Cycads:
A model group for *ex situ* plant conservation

Endangered Dioon spinulosum *with near mature female cone*

Public gardens collectively cultivate, study and protect at least one-third of Earth's plant diversity. One in five plant species now faces extinction, and many species already survive solely in "off-site" *ex situ* living collections. The global safety net of gardens which serves to prevent plant extinction is rapidly growing in breadth and depth, and at least one-third of threatened species are reported in living collections today.

To meet the goals of the Global Strategy for Plant Conservation, the plant conservation community can leverage their collections to build integrated plant conservation programs. Using existing *ex situ* plant diversity as a foundation, public gardens are increasingly working together to build genetically diverse living collections as a global safety net against plant extinction.

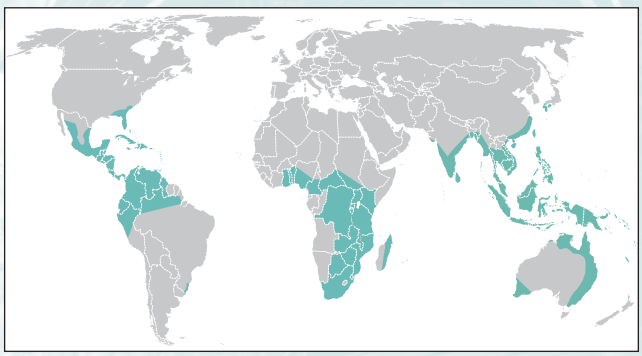
Cycads are the most threatened plant group in the world and face considerable conservation obstacles. *Ex situ* conservation is vital to most cycads' long-term survival. Central to this effort is planning and building genetically appropriate cycad collections.

Zamia lucayana *survives on just one beach habitat on one island*




Left to right: **Zamia nesophila, Cycas calcicola, Encephalartos lehmannii, Zamia roezlii.** ***Cycads are prized by collectors for their beauty and rarity.***

Cycads represent one of the oldest plant lineages known. Cycads are slow-growing gymnosperms with separate female and male plants, which are challenging to propagate, and produce seeds that are generally difficult to store long-term. These factors make them extremely interesting for research and education, but also problematic for conservation.



Global distribution of cycads
(Source: Esculapio, Wikimedia Commons)

Cycads occur naturally in four broad areas:
Africa, Australia, Southeast Asia and the New World.

Besides *Cycas*, a widespread genus, each of the other nine accepted genera occur in only one of the four regions. Many remaining natural populations fall inside of Biodiversity Hotspots.

What is a Biodiversity Hotspot?
In 2000, Conservation International highlighted 35 regions of the world that are the most biologically diverse and unique, and also facing the greatest threats, as Biodiversity Hotspots. These hotspots make up only 2.3% of Earth's landmass yet support about 50% of known plant diversity.

Highly sought after by collectors throughout the world, cycads are known for their ornamental value and drought tolerance. Their desirability, combined with their very slow growth rates and challenges in propagation, results in high prices in the marketplace. This high price drives one of the major threats to cycads today: over-collection of wild plants for the horticultural trade. Habitat destruction and invasive insect species are other significant threats.

Low seed germination, low seedling survival rates, and long generation times exacerbate cycad decline as natural regeneration cannot keep up with losses in nature. Remaining cycad habitats (and in some cases pollinators) are declining rapidly enough that *ex situ* conservation is a critical part of the long-term survival of many cycad species. Because *in vitro*, cryopreservation, and traditional seed banking technology is currently not effective for most cycads, living plant collections are the most viable *ex situ* method available. Four cycad species, including the famous *Encephalartos woodii*, are extinct in the wild and thus already fully dependent on *ex situ* cultivation. Finally, it has been demonstrated that proper seed collection is not detrimental to wild cycad populations. Given all of these circumstances, living plant collections are especially effective for the survival of cycads.

Current total cycad taxa	339
Cycad taxa fully assessed by IUCN	307 (91%)
Current threatened cycad taxa listed by IUCN	196 (58%)

Cycad taxonomic diversity and global threat status (2015)

Sand mining and development threaten the habitat of **Zamia lucayana**

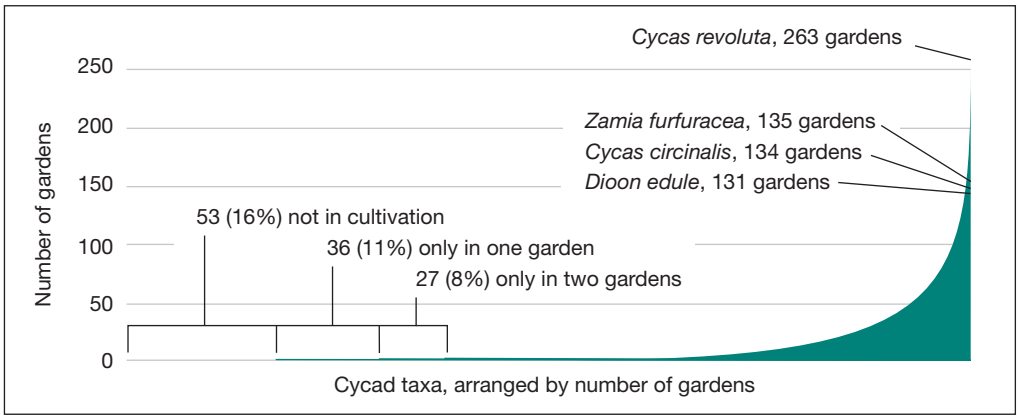
How can gardens help?

Current circumstances make it essential to grow cycads in public gardens. Thus, the most comprehensive cycad conservation plans (see www.cycadgroup.org) include *ex situ* collections at public gardens.

Using a list of 339 accepted cycad taxa, and collections data contributed by 1,137 institutions to BGCI's PlantSearch database as of 2015, BGCI conducted an assessment of cycad *ex situ* collections. Overall, 286 (84%) cycad taxa are maintained in at least one living collection. While that may suggest secure *ex situ* representation, more than 50% (176) of cycad taxa are held in five or less collections, including 16% (53 taxa) not known in any collections to-date. On the other hand, there are opportunities to implement *ex situ* provenance surveys and integrated *ex situ* programs for the 200+ cycad taxa currently maintained in more than one or a few collections.

Genus	Number of taxa
Ceratozamia	2
Cycas	31
Encephalartos	5
Macrozamia	4
Zamia	11

Cycad taxa absent from ex situ *collections (2015)*



Ex situ *cycad representation (BGCI PlantSearch database, 2015)*

Biology informs strategy

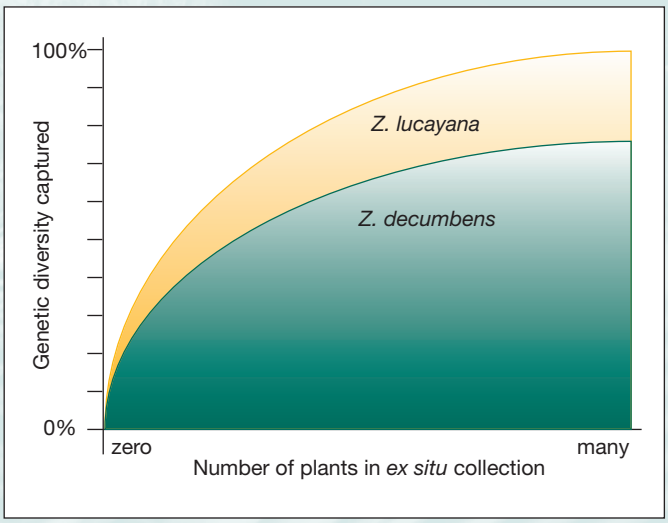
Ex situ collections with adequate genetic diversity are essential for conservation applications. Every species conserved *ex situ* may require a different sampling of wild-origin samples (from seeds, cuttings, etc.) to adequately capture the genetic diversity remaining in wild populations. This is demonstrated in the results of a recent comparative study. Genetic capture was measured based on collection size, using DNA data, and compared between two related cycad species, *Zamia decumbens* and *Zamia lucayana*. If sampled and curated correctly, fewer individual plants of *Z. lucayana* are required to attain a high percent of genetic diversity, while it takes many more unique plants of *Z. decumbens* to reach the same level of gene capture.

In this case, the much more frequent reproduction of *Zamia lucayana* means that limited seed collections can capture greater genetic diversity. The results suggest that careful consideration of each species' unique biology can help decide which plants to cultivate and how best to do so: biology informs strategy.

Why is genetic diversity so important?
Genetic diversity allows species to adapt and survive to environmental changes and threats. Species with high genetic diversity are more likely to survive external pressures, while too little genetic diversity can reduce a species' chances of surviving. Thus, adequate genetic diversity is the most important factor when using *ex situ* collections for future reintroduction.

Can *ex situ* conservation help other plants?
Cycads provide a model for *ex situ* conservation, but planning for genetic diversity is helpful for all plant groups. The first step in planning conservation collections is to consider the biology of the species of interest: biology informs strategy.

For additional resources on this topic, including detailed protocols for collecting genetic diversity from wild populations for *ex situ* conservation, visit: **www.montgomerybotanical.org/Pages/Collection_Genetics.htm**



Botanic garden cycad collections are an important learning resource

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Information presented above is based on these resources:

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