Living Plant Collections at Botanical Gardens

Pritchardia bakeri in a Living Collection at Lyon Arboretum

Establishing and maintaining living collections of plants in botanical gardens and arboreta are important components of plant conservation programs globally, and especially in Hawai'i, where significant threats to wild populations of many species still exist. **Display Collections** of living plants indirectly support conservation efforts by providing easy access to rare species for research, education, cultural/traditional-use, and outreach. These collections are increasingly important to raising awareness of the value and plight of Hawai'i's native plants because they are often the first or only place where the public can interact with them. **Conservation Collections**, while they can function as display collections in some circumstances, are well-curated *ex situ* collections that directly support *in situ* efforts by providing propagules for outplantings. Most of Hawai'i's native plants produce seeds that can be stored in conventional seed banks. Plants with seeds that cannot be stored and those that do not produce seeds in the wild are "Exceptional Species." For these, keeping living plants is the only option for maintaining an *ex situ* conservation collection (Fant et al., 2016).

Maintaining living plants as a Conservation Collection introduces significant challenges. They require more resources than species that can be conserved using traditional seed-banking methods (Fant et al., 2016) because they are constantly managed to preserve the integrity of the wild plants they represent. Living collections of plants can also serve the purpose of bridging *in situ* and *ex situ* efforts by establishing *inter situ* restoration outplantings where they are not in place near wild populations and are managed for their eventual return *in situ* while being maintained in more optimal conditions to help limit artificial selection in cultivation. For more information on the genetic consequences of artificial selection and other potential threats to wild plants in living collections see Table 1, adapted from Ensslin and Godefroid (2019) and Basey et al. (2015). Apart from exceptional species for which no other *ex situ* conservation method exists, species particularly suitable for conservation collections as living plants in gardens and/or arboreta are those that may benefit from an intra- or inter-institutional coordinated breeding program and for which research questions that would utilize living plants could be answered.

Display Collections

- Are valuable for outreach, education, supporting traditional/cultural uses, demonstration landscapes, and many other benefits that come from displaying native plant collections
- Can be established outside suitable habitat or historic range, or on another island, but should not be planted near a wild or outplanted population of the same genus.
- Are planted with material that is "in excess of conservation needs" and no other conservation opportunity exits. This is determined by written requests to DOFAW, the collector, and the land owner where the collection was made. If all parties decline the material, it can be used.
- Cannot be sold or exchanged for goods or services without proper DOFAW permits
- Threatened or Endangered species cannot be transferred out of the state without USFWS approval

Conservation Collections

- Contribute to the conservation of the species and are managed to maximize conservation value of the founders or population they represent
- Established using legally collected material under Federal/State permits
- Located on land dedicated to conservation of native plants (owned by the permittee, or an agreement is in place that protects the area for plants)
- Maintained by staff who can monitor plants and communicate management needs to species managers and other partners
- At a site within historic range or managed to match the ecological conditions at the wild source to alleviate concerns about artificial selection and maximize survivorship
- Protected from vandalism and theft of any plant material
- Impacts of invasive alien species: herbivory, seed-predation, competition with weeds, and fire are controlled or mitigated
- Established and maintained using material sourced from as close to the original founder as possible: 1) clones of wild founders or wild-collected seed (parent generation), 2) clones or propagules of first-generation (F1), or 3) second-generation (F2) material when the original parents are unavailable. Collections should have as many individuals as space and cost allows to represent a species or population targeted for restoration. The more individuals maintained in a conservation collection will increase genetic diversity conserved and the conservation value of the collection. Collections held across multiple sites can form a mega-collection.
- Labeled on grounds so that all plants are individually tagged and linked to propagation records that contain provenance and source information
- Propagated with the same detailed records so their progeny can be tracked to the original founder. This includes recording the maternal and paternal sources of seed stock and noting clonal lines for air-layers, cuttings, and grafts. Records must indicate how many generations each accession is removed from the original wild plants.
- If seeds generated on-site are to be used in situ, outcrossing between individual plants should be managed to match those expected in the source population. These collections need to be carefully managed to eliminate the chance of hybridization with congeners during flowering.
- Not permitted for commercial-use or in exchange for goods or services

Data Management

Standard fields for tracking the provenance and lineage of each plant:

- **Garden Accession #:** Unique number assigned to each plant or group of plants
- **Taxon Name**: Use accepted name
- **Founder HRPRG Reference Code**: Example: OA-PUK-A-0001
- **Source HRPRG Reference Code**: As above, or seed bank/nursery accession #
- **Paternal Source**: Pollen source used for controlled breeding
- **Propagule Type**: Seed, cutting, air-layer, division
- **Collection Date**: Date was the propagule collected

USFWS and DOFAW Requirements for T&E and PEPP Taxa

Display Collections

✓ Plant materials are in excess of conservation needs and verified with DOFAW

✓ Plants will be for purposes of outreach, education, or cultural or traditional use

✓ Commercial use is authorized under a DOFAW permit

Conservation Collections

✓ Established on land dedicated to conservation of native plants (either owned by the permittee, or an agreement is in place that protects the area for plants)

✓ Within historic range and/or is managed for suitable ecological conditions

✓ Goal to establish with 75% of at least available founders (up to 50)

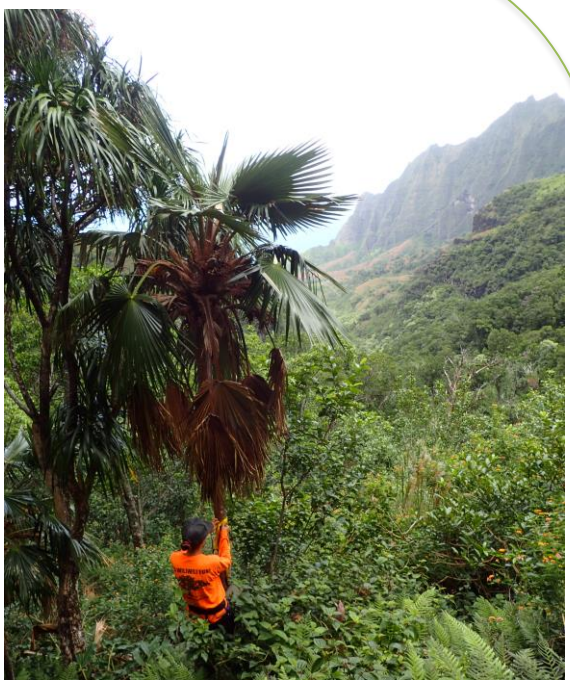
✓ Have detailed source and records of its history in cultivation

✓ Has a collection management plan that states its purpose, irrigation requirements, threat control needs and schedule, and protection of plants from vandalism and theft

✓ Not for commercial-use

CASE STUDY: *Pritchardia minor*

By: Seana Walsh, National Tropical Botanical Garden



NTBG staff with *Pritchardia minor* in Kalalau Valley
Photo: Ken Wood

Pritchardia minor is a Kaua'i single-island endemic palm with, as of 2019, ca. 200-250 individuals in 13 populations remaining in the wild. Like most of our native Hawaiian *Pritchardia* species, *P. minor* is disappearing from its native habitat with little to no regeneration. Seeds of *Pritchardia* taxa are thought to be recalcitrant or short-lived (Chau et al., 2019) and therefore conservation collections are maintained as live plants. Due to the challenges of curating live plants when compared to stored seed (e.g., space limitations, maintenance costs, etc.) conservation collections of *P. minor* curated at the National Tropical Botanical Garden (NTBG) on Kaua'i in 2018 represented only four of the 13 remaining populations.

From March 2018 through February 2019, scouting and collecting trips across Kaua'i were undertaken to expand and improve *ex situ* conservation collections of the species. Seeds were shared or reciprocated among Montgomery Botanical Center in Florida, San Francisco Botanical Garden in California, Waimea Valley Arboretum and Botanical Garden on O'ahu, NTBG's McBryde Garden on Kaua'i, and NTBG's Kahanu Garden on Maui in order to maintain a metacollection (combined holdings of a group of collections across multiple institutions) of live plants of the species. The metacollection increases potential coverage of genetic diversity, reduces maintenance costs, and assures necessary redundancy thus decreasing the risk of loss (Griffith et al., 2019). The work was supported in-part by the American Public Gardens Association and U.S. Forest Service Tree Gene Conservation Partnership.

Living Collection of *P. minor* at NTBG
Photo: Seana Walsh

Some of the other pitfalls of *ex situ* collections of live plants, besides the increased maintenance costs, include selection for *ex situ* environment, loss of seed dormancy in garden seeds (Ensslin et al., 2018), and hybridization with closely related taxa also held in the garden's collection, which has been observed in *Pritchardia* spp.. Therefore, care must be taken when seeds from *ex situ* collections of plants are being used for species-specific research, replenishment of *ex situ* collections, and/or *in situ* restoration. For example, if seeds of a Pritchardia species are needed from an *ex situ* plant, inflorescences (while flowers are still in bud) should be bagged to exclude floral visitors from depositing pollen potentially picked up from a closely related *Pritchardia* species. The conservation practitioner can hand pollinate open flowers from another plant in the collection, either originating from the same or a different population, depending on the need/use of the seeds to be obtained.

Table 1. Strategies to Mitigate Genetic Changes in *Ex situ* Conservation Collections

Problems	Effect	Mitigation Strategies
Genetic erosion: Drift and/or inbreeding	• Loss of genetic diversity • Loss of rare alleles • Fixation of deleterious alleles	• Start with a large effective population size (At least 50 individual founders when possible) • Frequent introduction of new founders from wild population when possible • Use plant material sourced from as close to the original founder as possible • Controlled pollination: Ensure crossing between individuals when pollinators are absent
Loss of adaptation to natural conditions: Selection for the *ex situ* environment/Adaptation to the garden environment resulting in changes in plant adaptations due to: • Novel garden conditions • Reduced selection pressure in cultivation • Unconscious selection by managers	• Genetic changes in traits • Reduction in trait variability	• Limit the number of generations in cultivation- more important for short-lived vs. long-lived species (Limit to one generation when possible) • Equalize male and female contributions to the next generation or minimally ensure all maternal lines are sampled for producing the next generation • When establishing a collection with seed grown plants, expose seeds to a range of conditions to ensure as many seeds germinated as possible and plant both early and late germinating seedlings • Simulate original habitat conditions. Consider planting *inter situ* • Minimize unconscious selection in cultivation whenever possible
Hybridization, introgression and genetic swamping: Admixture of unwanted genetic materials due to: • Unintended hybridization with similar taxa or different populations of the same taxon	• Loss of genetic integrity • Unwanted Cross-pollination with other species or populations can dilute unique gene combinations, introducing the possibility of genes from one population or species overriding another (genetic swamping)	• Isolate hybridization prone taxa • Avoid cross-pollinations between populations of the same taxa- isolate populations either spatially or temporally

References & More Information

Center for Plant Conservation Best Plant Conservation Practices to Support Species Survival in the Wild: https://saveplants.org/wp-content/uploads/2019/05/CPC-Best-Practices-5.22.2019.pdf

Basey, Adrienne & Fant, Jeremie & Kramer, Andrea. 2015. Producing native plant materials for restoration: ten rules to maximize genetic diversity. *Nativ. Plants J*. 16. 37-52.

Chau, M.M., Chambers, T., Weisenberger, L., Keir, M., Kroessig, T.I., Wolkis, D., Kam, R. and Yoshinaga, A.Y. 2019. Seed freeze sensitivity and *ex situ* longevity of 295 species in the native Hawaiian flora. *American Journal of Botany*, 106, 1248–1270.

Ensslin, Andreas & Godefroid, Sandrine. 2019. How cultivating wild plants in botanic gardens can change their genetic and phenotypic status and what it means for their conservation value. *Sibbaldia.* 17. 51-69.

Ensslin, A., Van de Vyver, A., Vanderborght, T. and Godefroid, S. 2018. *Ex situ* cultivation entails high risk of seed dormancy loss on short-lived wild plant species. *Journal of Applied Ecology*, 55, 1145–1154.

Fant, J. B., Havens, K., Kramer, A. T., Walsh, S. K., Callicrate, T., Lacy, R. C., Maunder, M., Hird Meyer, A., Smith, P. P. (2016) What to do when we can't bank on seeds: What botanic gardens can learn from the zoo community about conserving plants in living collections. *American Journal of Botany*, 103, 1541-1543. doi:10.3732/ajb.1600247.

Griffith, M.P., Beckman, E., Callicrate, T., Clark, J., Clase, T., Deans, S., Dosmann, M., Fant, J., Gratacos, X., Havens, K., Hoban, S., Lobdell, M., Jiménez-Rodriguez, F., Kramer, A., Lacy, R., Magellan, T., Maschinski, J., Meerow, A.W., Meyer, A., Sanchez, V., Spence, E., Toribio, P., Walsh, S., Westwood, M. and Wood, J. 2019. TOWARD THE METACOLLECTION: Safeguarding plant diversity and coordinating conservation collections. Botanic Gardens Conservation International-US (San Marino, USA).

Volis, Sergei. 2017. Complementarities of two existing intermediate conservation approaches. Plant Diversity, 39, 379-382. https://www.sciencedirect.com/science/article/pii/S246826591730077X

Volis, Sergei. 2017. Conservation utility of botanic garden living collections: Setting a strategy and appropriate methodology. Plant Diversity, 39 (2017) 365-372. https://www.sciencedirect.com/science/article/pii/S246826591730080X