Cycad collections development in the modern context: Challenges, opportunities, investments and outcomes.

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Abstract

This case study explores 21st Century living collections development within four modern contexts, analyzing several examples, united by three critical components. The modern contexts – Challenges, Opportunities, Investments, and Outcomes – provide an approach to decision making and evaluation for the collections development process. These examples illustrate the intersection of Collaboration, Research, and Development, three inseparable components of the modern collections development process. This case study is focused on the cycads, as these living treasures exemplify the role of *ex situ* conservation work.

Keywords

Collaboration; cycads; decision making; evaluation; planning; plant collections; research.

Collections development in the modern context

Gardens are built fundamentally around plant collections, and do not exist without them. The nineteenth and twentieth centuries saw tremendous effort and success in developing these collections. This work was difficult, fraught with mortal danger (Short, 2003). Modern plant collecting is thankfully much safer, but broader in scope as shown below.

Discussion on plant collection ethics and philosophy is well developed. We assume readers of this volume are familiar with the relevant canon and best practice. Here, we focus on the functional aspect of collections development in an organizational framework, and illustrate how this work moves forward in the 21st century.

Methods of modern strategy development are often advanced and criticized (Piercy & Giles, 1993; Hill & Westbrook, 1997). We employ four parameters in strategic decision making for cycad collections. The first of these are **Challenges** to plant populations and species. We consider how **Opportunities** influence the collections development process. **Investments** and **Outcomes** are the remaining parameters for decision making, representing efforts required versus results obtained.

Components of modern collections development

In traditional plant collecting referenced above, both investments in and outcomes from plant collections were narrowly focused on obtaining living plants for cultivation elsewhere. Current plant collecting is embedded in a broader framework. Three basic inseparable parts of current plant exploration practice are **Research**, **Collaboration**, and **Development**. The current study discusses how these interdigitate to produce parallel outcomes.

Case study: MBC cycad collections.

Montgomery Botanical Center (MBC) is organized around living collections of cycads, which contribute broadly to science, education, and conservation (the palm collection is

an equal, parallel focus; Noblick *et al.*, 2008). This cycad collection has great breadth (Table 1), and especially significant depth in *Dioon* and *Zamia*. Two thirds of cycad species are represented, and 60% of taxa and over 85% of accessions and plants are of known wild provenance. Although the collections date back to 1932, the majority were developed since 1994, with an accelerating rate of development since 2007 (Calonje *et al.*, 2009a). Three examples of recent collections development work are presented below.

First Example: *Cycas micronesica*

Cycas micronesica is Endangered and native to western Pacific islands (Figure 1). An invasive insect (*Aulacaspis yasumatsui*) has reduced populations on Guam by up to 80% since 2003 (Griffith and Calonje, 2007).

Rapid decline presents a clear crisis for this species. One result of this rapid decline is intense research interest in this cycad. MBC participated in extensive fieldwork (Figure 2) for population genetic research (Cibrian et al., 2008; 2010). A broad, multi-institutional team involving the University of Guam (UoG), New York Botanical Garden (NYBG), and MBC performed an intense month-long field sampling project, which also developed *ex situ* collections for MBC. MBC recently planted its most extensive single-species cycad collection derived from this fieldwork (Griffith and Husby, 2010). Further information is on the MBC website.

Analysis

This project reveals how the modern contexts (in this paper's title) guide decision making and evaluation for current collections development. Additionally, clear interlocking of collections development, research and collaboration is apparent. Here, the *challenge* is obvious: population extirpation, and possible extinction. An *opportunity* for extensive collections development fieldwork was located. This was coupled to scientific research, and was accomplished strictly within a clearly outlined collaborative framework. MBC, NYBG and UoG each made significant *investments* of resources in the work. *Outcomes* included important and novel research papers, and focused development of vitally important conservation collections.

Second Example: *Zamia decumbens*

For a Palaeozoic order with relatively few extant species, much cycad diversity remains unexplored. The Sinkhole Cycad is one such example. Fieldwork from 1997-2000 in Belize produced a few living collections, some herbarium specimens, and photographs of an intriguing *Zamia* which was known only from the bottom of two sinkholes. Total wild plants were estimated at less than 100, with only 7 plants in *ex situ* collections, and only at one garden (MBC). Wild-harvested seed were reportedly being traded, although origin of the material was uncertain. These plants were determined as *Z. prasina*, authored by William Bull in 1881. Yet, close examination of the *Z. prasina* type specimen showed some differences with the sinkhole cycad.

In short, here was a poorly understood, unique, very rare cycad, with inadequate *ex situ* representation. These factors prompted reaching out to collaborators in Belize. Jan Meerman, ecologist at Green Hills Botanical Collections (GHBC), Belize, had studied diversity in Belizean cycads since the 1990s, and with Jan we organized a joint project to evaluate, collect, and study this diversity. Partnering also with cycad expert Dr. Miguel

Angel Perez-Farrera from the Universidad de Ciencias y Artes de Chiapas, MBC developed funds, obtained permission, and performed fieldwork in 2008.

Obtaining these data and collections from remote field sites was challenging (although it could be much worse; see Griffith, 2005), but putting in this effort is essential to expand understanding of plant diversity (Figure 3). Direct results of these efforts were multifold. First, we now count over 300 extant plants in the wild, three times as many as were known before. Whereas there were previously only 7 plants at one garden, there are now over 120 in protective cultivation at MBC, GHBC, and Belize Botanic Gardens. In-depth field study revealed that the Sinkhole Cycad was in fact a new species, *Zamia decumbens* (Calonje *et al.*, 2009b), separate and distinct from *Zamia prasina* (Calonje and Meerman, 2009).

Analysis

This project shows clear use of modern decision making and evaluation contexts. A conservation challenge was noted, a limited population under harvesting pressure; a collaborative opportunity was developed; multiple institutions invested in the fieldwork; and publications, living *ex situ* collections, and greater understanding were the outcomes. A report on the MBC website provides further information.

Third Example: The Caribbean *Zamia* Project

Caribbean *Zamia* species have been extensively studied, yet remain poorly understood. Variability within and amoung populations plays a role here, as well as the physiographic nature of the Caribbean; barely distinguishable populations on different islands are sometimes given different names. This complex of species and populations is distributed over seven countries, so even political boundaries may have added to the taxonomic complexity. Dr. Alan Meerow of the USDA has studied these plants extensively. One recent breakthrough was his development of microsatellite markers for the Caribbean *Zamia* (Meerow and Nakamura, 2007). This advancement enables detailed assessment from the molecular genetic perspective.

Analysis

Examining this ongoing project in the modern contexts shows an exemplary model for collections development. Multiple challenges here are scale, scope, complexity, and capacity. By partitioning the project and working closely with collaborators, opportunities for fieldwork have been maximized. Field projects in Jamaica (2008), Dominican Republic (2009) and The Bahamas (2009-2010) involved the USDA, MBC, Fairchild Tropical Botanic Garden (FTBG), Jardín Botánico Nacional Dr. Rafael Moscoso de Santo Domingo (JBSD), The Bahamas National Trust, and the Plant Conservation Centre of Kingston. Including labwork and herbarium research, NYBG and Florida International University would be added to the list. Immediate plans for further fieldwork will bring Instituto Ecología y Sistemática into the project – making this an exceptionally broad collaboration throughout the Caribbean (Figure 4). Thus, investments have been broad and multi-institutional. Outcomes are even broader than investments. Research papers are forthcoming, and new living collections are cultivated at each participating garden, as well as distributed to colleagues in Xalapa, Mexico (Instituto de Ecología), Shenzen, China (Fairylake Botanic Garden), and Kirstenbosch, South Africa (SANBI). An unprecedentedly high level of integration of genetic, phytogeographic and morphological data with the living collections distinguishes this project.

The synthesis

Cycad collections exemplify the best aspects of a botanic garden living collection, and especially so when the modern contexts are considered. Cycads present many conservation *challenges*; there are tremendous research *opportunities* for these fascinating treasures; *investments* in colleagues, collections, and research is essential; and the *outcomes* of this work are important, tangible, and set the stage for further advancement of botany.

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Figure 1: *Cycas micronesica*, an Endangered cycad of the western Pacific. Prior to 2003, this was the most common canopy tree on Guam.

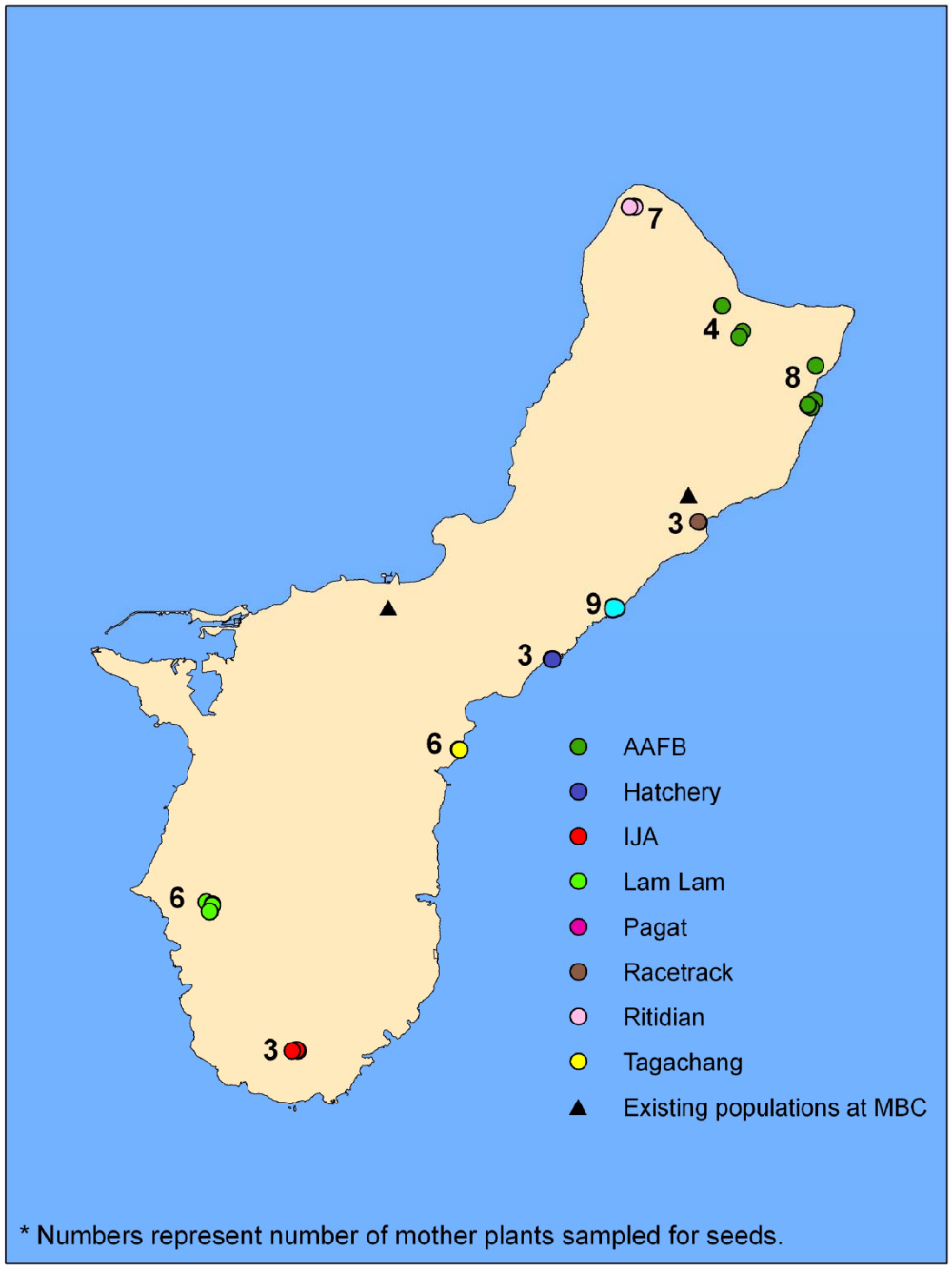

Figure 2: Accessions of *Cycas micronesica* collected in Guam during fieldwork in 2007. Phytogeographic and genetic diversity are important parameters in current collections development, especially for *ex situ* conservation purposes.

Figure 3. *Zamia decumbens* at the type locality, a sinkhole in southwestern Belize.

Figure 4. *Zamia pumila* at JBSD with Alberto Veloz, Javier Francisco-Ortega, Michael Calonje, and Francisco Jiménez Rodríguez.

Table 1.

MBC Cycad Collections, 2010.

Taxa (total)	227
Taxa: (wild collected)	202
Accessions: (total)	1,484
Accessions (wild-collected)	1,265
Plants (total)	3,756
Plants (wild-collected)	3,255
Valid taxa of Cycads:	339
% of taxa at MBC:	66%
% of taxa with data at MBC:	60%
% of accessions with data	85%
% of plants with data:	86%

Data are from the most recent inventory, January 2010. The taxonomic authority is Osborne *et al.* (in press).