T.E. (2012b). Cycad aulacaspis scale invades the Mariana Islands. *Memoirs New York Botanical Garden* 106: 20–35.

Marler, T.E. (2013a). Increased threat of island endemic tree's extirpation via invasion-induced decline of intrinsic resistance to recurring tropical cyclones. *Communicative & Integrative Biology* 6: e22361; http://dx.doi.org/10.4161/cib.22361

Marler, T.E. (2013b). Temporal variations in leaf miner, butterfly, and stem borer infestations of *Cycas micronesica* in relation to *Aulacaspis yasumatsui* incidence. *Hort Science* 48: 1334–1338.

Marler, T., J. Haynes & A. Lindström (2010). *Cycas micronesica*. In: IUCN 2014. IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on 1 November 2014.

Marler, T.E. & H. Hirsh (1998). Guam's *Cycas micronesica* population ravaged by Supertyphoon Paka. *HortScience* 33: 1116–1118.

Marler, T.E. & J.H. Lawrence (2012). Demography of *Cycas micronesica* on Guam following introduction of the armoured scale *Aulacaspis yasumatsui*. *Journal of Tropical Ecology* 28: 233–242; http://dx.doi.org/10.1017/S0266467412000119

Marler, T.E. & J.H. Lawrence (2013). Phytophagous insects reduce cycad resistance to tropical cyclone winds and impair storm recovery. *Hort Science* 48: 1224–1226.

Marler, T.E., V. Lee & C.A. Shaw (2005). Cycad toxins and neurological diseases in guam: defining theoretical and experimental standards for correlating human disease with environmental toxins. *Hort Science* 40: 1598–1606.

Marler, T.E., R. Miller & A. Moore (2013). Vertical stratification of predation on *Aulacaspis yasumatsui* infesting *Cycas micronesica* seedlings. *Hort Science* 48: 60–62.

Marler, T.E. & A. Moore (2010). Cryptic scale infestations on *Cycas revoluta* facilitate scale invasions. *Hort Science* 45: 837–839.

Marler, T.E. & R. Muniappan (2006). Pests of *Cycas micronesica* leaf, stem, and male reproductive tissues with notes on current threat status. *Micronesica* 39: 1–9.

Marler, T. & I. Terry (2013). The continuing demise of *Cycas micronesica*. *The Cycad Newsletter* 35(4)/36(1): 23–26.

Marler, T.E., L.S. Yudin & A. Moore (2011). *Schedorhinotermes longirostris* (Isoptera: Rhinotermitidae) on Guam adds to assault on the endemic *Cycas micronesica. Florida Entomologist* 94: 702–703; http://dx.doi.org/10.1653/024.094.0339

Moore, A., T. Marler, R.H. Miller & R. Muniappan (2005). Biological control of cycad aulacaspis scale on Guam. *The Cycad Newsletter* 28(5): 6–8.

Norstog, K.J. & T.J. Nicholls (1997). *The Biology of The Cycads*. Cornell University Press, Ithica, New York, xi+363pp.

Paine, R.T. (1995). A conversation on refining the concept of keystone species. *Conservation Biology* 9: 962–964.

Sagarin, R. & A. Pauchard (2009). Observational approaches in ecology open new ground in a changing world. *Frontiers in Ecology and the Environment* 8: 379–386; http://dx.doi.org/10.1890/090001

Simberloff, D. & B. von Holle (1999). Positive interactions of nonindigenous species: invasional meltdown? *Biological Invasions* 1: 21–32; http://dx.doi.org/10.1023/A:1010086329619

Whiting, M.G. (1963). Toxicity of cycads. *Economic Botany* 17:271-302.

Wu, L.-W., S.-H. Yen, D.C. Lees & Y.F. Hsu (2010). Elucidating genetic signatures of native and introduced populations of the Cycad Blue, *Chilades pandava* to Taiwan: a threat both to Sago Palm and to native *Cycas* populations worldwide. *Biological Invasions* 12: 2649-2669; http://dx.doi.org/10.1007/s10530-009-9672-4