AUGUST 2014

Hawai‘i Strategy for Plant Conservation

Phase 1: increasing *in situ* collecting and *ex situ* capacity

Increasing collaboration and capacity for plant conservation in Hawai‘i toward meeting the goals of the Global Strategy for Plant Conservation

1

Presented by the National Tropical Botanical Garden & Lyon Arboretum with support from the Hau‘oli Mau Loa Foundation

Prepared by:
Matthew Keir
Lauren Weisenberger

FOREWORD

2

This document, the Hawaiʻi Strategy for Plant Conservation (HSPC), promotes terrestrial plant conservation in Hawaiʻi, to preserve its unique flora and its essential role in ecosystem function and services. It presents a collaborative vision by presenting potential methodology to be reviewed and revised by Hawaiʻi's conservation community that is designed to overcome limiting factors presented in the 2012 *Ex Situ* Assessment. There has been strong, productive progress made by a large group of professionals. The HSPC is intended to highlight and build upon this ongoing effort, while placing our collaborative work in the context of global biodiversity conservation through the alignment of shared goals.

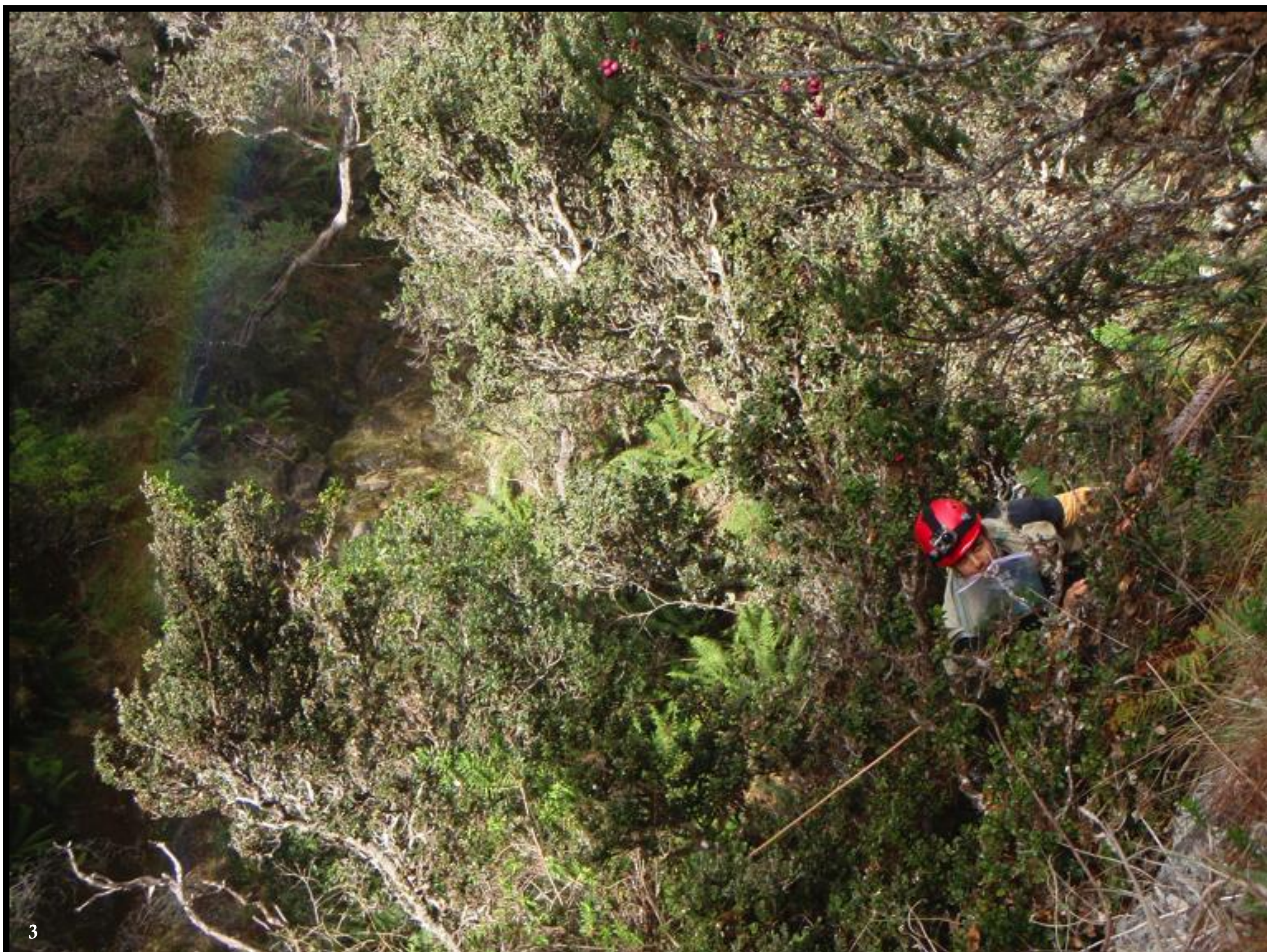
The five objectives of the Global Strategy for Plant Conservation (GSPC) are proposed as a framework for specific outcome-oriented targets for protecting native plant biodiversity in Hawaiʻi. These targets were modified from the GSPC targets to better represent the ongoing conservation efforts and unique challenges in Hawaiʻi. The targets were developed during strategizing sessions with conservation experts and are open to recommendations and revisions. Identifying and acknowledging shared targets will strengthen the relationship among conservation programs across Hawaiʻi and are intended to increase the quality and efficiency of our conservation efforts.

A primary focus of this first phase is to build *ex situ* collections with high conservation value that can be secured using cost-effective *ex situ* techniques either as germplasm repositories for rare taxa or as shorter-term storage for both common and rare taxa until habitats are suitable for restoration and recovery efforts. Phase 1 will focus on establishing and prioritizing *in situ* collecting, as well as building the capacity of *ex situ* facilities to support the increased quantity of collections. This includes the *in situ* management necessary for the production of viable propagules. In Phase 2, these efforts will expand to include the *in situ* natural resource management necessary to utilize the collections for habitat restoration and rare species recovery. Phase 3 will emphasize public outreach and education to improve the understanding, knowledge, and awareness of native habitats. Shortly after Phase 1 is initiated, Phase 2 should commence and all phases should operate concurrently.

The HSPC proposes the creation of an administered network of conservation programs and *ex situ* facilities, called Laukahi: The Hawaiʻi Plant Conservation Network, to facilitate progress toward targets. It will aim to serve the ongoing efforts of the conservation projects and initiatives undertaken by a multitude of individuals, institutions and organizations. Some of the benefits of establishing a network include increased information exchange and efficiency of conducting *in situ* actions among conservation organizations (by increased awareness of all activities), the ability to monitor the success of our collective conservation efforts through data sharing designed to protect sensitive data and the ability to attract new funding sources who value the shared goals among partnering organizations. Some benefits of an administered network include the creation of an advisory board to represent the multitude of programs, the ability to provide services to the partners that assist their own conservation efforts by reducing their limiting factors and the strengthening of the relationships and information exchange between local, national and international plant conservation organizations.

This document is designed to represent all existing conservation efforts, and facilitate support for these efforts. It is not intended to compete with existing organizations or their funding, but to strengthen those efforts through a partnership that allows us to attract new funding sources. Our intent is for this to be a ‘working document’ to be improved and revised by the plant conservation community for the benefit of their ongoing programs.

Matthew Keir
Lauren Weisenberger, Ph.D.
Hawai‘i Plant Conservation Network
hawaiiplantconservation@gmail.com
August 2014



3


4

Table of Contents

List of Participants at Strategy-Building Meetings

Table 1. List of Participants in Developing the Hawaiʻi Strategy for Plant Conservation. Participants contributed their expertise to the design of the HSPC proposal in the strategy-building meetings. Additional reviewers are found in the acknowledgements.

Institution / Agency	**Participants**
Bernice Pauahi Bishop Museum	Clyde Imada, Herbarium Pacificum
U.S. Fish and Wildlife Service	Loyal Mehrhoff, Field Supervisor
	Marie Bruegmann, Plant Recovery Botanist
	Vickie Caraway, Botanist
Hawaiʻi State Department of Land and Natural Resources Division of Forestry and Wildlife	Marigold Zoll, Native Ecosystems Protection & Management
	Charmian Dang, Rare Plant Permit Coordinator
	Maggie Sporck, Hawaiʻi State Botanist
	Lara Reynolds, Oʻahu Botanist
	Lyman Perry, Hawaiʻi Island Botanist
	Randy Kennedy, Manager-Native Ecosystems Protection & Management Section
The Nature Conservancy of Hawaiʻi	Sam Gon, Senior Scientist and Cultural Advisor
U.S. Geological Survey – Pacific Island Ecosystems Research Center	James Jacobi, Biologist
U.S. Forest Service	Susan Cordell
U.S. Army	H. Kapua Kawelo
Hawaiʻi Conservation Alliance	Lihla Noori
Hawaiʻi Association of Watershed Partnerships	Mary Ikagawa, Koʻolau Mountains
Plant Extinction Prevention Program	Joan Yoshioka, Statewide Coordinator
	Susan Ching Harbin, Oʻahu Coordinator
	Talia Portner, Oʻahu Program
Hauʻoli Mau Loa Foundation	Janis Reischmann, Executive Director
	Brant Chillingworth, Program Officer
National Tropical Botanical Garden	Chipper Wichman, Jr., CEO and Director
	John R. Clark, Co-Director of Science & Conservation
	Margaret Clark, Seed Bank Manager
Harold L. Lyon Arboretum	Christopher Dunn, Director
	Nellie Sugii, Hawaiian Rare Plant Program Manager
	Tim Kroessig, Seed Conservation Lab
University of Hawaiʻi	Tom Ranker, Chair of Botany
	Kenneth Kaneshiro, Center for Conservation Research & Training
Honolulu Botanical Gardens	Naomi Hoffman, Botanist

5

Introduction

Plant conservation is valuable and essential in Hawaiʻi to preserve its unique flora, which has a critical role in maintaining native ecosystem health and sustaining life. The flora of the Hawaiian Islands has one of the highest rates of endemism in the world (89% for angiosperms, 74% for ferns and lycophytes), with over half of all taxa at risk (Palmer 2003; Sakai et al. 2002; Vernon & Ranker 2013; Wagner et al. 1999). Approximately 10% of the flora is extinct (Wagner et al. 1999), and over 30% (of 1360 species; Imada 2012) is federally listed as threatened or endangered (USFWS 2010). For these reasons, and because of the alarming rate of habitat loss, the Hawaiian Islands are part of the Polynesia/Micronesia biodiversity hotspot (Myers et al. 2000). The conservation of Hawaiʻi's rare flora is challenging. Reasons for the decline of native species are numerous, often centered around the introduction of many invasive species, including other plants, invertebrates, and large ungulates, which can cause vast habitat degradation (Athens 2009; Cuddihy & Stone 1990; Diong 1982; Joe & Daehler 2008; Loope 1992; Loope et al. 1988; Weller et al. 2011). New introductions of invasive species will continue to assault Hawaiʻi's threatened native ecosystems. Many populations of native plants are small and fragmented, and face threats, such as dwindling genetic variation and reduced outcrossing as pollinator populations decline or disappear (Frankham 1998; Kearns et al. 1998). Programs have been active on every island to conserve native ecosystems and rare species for decades. Federal, state, and county agencies, non-profit organizations, community groups, and private individuals are all involved in plant conservation in Hawaiʻi. These programs have collected from hundreds of rare plant species statewide and conducted dozens of restoration projects on each island, all while protecting thousands of acres of native habitat. However, despite widespread engagement and activity across many sectors, there is currently no broad, comprehensive plant conservation strategy guiding and uniting these diverse efforts. Even without additional funding, a statewide yet island-focused collaborative partnership could benefit all programs with conservation efforts in habitat protection and restoration (*i.e.* watershed protection, fire restoration, threat control, ecosystem health) and rare plant recovery (*i.e.* conservation research, biodiversity preservation).

6

The primary intention of plant conservation projects in Hawaiʻi is to restore thriving populations within protected habitat to resume their roles in native ecosystems. The recovery of native plant species and habitats is the ultimate goal. Local efforts, such as the U.S. Fish and Wildlife Service's Hawaiʻi and Pacific Plants Recovery Coordinating Committee, can provide guidance in defining recovery steps and goals. In practice, this requires two approaches: 1) *in situ* management to preserve and restore habitats, and 2) *ex situ* techniques to secure and maintain viable propagules in a "genetic safety net" for future restoration and recovery efforts (Barrett & Kohn 1991; Havens et al. 2004). Restoring native habitats by excluding or reducing threats to native plants may take years or even decades. The rapid degradation of native ecosystems, the looming threat from alien species and climate change all contribute to the realization that it might not be possible to recover habitats in a timely manner to prevent the loss of many native plants. Therefore, *ex situ* techniques can be necessary to conserve plant biodiversity and prevent the extinction of threatened taxa. In addition to providing a "genetic safety net" for species of conservation importance, collecting from species prior to and during habitat protection and threat removal efforts will provide a genetically diverse and representative pool of propagules for future restoration and recovery efforts. Well-maintained *ex situ* collections are insurance against extinction while habitat restoration is proceeding. In habitats that are already protected and ready for restoration and rare plant outplantings, propagules collected from wild sites can be grown and immediately outplanted. These outplanting sites could then provide propagules for *ex situ* storage, especially in the case of mixed-source outplantings where outcrossing could provide more fit progeny. Preventing further decline of plant populations by immediately conducting *in situ* threat mitigation and restoration outplantings is the most cost-effective approach. The risk of outplanting failure, however, needs to be well assessed with this approach to ensure that germplasm will be available for eventual *ex situ* collections. Ideally, where opportunities exist to proceed with both *in situ* and *ex situ* approaches, they should be conducted concurrently.

We view the *in situ* and *ex situ* approaches to plant conservation as a continuum; they are dependent on the success of both. In other words, building and maintaining *ex situ* collections is less meaningful without the utilization of those propagules for preserving biodiversity *in situ*. On the other hand, relying on *in situ* management alone to prevent extinction risks the loss of many individual plants as the impacts of several decades of habitat degradation and disruption of ecosystem function prevent many species from recovering on their own. Conservation programs in Hawai'i are currently placing great effort into both *ex situ* and *in situ* conservation. This document aims to acknowledge Hawai'i's current plant conservation efforts and to develop a strategy, as a community, to support and strengthen these efforts.

For the purpose of this document, the species these conservation agencies work to protect are referred to here as "species of conservation importance." Species of conservation importance (SCI) include U.S. federally listed endangered, threatened, and candidate taxa, all species with less than 100 known individuals remaining regardless of federal listing, IUCN Red List vulnerable, endangered or critically endangered species, and species listed by the State of Hawai'i as important habitat or community-dominant species (Mitchell et al. 2005; USFWS 2010). In addition, any taxon already represented by some type of germplasm collection in a garden, seed bank, nursery or micropropagation facility was included. In 2012, there were 724 native plant taxa listed as SCIs (Appendix A; Weisenberger & Keir *in press*).

Framing Hawai'i's plant conservation efforts within a global context will increase international awareness of Hawai'i's imperiled flora and may attract additional resources. An international agenda, stemming from the 1999 Global Botanical Garden Congress, was developed to increase the focus on conserving plant biodiversity. The Global Strategy for Plant Conservation (GSPC) was developed in 2002 within the structure of the Convention of Biological Diversity. In 2010, an updated version of the GSPC was released with five main objectives consisting of 16 global targets to be reached in the year 2020 (Appendix B). The objectives range from public outreach and education to understanding the basic biology of plants and the urgent necessity of conserving plant biodiversity. Under Objective 2 ("plant diversity is urgently and effectively conserved”), Target 7 states, “at least 75% of known threatened plant species conserved *in situ*” and Target 8 states, “at least 75% of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20% available for recovery and restoration programs.” Many countries have adopted the updated GSPC, with progress monitored by Botanic Gardens Conservation International (BGCI). The GSPC provides a framework for working together at all levels- local, national, regional and global- to understand and conserve Hawai‘i’s plants while promoting awareness of the importance of preserving and restoring biodiversity. This framework and timeline and these targets should serve as benchmarks to reach and measure progress for native plant conservation in Hawai‘i. An assessment of Hawai‘i’s progress towards reaching some of these targets (Wichman & Clark 2013) found that much progress has been made on establishing an online flora of all known plants (GSPC Target 1), conducting an assessment of the conservation status of all known plants (GSPC Target 2) and the development and sharing of research and methodology for conserving plants (GSPC Target 3). However, progress on other GSPC targets has not been substantially quantified. The Hawai‘i Strategy for Plant Conservation (HSPC) describes a collective vision for plant conservation in Hawai‘i in line with the GSPC to promote awareness globally and leverage support for individual projects to make and measure progress on reaching all GSPC targets.

8

Restoration outplantings are dependent on adequate field collections of propagules. Therefore, we view the HSPC in phases, with an initial emphasis on building *ex situ* collections of the most threatened taxa to prevent extinction, as well as species essential for urgent habitat restoration, such as fire-susceptible dry land taxa. While these species are being secured in collections, emphasis can shift to outplanting. Therefore, for the purposes of this Strategy, we present plans for the first phases of *in situ* work to secure collections and the *ex situ* work to build facility capacity, maintain collections, and conduct necessary research. The second phase will focus on the *ex situ* work to propagate plants and the *in situ* work of habitat restoration (see Appendix K). This includes threat management and outplantings, as well as the workforce development necessary to accomplish this phase. The third phase will focus on increasing outreach and on education to improve public understanding of the negative human impact of deteriorating ecosystem health and the great need for conservation-driven research, interacting with the business and commercial sectors, as well as strengthening the network and expanding it from terrestrial ecosystems to marine ecosystems and culturally significant plants.

A review was conducted in 2012 of the inventories, capacity, and potential of 28 *ex situ* facilities in Hawai‘i (Weisenberger & Keir *in press*). The Assessment determined that over half (54%, 724/1360) of native Hawaiian plants are of conservation concern and are considered species of conservation importance (SCI), which supports the findings of Sakai et al. (2002), who estimated that half of Hawai‘i’s flora is at risk of extinction. Collections of 528 SCI (73%) exist in the inventories of *ex situ* facilities across the state. This statistic highlights the enormous amount of work that has been accomplished toward preventing plant extinctions and would suggest that Hawai‘i is close to achieving GSPC Target 8. *Ex situ* collections, however, have most conservation value when they are genetically diverse and representative of the majority of known wild populations (Brown & Marshall 1995; Crossa & Vencovsky 2011). Unfortunately, 64% of these “secured” species are represented by collections from only ten percent or less of the remaining naturally occurring individuals. Furthermore, most taxa are secured in only one *ex situ* facility, making them vulnerable to disasters such as hurricanes, fires and other catastrophes. Therefore, the majority of these collections are not an adequate “genetic safety net” to preserve species *ex situ*. The Assessment was able to identify the remarkable success of past and current collection efforts across Hawai’i for restoration purposes. Almost 19% of the SCI *ex situ* collections are abundant enough to be used for restoration efforts, and it should not require significant further effort to surpass the 20% minimum goal of the GSPC Target 8 by 2020.

As of 2011, North America as a continent had only 39% of its threatened species represented, and 45% of these are considered inadequate (Kramer et al. 2011). Despite Hawaiʻi being well ahead of the country's average for securing threatened flora (73%), it is home to over 42% of the country's endangered plant species with only 0.2% of the land area. Plants comprise over half of the federally listed species in the U.S., however, during the period of 2007 to 2011, they received on average just 4.1% of the funding available from the FWS and partner agencies (Negrón-Ortiz 2014). With 115 plant taxa added to the endangered species list for Hawaiʻi within the last four years, the current rate of progress in securing adequate *ex situ* representation for SCI is not fast enough to create a satisfactory genetic safety net for the declining flora without increasing the quantity and quality of *ex situ* collections. Thus, financial support for both *ex situ* facilities and field collection efforts must increase. This will require coordination between various conservation managers and *ex situ* facilities to prioritize and cooperate on the collection effort. The 2012 Assessment determined that much progress has been made in collecting from critically rare taxa (<100 plants remaining). This effort should be expanded to secure collections of species estimated to have between 100 and 250 naturally occurring individuals remaining. Additionally, non-threatened species should be collected for short-term storage to be available for habitat restoration projects and post-fire restoration efforts. This expanded effort will require additional resources to support *in situ* collections, an increase in the capacity of *ex situ* facilities to research, store and maintain collections and coordination among conservation agencies.

9

To measure progress towards GSPC Targets, we must ensure that the provenance data and history in cultivation are well documented. For example, for any given population, progress toward collection goals is typically measured by how many plants have been collected from. Historically, due to the lack of systematic and unique identifiers for wild plants, it has been difficult to quantify how many wild plants are represented *ex situ* besides using the maximum number of wild plants represented in the largest *ex situ* collection for each species. It is often not clear whether collections held at one facility are from the same individual as those held in another facility because the wild plant was never given a unique identifier. Implementing a system that uses a unique code per population and plant is currently ongoing and when reconciled with previous collections, this should substantially increase the number represented without requiring additional collections. In addition, definitions of adequate *ex situ* representation are necessary to track progress toward GSPC/HSPC Targets. Lastly, the collections should be maintained under conditions that best preserve them for both research and restoration projects. These conditions should be determined through documented success of maintaining replication or viability of collections in each *ex situ* method.

Programs across Hawaiʻi are engaged in all aspects of *ex situ* conservation including greenhouse propagation, tree nurseries, living collections in botanical gardens, field nurseries, micropropagation, cryopreservation and seed banking. Access to *ex situ* services and the capacity of the institutions that provide them must increase to meet the needs of these programs. The 2012 Assessment concluded that increasing the capacity for seed storage statewide is the most efficient way to expand *ex situ* services to secure all of Hawaiʻi's SCI. Long-term seed bank storage potential varied among taxa, but 78% of the 724 SCI are likely candidates for long-term seed storage. Because seed storage is the optimal *ex situ* method for most SCI, more investment is needed to build the capacity of the existing facilities on Kauaʻi, Oʻahu and Hawaiʻi Island, and to create a new facility on Maui. All seed banking facilities should have a hurricane-resistant structure with emergency back- up power, have the equipment needed to follow standardized research-driven protocols and provide for all storage conditions and enough adequately trained staff to handle expanded services. Since the 2012 Assessment, the Hawaiʻi Seed Bank Partnership Initiative was drafted to outline the strategies necessary for promoting and improving seed banking efforts across the state (Appendix C, E). Access to seed storage facilities should be improved and more information about the benefits and protocols of seed banking should be promoted to provide the best genetic safety net. Additionally, sound protocols must be established for storing species with seeds that are desiccation-sensitive or otherwise cannot be stored conventionally in seed banks.

The HSPC seeks to develop a plan for filling gaps in the current plant conservation efforts in Hawai‘i, attracting new funding sources to supplement current spending, and facilitating increased collaboration among conservation programs in the form of a partnership. The partnership will allow for easier exchange of information, expedite multi-agency restoration and *in situ* management, and track plant conservation efforts on an island and statewide level. Existing conservation programs have been extremely successful in developing projects and models that benefit Hawai‘i's plants, but have been limited by funding, staffing and infrastructure (Weisenberger & Keir *in press*). Previous studies show that plant species recovery is positively correlated with funding (Negrón-Ortiz 2014). The HSPC seeks to increase the amount of plant conservation work by establishing a coordinated network of existing conservation programs that can provide the expertise needed to expand efforts and build upon existing collaborations. The HSPC strives to increase plant conservation efforts by acknowledging the existing efforts and working with them while providing complimentary services to overcome the limiting factors of these programs. While both *in situ* and *ex situ* plant conservation efforts are ongoing, the HSPC will initially build *ex situ* collections, except where partnering agencies have identified an opportunity to secure SCI with immediate habitat protection. A partnership, demonstrating unity, efficiency, synergy, strength and determination, increases the opportunity to bring additional funding to plant conservation efforts in Hawai‘i. The network of conservation programs will be united in their shared focus on conservation; hence, Laukahi (translated as "single leaf"): The Hawai‘i Plant Conservation Network.

Hawai‘i Strategy for Plant Conservation Objectives

The five objectives of the GSPC incorporate a broad range of ecological, cultural, human health and educational, and economic strategies for plant conservation worldwide. While all avenues of support are beneficial, these objectives can be tailored to Hawai‘i's unique islands, ecosystems, and culture to best promote conservation of our local native flora. Objectives for the Hawai‘i Strategy for Plant Conservation as a contribution to the GSPC have been proposed below (Table 2). Meeting these objectives will require the participation of and additional support for all active conservation programs. The partners listed here are currently executing many key proposed actions, but many more organizations can and will hopefully be involved.

The HSPC Objectives also incorporate a broad range of strategies to organize data, expand capacity, build a workforce, increase public awareness of native plants and guide practices for sustainable and appropriate use. In order to gradually build capacity and enable network collaboration, an incremental implementation of the strategy, in phases, is needed. Ultimately, any action would be beneficial, and each island, species and conservation need is unique. However, a basic sequence to gather funding and data, secure collections, begin restoration and sustain conservation activities is needed. The targets described for Phase 1 in Objectives I, II and III (Table 2), are proposed as the immediate focus of the HSPC. These targets emphasize the organization needed to a) bring partners together, b) build tools to collect and analyze the data needed to plan priority actions, c) increase the capacity to make and process germplasm collections, d) begin *in situ* restoration where possible, and e) build the knowledge and workforce needed to implement the Strategy. The targets described for Phase 2 in Objectives II and III should be initiated no more than three years later and focus on securing adequate habitat, preventing and managing threats, conducting restoration and professional development. These targets should be further described in Phase 2 of the Hawai‘i Strategy for Plant Conservation: *"In situ* habitat protection, restoration ecology and rare plant recovery" (see Appendix K). Lastly, targets for Phase 3 in Objective IV and V should begin within five years and are important towards investing in the awareness of preserving Hawaiian plants and maintaining cultural connections. Once initiated, each action will need to continue to support subsequent phases. Phase 1 actions should be initiated in the first three years and continue through Phases 2 and 3. Priority actions for Phase 2 are recommended for implementation starting by year three and Phase 3 actions starting by year five.

Table 2. Hawaiʻi Strategy for Plant Conservation Objectives I-V. All Hawaiʻi Targets and Partners are subject to review and revision. All proposed actions are assigned Phase 1, 2, or 3. Sub-tables are structured by HSPC Objective, followed by a brief status review of the great work already or currently being done toward each objective, the Hawaiʻi targets developed by local resource managers, a list of partners involved, proposed actions, and a discussion of desired outcomes. A list of acronyms for partner organizations is available in Appendix H (page 99).

Organization and Planning

HSPC Objective I: Plant diversity is well understood, documented and recognized (GSPC Targets 1-3)

Status: An online flora exists and an *ex situ* assessment was recently completed. Data management systems are being developed independently according to the needs of each conservation group, but data security and sharing both should increase to expedite our conservation efforts and increase information sharing and learning. Research is ongoing, but is not necessarily being prioritized for the SCI most in need.

Hawaiʻi Targets	Partners		Proposed Actions
1. An online Flora of native Hawaiian plants. **(GSPC-1)**	BISH NTBG SMI	Phase 1	▸ Support maintaining the online Flora of the Hawaiian Islands. This valuable resource is a product of the collaboration between the Smithsonian Institution Department of Botany and the National Tropical Botanical Garden. Consider adding keys, links to herbarium specimens, more pictures and line drawings. ▸ Support field surveys and research to revise and update taxonomy
2. An annual assessment of the conservation status (*in situ* and *ex situ*) of all known plant species, as far as possible, to guide conservation action. **(GSPC-2)**	DOFAW HRPRG PEPP USFWS HPCN	Phase 1	▸ Support for repeating the 2012 Assessment to track progress and identify priorities for collection and other management. ▸ Delineate population units for SCI to facilitate reporting and management. ▸ Promote existing standards for labeling individual *in situ* plants with unique codes. ▸ Adopt standards to link *ex situ* collections to the unique codes for each *in situ* plant. ▸ Conduct regular meetings on each island to update population data. ▸ Conduct regular meetings on each island to update *ex situ* inventories. Curate *ex situ* collections; link each to a corresponding *in situ* code.
3. An access-restricted central information management system for compiling and administering geospatial and tabular datasets on biological data.	BISH CCRT HCA HRPRG	Phase 1	▸ Evaluate existing databases for compatibility and overlap. ▸ Identify an appropriate online host and database developer. ▸ Develop and administer an information management system to compile and report on biological, geographic, and resource management data from multiple mobile and operational sources. Access to sensitive data will be contributor-controlled. ▸ Promote broad use and open exchange (as appropriate) between organizations to create a climate more amenable to data sharing. ▸ Develop and maintain an exclusive online geospatial database that will preserve and update data on plants. Access to sensitive data will be contributor-controlled. ▸ Administer the database to facilitate project planning, reporting on progress and overcoming knowledge gaps. ▸ Coordinate with national/global efforts to develop information management systems to link local work with progress on global goals. ▸ Document resource management data (i.e. threat control, land managers, zoning) to track progress and identify gaps in management.

Organization and Planning

HSPC Objective I: Plant diversity is well understood, documented and recognized (GSPC Targets 1-3)

Hawai‘i Targets	Partners		Proposed Actions
4. Increased research on the pollination & seed biology, genetic analysis, life history, phenology and limiting factors of native plants to facilitate restoration efforts and inform conservation practice. **(GSPC-3)**	CREW HRPRG LYON NTBG UH	**Phase 1**	▸ Encourage increased coordination between conservation practitioners and permitted researchers by hosting regular meetings to identify research topics and priorities and assist with obtaining permits and transfer of propagules. ▸ Develop and maintain a list of research topics prioritized by conservation groups. ▸ Identify research needs for taxa that are difficult to secure with existing methods or are not represented despite repeated collections and propagation attempts. ▸ Identify SCI that require controlled breeding and the facilities and researchers needed to secure propagules. ▸ Develop a phenology database and bio-information hub for life history and restoration techniques to reveal knowledge gaps and identify research needs. ▸ Support molecular research that will inform taxonomy, population genetics, delineation of population units and setting conservation targets. ▸ Compile field observations to help identify and promote opportunities for environmental monitoring and research on reasons for the decline of native taxa. ▸ Determine biotic symbioses among SCI and other plants and animals, including pollinators, seed predators and dispersers, herbivores.

Outcomes: Increased support for accessible, current, biological and geospatial data will result in more efficient data exchange and use among conservation partners in Hawai‘i. It would preserve valuable historic geospatial and biological information from the existing data holders, such as the Hawai‘i Biological and Mapping Program, and result in better coordination of plant conservation efforts. A central information management system that can compile field data, *ex situ* inventories, and resource management status would enable partners statewide to identify gaps in securing collections, prioritize and coordinate management actions, and measure progress in achieving targets. Reporting can be aligned with global standards (*i.e.* Element Occurrence Records, IUCN red listing, BGCI GardenSearch and PlantSearch, U.S. federal status) to appeal for support for local efforts that align with international targets. Locally, it will enable reporting on plant taxa found on multiple islands by compiling data from multiple agencies. Research on population genetics, reproductive biology and threat mitigation will have clear benefits to conservation planning and project success. Some measures of success for Objective I are:

- Establishment of an administered information management system to support native plant conservation
- Annual reports shared amongst network partners on the *in situ* and *ex situ* status of SCI and progress on habitat management. Sensitive data would be restricted or redacted on public records.
- The number of SCI being tracked in the statewide database
- The number of agencies and organizations contributing to the database and information hub
- The number of research projects originating from efforts to identify and request information on developing optimal *ex situ* methods, threat mitigation techniques, standard collection protocols, controlled breeding plans, *in situ* limiting factors, population genetics, reproductive biology, phenology and taxonomy.
- The strength of the information and the collaborative nature of the HSPC would allow partners to pursue funding from a wider variety of sources

Increasing Capacity

HSPC Objective II: Plant diversity is urgently and effectively conserved (GSPC Targets 4,5,7,8,10)

Status: Substantial *ex situ* and *in situ* progress has already been made by many organizations to reach these targets. Some more protected and/or restored habitat is still needed to support plant diversity. Many *ex situ* collections are currently inadequate to represent SCI or provide plant material for recovery and restoration projects, and more collections from other SCI need to be made.

NOTE: All percentage (%) goals are adopted directly from the GSPC targets.

Hawaiʻi Targets	Partners		Proposed Actions
5. At least 15% of each ecological region or vegetation type is secured through effective management and/or restoration. **(GSPC-4)**	DOFAW NPS HCA HRPRG USGS HAWP	Phase 1	‣ Compile natural resource management information and track the status of conservation areas, protected habitat, threat management and progress on restoration.
		Phase 2	‣ Standardize definitions for "ecological regions" in Hawaiʻi using a statewide geospatial database and best available current research. ‣ Secure, restore and manage vegetation in each ecological region on each island to provide native habitat.
6. At least 75% of the most important areas for plant diversity of each ecological region protected with effective management are in place for conserving plants and their genetic diversity. **(GSPC-5)**	DOFAW NPS HCA HRPRG USGS HAWP	Phase 2	‣ Define 'important areas' in Hawaiʻi to track progress on habitat protection for areas with high endemism and important plant communities. ‣ Identify threats (ungulates, weeds, invertebrates, fire, etc.) to each SCI and the appropriate control methods for mitigating each threat. ‣ Include threats and their management status to track the progress of management and resource responses in the statewide database. ‣ Expand conservation areas and habitat protection measures by conducting invasive species management and restoration projects.
7. At least 75% of known threatened plant species are conserved *in situ*. **(GSPC-7)**	HAWP DOFAW	Phase 2	‣ Identify opportunities for restoration outplantings using existing *ex situ* collections. ‣ Develop and maintain a database with information on to inform prioritization and track progress on each SCI. ‣ Develop and maintain a database to track *in situ* population status for SCI including ongoing recovery outplantings. ‣ Seek funding to conduct restoration outplantings.
8. At least 75% of SCI are secured with adequate *ex situ* collections by 2020. **(GSPC-8)**	PEPP DOFAW NTBG NPS HRPRG	Phase 1	‣ Define "adequate representation" for each SCI using the best available standards ‣ Develop and make available *in situ* collection plans and protocols ‣ Support the hiring and training of additional field botanists to secure collections, starting with the expansion of existing programs
		Phase 2	‣ Increase the number of trained professional collectors by sponsoring workshops to bring expertise to new staff. ‣ Develop and administer a program modeled on the Seeds of Success for common SCI in Hawaiʻi. Organize collection projects with school, community and cultural groups for common native taxa.

Increasing Capacity

HSPC Objective II: Plant diversity is urgently and effectively conserved
(GSPC Targets 4,5,7,8,10)

Hawaiʻi Targets	Partners		Proposed Actions
9. Collections of at least 20% of SCI are available for rare species recovery, habitat restoration and watershed protection projects. **(GSPC-8)**	PEPP DOFAW HAWP	**Phase 1**	‣ Determine taxa that are needed for restoration projects and secure collections. ‣ Secure collections that are most needed in the case of catastrophe (fire, hurricane), to restore habitat for wildlife and watershed protection.
		Phase 2	‣ Expand the HPCN database to be able to indicate the collections of SCI available (and to whom) for restoration projects.
10. Collections are duplicated whenever possible and held at facilities either on-island, within state, nationally or internationally. **(GSPC-8)**	HSBP KRPF LAML ORPF PRPF VRPF	**Phase 2**	‣ Secure a permanent back-up facility for micropropagation collections held only at Lyon Arboretum and consider cryopreservation of *in vitro* collections as additional backup. ‣ Coordinate the transfer of duplicate collections and maintain replicates as insurance against catastrophe. ‣ Administer an agreement with Kew MSB or NCGRP or Seeds of Success to hold duplicate collections of SCI.
11. Conservation plans are developed for SCI to help guide efforts and engage partners to implement habitat protection and secure collections.	PEPP DOFAW	**Phase 2**	‣ Develop detailed conservation plans for SCI (Appendix F). ‣ Add new taxa to the SCI list as they are determined to be vulnerable to catastrophe (i.e. fire modeling), climate change, development, or rapid population decline. ‣ Identify a single entity to organize and update *in situ* data, coordinate *ex situ* collections and identify storage goals for each SCI.
12. Effective management plans and biosecurity measures are in place to prevent new biological invasions. **(GSPC-10)**	HDOA CGAPS	**Phase 2**	‣ Support ongoing efforts to revise biosecurity measures to prevent new biological invasions. ‣ Increase understanding and awareness of the impact of biological invasions by compiling observations of invaded areas and the impacts to SCI.
13. Manage important areas for plant diversity negatively impacted by biological invasions. **(GSPC-10)**	DOFAW HAWP	**Phase 2**	‣ Identify and control priority alien plant species in important habitats. ‣ Conduct research on soil seed bank persistence, life history and control of non-native plants that threaten native plants and habitats. ‣ Develop efficient methods for controlling threats to SCI from biological invasions.

Increasing Capacity

HSPC Objective II: Plant diversity is urgently and effectively conserved (GSPC Targets 4,5,7,8,10)

Outcomes: This objective covers the widest range of activities and has the most specific targets for conserving plant biodiversity from the conservation of individual species to landscape scale conservation. Potential results will be many, including a greater amount of native habitats that are protected from introduced threats and sufficient propagules available to restore habitats suitable for recovery efforts. Some measures of success for Objective II are:

- The acreage of protected habitat in all ecological regions to provide areas for restoration
- The number of acres where invasive species have been controlled or eradicated
- Adoption of standard definitions for "ecological regions" and "important areas for plant diversity"
- The ability to track the implementation of threat control on a central database
- The ability to report on restoration success and failures
- Establishment of a statewide *ex situ* collection of native Hawaiian plants to complement and support *in situ* restoration efforts and serve as a "genetic safety net" to help prevent the extinction of threatened plants
- The number of *ex situ* collections secured for each SCI and number of SCI that meet safeguarding targets
- The number of SCI with *ex situ* collections available for immediate propagation for restoration
- Development of agreements between HPCN and landowners, collectors, and *ex situ* facilities
- The number of *ex situ* collections replicated at more than one facility
- Development of agreements with national/international groups to provide research and facilities to secure duplicate collections. This will help to protect valuable collections in the case of catastrophe.
- The number of HPCN Species Conservation Plans utilized by partners to direct prioritization
- The number of SCI with a "lead agency" designated to coordinate efforts and update data
- Improvements of biosecurity measures to prevent the importation and transport of invasive organisms


10


12


11

Workforce and Network Development

HSPC Objective III: The capacities and public engagement necessary to implement the strategy have been developed (GSPC 15-16)

Status: The current conservation workforce will need to increase to reach GSPC/HSPC Targets. New employees for existing organizations will benefit from the existing experts to secure collections, manage habitat and staff *ex situ* facilities to conserve the native flora. An administered network could seek additional funding, provide training, and support the staff needed to meet local and global conservation targets.

Hawaiʻi Targets	**Partners**		**Proposed Actions**
14. Trained people working in facilities, according to local needs are sufficient to achieve the targets of HSPC. **(GSPC-15)**	HRPRG HPCN	**Phase 1**	‣ Expand the workforce, starting with existing programs, to make and process more plant collections, conduct habitat protection and promote plant conservation in Hawaiʻi.
		Phase 2	‣ Provide training, workshops and information on when, where and how to make collections, how to prepare them for storage, when to re-collect, and how to curate *ex situ* collections. ‣ Organize and provide support for a work exchange program to bring together experienced practitioners and new programs. ‣ Engage national and international conservation groups.
		Phase 2	‣ Develop a program (modeled on the BLM Seeds of Success program) for training and organizing volunteer groups and seasonal internship crews to make collections of common SCI.
15. Increase the capacity to provide adequate infrastructure for *ex situ* facilities. Improve access to *ex situ* facilities and facilitate inter-island transport of germplasm and plants. **(GSPC-15)**	HSBP KRPF LAML LYON NTBG ORPF PRPF VRPF	**Phase 1**	‣ Expand and improve existing seed banking facilities to provide adequate space to secure duplicate collections. ‣ Collaborate on grant applications to upgrade equipment, increase germplasm storage capacity and enhance research capabilities at each *ex situ* facility. ‣ Assist in establishing and enhancing nurseries on each island. ‣ Develop transport and phytosanitation protocols to improve access to and from all facilities.
		Phase 2	‣ Assist with economic valuing of habitat restoration methods and *ex situ* services to incorporate fees into project planning. ‣ Seek funding to support conservation horticulture.

Workforce and Network Development

HSPC Objective III: The capacities and public engagement necessary to implement the strategy have been developed (GSPC 15-16)

Hawai‘i Targets	Partners		Proposed Actions
16. Partnerships for plant conservation are established or strengthened at national, regional and international levels. **(GSPC-16)**	BGCI CPC HSBP IUCN	**Phase 1**	▸ Coordinate meetings of the Hawai‘i Seed Bank Partnership ▸ Complete proposals for Hawaiian plants to the IUCN Red List.
		Phase 2	▸ Integrate with national/international plant conservation initiatives. ▸ Engage the Center for Plant Conservation and other national *ex situ* conservation networks in an effort to revisit its role in Hawai‘i’s plant conservation efforts.

Outcomes: Baselines should be well defined for these targets by conducting assessments of the need for and costs of habitat protection and restoration statewide. Where capacity and facilities already exist, technical knowledge transfer should be encouraged through increased networking. Accelerated and increased investment in training new conservation workers and improving the infrastructure and capacity of ex situ facilities is needed. This objective plays a more supportive role than the others, but is critical for the overall achievement of all the targets. Some measures of success for Objective III are:

- The number of participants in the Hawai‘i Plant Conservation Network
- The number of professional positions engaged in making and maintaining *ex situ* collections
- Increased expertise in making and storing *ex situ* collections
- The number of seasonal, intermittent and volunteer workers for making and maintaining collections
- The creation, publication and use of standard protocols for transporting native plants and propagules
- Increase in physical capacity to process collections, collaborate on research and produce plants
- Additional funding for collections and conservation efforts
- An enhanced statewide network of conservation nurseries with improved horticultural technology
- The number of partnerships with other conservation groups to develop and transfer new technologies


16


17


19


18

Outreach and Education

HSPC Objective IV: Education and awareness about plant diversity, its role in sustainable livelihoods and importance to all life is promoted (GSPC Target 14)

Status: Broad community and global support is necessary to expand and secure more support for plant conservation in Hawai‘i. There are many existing organizations actively reaching out to communities with regard to plant conservation. HPCN would ask their assistance in identifying their needs and how HPCN could support their cause and functionality in the network.

Hawai‘i Targets	Partners		Proposed Actions
17. Broad public understanding of the natural and cultural value of Hawai‘i's native plant diversity is achieved by supporting education and awareness. **(GSPC-14)**	HCA HDOE PICCC	Phase 3	▸ Support Hawai‘i's botanical gardens and related partners to engage communities in plant conservation topics ▸ Encourage stewardship of Hawai‘i's plants by producing materials that meet standards for curriculum development, education on plant science and environmental outreach programs. ▸ Create materials to describe HSPC targets, measures of success and demonstrate the need to preserve native plants to policy makers. ▸ Assist in producing materials on potential climate change impacts on native ecosystems, and the importance of native plants in watershed health to engage the general public in conservation issues.
18. Plant conservation in Hawai‘i is promoted to national and international conservation groups, local business interests, and visitors to mobilize additional support. **(GSPC-14)**	HCA HTA	Phase 3	▸ Represent statewide efforts at conferences, maintain a website, and publish updates and informational materials to international conservation groups. ▸ Encourage local businesses to support and sponsor plant conservation. ▸ Produce materials that promote plant conservation and sustainability to the tourism industry, such as airline magazines and other media platforms.

Outcomes: Broad public support from community and cultural groups, business interests and visitors is needed to sustain public interest and financing for plant conservation projects. Baselines could be better defined for these targets by conducting assessments of local awareness of the needs and benefits of plant conservation in Hawai‘i. Where capacity already exists for environmental education, the plant conservation community can partner to develop outreach and curriculum materials. Increasing exposure for native plants and biodiversity conservation to tourists would help reshape Hawai‘i's image as a biodiversity hotspot, with valuable bio-cultural connections and as a leader in developing conservation practices. Measuring success of awareness raising targets using surveys is difficult, but the key audiences are: policy makers, children and young people, teachers and students of conservation, landowners and managers, general public, business and tourism. Some measures of success for Objective IV are:

- The number of landowners/managers engaged as stakeholders in plant conservation through the HPCN
- Materials for policy makers using sound scientific data to show successes, economic benefits of biodiversity and where legislation is failing plant conservation
- Programs for young people that link plant science to examples in native ecosystems. Site visits to reserves.
- The number of educators, students and general public exposed to plant conservation in Hawai‘i by HPCN partners (i.e. botanic garden visitors and school groups)
- Updates on the status of SCI to leverage support for conservation legislation, education and outreach.
- Participation in the GSPC Plants2020 initiative and other national and international efforts.
- More awareness of Hawai‘i as a hotspot for biodiversity, a center for developing conservation practices

Sustainability and Appropriate Use

HSPC Objective V: Plant diversity is used in a sustainable and equitable manner
(GSPC Target 11, 13)

Status: Compared with the number of non-native species, few native plant species are readily available for use in the comercial trade. This favors the use of non-native plants. Increased support and resources may be necesary to increase the accessibility of native plants to the public.

Hawaiʻi Targets	Partners		Proposed Actions
19. No native plant species are endangered by commercial trade. Only certified responsibly-sourced native plants are used in commercial trade and restoration projects. **(GSPC-11)**	DOFAW LICH	Phase 3	▸ Support efforts to revise the regulatory process to certify that native plant material for commercial use doesn't impact wild populations. ▸ Assist in providing information on the regulations governing native plant use to the public. ▸ Create a mechanism for commercial activities to contribute to the conservation of native plants (i.e. donating a portion of proceeds to fund efforts to protect native habitats). ▸ Maintain inventory of "responsibly-sourced" native plant material available from each region at botanical gardens or other institutions. ▸ Partner with landscape industry groups to identify, obtain and develop commercially available native plants suitable for each region.
20. Indigenous and local knowledge innovations and practices associated with plant resources are maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care. **(GSPC-13)**	AGEG HBG HRPRG LYON NTBG OHA WBG	Phase 3	▸ Partner with community groups to identify culturally valuable plant resources ▸ Maintain an online list of plant resources available for public use in traditional practices. ▸ Secure collections of culturally important plant species in areas accessible to the public in botanical gardens, public parks and government building landscapes. ▸ Promote traditional knowledge, innovations and practices of local and indigenous communities that relate to conserving plant diversity.

Outcomes: A process to certify plant material for the commercial trade will help prevent harm to wild populations. Increased awareness and use of local varieties by commercial landscapers will help to preserve diversity. The second target will require supporting community groups to identify valuable plant-based cultural resources and increase the awareness and understanding of traditional uses. Better access to native plant resources for traditional, cultural and medicinal use will help to preserve traditional practices and help local communities relate to conserving plant diversity. Some measures of success for Objective V are:

- A transparent process to certify that native plants used for commercial landscaping have been responsibly-sourced, causing no harm to wild populations and ensures a portion of proceeds will benefit plant conservation
- A mechanism to receive contributions from public and private sources that support plant conservation efforts
- The number of native species commercially-available for use in public and private landscapes
- The number of sites where collections are held as seed sources for both conservation and commercial use
- An online inventory of plants available for use in public and private landscapes and for cultural practices
- The number of partnerships created between cultural groups and public plant collections
- The number of groups and individuals utilizing collections for use in traditional practices

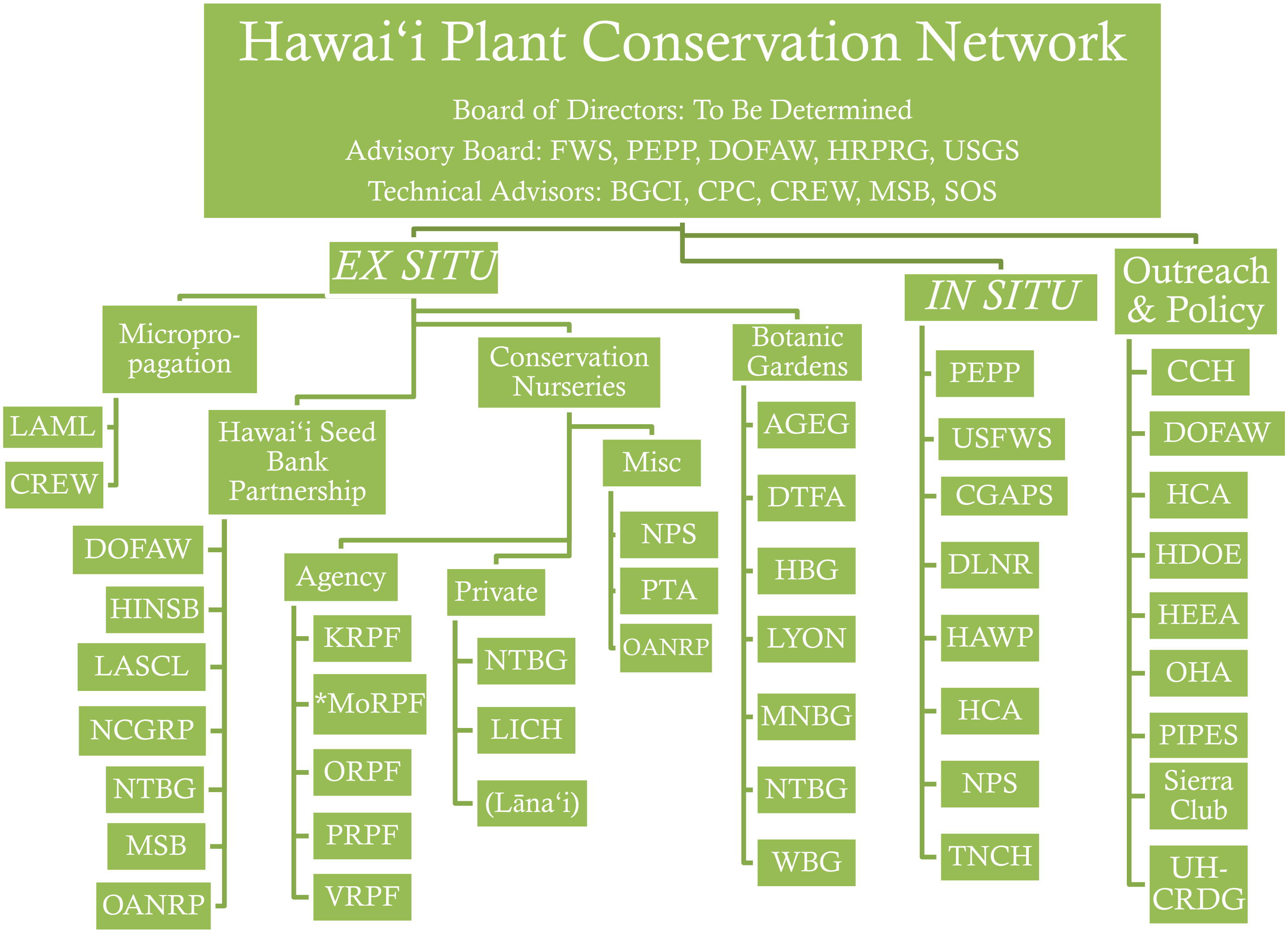


Fig. 1. Proposed structure of the Hawaiʻi Plant Conservation Network. *Proposed new facility. This is a draft diagram to recommend how HPCN could attempt to integrate conservation partners in all three Phases of the HSPC (list may not be complete). Acronyms are available in Appendix H.

Implementation

Building a Plant Conservation Network

Conserving threatened flora in Hawaiʻi requires an integrated approach to protect habitat and secure germplasm collections and substantial financial support. The implementation of actions described in Table 1 will require a strong commitment by a partnership of state, federal, private, other conservation programs and *ex situ* facilities. To strengthen the relationships and communication among partners, track progress towards the objectives above and represent shared interests, a formal partnership could be created. We propose the establishment of an official partnership of Hawaiʻi conservation agencies called Laukahi: The Hawaiʻi Plant Conservation Network (HPCN; Fig. 1). A unified partnership for plant conservation in Hawaiʻi could increase the quality of research and knowledge, and the quality, replication and quantity of collections representing the native flora. It would also facilitate increased interaction between local *ex situ* facilities, conservation programs conducting *in situ* management and specialists worldwide, to improve the quality of collections and provide knowledge resources. By forming an official partnership, we can highlight common goals, collaborate on projects that benefit more species and potentially attract new funding sources that are intrigued by Hawaiʻi's unified plant conservation effort. Hawaiʻi's relatively small plant conservation community has a long history of working together and a unique opportunity to incorporate culture and science into landscape-scale watershed management in ahupuaʻa to the benefit of native ecosystems. The Hawaiʻi Conservation Alliance (hawaiiconservation.org) and the Hawaiʻi Rare Plant Restoration Group (hrprg2.webnode.com) have already collaborated to recommend population-monitoring protocols, collection and reintroduction methods and have compiled data for multi-agency projects. In order to support and expand these partnerships, we recommend that a formal organization be created, with staff directed by an appointed Board of Directors and Advisors and the ability to seek and receive funding to represent shared interests. In addition to the benefits of emphasizing a partnership, staff employed by HPCN could be directed by the partnership to provide services that benefit the network such as data management and reporting on statewide progress. Creating a formal entity to represent the shared interests for plant conservation in Hawaiʻi must not detract from existing projects or groups. While there may be some costs to formalizing a partnership, a single, politically neutral entity can seek both private and public support for shared interests.

Coordinating the many diverse partners and conservation activities and documenting accountability toward meeting the targets are primary functions of the HPCN. Obtaining and increasing financial support for plant conservation activities statewide can also be a function of the HPCN. No one entity can or should fund all plant conservation actions, and the lack of funding was identified as a liming factor by 100% of the conservation programs surveyed (Weisenberger & Keir *in press*). By defining statewide conservation goals and priorities, existing funding for programs across the state can be used to leverage additional support from grants and organizations that value the collaborative nature of a statewide plant conservation strategy and partnership. Partner organizations can apply for funding for conservation actions that benefit the most partners and species. Currently, most funding for plant conservation projects comes from government sources. An entity that can be used to leverage support from private groups to match and supplement government sources would broaden the funding base. By demonstrating how various individual entities are connected through a partnership with a common strategy (HSPC), each member could benefit by showing a strong link between individual efforts and global biodiversity conservation. HPCN staff can fundraise for services, such as data management, reporting and

hosting meetings, as well as fundraise for HPCN partners' ongoing actions, such as airfare and helicopter time to visit *in situ* populations. If HPCN services become established for the partnership, internal revenue-producing mechanisms such as fees for training, subscriptions for access to an online information hub and fees for submitting collections to *ex situ* facilities could be developed.

One of the services HPCN has already provided was the establishment of the Hawai'i Seed Bank Partnership in July 2013 (Appendix E; see also Appendix C), which will serve as the foundation for the future network that will be expanded to include more *ex situ* facilities, collectors, conservation groups and government agencies (Appendix D). With a coordinator position at HPCN, he/she can begin hosting a series of meetings among conservation programs to establish better data management that can inform prioritization and measure progress. Fieldwork can be made more efficient by making collectors aware of germplasm needs, through better data management and communication about the quality of seeds and plant material suitable for long-term storage.

Having a single entity to represent Hawai'i's common interests will strengthen relationships with national and international conservation groups such as Botanic Gardens Conservation International (BGCI), Center for Plant Conservation (CPC), International Union for Conservation of Nature (IUCN), Royal Botanic Gardens Kew Millennium Seed Bank Partnership (MSB) and NatureServe. The CPC has had a long history working in Hawai'i, but over the last decade or so has been largely absent from ongoing conservation efforts. The financial support provided to the affiliated CPC botanical gardens in Hawai'i is not enough to maintain adequate *ex situ* representation of the CPC designated species. If determined to be beneficial to partners, the HPCN could reach out to the CPC to strengthen the relationship and support. CPC could provide workshops, expertise, and funding. They are recognized internationally as a primary plant conservation partnership in the United States and have existing agreements with other national *ex situ* and plant conservations programs and international programs such as MSB. Closer affiliation with the CPC could facilitate agreements with a host of other programs and lead to better access to their services and collaborations. By creating agreements with the CPC and other international programs, HPCN partners could benefit from their expertise, guidelines, financial support and services. These services include well-adopted and supported conservation strategies, training, data, database structure or other data management services.

<u>Developing a Unified Database and Bio-Information Management System</u>

One of the most powerful products of the HPCN would be a unified data management system (Fig. 2). A statewide database can allow partners to hold the data and reports relevant to their needs, as well as provide a metadata set that will allow for a better understanding of large-scale conservation efforts. A statewide database could be a substantial step toward tracking Hawai'i's progress towards HSPC Targets. Reports will keep track of restoration progress and success across all of the organizations working within similar locations, document progress for species *ex situ* and *in situ* conservation (regardless of landowner or collecting agency), as well as identify where the propagules are stored.

This statewide database should coordinate existing databases, delineate population units, track population size and compile *in situ* monitoring data, track habitat protection needs and efforts (fencing, fire protection, invasive species control), include information on restoration outplantings, compile *ex situ* inventories and manage the statewide collection of native plant germplasm. Managing Hawai'i's germplasm collection at a

Taxon Information

Information fields at the Taxon level:

- **Taxon Name** (Genus, Species, sub-species, variety)
- Plant Family
- Distribution
- Links to the Flora of the Hawaiian Islands website
- USFWS Status (Endangered, Threatened, Candidate)
- IUCN Status
- Tracking of synonyms and nomenclature changes
- Links to photo and literature resources, DNA barcodes, herbaria
- Phenology, biology (life history, reproductive, etc.)
- The HPCN 'Lead Agency' to coordinate conservation actions

The common field linking data at the Taxon and Population Management levels is the **Taxon Name**, compiling data from all populations for reports.

Population Management

Information fields at the Population Management level:

- **Population Name**
- Management Areas
- Landowner/land manager/contact
- Threat Control Status (ungulate, invertebrate, weeds, fire)
- Collection Goals
- Population Trend tracking (demographic data)
- Recovery Efforts
- Population Monitoring Data
- Wild Plant observations
- Outplanting monitoring

The common field linking data at the Population Management and *In situ* Monitoring levels is the **Population Name**, compiling data from each site monitored.

In situ Monitoring

Information fields at the *In situ* Monitoring level:

- **HRPRG Population Reference Code & Plant Number**
- HRPRG Rare Plant Monitoring Form Data
- Habitat Characteristics
- Associated Species (plants, invertebrates, fungi, microbes, birds)
- Elevation and location information
- Current census (# Dead, Mature, Immature, Seedlings)
- Collections
- Outplanting and Reintroduction Site Monitoring Data
- Date occurrence was discovered and last observed

The common field linking data at the *In situ* Monitoring and *Ex Situ* Collections levels is the **HRPRG Population Reference Code & Plant Number**. This unique code is assigned to each individual wild plant to track the provenance of all related collections.

Ex situ

Information fields at the *Ex situ* Collections level:

- **HRPRG Population Reference Code & Plant Number**
- Seed Bank, Nursery, Micropropagation and Garden Collections
- Facility and Location of Collection
- Propagule Type
- Number of propagules/# of accessions/individuals represented
- Viability of collection and date verified
- Propagation methods and horticultural notes
- Source information
- Collection ownership

Fig. 2. Structure and Relationships proposed for the Hawaiʻi Plant Conservation Network Database

species level could inform prioritization, update collection needs, and indicate collections available for restoration projects. Some benefits include: a) provide access to organized phenology records and life history traits, b) identify successful collection, transporting, propagation, restoration and germplasm storage protocols, c) collaborate with HCA efforts to track progress in meeting native ecosystem management goals, d) list research needs, e) provide a web-based library of resources on plant conservation, including species plans, and f) provide a list of collections that are available for use.

There are many advantages to compiling data and making biodiversity information freely available wherever possible, in the interest of science and the environment. There are serious concerns, however, that if not properly addressed would completely undermine the database's utility (Chapman & Grafton 2008). Foremost, is the concern that revealing the location of certain plants will lead to trespassing, deliberate vandalism or destruction of resources, illegal harvest and increased damage to fragile ecosystems. Other concerns include: private property rights, intellectual property rights, compliance with the Freedom of Information Act, over-collection of propagules and exploitation of natural resources for commercial use.

These are all valid concerns that if not allayed would certainly alienate important partners. In order to have incentive to participate, network partners must see a direct benefit from sharing their data, and have legal assurances that access to their data will be contributor-controlled and released only on a need-to-know basis. Trust must be earned and maintained. While this is no small task, it can be done by structuring the database properly so that security can be controlled at each level: within partner agencies, between partner agencies and by distributing only reports to the public. For the most part, both the metrics proposed to measure progress towards HSPC goals and the topics recommended for public outreach rely only on tabular population data. This alone should alleviate concerns about sharing geospatial data. Another important point is that the data will not be available to all network partners or the public. Only reports cleared by contributing partners would be published. The data is held offline and any online interface would search for and display data the user was given permission to access. When the metadata (see Fig. 2) with geospatial or tabular data on biological resources is complete, access to the sensitive components can be limited by: federal status, landowner, 'lead-agency', or any other data field. International standards and best practices are available for determining and generalizing sensitive data (Chapman & Grafton 2008) and would be followed for any HPCN efforts. Sensitive data that programs do not want to share can be maintained within that program's database, and not be uploaded to the shared database, or can be coded for anonymity. Data can also be password-protected, with different levels of access for different partners and administration. A variety of data management systems are currently being designed, and an expansion of this effort will strengthen the quality of analysis of the data collected.

DEVELOPMENT OF PHASE 1 GUIDELINES

Monitoring Populations, Species Plans and Making Collections

HPCN partners should identify an agency to serve as the primary lead for managing the species. This agency could collaborate with other HPCN partners in developing and writing standardized species plans (Appendix F; draft template) that can then be reviewed by all involved with managing each species, and offered as guidelines for their recovery or restoration. As drafting plans for each SCI would require a large effort, priorities could be made for species with less than 50 wild plants, with ongoing management, those requiring multi-agency coordination and those particularly imperiled by threats without known control methods. Authors include HPCN staff, lead agency staff, and other HPCN partners. A survey of HPCN partners on which SCI are most in need of plans could be conducted regularly. These will be targeted to conservation programs, *ex situ* facilities, and collectors, and regularly updated via the database. Sensitive data will only be distributed to select partner organizations when approved by the contributing organization. Data include:

1. **Species Description**: biology, distribution, habitat, conservation status and taxonomic notes
2. **Photo Gallery**: habitat, habit, morphology, size classes and stages of maturing fruit and seed, etc.
3. **Reproductive Biology**: phenology, suspected/known pollinator, pollinator syndromes, mating system, breeding system, seed biology
4. **Habitat Characteristics**: abiotic data and associated species from field observation forms
5. **Research**: ongoing, proposed and needed studies on biology, ecology, threats and the researchers involved
6. **Populations**: to delineate groups of plants using standard methods and labeling
7. **Population Structure & Estimates**: summary of population demography and numbers of plants reported on field observation forms and agency reports
8. **Threats and Control Methods**: from *in situ* observations and management reports
9. ***Ex situ* Goals**: for the number of propagules needed to secure each plant and population
10. **Collection Protocols**: optimal harvest time, mature fruit characteristics, seed set and vegetative propagation methods, treatment and transport of the propagules
11. **Collection Sampling Strategy**: number of plants, population occurrences, and regions to collect
12. **Propagule Viability Maintenance**: optimal storage conditions, re-collection intervals and regeneration strategies
13. **Restoration**: reintroduction design, including the number of sites, number of plants, provenance of stock, number of founders, etc.
14. **Conservation Partners**: lead agency, collectors, land managers, landowners, *ex situ* facilities, etc.
15. **Logistical Considerations**: access to field sites, coordinating research, transporting propagules
16. **Estimated Time and Supplies**: staff, transportation, transferring propagules, data management, etc.
17. **Action Plan**: organizations involved, objectives, actions, timeline and measures of success

Species plans could be made accessible via the HPCN database with strictly controlled access to any sensitive information. As collections increase, more data will be available to develop protocols and species plans. While species plans and protocols will not initially include most *in situ* management actions (Phase 2), there are many *in situ* needs regarding the monitoring of wild populations, including the collection of data on the ecological, reproductive and population biology for SCI that will allow us to assess prioritization and execution of collections. Increasing the amount of *in situ* collecting will depend on the number of trained collectors, which will need to correspondingly increase in this effort. An investment in establishing collection protocols, organizing a core of expert collectors and training new collectors will be essential to maintain the desired quality of collections.

The primary intention of plant conservation projects in Hawai'i is to restore thriving populations *in situ*, within protected habitat to resume their roles in native ecosystems. Monitoring these populations is critical to prioritizing the actions needed to maintain them. Monitoring is also essential from the early stages to understand the taxonomy and basic biology of species, including surveys to determine species representation and the number of populations and population sizes, as well as phenology, breeding system and pollination biology of SCI. Over time, we can track population sizes to determine the urgency of collections, so that if populations are declining we can secure collections prior to large decreases in population size. Also, we can describe the phenology of a species, and potentially track changes in fruiting times along with climatic and environmental data. Comparing phenological data among populations of the same species could also help indicate genetic or phenotypic differences within a taxon. Monitoring data can be used to inform priorities for and measure progress on habitat protection. As new and changing threats are detected as populations are monitored, collection priorities can shift. Also, as more reintroductions are executed and monitored, and these populations recruit and grow, new generations of wild plants can be represented *ex situ*.

Information from *in situ* observations will be a key component of the collection strategy for each species. Initially, strategies will be broadly defined to species distribution, abundance and seed "bank-ability." As we gather more information on species we can better classify which SCI fall into what HPCN collection category (Table 3; Appendix F). Eventually, collection strategies will be species specific as part of each species plan. They can further include details such as *in situ* collecting partners, preferred *ex situ* locations, and transport protocols. Species biology will help determine which *ex situ* method (seed bank, micropropagation, nursery, garden), or combination of methods is most suitable for each species. Seed storage is more cost effective, less detrimental to the wild plants, and captures a higher level of genetic variation in a single collection than other *ex situ* methods (Havens et al. 2004). When viable, desiccation-tolerant, mature seeds cannot be obtained, clonal material, desiccation-sensitive seeds, or immature seeds can be harvested and preserved using micropropagation techniques or cryopreservation. If these methods fail, plants can be propagated and maintained as collections in nurseries and botanical gardens from seeds, clonal techniques such as cuttings, air layers, and grafts, or even whole plants. Each *ex situ* type presents advantages and challenges, which can help direct the optimal method for each taxon. Breeding system and reproductive biology may limit *ex situ* types (*i.e.* whether a plant can produce viable seed). Reduced or absent seed set due to lack of pollination or depredation of fruit may require increased field visits or a combination of *ex situ* methods to secure collections. On a broader level, habit (fern, herb, tree) and life span (*i.e.* annual, perennial, short-lived, long-lived) will also determine which *ex situ* types are suitable. Lastly, whether or not a seed-bearing species produces seeds that are desiccation-tolerant or whether further research and facilities are necessary to store desiccation-sensitive seeds (*i.e.* cryopreservation) may be considered. Desiccation-tolerant species can be dried and stored conventionally in freezers in seed banks. Desiccation-sensitive seeds cannot tolerate drying, and therefore cryopreservation and micropropagation protocols are necessary to utilize these methods of *ex* situ storage; and the development of these protocols and these storage methods can be much more costly. The procedures and protocols for determining the optimal *ex situ* method for each taxon should be standardized and cost-efficient. However, new methods should be evaluated as they become available and incorporated into *ex situ* strategies. Once the best handling and storage protocols are


26


27

determined for each species, they should be implemented across all agencies and facilities.

Species can also be identified as potential candidates for establishing reintroductions prior to the establishment of large germplasm collections. In certain instances, beginning an outplanting is the best first step to restore populations and preserve heterozygosity. Where protected habitat, resources and ample propagules are available, establishing an *in situ* or *inter-situ* outplanting using wild-collected stock is the ideal primary conservation action. Once established, these restoration outplantings can also be a source for securing propagules to maintain *ex situ* collections as insurance for outplanting failure. This may especially be appropriate for a species we know can produce viable seed on its own, or may actually benefit from outcrossing at an outplanting that could increase the number of plants and/or number of source populations. For species that do not produce seeds or seeds that can be stored conventionally, these outplanting sites, as long as they are well secured, could be essential in maintaining representation while efforts to utilize other *ex situ* methods are underway. While this situation may currently exist for some conservation programs and land managers, particularly on Hawai‘i Island, it is often not an option on other islands. The decision to establish outplantings prior to *ex situ* collections is the decision of the lead agency and partners working on that plant species or specific habitat, and should be written into the species plans.

Strategies for securing *ex situ* collections of SCI should be based on the factors discussed above. Some species may require more than one type of *ex situ* method until the final preferred storage strategy is either understood or achieved. In certain cases, determining optimal *ex situ* methods and maintaining viable collections will require the use of all the available *ex situ* methods. For example, micropropagation may initially be needed to secure collections, especially if fruits are immature, and nurseries and gardens may be used for keeping breeding collections that can ultimately be used to produce enough seeds to secure in seed banks. In turn, seed banks will require micropropagation and nursery facilities to grow out seedlings from ongoing viability tests and to regenerate plants for restoration projects. Taxa that require a combination of *ex situ* methods to reach the goal of securing collections with a high conservation value will also accrue the costs associated with each method.

<u>Collection Prioritization</u>

There are several factors that contribute to the prioritization of which species to collect first. Collections must first be made for the purposes of preventing the imminent extinction of imperiled taxa (those taxa on the Plant Extinction Prevention Program’s list (PEPP)). Collections of critically rare taxa (<100 individuals, HPCN Collection Group A-C, Table 3) need to be made immediately from every available individual to provide the best chance for recovery from the perspective of conservation genetics (Frankham et al. 2007). Next, collections should be made for safeguarding threatened taxa (100-250 individuals, HPCN Collection Group D-E), particularly from very small populations, those in high-threat areas, in rapid decline or not reproducing, and from populations in unique habitats or in margins of the known range of the taxon. Lastly, securing *ex situ* collections of more common taxa (HPCN Collection Groups F-G) is important for keeping propagules available when needed for restoration. Collections of more common SCI will require a strategy to sample from across their ranges, rather than obtaining collections from each individual. Taxa with a multi-island distribution will require a strong partnership and collaboration of multiple agencies to ensure standardized collection procedures, handling, data management, and *ex situ* protocols. Within these groups of SCI ranked by rarity and decline, additional factors, such as dioecy, soil seed bank potential, and population structure will help further prioritize collections as the data becomes available. The determination of these criteria can be further explored with the guidance of local collectors and other plant conservation experts. Prioritizing collections is important to secure the most urgent *ex situ* collections first. No prioritization strategy, however, takes the place of efficiency of *in situ* collecting, and opportunistic collecting on a location (*i.e.* gulch) level and making collections of more common taxa while targeting high-priority SCI will help reduce costs.

Table 3. Coding for collection strategies (see Appendix F for details).

COLLECTION STRATEGIES	Conventional Seed Banking	Not Suitable for conventional seed banking (exceptional Species)	Multi-Island Distribution
Critically Rare (<100 plants)	A	B	C
Imperiled (>100 plants, but not common)	D	E	D,E
Common (important for habitat, cultural use and watershed restoration)	F	G	F,G

While creating long-term *ex situ* storage collections is critical for preventing extinction, other needs influence prioritization of short-term *ex situ* storage collections. Prioritization of these types of collections will be more user-driven and constantly shifting.

- **Rare plant reintroductions to support recovery efforts:** Rare plant recovery efforts may proceed as mandates change, new habitat for restoration outplanting is secured, or sufficient propagules become available.

- **Watershed protection and habitat restoration planting:** Collections important for watershed protection will be increasingly in demand for restoration plantings as fences are constructed.

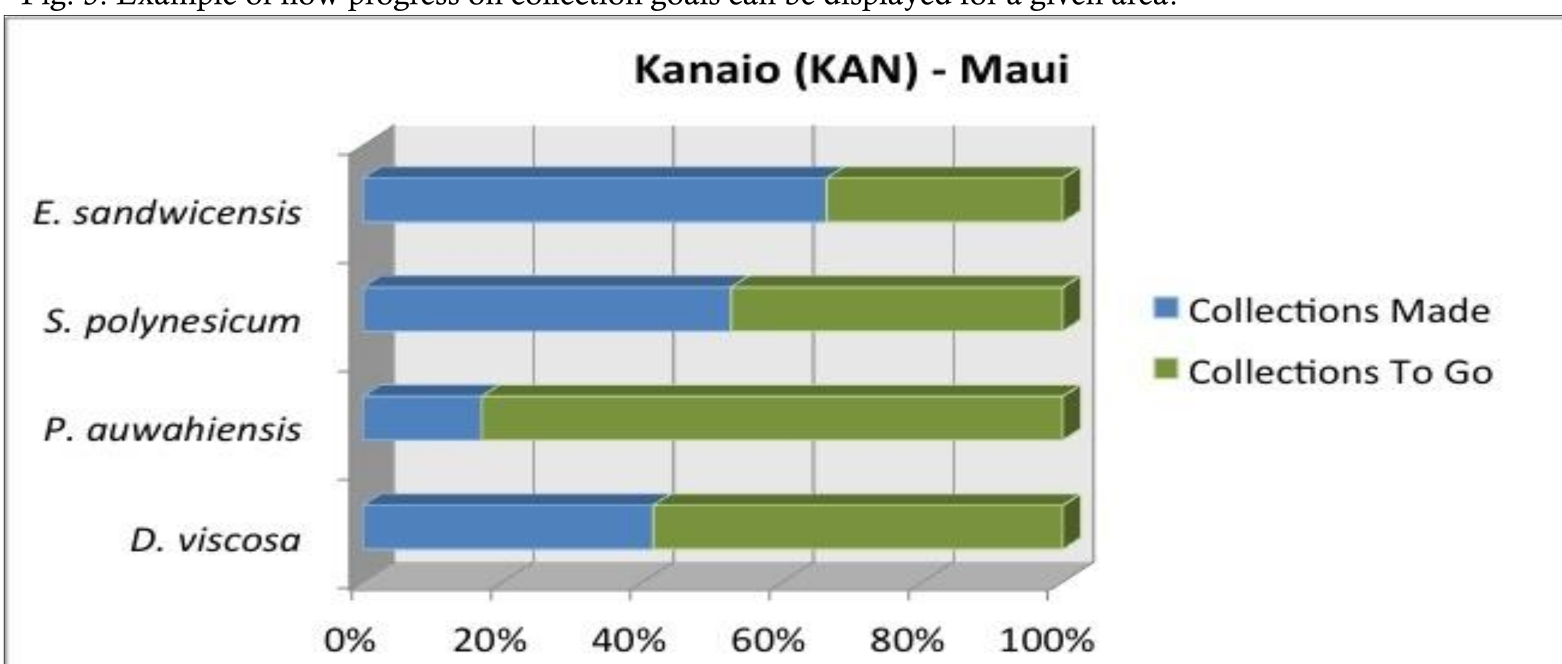
- **Post-fire soil conservation and restoration projects:** Priorities for collections needed to restore areas after wildfires will be adjusted as land managers develop plans for post-fire restoration statewide. The State of Hawai'i Department of Land and Natural Resources Division of Forestry and Wildlife (DOFAW), has identified the lack of banked seed collections of species that can be broadcasted or propagated in areas that have been impacted by fires as a problem. This can lead to further habitat damage post-fire, such as soil erosion or the use of non-native species or native species out of their historic ranges in the absence of an immediate source of seeds of appropriate native species (Sheri Mann, DOFAW; pers. comm.). The land management programs affected by fires can determine the species needed for broadcasting and propagation post-fire, and collectors can target these species, especially in areas that are fire-prone or have experienced fires in the past. Furthermore, restoration protocols should be developed to allow collectors and *ex situ* facilities to immediately respond to catastrophic natural or man-made disasters.

- **Species that are highly vulnerable to climate change:** Taxa predicted to be highly vulnerable to climate change should also become priority species to target for collection. Native plants are already being negatively impacted by climate change, particularly due to longer periods of warmer and drier conditions (Krushelnycky et al. 2013). Other studies have shown a gradual increase in minimum temperatures (Safeeq et al. 2013), which may consequently have an affect on plant phenology and seed dormancy-breaking conditions necessary for seed germination and soil moisture necessary for seedling recruitment (Cleland et al. 2007; Walck et al. 2011). Higher priority for development of conservation plans and securing collections should be assigned to species that are most susceptible to losing their ecosystems due to climate change or predicted natural disasters. Collections should be secured from species with seeds that require a period of cooler temperatures to overcome dormancy. Work with groups such as the Hawai‘i Conservation Alliance's Pacific Islands Climate Change Cooperative (PICCC) will be essential to assessing the vulnerability of the Hawaiian flora to climate change (See Fortini et al. 2013). Each SCI will be ranked, along with its collection strategy, and lists will be maintained by HPCN.

- **Species highly susceptible to introduced pests:** As new biological invasions are detected, species that may be particularly susceptible should be surveyed for impacts and collections quickly secured as insurance against population collapse and extinction. Recent examples of invasions that highlight the importance of this factor include: Naio Thrips (*Klambothrips myopori*), Erythrina Gall Wasp (*Quadrastichus erythrinae*), and 'ōhi'a Rust (*Puccinia psidii*).

Determining priorities for collections of SCI requires balancing the need to preserve biodiversity in the face of imminent extinction by securing propagules in long-term *ex situ* storage with the additional need to obtain collections for short-term storage that are available for recovery and restoration efforts. If collections of rare plants can be secured in *ex situ* storage, their extinction in the wild can be reversed via reintroduction. Therefore, the primary collection objective is to secure the species most threatened with extinction by representing all remaining populations *ex situ*. However, meeting full representation requirements for rare plants should not necessarily come before initiating collections for more common species. Collections to serve immediate restoration and/or research purposes may also take priority over completing collections from rare SCI as their need dictates. In these cases, an awareness of which collections are still needed is imperative. The easiest way to facilitate this is by supporting the opportunistic nature of collections, especially for remote locations. Ultimately,

Fig. 3. Example of how progress on collection goals can be displayed for a given area.



to execute efficient field outings to remote areas, it will be prudent to maximize collection efforts for a particular field day to limit the amount of trips to a particular region or population and to collect from all SCI within a particular area. Since many private, state and federal programs are dedicated to preventing the further extinction of plant species, this will require compiling distribution, phenology, and *in situ* monitoring data with current *ex situ* inventories to understand in which areas the most valuable collections can be made on each day. This emphasizes the need for a centrally administered statewide database to task local collectors with efficient collection plans that compile lists of target taxa for each area every week. Once collection goals are determined for each location, progress and targets can be displayed to help task collection teams (Fig. 3).

29

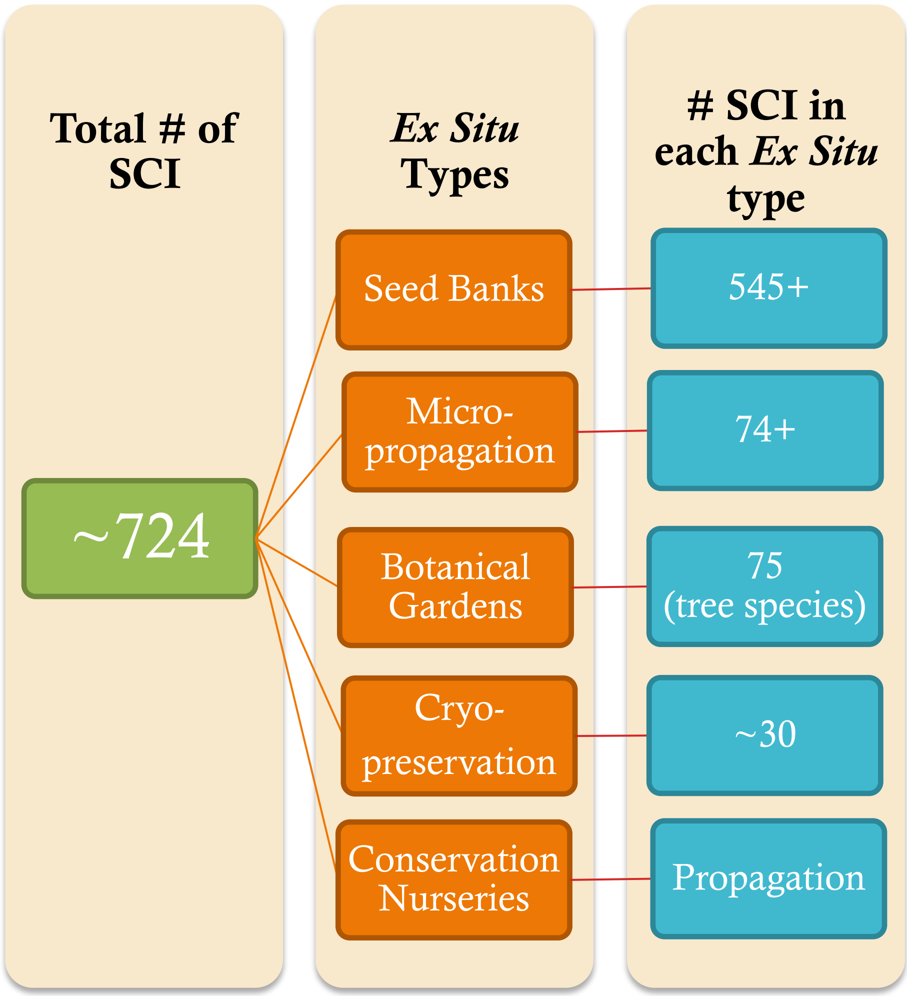
<u>*Ex situ* Facilities</u>

Conservation programs across Hawai‘i utilize most methods of *ex situ* plant conservation (*i.e.* seed banking, micropropagation, conservation nurseries and botanical garden collections), and building upon and improving the existing facilities is essential to storing *ex situ* collections of SCI. Conserving rare species requires utilizing all appropriate horticultural techniques to secure adequate plant material *ex situ*, replicate propagules for restoration, represent and retain sufficient genetic diversity for each taxon, and store replicates to be available as a backup in perpetuity. Research leads should be identified for each of these *ex situ* methods and supported to develop protocols for propagation and storage of SCI. Institutions and facilities identified as research leads on protocol development and/or securing and storing germplasm will need to be properly equipped and adequately staffed. In order to meet the need for seed banking and micropropagation services on each island without needlessly duplicating facilities or staffing redundant positions, we recommend a structure of smaller partner institutions built around a central research lead. For conservation nurseries and botanical gardens, there is a need for at least one of each on every island and this is nearly met. Improvements and expansions, however, are needed for existing facilities, and new nurseries and habitats for botanical gardens are necessary for underrepresented islands and habitats, such as on Moloka‘i and dry lowland habitat on Hawai‘i Island. There is also a need for increased collaboration on curating collections, knowledge transfer and standardizing protocols (Weisenberger & Keir *in press*).

Seed storage is the optimal *ex situ* method for conserving flowering plants (Havens et al. 2004; Li & Pritchard 2009); this is also true for most SCI in Hawai‘i (Weisenberger & Keir *in press*). More information about the benefits and protocols of seed banking should be promoted. Access to seed storage on each island should be improved. To be able to meet the needs for this service, more investment is needed to build the capacity of the existing facilities on Kaua‘i, O‘ahu and Hawai‘i. This must include obtaining equipment for conducting adequate research and adoption of best storage practices. Cost estimates for expanding seed bank services are available (Appendix C). The newly formed Hawai‘i Seed Bank Partnership (HSBP; Appendix E) is a substantial step forward in increasing capacity. This partnership currently includes four seed banks plus a potential group of State of Hawai‘i DOFAW short-term common natives seed banks for habitat restoration. Two meetings have been held to develop a) standardized operational protocols, b) priority research objectives, c) data recording practices (database), and d) a newsletter to spread the word on the value of seed banking. Lyon Arboretum Seed Conservation Laboratory (LASCL) continues to serve as the main repository for O‘ahu and Maui Nui collections as well as most PEPP collections, while the National Tropical Botanical Garden and DOFAW could serve as the main repository for Kaua‘i, and the Hawai‘i Island Native Seed Bank can serve as the main repository for Hawai‘i Island. The fifth member agency, O‘ahu Army Natural Resources Program (OANRP) will continue to store the species it is contracted to stabilize. Once protocols and data management are standardized, they can be adopted at all of the facilities, and collections can be distributed to and replicated at multiple facilities to reduce the risk of a single catastrophe eliminating entire collections of certain taxa or regions. The LASCL and OANRP should continue to serve as the research facilities and leads on protocol development, especially for SCI with unknown viability or germination, preferred storage conditions for seeds, spores, and pollen and re-collection intervals. Their research will be coordinated with National Center for Genetic Resources Preservation (USDA-NCGRP), the leading research and seed/germplasm storage facility in the country. Seed banks in Hawai‘i have had a professional relationship with NCGRP, which is interested in developing storage protocols for species that cannot be conventionally banked including fern and lycophyte spores, as they are responsible for storing all agricultural species. NCGRP will serve as a mentor for research methods, especially related to cryopreservation. Ultra-low temperature storage and cryopreservation practices are currently being researched and facilities and protocols have yet to be established for Hawaiian taxa. Research is being conducted at OANRP and NCGRP. The laboratory facilities and expertise to research cryopreservation should be available in at least one seed bank in Hawai‘i (Christina Walters, pers. comm. 2012).

Micropropagation services are critical for germinating seeds from immature fruit (Sugii 2011) and researching methods for propagating plants from non-reproductive tissue. It is undetermined which Hawaiian species can and cannot be maintained *in vitro*. Species in the Campanulaceae, Lamiaceae and Gesneriaceae families (Sugii 2011), ferns, lycophytes, and bryophytes (Ballesteros et al. 2012; Pence 2004), and Orchidaceae (Long et al. 2010; Sarasan et al. 2006) may be best suited to this method for long-term storage. Current research at the Lyon Arboretum Micropropagation Laboratory (LAML) has recommended protocols for 41% (299:724 taxa) of SCI already developed. Micropropagation techniques require expensive facilities and highly trained staff, and should only be prioritized for taxa that cannot be stored in seed banks. The second location that serves as a backup facility to Lyon Arboretum is currently located within the same valley and a facility at another location may serve as better protection from the threat of natural or otherwise catastrophic disaster that could jeopardize both facilities. Additional facilities, if established, should be overseen by existing staff at LAML, especially with regard to protocol development, and should serve as satellite storage facilities while LAML staff conducts the research. Further recommendations have been made in the 2012 Assessment (Weisenberger & Keir *in press*). If cryopreservation methods become available and worthwhile for SCI, micropropagation services will be needed to propagate these collections. Furthermore, cryopreservation of *in vitro* material could serve as a cost-efficient backup if services become available.

Conservation nurseries play a crucial role in producing plants for restoration projects and holding living collections of rare taxa as part of breeding collections. The system of mid-elevation nurseries (KRPF, PRPF, ORPF, VRPF) potentially serves many plant conservation programs in Hawai‘i and could be expanded. For SCI that cannot be stored in seed banks or tissue culture, nurseries can maintain living collections, particularly for non-tree species and for short-term while research is ongoing for alternative storage techniques. Nurseries also play a large role in the regeneration of stored seed collections that are aging, as well as maintaining collections of plants for controlled breeding projects. The lack of a facility to propagate collections on Moloka‘i provides the greatest opportunity to expand these services. Another opportunity to expand *ex situ* nursery services would be to establish a nursery on Hawai‘i Island at a lower elevation that could be used to grow plants for dry-forest restoration. As nurseries play these additional substantial roles, and the price for maintaining plants can be much higher than their propagules in seed banks and tissue culture, SCI should be stored by other *ex situ* methods if that is possible.



75% of SCI can be stored in Seed Banks

An additional 10% of SCI can be kept in Tissue Culture (currently)

An additional 10% are tree species that may be maintained in botanical gardens

The remaining 5% will require protocol development

Fig. 4. Estimates of division of the 724 SCI by *ex situ* storage type. At least 545 SCI can be stored in conventional seed banks. An additional 74 species already have micropropagation protocols established. An additional 75 SCI are tree species that likely cannot be stored in seed banks or tissue culture and hence, could require botanical gardens to maintain adequate representation, or until cryopreservation or other protocols could be established. The remaining ~30 (5%) SCI also require research to determine the most cost-efficient *ex situ* storage type. While any SCI could be maintained in nurseries, these resources are best served for propagation for outplantings and living collection of non-tree species, especially for controlled breeding studies and regeneration of aging seed bank collections.

Botanical Gardens throughout Hawai‘i are used for plant conservation and are found on Kauai, O‘ahu, Maui, and Hawai‘i Island. Species that may not be suitable for seed banking, tissue culture, or a nursery living collection can be maintained at botanical gardens located in areas with compatible environmental conditions. Several taxa are good candidates for establishing living collections at botanical gardens, particularly those that are trees and/or long-lived, in need of controlled breeding or exposure to ambient pollination, have research needs that would benefit from a living collection, will not interbreed with related species, have high ornamental value and/or are culturally significant. For taxa such as trees, this may be an important intermediate step to establish clones that can be used for breeding viable seeds, which ultimately can be used for storage and restoration projects. Taxa that require regular applications of registered pesticides that cannot be legally applied in a forest setting can be maintained in a garden where treatments are legal. Techniques used to establish living collections in botanical gardens can also be used to guide more successful outplantings, for example, by identifying environmental conditions that promote plant vigor. There are few collections of native plants at botanical gardens that are of high conservation value due to unknown provenance or having been cultivated from only a single wild source plant. Stronger partnerships between conservation programs and botanical gardens are needed to enhance the conservation value of their collections, build wild-provenance collections that can be used for restoration projects and develop display gardens that educate about Hawaiian plant conservation.

The capacity of *ex situ* facilities across the state must be increased to ensure that services are available to meet the needs of conservation programs. An increase in funding is needed to expand staff and improve infrastructure at all *ex situ* facilities. The different *ex situ* types and facilities will grow together, as all heavily rely on each other's services for research objectives, propagation, and propagule viability maintenance (see below). Current and new *ex situ* facilities will be increasingly interdependent and unified, as improvements in coordinating the statewide collection increases via a universal data management system. A partnership of these institutions will facilitate collaboration, curate a statewide collection by linking the inventories of each facility, exchange expertise through training and workshops and can seek financial support for the *ex situ* system in Hawai'i (Appendix C).

<u>*Ex situ* Goals</u>

The full ex situ needs for each taxon are to: 1) secure a genetically representative germplasm collection that will safeguard against the loss of variation if populations decline; 2) be large enough to allow for monitoring viability by germinating/propagating germplasm at regular intervals for the expected life of the collection; 3) be duplicated in at least one other facility on another island, state or country; and 4) include a sufficient quantity of propagules to produce plants for restoration, research and other related needs.

The purpose of adequate *ex situ* representation is to provide the best material for future outplantings. Defining adequate *ex situ* representation of a species is complex. Factors to be considered include number of populations, plants, and propagules to sample, as these factors guide wild plant representation for outplanting efforts. Consideration must be given to field logistics, species priority, collection protocols, the type of propagules collected and a suite of biological and ecological factors. Goals for the number of plants to secure should be based on capturing the morphological and genetic variation across the geographic range of the remaining plants. Prioritization is driven largely by species rarity, habitat stability and vulnerability, and the demand for propagules for restoration and recovery efforts. Additional information from molecular research could be incorporated to increase our understanding of a species' biology to help define biological populations and ecologically significant units, guide reintroduction strategies, prioritize which individuals to preserve *ex situ* and determine which to use in each restoration site.

Sampling strategies have been modeled and developed over the last several decades in an attempt to quantify collection protocols for representing species *ex situ* (Brown & Marshall 1995; Crossa & Vencovsky 2011;

Lawrence 2002). Rough estimates have been described, stressing the uncertainty in establishing a minimum number of plants to represent a species or population in *ex situ* collections, and how changes in outcrossing rates, breeding systems, and the actual amount of genetic diversity within populations and species will greatly affect proposed minimums. Recommendations are designed to maintain allelic diversity of the wild populations in the *ex situ* collections. "Sufficient" genetic diversity to adequately represent a taxon has been defined and adopted by plant conservation programs (including the Center for Plant Conservation (CPC)) as capturing at least one copy of all of the alleles that occur in at least one population of a species and at a frequency greater than 0.05 with 90-95% confidence for an *ex situ* collection (CPC 1991; Marshall & Brown 1975). Initial sampling recommendations to meet these goals presented minimums, and coupled with concerns of over-collecting from rare plants, may have inadvertently led to underrepresentation of wild populations in *ex situ* collections. These minimums ranged from collecting from 5-50 populations and 10-50 randomly selected plants per population (Brown & Briggs 1991; Brown & Marshall 1995; CPC 1991).

More recently, revisions have had conflicting opinions on whether these initial estimates were likely to adequately capture allelic diversity. Neel and Cummings (2003) determined that 53-100% of known populations should be represented to capture at least one copy of all common alleles, which is much larger than previous recommended minimums. In 2004, the CPC revised its collection guidelines to include collecting from all known populations if there are fewer than 50 known populations, and collecting up to 50 if there are more than 50 known populations, a substantial increase from a minimum of 5 populations. Furthermore, this revised strategy was also applied to the number of individuals sampled, as 50 individuals became the minimum (Guerrant Jr. et al. 2004). A revision of the Brown and Marshall (1995) sampling strategy in 2011 (Crossa & Vencovsky) recommends collection minimums of 25 plants per population for outcrossing species and 50 plants per population for selfing species. They continue to recommend collecting fewer seeds from many plants versus many seeds from fewer plants. Lastly, they recommend representing as many sites as possible and all biogeographical regions.

Brown and Marshall (1995) suggested general collection minimums and recommendations. Minimums are just that: the first step in establishing adequate genetic storage of SCI. Minimums are based on "adequate" representation as a likely (90-95%) chance that at least one copy of each common (>5% occurrence) allele is captured in an *ex situ* collection. This takes into account allelic richness. To capture allelic diversity, collections should reflect the frequencies at which alleles occur within each population. To capture this frequency, Brown and Marshall (1995) recommend collections from about 200 plants per population. Considering the high number of threatened SCI in Hawai‘i, (525 species) and that nearly half of those are exceedingly rare with fewer than 200 plants, HSPC collection goals are a compromise within the range of recommendations listed above. The Minimum Safeguarding Goal for each SCI is to secure collections from 50-200 plants per population, and to collect from 3-50 populations (Table 4). All islands and biogeographical regions should be represented as defined by Price et al. (2012). Collections of more common SCI will require a strategy to sample from across their ranges, rather than obtaining collections from each individual. Generally, we recommend collecting from all plants for SCI with 150 plants or less. For SCI with 151-999 we recommend collecting from 150 plants. For SCI with 1000 plants or more, but not a widespread common species found on most islands, we recommend a collection goal of 250 plants. Lastly, for common SCI, with recommend SOS protocols and collections from 1000 plants.

Table 4. Hawai‘i *Ex situ* Goals for Safeguarding Collections of SCI. Recommendations for number of propagules to collect for both a Minimum and Complete Safeguarding Collection are based on the rarity of the species (threatened or common SCI) and the type of propagule. Propagule types include viable seeds in seed banks, explants in micropropagation facilities and living collections in nurseries and botanical gardens. *Indicates complete representation if there are less than 50 plants or 3 populations. These propagule numbers are in addition to propagules needed for *ex situ* protocol development and outplantings.

Type of SGP	Minimum Safeguarding Goal			Complete Safeguarding Goal		
	# Propagules	# Plants	# Populations	# Propagules	# Plants	# Populations
Threatened SGP	50 viable seeds 4 explants 3 plants	50*	3*	100 viable seeds 8 explants 6 plants	200	50
Common SGP	50 viable seeds 4 explants 3 plants	50	20	100 viable seeds 8 explants 6 plants	200	50

Initially, collections/propagules are necessary for conducting research to determine the best propagules and storage conditions to represent and propagate plants. These research collections are important for understanding which collections will store in seed banks, how best to maintain collections in tissue culture, and the number of propagules needed to accomplish this research is separate from the totals given in Table 4 for genetic storage representation. *Ex situ* goals for restoration efforts should also be in addition to the propagule needs to establish a genetic safety net to safeguard a taxon. Seed collections from wild populations are the optimal propagules for both *ex situ* storage and starting *in situ* restoration outplantings. When viable, mature seeds cannot be obtained, clonal material can be harvested and secured using micropropagation techniques, cryopreservation, or propagation in nurseries and gardens.

Once the optimal type of propagule for each taxon is determined, the number of propagules collected should be sufficiently large to maintain its representation of each individual until re-collection is needed. The propagules retrieved from stored collections should be able to be grown into a reproductive plant that will produce propagules itself. Furthermore, seed collections will gradually age in storage, and as selection should be minimized as much as possible, reductions in viability as collections age should be managed (Guerrant Jr. et al. 2004). Crossa and Vencovsky (2011) recommend maintaining viability above 60-70%, but this may not be practical for all taxa, as some wild collections may not have an initial viability above these thresholds. While a safe minimum number of propagules needed to preserve each individual is difficult to assess for all species, guidelines currently followed in Hawai‘i by the Hawai‘i Plant Extinction Prevention Program (PEPP) and OANRP for seed banking are to secure 50 seeds of each plant (MIT 2003). In an effort to ensure that a sufficient number of mature viable plants could be produced from stored propagules, the OANRP recently revised its annual reporting of *ex situ* storage status to document an estimate of how many plants have at least 50 *viable* seeds banked. This is calculated using an average initial viability for a species or population or wild individual (depending on the best data available). Viability is periodically monitored and re-collection is scheduled when the viability of the stored collection declines (OANRP 2011).

The Minimum Safeguarding Goal for seed banking is to represent each individual of all SCI with 50 viable seeds. However, understanding that seed production is unique per plant and species, modifications will be necessary. In order to meet the Complete Safeguarding Goal, seed collections should be duplicated at a second facility on another island, state, or country, doubling the minimum goal to 100 seeds. For common SCI, the goal is to maintain a minimum of 50 plants collected per population, but to strive for a minimum total number per seeds at a population level. Fifty seeds from 50 plants would yield 2500 seeds per population (plus duplication; 5000 seeds). For populations with hundreds of plants, it may be practical to collect fewer than 50 seeds per plant, but collect from more than 50 plants, as long as the total number of seeds for a population is above 5000. Sampling protocols for these large populations will be developed and implemented to help standardize collection efforts for common SCI.

Replication for maintaining lines in tissue culture and living collections is currently based on a general number of replicates needed for preventing the loss of any particular maternal line. Recommendations for micropropagation collections are to maintain four explants of each wild plant (Nellie Sugii pers. comm. 2013). Living collections of three to four replicates per wild plant should also suffice in maintaining representation of most SCI in nursery or garden conditions. Collections from each wild individual should be kept separate for every SCI, including common taxa, to maintain the ability to maximize the amount of genetic diversity from the stored collections (Crossa & Vencovsky 2011). Lastly, collections should be replicated at a second facility that is not located on the same island and preferably located out of the state. This replication, while essential to reduce the risk of *ex situ* storage failure, would effectively double the goals described here.

Suggestions for how many propagules to remove from a population of a rare species have also changed over the last several decades. Past CPC guidelines recommend not collecting more than 20% of the propagules from a plant or population during a given season (CPC 1991). Revised guidelines (Guerrant Jr. et al.) acknowledge the urgency behind securing collections prior to the extirpation of populations. For populations with 10 or fewer plants, the CPC recommends that collections can include 100% of the seed available. Additionally, they advise spreading collections out over a two-year interval or more to minimize the impact on the population during the time of collection. In circumstances where none of the propagules produced are expected to survive due to severe threats, more may be taken. In reality, it will likely take many years to obtain these collections. Following the establishment of these collections, their viability should be monitored to limit the amount of loss of representation and artificial selection.

With a minimum goal of 50 plants per population and representation from at least three of the known populations (or 150 plants total if fewer than three populations), a substantial number of collections need to be made by 2020 to reach the GSPC goal that 75% of threatened species are conserved in *ex situ* storage. Not all SCI are considered “threatened” for the purposes of this strategy. Threatened species are defined as those that are federally listed, on the PEPP lists of species with fewer than 100 known individuals and rare on specific islands, and any other species with 150 individuals or fewer remaining. To secure 75% of “threatened” Hawaiian SCI by 2020, collection from approximately 30,000 currently unrepresented plants, or roughly 4,000 a year (or a 5% increase in species representation) for the next seven years, will be required. While this seems daunting, it is necessary and possible. First, proper curation and identification of collections already secured, using unique codes for all threatened individuals, will clarify the baseline and vastly improve our ability to recognize how many plants have been collected and will reduce the number needed to reach goals. Second, awareness of statewide goals will promote *ex situ* services among conservation groups and increase capacity for making collections. With proper curation of the existing collections and an increase in the annual collection rate, these goals can be met by 2020.

Propagule Viability Maintenance

Once adequate collections are secured for each SCI, their viability will need to be monitored and maintained. Assessing viability of collections requires research to determine optimal storage conditions, data management to ensure adequate documentation and communication between land managers and *ex situ* facilities about the status of the wild populations and stored collections. Once their viability declines, collections will need to be refreshed or regenerated to minimize artificial selection in *ex situ* conditions (Lawrence 2002). Re-collecting from wild plants or from reintroduced plants that represent wild maternal lines is the optimal way to refresh collections. If these sources are not available, *ex situ* collections will need to be regenerated. Collections in micropropagation, nurseries and gardens can be cloned. Collections in micropropagation should be regularly regenerated in a nursery or garden living collection to ensure the ability to produce mature, morphologically representative plants from the explants and identify possible mutations. This should be repeated every 3-5 years, assuming a six-month cycle for subculturing (Nellie Sugii, pers. comm. 2013). Partners should discuss the benefit of all propagule sources and make a decision on where and how re-collection should happen on a species and population basis.

Seed bank collections will need to be removed from storage, germinated, and plants grown to maturity, from which another generation can then be produced, collected and banked. Care must be practiced in this process to minimize artificial selection and maintain representativeness of wild populations. Recommendations of the CPC are to determine the best storage protocols to maximize longevity and limit artificial selection (Guerrant Jr. et al. 2004). This can be accomplished by using research collections to determine the storage conditions that maintain viability for the longest period of time, and the rate in which seeds age in storage at these preferred conditions. Once seeds are removed from storage and propagated to maturity, they can be outplanted into a site where natural or controlled cross-pollination can be used to produce viable germplasm. This process should be managed as a controlled breeding program ensuring that the original founder lines are maintained. Such strategies are described in Lawrence (2002) and can be applied to Hawaiian plants.

Because many SCI in Hawai‘i do not have appropriate habitat where threats have been controlled (fenced units, weed control, etc.), establishing *inter situ* sites for maintaining plantings is a necessary strategy. While this can often be conducted in botanical gardens, mid to high elevation species without secured habitats could be represented in plantings that are in or close to appropriate habitat and are accessible for threat management (Volis & Blecher 2010). Such areas should be identified and developed throughout the state for species that may benefit from *inter situ* sites. These species may include large trees that cannot be stored or are cumbersome to store in seed banks, micropropagation facilities, and conservation nurseries, and for which there are no botanical gardens in locations that have conditions allowing trees to produce viable seeds. These sites could also be used for research and controlled breeding. Depending on the circumstances, they could also serve as sites for conducting research on threat management and the development of pest control protocols.

Propagation of *Ex situ* Collections

Collections stored *ex situ* for the short-term (<10 years), long-term (>10 years), or indefinitely, will all eventually need to be propagated for restoration or regeneration. The process of retrieving collections from storage and producing plants that can be transferred to nurseries or outplantings can be costly, complex and unpredictable. The purpose and propagation needs of some collections may be known and can be anticipated. Some collections may be for immediate propagation, such as those for ongoing reintroductions that already have suitable habitat secured. Many collections, however, may be intended for eventual restoration efforts, but the length of time until they are needed may be unclear. Other collections are made for the purpose of having them available at any time for emergency purposes, such as post-fire restoration efforts. When collections are retrieved from storage, care must be taken to provide propagules that are appropriately sourced for each use and do not deplete the safeguarding collections. *Ex situ* facilities must keep track of the propagules from each individual or population in order to make sure the plants or seeds provided for restoration are sufficiently representative. Combining *in situ* monitoring data of individual plants (alive/dead), their collection history, *ex situ* inventories, restoration needs and tracking their progeny will give conservation planners the tools to efficiently direct collection propagation efforts. An example of this type of report is displayed in Figure 5 below. Retrieving collections from storage, producing plants appropriate for restoration and preventing extinction requires a concerted effort to track provenance, horticultural staff dedicated to preserving individual plant stocks and a robust data tracking system to document the process. This will require an investment in training and information management systems.

In addition to maintaining provenance data, *ex situ* facilities also need to track ownership of the propagules they store and propagate. Some potential apprehensions may exist about the loss of ownership and fate of germplasm deposited into seed banks or other *ex situ* facilities. Concerns about losing control over intellectual property and propagules may dissuade partners from collaborating with these facilities. These concerns can be quelled by adopting strict policies on the ownership of propagules and agreements between landowners, collecting and plant recovery programs and *ex situ* facilities. In addition to existing state and federal policies, agreements and policies used by other plant conservation networks and seed bank partnerships are available to guide Hawai'i's efforts. These can help create propagule ownership policies specific to Hawai'i that can be adopted across all *ex situ* facilities and reassure collectors and landowners that ownership is maintained. Abiding by and enforcing these policies is as important as maintaining germplasm viability and provenance data. All germplasm collected from wild plants belongs to the owner of the land parcel it was collected from. In most cases, the individual or agency that made the germplasm collection is the landowner. If the collector is not an agent of the landowner, they are responsible for securing state and federal permits and landowner permission for collecting any propagules. Restrictions on access to each accession can be specified by the germplasm owner based on propagule use (research, restoration, commercial), or requestor (watershed partner, cooperating agency, institution, public), and can be altered as collections age. User agreements must be established, followed and enforced in order to maintain the trust among conservation partners. There is a concern that organizations other than the landowner, and particularly from outside Hawai'i, will make requests for germplasm directly to the *ex situ* facility. It is the responsibility of the *ex situ* facilities to direct these requests to the germplasm owner. A coordinated network can facilitate these agreements across conservation programs and *ex situ* facilities to help secure more collections and maintain germplasm viability and data to ensure proper use of each accession.

Figure 5. Example Report showing *in situ* data, outplanting needs and *ex situ* inventories

Species: Cyanea st.-johnii Plant: AWA-A-1						
SOURCE	WILD			OUTPLANTINGS		
Ex Situ Type	Seed Bank	Tissue Culture	Nursery – Garden	Seed Bank	Tissue Culture	Nursery - Garden
Ex Situ Unit	(seeds)	(explants)	(plants)	(seeds)	(explants)	(plants)
	56	5	15	267	0	0

OUTPLANTING NEEDS	**TARGET**	**# PLANTED**	**# DIED**	**NEED**
Outplanting 1	10	0		10
Outplanting 2	20	25	8	3
TOTAL				13

Funding Needs


31

Funding opportunities have been identified for Phase 1, 2, and 3 actions, as well as for operations of the HPCN. Raising support for Phase 1 actions is the first priority, including the hiring of HPCN staff, initiating steps to unify and standardize current data management systems, building *ex situ* facility capacity, and supporting *in situ* collecting through increased staff, helicopter time and other field assistance. These actions and funding needs are developed for HPCN and all existing conservation programs and potential partners. The actions needed are not only for the HPCN staff to execute, but rather the funding needs for conservation programs statewide at this current time.

Funding Needs for HPCN

In order to help implement the HSPC, the HPCN would benefit from formalization, staff, and fund-raising capabilities to provide services to the partnership. To begin collaborations and partnerships, financial support is needed to **formalize and administer the Hawai‘i Plant Conservation Network**. Initial funding should be pursued to host (office space, utilities, transportation) and secure staff to coordinate the creation of the network. This would enable the HPCN to: a) formalize the partnership of conservation managers, gardens and *ex situ* facilities; b) begin to implement network services, such as facilitating the Hawai‘i Seed Bank Partnership; c) manage a contract to build the statewide database; and d) collaborate on applications for funding to upgrade equipment and enhance research capacity. Network partners will determine details on the governance, scope and decision-making processes to prioritize network services. Initially, network partners could provide the support needed to host HPCN staff, hold a server for the database and provide a venue for holding meetings of network partners. Some proposed HPCN actions should continue through later phases.

Support for business and financial planning will help identify revenue strategies and funding opportunities that will allow the network to remain relevant, viable and perpetuate conservation efforts. Planning should also explore options for sustaining the HPCN through avenues such as fees for services (training, *ex situ* work, data management), endowments to sponsor certain collections, species or research and creating a system to receive revenue from commercial use of certified "responsibly-sourced" native plants that will be used to support conservation projects.


32

Lastly, administrative and financial support is needed to **formalize operating agreements** between the HPCN and institutions that can assist in advising, business planning and fundraising. Examples of these institutions include: Hawai‘i Conservation Alliance, Kew MSB Partnership, NCGRP, BLM-Seeds of Success, CPC, and Cincinnati Zoo & Botanical Garden Center for Conservation & Research of Endangered Wildlife (CREW). Memoranda to describe agreements and relationships between partners should be finalized. A mechanism is needed to receive funding from grants, donations, contracts, endowments, subscription fees, service fees, and corporate sponsorships for conservation activities. This can be done using existing network partners or by creating a new entity to receive and disseminate funds.

<u>Funding Needs for Phase 1</u>

- Once established, the HPCN should manage the **development and maintenance of a statewide database system**. A contract will be needed to hire expertise for database design, integration of existing systems and continued support for continuing updates on data management, report design, system networking, data security and software upgrades. Once compiled, biological data on Hawaiian plants should be made <u>accessible</u> by funding the **creation of a web-based bio-information hub** to analyze data to improve and track our conservation efforts.

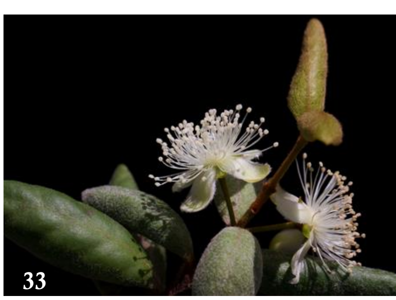
- Monitor collection progress by **curating the statewide native plant germplasm collection** at all *ex situ* facilities. This will require identifying provenance for existing collections and linking them to the wild source plant or location. Reconciling collections statewide will create a shared inventory tracking the comprehensive *ex situ* status of Hawaiian plants. The **maintenance of the SCI lis**t is also needed, including the determination of species in need of restoration and *ex situ* collections.

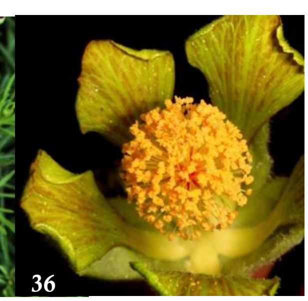
- Seed banking is currently the most efficient method for securing *ex situ* collections. Funding is first needed to **improve and expand seed banking capacity**. The priority should be to upgrade the infrastructure and equipment at existing facilities on Kauai, O‘ahu, and Hawai‘i (Appendix C). The Hawai‘i Seed Bank Partnership should be formalized and used as a mechanism to expand the network of seed banks to Maui. Adequate staffing is also needed at each seed bank (2 FTE).

- Financing and infrastructure support are needed to **increase the number of trained, full-time plant conservation workers**. The workforce on each island should be expanded to secure *ex situ* collections from all SCI and manage threats to native habitats. Increasing the capacity of existing organizations engaged in making collections, such as PEPP, NTBG and NEPM, is the highest priority. Formalizing existing partnerships and providing increased financial support for more staff and field expenditures, such as helicopter time are critical. Additional support is needed to expand the number of positions at *ex situ* facilities on each island. Lyon Arboretum micropropagation requires at least (5 FTE), conservation nurseries (1-3 FTE), and gardens (varies) commensurate with regional needs and restoration plans.

- Increased **support is needed for nurseries and gardens** to upgrade equipment to be more efficient and sustainable (*i.e.* watering, nutrition, pest control), expand the Mid-elevation Rare Plant Nursery system to Moloka‘i, develop and maintain collections that can be used as propagule sources for restoration, and propagate for projects such as controlled breeding and restoration research.

- **Provide support for local taxonomic and biological research** by providing a list of topics prioritized by local experts that will assist conservation efforts by bringing conservation hurdles to the attention of local and international researchers. Priority research areas include basic plant biology, cryopreservation, taxonomy/phylogeny (including molecular techniques), plant-animal interactions, climate change and threat control. This also includes **protocol development for *ex situ* services** such as propagule transport, seed storage, propagation, and phytosanitation protocols.





- To increase collaboration, funding is needed to cover **travel expenses for work exchange and meetings** among HPCN partners on each island to plan collections, update population data and *ex situ* inventories, review reports, identify gaps, develop protocols, define key biological definitions such as "adequate *ex situ* representation" and discuss conservation priorities.

- The **Flora of the Hawaiian Islands website must be maintained** as an important online resource for presenting current native plant taxonomy, biology and distribution. It is currently supported through a cooperative arrangement between the NTBG and SMI. This is currently not a funding need but could be if the online flora becomes unsupported by current hosts or is expanded to include taxonomic keys, links to pictures, herbarium specimens and line drawings.

Funding Needs for Phase 2

- Collections from species needed for large-scale habitat restoration should be secured in the case they are needed. Funding for specific projects such as **post-fire restoration and wildlife habitat enhancement** should be sought. Ongoing efforts to predict where fires may occur and develop cost-effective fuel breaks and other control measures should be supported.

- A Species Conservation Plan, coordinated by the "lead agency" for each SCI, would help to identify partners, priority actions, funding needs and describe restoration goals. Support to **host meetings, fund travel expenses and develop materials** is needed to ensure that the plans include all partners and are updated as needed.

- Ongoing efforts by the HCA to **document the *in situ* habitat management** and threat around populations of SCI should be expanded to include all network partners. This will provide a tool for identifying gaps, prioritizing landscape-scale projects and facilitate cooperation amongst network partners.

- **Investments in expanding habitat protection**, refining threat control techniques, and restoring native ecosystems will be required. Also, ongoing efforts would benefit by having **a geospatial database system** to track progress in installing habitat protection measures and threat control efforts to assist in identifying gaps and prioritizing solutions.

- Once appropriate habitat is secured, funding is needed for supporting the expenses associated with **conducting restoration outplantings of SCI**, including propagating, transporting (helicopter time) and planting into remote field sites. In addition, the HPCN database should be expanded to include information on outplanting methods, survivorship and population stability.

- In addition to increasing the capacity and staff of *ex situ* facilities, support is needed to **sponsor workshops** to train and facilitate knowledge transfer between network partners. Funding could be leveraged to **develop a program for organizing and training** volunteer groups and seasonal internship crews to make and/or process collections with existing programs and under the guidance of collection and *ex situ* experts to prepare a local workforce for a career in plant conservation.

- Important *ex situ* **collections of SCI should be duplicated** whenever possible. This is particularly true for collections held in facilities in Hawai'i that are vulnerable to catastrophe such as hurricanes. Support is needed to **secure and administer agreements** with institutions outside Hawai'i, such as Kew MSB and Seeds of Success and to provide **funding to transport germplasm** and plant material between facilities.

- Ongoing efforts by CGAPS and HDOA to develop **biosecurity measures and invasive species management plans** must be supported. In addition, the impact of invasive species in Hawai‘i should be documented and disseminated to help build public awareness and support for enforcing biosecurity measures. **Widespread control of invasive species** is needed to mitigate their impact to native ecosystems and SCI. The development of new technologies and more efficient methods must be supported.

- Funding support is needed to **organize workshops on plant conservation** to help strengthen partnerships, standardize best practices and increase the trained workforce. Workshops on collection, storage, propagation, and restoration protocols and a work exchange program to bring experienced local practitioners to work together on projects would all benefit plant conservation in Hawai‘i. Conferences and seminars on theoretical and applied conservation biology and practices could also be beneficial.

Funding Needs for Phase 3

- Support is needed to cover expenses for **training and facilitating collaboration** between local groups and national and international conservation experts. This will improve knowledge transfer, allow Hawai‘i to stay current on international standards and develop leadership potential. Many opportunities exist with organizations such as: APGA, BGCI, CPC, CREW, IUCN, Kew MSB, USDA-NCGRP. **Support for IUCN Red-Listing** of more native plants would bring needed attention to the importance of plant conservation in Hawai‘i.

- Funding is needed for network partners to **develop curricula, outreach materials and a conservation scorecard** that can define needs for preserving native plants, identify statewide targets, promote achievements and appeal for support from national interests, private foundations, and government agencies. This should describe and promote local conservation and how it relates to the GSPC and IUCN Red List. Key audiences include: policy makers, educators, and business leaders.

- **Develop outreach materials and educational resources** that promote biodiversity conservation to Hawai‘i’s visitors and residents. This should include images of plant conservation activities, information on where to find native plant displays and habitats and steps to encourage both residents and visitors to learn more and get involved through volunteer opportunities in plant conservation. HPCN partners can support this effort by providing summary data on native plants, pictures of native habitats, threats and partner management efforts, etc.

- In order to increase public exposure to native plants and their use in landscapes, a feasibility study should be conducted to **assess the ornamental potential of more Hawaiian plants**, and more support should go into the creation of hardy cultivars. This will require a partnership of conservation groups, botanical gardens and landscape industries.

- To provide better access to well-sourced plant resources and promote their use in traditional practices, an **online inventory of collections** should be developed. Appropriate collections could be identified by HPCN partners, botanical gardens and interested cultural groups and linked though a web-based database.

Conclusions

As mentioned earlier, it is impossible to separate the *ex situ* and *in situ* conservation efforts in Hawaiʻi. Due to the extreme rarity of the flora and native habitats, we have generally placed the strengthening and capacity building of securing collections and *ex situ* conservation ahead of *in situ* habitat management by one to three years. While it may initially appear as a salvage technique and heighten the dire situation of Hawaiʻi's flora, we believe it is necessary to fortify a backup system not only to prevent extinction of critically rare species, but to prevent the rapid depletion of genetic diversity within a species and extirpation of populations, particularly in dry-land habitats or populations found in unique habitats for a species. Lastly, we wanted to stress the importance of outplantings whenever they can be executed into secure habitats.

The primary recommendations of the 2012 Assessment included the formation of a statewide network of conservation programs and *ex situ* facilities and the drafting of a plant conservation strategy to increase the quality and quantity of representation of plants in *ex situ* storage. The ultimate goal of this initiative is to prevent extinction for threatened species and to provide propagules for restoration and recovery efforts for conservation programs. After the initial meeting of potential network partners in May 2013, the recommendations were prioritized to draft the conservation strategy, and to design the framework for implementation once a strategy was reviewed.

We have attempted to present a streamlined, concise description of the actions that will define our strategy to secure collections of SCI. We believe that tracking progress towards securing collections will be guided by global conservation goals, which will hopefully provide measures of success, garner support for Hawaiʻi's conservation efforts, and promote local and global awareness of the overwhelming rarity of the Hawaiian flora and its native habitats. We view this document as flexible and adaptable to our progress and increasing knowledge of the flora. The timeline is also an estimate that will fluctuate as new information is acquired, but we believe it is a good framework to keep us on track for 2020 goals. Accomplishing Target 8 objectives for our native flora is challenging considering the large amount of threatened SCI compared to the current minimal trained staff and funding in Hawaiʻi.

It is essential to tailor the Strategy to the needs of the programs involved, and construct HPCN as a facilitating entity for plant conservation on every island. It is intended that this strategy will attract financial support to bolster the ongoing efforts and disseminate information among programs of best practices for all steps in securing collections. Hawaiʻi's native flora and habitats are unique and in need of preservation and conservation efforts. The formal existence of the network should best be molded by the needs of the user, and maintain plasticity as progress is tracked, needs develop or change, and the knowledge of our precious flora is gathered. We hope that the feedback on the HSPC will allow it to fit the needs of all conservation programs and agencies and they will want to be partners in this effort.

Finally, it is impossible to overstate the great success of so many dedicated professionals in locating, describing, protecting and conserving the Hawaiian flora over the past several decades. This work has certainly prevented the extinction of many species and further degradation of native habitats that are invaluable to Hawaiʻi and to global biodiversity. Hawaiʻi's past and current conservationists have laid a foundation for preserving a unique and rare flora. This document is inspired by all of those devoted to plant conservation in Hawaiʻi and we hope it can contribute to the future realization of their goals and help overcome limiting factors that hinder our protection of the native Hawaiian flora and the habitats they depend on.

Acknowledgments

We would like to thank the National Tropical Botanical Garden and Harold L. Lyon Arboretum for the guidance and sponsorship of this project. We thank the Hau‘oli Mau Loa Foundation for their gracious support, motivation, and interest in this project and the native Hawaiian flora.

Interviews and surveys were conducted with many individuals and representatives in the preparation of this document. We appreciate your patience and time to convey program goals, priorities and future needs for plant conservation. We acknowledge your help in informing this strategy: Nick Agorastos, Ane Bakutis, Marie Bruegmann, Keahi Bustamente, Vickie Caraway, Brant Chillingworth, Susan Ching-Harbin, John Clark, Margaret Clark, Makena Coffman, Susan Cordell, Chris Dacus, Charmie Dang, Mike Demotta, Christopher Dunn, Lucas Fortini, Sam Gon, Abby Hird, Naomi Hoffman, Clyde Imada, Jim Jacobi, Ken Kaneshiro, Kapua Kawelo, Randy Kennedy, Wendy Kishida, Brian Kiyabu, Greg Koob, Tim Kroessig, Kay Lynch, Greg Mansker, Joyce Maschinski, Sierra McDaniel, Loyal Mehrhoff, Yumi Miyata, Patty Moriyasu, Lihla Noori, Peggy Olwell, Hank Oppenheimer, David Orr, Anna Palomino, Steven Perlman, Lyman Perry, Tom Ranker, Janis Reischmann, Lara Reynolds, Rob Robichaux, Maggie Sporck, Elizabeth Stacy, Forest Starr, Kim Starr, Nellie Sugii, Natalia Tangalin, Peter Van Dyke, Jill Wagner, Christina Walters, Stephen Weller, Chipper Wichman, Kaleo Wong, Joan Yoshioka, and Marigold Zoll.

Literature Cited

Athens, J. S. 2009. *Rattus exulans* and the catastrophic disappearance of Hawai'i's native lowland forest. Biological Invasions **11**:1489-1501.

Ballesteros, D., E. Estrelles, C. Walters, and A. M. Ibars. 2012. Effects of temperature and desiccation on ex situ conservation of nongreen fern spores. American Journal of Botany **99**:721-729.

Barrett, S. C. H., and J. R. Kohn. 1991. Genetic consequences of small population size in plants. Pages 3-30 in D. A. Falk, and K. E. Holsinger, editors. Genetics and conservation of rare plants. Oxford University Press, New York.

Brown, A. H. D., and J. D. Briggs. 1991. Sampling strategies for genetic variation in ex situ collections of endangered plant species in D. A. Falk, and K. E. Holsinger, editors. Genetics and conservation of rare plants. Oxford University Press, New York.

Brown, A. H. D., and D. R. Marshall. 1995. A basic sampling strategy: theory and practice. Pages 75-91 in L. Guarino, V. R. Rao, and R. Reid, editors. Collecting Plant Genetic Diversity: Technical Guidelines. CAB International, Wallingford, UK.

Chapman, A. D., and O. Grafton. 2008. Guide to best practices for generalising primary species-occurrence data, version 1.0. Page 27 in G. B. I. Facility, editor, Copenhagen.

Cleland, E. E., I. Chuine, A. Menzel, H. A. Mooney, and M. D. Schwartz. 2007. Shifting plant phenology in response to global change. Trends in Ecology & Evolution **22**:357-365.

CPC. 1991. Genetic sampling guidelines for conservation collections of endangered plants in D. A. Falk, and K. E. Holsinger, editors. Genetics and conservation of rare plants. Oxford University Press, New York.

Crossa, J., and R. Vencovsky. 2011. Basic sampling strategies: theory and practice in L. Guarino, V. R. Rao, and E. Goldberg, editors. Collecting plant genetic diversity: technical guidelines - 2011 update. Biodiversity International, Rome.

Cuddihy, L. W., and C. P. Stone 1990. Alteration of native Hawaiian vegetation; effects of humans their activities and introduction. University of Hawaiʻi Press, Honolulu.

Diong, C. H. 1982. Population biology and management of the feral pig (*Sus scrofa* L.) in Kipahulu Valley, Maui. University of Hawaiʻi, Honolulu.

Fortini, L., J.P. Price, J.D. Jacobi, A. Vorsino, J. Burgett, K. Brinck, F. Amidon, S. Miller, S.O. Gon III, G. Koob, and E. Paxton. 2013. A landscape-based assessment of climate change vulnerability for all native Hawaiian plants. Hawaiʻi Cooperative Studies Unit Technical Report HCSU-044.

Frankham, R. 1998. Inbreeding and extinction: island populations. Conservation Biology **12**:665-675.

Frankham, R., J. D. Ballou, and D. A. Briscoe 2007. Introduction to conservation genetics. Cambridge University Press, New York.

Guerrant Jr., E. O., P. L. Fiedler, K. Havens, and M. Maunder. 2004. Revised genetic sampling guidelines for conservation collections of rare and endangered plants in E. O. Guerrant Jr, K. Havens, and M. Maunder, editors. Ex situ plant conservation: supporting species survival in the wild. Island Press, Washington, D.C.

Havens, K., E. O. Guerrant Jr, M. Maunder, and P. Vitt. 2004. Guidelines for ex situ conservation collection management: minimizing risks. Pages 454-473 in E. O. Guerrant Jr, K. Havens, and M. Maunder, editors. Ex Situ Plant Conservation. Island Press, Washington, DC.

Imada, C. T. 2012. Hawaiian native and naturalized vascular plant checklist (December 2012 update). Bishop Museum Technical Reports **60**.

Joe, S. M., and C. C. Daehler. 2008. Invasive slugs as under-appreciated obstacles to rare plant restoration: evidence from the Hawaiian Islands. Biological Invasions **10**:245-255.

Kearns, C. A., D. W. Inouye, and N. M. Waser. 1998. Endangered mutualisms: The conservation of plant-pollinator interactions. Annual Review of Ecology and Systematics **29**:83-112.

Kramer, A. T., A. Hird, K. Shaw, M. Dosmann, and R. Mims. 2011. Conserving North America's threatened plants: progress report on target 8 of the Global Strategy for Plant Conservation in B. G. C. I. U.S.,

editor. Botanic Gardens Conservation International U.S., Glencoe, IL.
Krushelnycky, P. D., L. L. Loope, T. W. Giambelluca, F. Starr, K. Starr, D. R. Drake, A. D. Taylor, and R. H. Robichaux. 2013. Climate-associated population declines reverse recovery and threaten future of an iconic high-elevation plant. Global change biology **19**:911-922.
Lawrence, M. J. 2002. A comprehensive collection and regeneration strategy for ex situ conservation. Genetic Resources and Crop Evolution **00**:1-11.
Li, D. Z., and H. W. Pritchard. 2009. The science and economics of ex situ plant conservation. Trends in Plant Science **14**:614-621.
Long, B., A. Niemiera, Z.-y. Cheng, and C.-l. Long. 2010. In vitro propagation of four threatened Paphiopedilum species (Orchidaceae). Plant Cell, Tissue and Organ Culture (PCTOC) **101**:151-162.
Loope, L. L. 1992. An overview of problems with introduced plant species in national parks and biosphere reserves of the United States. Pages 3-28 in C. P. Stone, C. W. Smith, and J. T. Tunison, editors. Alien Plant Invasions in Native Ecosystems of Hawai'i: Management and Research. University of Hawai'i Press, Honolulu.
Loope, L. L., O. Hamann, and C. P. Stone. 1988. Comparative conservation biology of oceanic archipelagoes: Hawaii and the Galápagos. BioScience **38**:272-282.
Marshall, D. R., and A. H. D. Brown. 1975. Optimum sampling strategies in genetic conservation in O. H. Frankel, and J. H. Hawkes, editors. Crop genetic resources for today and tomorrow. Cambridge University Press, Cambridge.
MIT. 2003. Implementation Plan: Makua Military Reservation; Island of Oahu in I. Makua Implementation Team & Hawaii Natural Heritage Program & Wil Chee Planning, editor. Wil Chee Planning, Inc., Honolulu.
Mitchell, C., C. Ogura, D. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard, and A. McClung. 2005. Hawai'i's comprehensive wildlife conservation strategy. Page 772 in D. o. L. a. N. Resources, editor, Honolulu, HI.
Myers, N., R. A. Mittermeler, C. G. Mittermeler, G. A. B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature **403**:853-858.
Neel, M. C., and M. P. Cummings. 2003. Effectiveness of conservation targets in capturing genetic diversity. Conservation Biology **17**:219-229.
Negrón-Ortiz, V. 2014. Pattern of expenditures for plant conservation under the Endangered Species Act. Biological Conservation **171**:36-43.
OANRP. 2011. 2011 Status Report for the Makua and Oahu Implementation Plans in E. D. USAG-HI Directoriate of Public Works, Natural Resources, editor, Schofield Barracks, HI.
Palmer, D. D. 2003. Hawai'i's Ferns and Fern Allies. University of Hawaii Press, Honolulu.
Pence, V. 2004. Ex situ conservation methods for bryophytes abd pteridophytes. Pages 206-227 in E. O. Guerrant Jr, K. Havens, and M. Maunder, editors. Ex situ plant conservation: supporting species survival in the wild. Island Press, Washington, D.C.
Price, J. P., J. D. Jacobi, S. M. Gon III, D. Matsuwaki, L. A. Mehrhoff, W. L. Wagner, M. Lucas, and B. Rowe. 2012. Mapping plant species ranges in the Hawaiian Islands - developing a methodology and associated GIS layers. Page 34 in U. S. G. S. O.-F. Report, editor.
Safeeq, M., A. Mair, and A. Fares. 2013. Temporal and spatial trends in air temperature on the Island of Oahu, Hawaii. International Journal of Climatology **33**:2816-2835.
Sakai, A. K., W. L. Wagner, and L. A. Mehrhoff. 2002. Patterns of endangerment in the Hawaiian flora. Systematic biology **51**:276-302.
Sarasan, V., R. Cripps, M. Ramsay, C. Atherton, M. McMichen, G. Prendergast, and J. Rowntree. 2006. Conservation in vitro of threatened plants: progress in the past decade. In Vitro Cellular & Developmental Biology - Plant **42**:206-214.
Sugii, N. 2011. The establishment of axenic seed and embryo cultures of endangered Hawaiian plant species: special review of disinfestation protocols. In Vitro Cellular & Developmental Biology - Plant **47**:157-169.
USFWS. 2010. Hawaiian Islands Plants: Listed and Candidate Species in U. S. F. a. W. Service, editor,

Honolulu.
Vernon, A. L., and T. A. Ranker. 2013. Current Status of the Ferns and Lycophytes of the Hawaiian Islands. American Fern Journal **103**:59-111.
Volis, S., and M. Blecher. 2010. Quasi in situ: a bridge between ex situ and in situ conservation of plants. Biodiversity and Conservation **19**:2441-2454.
Wagner, W. L., D. R. Herbst, and S. H. Sohmer 1999. Manual of the flowering plants of Hawai‘i. University of Hawai‘i Press & Bishop Museum Press, Honolulu.
Walck, J. L., S. N. Hidayati, K. W. Dixon, K. E. N. Thompson, and P. Poschlod. 2011. Climate change and plant regeneration from seed. Global change biology **17**:2145-2161.
Weisenberger, L., and M. J. Keir. *in press*. Assessing the status, capacity and needs for the ex situ conservation of the native Hawaiian flora. Pacific Science **68**.
Weller, S. G., R. J. Cabin, D. H. Lorence, S. Perlman, K. Wood, T. Flynn, and A. K. Sakai. 2011. Alien plant invasions, introduced ungulates, and alternative states in a mesic forest in Hawaii. Restoration Ecology **19**:671-680.
Wichman, C., and M. Clark. 2013. Toward the Implementation of Global Strategy for Plant Conservation Targets 1 to 3 in Hawai‘i1. Annals of the Missouri Botanical Garden **99**:236-243.

HSPC APPENDICES A-K

HSPC Appendix A. Hawaiʻi Species of Conservation Importance

Species of Conservation Importance (SCI) are listed with a recent estimate for the total wild mature plants, collection goals and collection group. The collection groups are as follows: A = critically rare taxa, seeds store conventionally; B = critically rare taxa, seeds difficult to store (or spores); C = critically rare taxa, on multiple islands; D = imperiled taxa, seeds store conventionally; E = imperiled taxa, seeds difficult to store (or spores); F = common taxa, seeds store conventionally; G = common taxa, seeds difficult to store (or spores). Common taxa do not have population estimates and collection of 50 plants from 20 populations each is recommended.

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Abutilon eremitopetalum	Malvaceae	A	10	10
Abutilon menziesii	Malvaceae	D	425	250
Abutilon sandwicense	Malvaceae	D	140	140
Acacia koa	Fabaceae	F	common	~1000
Acacia koaia	Fabaceae	D	1000	250
Achyranthes mutica	Amaranthaceae	C	38	38
Achyranthes splendens var. rotundata	Amaranthaceae	D	2000	250
Achyranthes splendens var. splendens	Amaranthaceae	D	10000	250
Adenophorus periens	Polypodiaceae	B	100	100
Alectryon macrococcus var. auwahiensis	Sapindaceae	B	7	7
Alectryon macrococcus var. macrococcus	Sapindaceae	E	250	150
Alphitonia ponderosa	Rhamnaceae	D	2500	250
Alyxia stellata	Apocynaceae	F	common	~1000
Amaranthus brownii	Amaranthaceae	A	40	40
Anoectochilus sandvicensis	Orchidaceae	D	1000s	250
Antidesma platyphyllum	Phyllanthaceae	G	common	~1000
Antidesma pulvinatum	Phyllanthaceae	G	common	~1000
Argyroxiphium caliginis	Asteraceae	D	10000	250
Argyroxiphium kauense	Asteraceae	D	794	250
Argyroxiphium sandwicense ssp. macrocephalum	Asteraceae	D	50000	250
Argyroxiphium sandwicense ssp. sandwicense	Asteraceae	A	27	27
Asplenium dielerectum	Aspleniaceae	B	37	37
Asplenium dielfalcatum	Aspleniaceae	E	1000s	250
Asplenium dielmannii	Aspleniaceae	B	67	67
Asplenium dielpallidum	Aspleniaceae	B	11	11
Asplenium haleakalense	Aspleniaceae	E	200	150
Asplenium peruvianum var. insulare	Aspleniaceae	E	776	250
Asplenium schizophyllum	Aspleniaceae	E	5000	250

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Asplenium unisorum	Aspleniaceae	E	1200	250
Asplenium x laui	Aspleniaceae	E	100s	250
Astelia menziesiana	Asteliaceae	D	1000s	250
Astelia waialealae	Asteliaceae	A	10	10
Athyrium microphyllum	Athyriaceae	G	common	~1000
Bidens amplectens	Asteraceae	D	750	250
Bidens campylotheca ssp. campylotheca	Asteraceae	D	5000	250
Bidens campylotheca subsp. pentamera	Asteraceae	A	100	100
Bidens campylotheca subsp. waihoiensis	Asteraceae	D	400	250
Bidens conjuncta	Asteraceae	D	1000	250
Bidens cosmoides	Asteraceae	D	1000s	250
Bidens hawaiensis	Asteraceae	A	100	100
Bidens hillebrandiana ssp. hillebrandiana	Asteraceae	A	50	50
Bidens mauiensis	Asteraceae	D	3000	250
Bidens micrantha subsp. ctenophylla	Asteraceae	D	135	135
Bidens micrantha subsp. kalealaha	Asteraceae	D	1750	250
Bidens molokaiensis	Asteraceae	D	3000	250
Bidens populifolia	Asteraceae	D	5000	250
Bidens sandvicensis ssp. confusa	Asteraceae	D	1000	250
Bidens valida	Asteraceae	D	500	250
Bidens wiebkei	Asteraceae	D	500	250
Bobea brevipes	Rubiaceae	D	1000s	250
Bobea elatior	Rubiaceae	F	common	~1000
Bobea sandwicensis	Rubiaceae	D	250	250
Bobea timonioides	Rubiaceae	D	450	250
Boehmeria grandis	Urticaceae	F	common	~1000
Bolboschoenus maritimus	Cyperaceae	F	common	~1000
Bonamia menziesii	Convolvulaceae	D	139	139
Brighamia insignis	Campanulaceae	C	1	1
Brighamia rockii	Campanulaceae	C	45	45
Broussaisia arguta	Hydrangeaceae	F	common	~1000
Calamagrostis expansa	Poaceae	D	600	250
Calamagrostis hillebrandii	Poaceae	D	200	150
Canavalia molokaiensis	Fabaceae	A	100	100
Canavalia napaliensis	Fabaceae	D	206	150
Canavalia pubescens	Fabaceae	D	200	150
Capparis sandwichiana	Capparidaceae	D	100s	250
Carex alligata	Cyperaceae	F	common	~1000
Carex wahuensis subsp. herbstii	Cyperaceae	A	0	0
Cenchrus agrimoniodes var. agrimonioides	Poaceae	D	150	150

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Charpentiera densiflora	Amaranthaceae	D	400	150
Charpentiera obovata	Amaranthaceae	F	common	~1000
Charpentiera ovata var. niuensis	Amaranthaceae	D	1000s	250
Cheirodendron dominii	Araliaceae	D	1000s	250
Cheirodendron forbesii	Araliaceae	D	1000s	250
Cheirodendron platyphyllum	Araliaceae	F	common	~1000
Cheirodendron trigynum	Araliaceae	F	common	~1000
Chenopodium oahuense	Amaranthaceae	F	common	~1000
Cibotium chamissoi	Cibotiaceae	G	common	~1000
Cibotium glaucum	Cibotiaceae	G	common	~1000
Cladium jamaicense	Cyperaceae	F	common	~1000
Cladonia solitaria	Cladoniaceae	B	100	100
Claoxylon sandwicense	Euphorbiaceae	F	common	~1000
Clermontia arborescens subsp. arborescens	Campanulaceae	D	100s	250
Clermontia calophylla	Campanulaceae	D	1000	250
Clermontia clermontioides	Campanulaceae	D	1000s	250
Clermontia drepanomorpha	Campanulaceae	D	300	250
Clermontia fauriei	Campanulaceae	D	1000s	250
Clermontia grandiflora ssp. maxima	Campanulaceae	D	140	140
Clermontia lindseyana	Campanulaceae	D	200	150
Clermontia oblongifolia ssp. brevipes	Campanulaceae	A	3	3
Clermontia oblongifolia ssp. mauiensis	Campanulaceae	C	5	5
Clermontia peleana ssp. peleana	Campanulaceae	A	5	5
Clermontia peleana ssp. singuliflora	Campanulaceae	C	30	30
Clermontia persicifolia	Campanulaceae	D	50000	250
Clermontia pyrularia	Campanulaceae	A	8	8
Clermontia samuelii ssp. hanaensis	Campanulaceae	D	350	250
Clermontia samuelii ssp. samuelii	Campanulaceae	A	24	24
Clermontia tuberculata	Campanulaceae	D	1000	250
Clermontia waimeae	Campanulaceae	D	500	250
Colubrina oppositifolia	Rhamnaceae	D	2000	250
Coprosma elliptica	Rubiaceae	D	1000s	250
Coprosma ernodeoides	Rubiaceae	D	1000s	250
Coprosma kauensis	Rubiaceae	F	common	~1000
Coprosma menziesii	Rubiaceae	D	100s	250
Coprosma montana	Rubiaceae	D	1000s	250
Coprosma ochracea	Rubiaceae	F	common	~1000
Coprosma pubens	Rubiaceae	D	1000s	250
Coprosma rhynchocarpa	Rubiaceae	D	1000s	250

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Cryptocarya mannii	Lauraceae	E	100s	150
Ctenitis squamigera	Dryopteridaceae	D	200	150
Cyanea acuminata	Campanulaceae	D	293	250
Cyanea asarifolia	Campanulaceae	A	20	20
Cyanea asplenifolia	Campanulaceae	A	32	32
Cyanea calycina	Campanulaceae	D	332	250
Cyanea cf. fernaldii	Campanulaceae	A	3	3
Cyanea copelandii ssp. haleakalaensis	Campanulaceae	D	300	250
Cyanea coriacea	Campanulaceae	D	1000s	250
Cyanea crispa	Campanulaceae	A	17	17
Cyanea dunbariae	Campanulaceae	A	7	7
Cyanea duvalliorum	Campanulaceae	D	110	110
Cyanea floribunda	Campanulaceae	D	100s	250
Cyanea gibsonii	Campanulaceae	A	3	3
Cyanea glabra	Campanulaceae	A	0	0
Cyanea grimesiana ssp. grimesiana	Campanulaceae	C	0	0
Cyanea grimesiana ssp. obatae	Campanulaceae	A	20	20
Cyanea habenata	Campanulaceae	D	1000s	250
Cyanea hamatiflora ssp. carlsonii	Campanulaceae	A	14	14
Cyanea hamatiflora ssp. hamatiflora	Campanulaceae	D	600	250
Cyanea hardyi	Campanulaceae	D	500	250
Cyanea horrida	Campanulaceae	A	33	33
Cyanea humboldtiana	Campanulaceae	D	259	250
Cyanea kahiliensis	Campanulaceae	D	2000	250
Cyanea kauaulaensis	Campanulaceae	A	62	62
Cyanea koolauensis	Campanulaceae	D	115	115
Cyanea kunthiana	Campanulaceae	D	1500	250
Cyanea lanceolata	Campanulaceae	D	123	123
Cyanea leptostegia	Campanulaceae	D	50000	250
Cyanea lobata ssp. baldwinii	Campanulaceae	A	3	3
Cyanea lobata ssp. lobata	Campanulaceae	A	3	3
Cyanea longiflora	Campanulaceae	A	83	83
Cyanea magnicalyx	Campanulaceae	A	5	5
Cyanea mannii	Campanulaceae	D	200	150
Cyanea maritae	Campanulaceae	A	60	60
Cyanea marksii	Campanulaceae	A	2	2
Cyanea mceldowneyi	Campanulaceae	A	100	100
Cyanea membranacea	Campanulaceae	D	2000	250
Cyanea munroi	Campanulaceae	C	2	2
Cyanea obtusa	Campanulaceae	A	6	6
Cyanea pinnatifida	Campanulaceae	A	0	0

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Cyanea platyphylla	Campanulaceae	A	37	37
Cyanea procera	Campanulaceae	A	2	2
Cyanea profuga	Campanulaceae	A	17	17
Cyanea pseudofaurei	Campanulaceae	D	300	250
Cyanea purpurellifolia	Campanulaceae	A	21	21
Cyanea recta	Campanulaceae	D	203	150
Cyanea remyi	Campanulaceae	A	24	24
Cyanea rivularis	Campanulaceae	A	15	15
Cyanea shipmanii	Campanulaceae	A	4	4
Cyanea solanacea	Campanulaceae	C	17	17
Cyanea solenocalyx	Campanulaceae	D	5000	250
Cyanea st.-johnii	Campanulaceae	A	62	62
Cyanea stictophylla	Campanulaceae	A	45	45
Cyanea superba ssp. superba	Campanulaceae	A	0	0
Cyanea tritomantha	Campanulaceae	D	350	250
Cyanea truncata	Campanulaceae	A	2	2
Cyanea undulata	Campanulaceae	A	13	13
Cyclosorus boydiae	Thelypteridaceae	E	300	250
Cyclosorus interruptus	Thelypteridaceae	G	common	~1000
Cyclosorus wailele	Thelypteridaceae	E	500	250
Cyperus fauriei	Cyperaceae	D	5000	250
Cyperus laevigatus	Cyperaceae	F	common	~1000
Cyperus odoratus	Cyperaceae	C	29	29
Cyperus pennatiformis ssp. bryanii	Cyperaceae	D	488	250
Cyperus pennatiformis ssp. pennatiformis	Cyperaceae	C	0	0
Cyperus trachysanthos	Cyperaceae	D	1000	250
Cyrtandra biserrata	Gesneriaceae	D	1000s	250
Cyrtandra cyaneoides	Gesneriaceae	D	800	250
Cyrtandra dentata	Gesneriaceae	D	684	250
Cyrtandra ferripilosa	Gesneriaceae	A	5	5
Cyrtandra filipes	Gesneriaceae	C	30	30
Cyrtandra giffardii	Gesneriaceae	D	112	112
Cyrtandra gracilis	Gesneriaceae	A	7	7
Cyrtandra halawensis	Gesneriaceae	D	200	150
Cyrtandra hematos	Gesneriaceae	A	30	30
Cyrtandra kaulantha	Gesneriaceae	A	28	28
Cyrtandra kealiae ssp. kealiae	Gesneriaceae	D	1000s	250
Cyrtandra kealiae subsp. urceolata	Gesneriaceae	D	10000	250
Cyrtandra kohalae	Gesneriaceae	A	0	0
Cyrtandra lydgatei	Gesneriaceae	D	200	150

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Cyrtandra macrocalyx	Gesneriaceae	D	1000s	250
Cyrtandra menziesii	Gesneriaceae	D	1000	250
Cyrtandra munroi	Gesneriaceae	C	100	100
Cyrtandra nanawaleensis	Gesneriaceae	D	200	150
Cyrtandra oenobarba	Gesneriaceae	D	360	250
Cyrtandra oxybapha	Gesneriaceae	D	200	150
Cyrtandra paliku	Gesneriaceae	A	10	10
Cyrtandra pickeringii	Gesneriaceae	D	2000	250
Cyrtandra polyantha	Gesneriaceae	A	32	32
Cyrtandra rivularis	Gesneriaceae	D	300	250
Cyrtandra sandwicensis	Gesneriaceae	D	500	250
Cyrtandra sessilis	Gesneriaceae	A	80	80
Cyrtandra subumbellata	Gesneriaceae	D	211	150
Cyrtandra tintinnabula	Gesneriaceae	A	58	58
Cyrtandra viridiflora	Gesneriaceae	A	58	58
Cyrtandra wagneri	Gesneriaceae	A	8	8
Cyrtandra wainihaensis	Gesneriaceae	D	1000s	250
Cyrtandra waiolani	Gesneriaceae	D	2000	250
Cystopteris douglasii	Cystopteridaceae	E	1000s	250
Cystopteris sandwicensis	Cystopteridaceae	E	1000s	250
Delissea kauaiensis	Campanulaceae	A	9	9
Delissea rhytidosperma	Campanulaceae	A	0	0
Delissea waianaeensis	Campanulaceae	A	24	24
Deschampsia nubigena	Poaceae	D	1000s	250
Dicranopteris linearis	Gleicheniaceae	G	common	~1000
Diospyros sandwicensis	Ebenaceae	G	common	~1000
Diplazium molokaiense	Athyriaceae	B	65	65
Diplazium sandwichiananum	Woodsiaceae	G	common	~1000
Dissochondrus biflorus	Poaceae	D	1000s	250
Dodonaea viscosa	Sapindaceae	F	common	~1000
Doodia lyonii	Blechnaceae	E	3000	250
Doryopteris angelica	Pteridaceae	B	68	68
Doryopteris takeuchii	Pteridaceae	E	109	109
Dryopteris crinalis var. podosorus	Dryopteridaceae	B	39	39
Dryopteris glabra var. pusilla	Dryopteridaceae	B	65	65
Dryopteris tetrapinnata	Dryopteridaceae	E	1000	250
Dubautia arborea	Asteraceae	D	1000s	250
Dubautia hanaulaensis	Asteraceae	D	200	150
Dubautia herbstobatae	Asteraceae	D	1239	250
Dubautia imbricata ssp. acronaea	Asteraceae	D	350	250
Dubautia imbricata ssp. imbricata	Asteraceae	D	1400	250

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Dubautia kalalauensis	Asteraceae	A	26	26
Dubautia kenwoodii	Asteraceae	A	1	1
Dubautia knudsenii ssp. filiformis	Asteraceae	D	2000	250
Dubautia latifolia	Asteraceae	A	100	100
Dubautia microcephala	Asteraceae	D	750	250
Dubautia paleata	Asteraceae	D	3000	250
Dubautia pauciflorula	Asteraceae	A	57	57
Dubautia plantaginea ssp. humilis	Asteraceae	A	35	35
Dubautia plantaginea ssp. magnifolia	Asteraceae	A	100	100
Dubautia platyphylla	Asteraceae	D	300	250
Dubautia raillardioides	Asteraceae	D	3000	250
Dubautia reticulata	Asteraceae	D	100s	250
Dubautia sherffiana	Asteraceae	D	300	250
Dubautia syndetica	Asteraceae	D	200	150
Dubautia waialealae	Asteraceae	D	3000	250
Elaeocarpus bifidus	Elaeocarpaceae	F	common	~1000
Embelia pacifica	Primulaceae	F	common	~1000
Eragrostis deflexa	Poaceae	D	2000	250
Eragrostis monticola	Poaceae	D	1000s	250
Eragrostis variabilis	Poaceae	F	common	~1000
Erythrina sandwicensis	Fabaceae	F	common	~1000
Eugenia koolauensis	Myrtaceae	E	146	146
Euphorbia arnottiana	Euphorbiaceae	D	1000s	250
Euphorbia atrococca	Euphorbiaceae	D	100000	250
Euphorbia celastroides var. kaenana	Euphorbiaceae	D	1082	250
Euphorbia celastroides var. laehiensis	Euphorbiaceae	D	300	250
Euphorbia celastroides var. lorifolia	Euphorbiaceae	D	1000s	250
Euphorbia clusiifolia	Euphorbiaceae	D	5000	250
Euphorbia deppeana	Euphorbiaceae	A	50	50
Euphorbia eleanoriae	Euphorbiaceae	A	51	51
Euphorbia haeleeleana	Euphorbiaceae	D	660	250
Euphorbia halemanui	Euphorbiaceae	D	350	250
Euphorbia herbstii	Euphorbiaceae	A	25	25
Euphorbia kuwaleana	Euphorbiaceae	D	2000	250
Euphorbia olowaluana	Euphorbiaceae	D	10000	250
Euphorbia remyi var. kauaiensis	Euphorbiaceae	D	1000	250
Euphorbia remyi var. remyi	Euphorbiaceae	D	350	250
Euphorbia rockii	Euphorbiaceae	D	136	136
Euphorbia skottsbergii var. skottsbergii	Euphorbiaceae	D	700	250
Euphorbia skottsbergii var. vaccinioides	Euphorbiaceae	D	2500	250
Euphorbia sparsiflora	Euphorbiaceae	D	4000	250

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Eurya sandwicensis	Pentaphylacaceae	D	1000s	250
Exocarpos gaudichaudii	Santalaceae	D	300	250
Exocarpos luteolus	Santalaceae	A	39	39
Festuca aloha	Poaceae	D	1000	250
Festuca hawaiiensis	Poaceae	D	1000	250
Fimbristylis hawaiiensis	Cyperaceae	D	2000	250
Flueggea neowawraea	Phyllanthaceae	C	100	100
Fragaria chiloensis subsp. sandwicensis	Rosaceae	D	1000s	250
Freycinetia arborea	Pandanaceae	G	common	~1000
Gardenia brighamii	Rubiaceae	C	6	6
Gardenia mannii	Rubiaceae	A	84	84
Gardenia remyi	Rubiaceae	C	91	91
Geranium arboreum	Geraniaceae	A	30	30
Geranium cuneatum subsp. tridens	Geraniaceae	D	1000s	250
Geranium hanaense	Geraniaceae	D	500	250
Geranium hillebrandii	Geraniaceae	D	10000	250
Geranium kauaiense	Geraniaceae	D	140	140
Geranium multiflorum	Geraniaceae	D	3000	250
Gossypium tomentosum	Malvaceae	D	1000s	250
Gouania hillebrandii	Rhamnaceae	D	2000	250
Gouania meyenii	Rhamnaceae	C	36	36
Gouania vitifolia	Rhamnaceae	C	64	64
Gynochthodes trimera	Rubiaceae	D	4000	250
Haplostachys haplostachya	Lamiaceae	D	10000	250
Heliotropium anomalum var. argenteum	Boraginaceae	F	common	~1000
Heliotropium curassavicum	Boraginaceae	F	common	~1000
Hesperomannia arborescens	Asteraceae	D	288	250
Hesperomannia arbuscula	Asteraceae	C	6	6
Hesperomannia lydgatei	Asteraceae	A	100	100
Heteropogon contortus	Poaceae	F	common	~1000
Hibiscadelphus distans	Malvaceae	A	20	20
Hibiscadelphus giffardianus	Malvaceae	A	0	0
Hibiscadelphus hualalaiensis	Malvaceae	A	0	0
Hibiscadelphus sp. A (Maui)	Malvaceae	A	75	75
Hibiscus arnottianus ssp. immaculatus	Malvaceae	A	100	100
Hibiscus brackenridgei ssp. brackenridgei	Malvaceae	C	43	43
Hibiscus brackenridgei ssp. mokuleianus	Malvaceae	A	53	53
Hibiscus clayi	Malvaceae	A	5	5
Hibiscus kokio ssp. kokio	Malvaceae	D	500	250
Hibiscus kokio ssp. saintjohnianus	Malvaceae	D	1000s	250
Hibiscus tiliaceus	Malvaceae	F	common	~1000

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Hibiscus waimeae ssp. hannerae	Malvaceae	A	83	83
Hillebrandia sandwicensis	Begoniaceae	D	1000s	250
Huperzia mannii	Lycopodiaceae	B	8	8
Huperzia nutans	Lycopodiaceae	B	9	9
Huperzia stemmermanniae	Lycopodiaceae	B	17	17
Hypolepis hawaiiensis var. mauiensis	Dennstaedtiaceae	B	10	10
Ilex anomala	Aquifoliaceae	F	commo	~1000
Ipomoea tuboides	Convolvulaceae	D	1000s	250
Isachne distichophylla	Poaceae	F	common	~1000
Ischaemum byrone	Poaceae	D	300	250
Isodendrion hosakae	Violaceae	D	300	250
Isodendrion laurifolium	Violaceae	D	170	150
Isodendrion longifolium	Violaceae	D	2000	250
Isodendrion pyrifolium	Violaceae	C	4	4
Isoetes hawaiiensis	Isoetaceae	D	100000	250
Jacquemontia sandwicensis	Convolvulaceae	F	common	~1000
Joinvillea ascendens subsp. ascendens	Joinvilleaceae	D	150	150
Kadua affinis	Rubiaceae	F	common	~1000
Kadua cookiana	Rubiaceae	D	110	110
Kadua cordata subsp. remyi	Rubiaceae	A	2	2
Kadua coriacea	Rubiaceae	D	160	150
Kadua degeneri subsp. degeneri	Rubiaceae	D	195	150
Kadua elatior	Rubiaceae	D	5000	250
Kadua fluviatilis	Rubiaceae	D	1200	250
Kadua flynii	Rubiaceae	D	500	250
Kadua formosa	Rubiaceae	D	300	250
Kadua haupuensis	Rubiaceae	A	0	0
Kadua littoralis	Rubiaceae	D	100s	250
Kadua parvula	Rubiaceae	D	197	150
Kadua st.-johnii	Rubiaceae	A	91	91
Kadua tryblium	Rubiaceae	D	500	250
Kanaloa kahoolawensis	Fabaceae	A	1	1
Keysseria erici	Asteraceae	D	1000s	250
Keysserria helenae	Asteraceae	D	1000	250
Keysserria maviensis	Asteraceae	D	300	250
Kokia cookei	Malvaceae	A	0	0
Kokia drynarioides	Malvaceae	A	5	5
Kokia kauaiensis	Malvaceae	D	300	250
Korthalsella degeneri	Santalaceae	D	1000	250
Labordia cyrtandrae	Loganiaceae	A	79	79
Labordia helleri	Loganiaceae	D	450	250

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Labordia hosakana	Loganiaceae	D	200	150
Labordia kaalae	Loganiaceae	D	1500	250
Labordia lorenciana	Loganiaceae	A	4	4
Labordia lydgatei	Loganiaceae	A	20	20
Labordia pumila	Loganiaceae	D	500	250
Labordia tinifolia var. lanaiensis	Loganiaceae	D	550	250
Labordia tinifolia var. wahiawaensis	Loganiaceae	A	34	34
Labordia triflora	Loganiaceae	A	4	4
Labordia waialaeale	Loganiaceae	D	1000	250
Lepechinia hastata	Lamiaceae	A	100	100
Lepidium arbuscula	Brassicaceae	D	1000	250
Lepidium bidentatum var. o-waihiense	Brassicaceae	D	5000	250
Lepidium orbiculare	Brassicaceae	A	50	50
Lepidium serra	Brassicaceae	D	3000	250
Leptecophylla tameiameiae	Ericaceae	F	common	~1000
Lepturus repens	Poaceae	D	1000s	250
Lindsaea repens var. macraeana	Lindsaeaceae	D	500000	250
Liparis hawaiensis	Orchidaceae	D	1000s	250
Lipochaeta lobata var. leptophylla	Asteraceae	D	400	250
Lobelia dunbarii ssp. paniculata	Campanulaceae	D	1000	250
Lobelia gaudichaudi	Campanulaceae	D	150	150
Lobelia kauaiensis	Campanulaceae	D	1000s	250
Lobelia koolauensis	Campanulaceae	D	345	250
Lobelia monostachya	Campanulaceae	A	10	10
Lobelia niihauensis	Campanulaceae	D	1700	250
Lobelia oahuensis	Campanulaceae	A	37	37
Lobelia villosa	Campanulaceae	D	1000s	250
Lobelia wahiawa	Campanulaceae	D	1000s	250
Lobelia yuccoides	Campanulaceae	D	1000s	250
Lysimachia daphnoides	Primulaceae	D	250	250
Lysimachia filifolia	Primulaceae	D	200	150
Lysimachia iniki	Primulaceae	A	40	40
Lysimachia lydgatei	Primulaceae	A	30	30
Lysimachia maxima	Primulaceae	A	60	60
Lysimachia pendens	Primulaceae	A	8	8
Lysimachia scopulensis	Primulaceae	A	15	15
Machaerina angustifolia	Cyperaceae	F	common	~1000
Marsilea villosa	Marsileaceae	E	2000	250
Melanthera fauriei	Asteraceae	D	220	150
Melanthera kamolensis	Asteraceae	A	25	25
Melanthera micrantha ssp. exigua	Asteraceae	D	125	125

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Melanthera micrantha ssp. micrantha	Asteraceae	D	400	250
Melanthera remyi	Asteraceae	D	1000s	250
Melanthera tenuifolia	Asteraceae	D	2446	250
Melanthera tenuis	Asteraceae	D	1000	250
Melanthera venosa	Asteraceae	D	4180	250
Melanthera waimeaensis	Asteraceae	A	100	100
Melicope adscendens	Rutaceae	A	1	1
Melicope anisata	Rutaceae	D	1000s	250
Melicope christophersenii	Rutaceae	D	250	250
Melicope cinerea	Rutaceae	D	250	250
Melicope clusiifolia	Rutaceae	F	common	~1000
Melicope cruciata	Rutaceae	A	20	20
Melicope degeneri	Rutaceae	A	11	11
Melicope haleakalae	Rutaceae	D	1000s	250
Melicope haupuensis	Rutaceae	A	18	18
Melicope hawaiensis	Rutaceae	D	100s	250
Melicope hiiakae	Rutaceae	A	40	40
Melicope kaalaensis	Rutaceae	D	100s	250
Melicope knudsenii	Rutaceae	C	4	4
Melicope lydgatei	Rutaceae	A	24	24
Melicope makahae	Rutaceae	D	200	150
Melicope mucronulata	Rutaceae	C	3	3
Melicope munroi	Rutaceae	D	550	250
Melicope orbicularis	Rutaceae	D	1000s	250
Melicope ovalis	Rutaceae	D	300	250
Melicope pallida	Rutaceae	D	257	250
Melicope paniculata	Rutaceae	D	200	150
Melicope puberula	Rutaceae	D	900	250
Melicope quadrangularis	Rutaceae	A	13	13
Melicope reflexa	Rutaceae	A	6	6
Melicope saint-johnii	Rutaceae	D	200	150
Melicope sandwicensis	Rutaceae	D	100s	250
Melicope sp. nov. 1 (West Maui)	Rutaceae	A	3	3
Melicope sp. Nov. 2 (Maui)	Rutaceae	D	200	150
Melicope waialealae	Rutaceae	D	1000	250
Melicope wawraeana	Rutaceae	D	1000s	250
Melicope zahlbruckneri	Rutaceae	A	24	24
Metrosideros macropus	Myrtaceae	F	common	~1000
Metrosideros polymorpha	Myrtaceae	F	common	~1000
Metrosideros rugosa	Myrtaceae	F	common	~1000
Mezoneuron kavaiense	Fabaceae	C	50	50

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Microlepia strigosa var. mauiensis	Dennstaedtiaceae	B	50	50
Microsorum spectrum	Polypodiaceae	E	250	250
Mucuna sloanei var. persericea	Fabaceae	A	50	50
Myoporum sandwicense	Scrophulariaceae	F	common	~1000
Myoporum stellatum	Scrophulariaceae	D	150	150
Myrsine degeneri	Primulaceae	E	1000s	150
Myrsine fernseei	Primulaceae	E	500	150
Myrsine fosbergii	Primulaceae	E	141	141
Myrsine helleri	Primulaceae	B	30	30
Myrsine juddii	Primulaceae	E	486	150
Myrsine knudsenii	Primulaceae	B	19	19
Myrsine lessertiana	Primulaceae	G	common	~1000
Myrsine linearifolia	Primulaceae	E	175	150
Myrsine mezii	Primulaceae	B	1	1
Myrsine petiolata	Primulaceae	E	1000s	150
Myrsine sandwicensis	Primulaceae	G	common	~1000
Myrsine vaccinioides	Primulaceae	E	500	150
Nama sandwicensis	Boraginaceae	F	common	~1000
Neraudia angulata var. angulata	Urticaceae	D	140	140
Neraudia angulata var. dentata	Urticaceae	A	1	1
Neraudia kauaiensis	Urticaceae	D	300	250
Neraudia melastomifolia	Urticaceae	D	1000s	250
Neraudia ovata	Urticaceae	A	10	10
Neraudia sericea	Urticaceae	C	27	27
Nestegis sandwicensis	Oleaceae	G	common	~1000
Nothocestrum breviflorum	Solanaceae	D	150	150
Nothocestrum latifolium	Solanaceae	D	1000	250
Nothocestrum longifolium	Solanaceae	D	1000s	250
Nothocestrum peltatum	Solanaceae	A	27	27
Nototrichium divaricatum	Amaranthaceae	D	200	150
Nototrichium humile	Amaranthaceae	D	813	250
Ochrosia compta	Apocynaceae	E	1000s	150
Ochrosia haleakalae	Apocynaceae	E	450	150
Ochrosia kauaiensis	Apocynaceae	E	5000	150
Ochrosia kilaueaensis	Apocynaceae	B	0	0
Oreobolus furcatus	Cyperaceae	F	common	~1000
Osteomeles anthyllidifolia	Rosaceae	F	common	~1000
Pandanus tectorius	Pandanaceae	G	common	~1000
Panicum lineale	Poaceae	D	1000s	250
Panicum niihauense	Poaceae	C	7	7
Panicum ramosius	Poaceae	A	<50	49

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Peperomia ligustrina	Piperaceae	D	100s	250
Peperomia membranacea	Piperaceae	D	1000s	250
Peperomia rockii	Piperaceae	D	300	250
Perrottetia sandwicensis	Dipentodontaceae	F	common	~1000
Peucedanum sandwicense	Apiaceae	D	3000	250
Phyllostegia ambigua	Lamiaceae	D	1000s	250
Phyllostegia bracteata	Lamiaceae	A	1	1
Phyllostegia brevidens	Lamiaceae	C	2	2
Phyllostegia floribunda	Lamiaceae	A	50	50
Phyllostegia haliakalae	Lamiaceae	C	1	1
Phyllostegia hirsuta	Lamiaceae	A	39	39
Phyllostegia hispida	Lamiaceae	A	2	2
Phyllostegia kaalaensis	Lamiaceae	A	0	0
Phyllostegia kahiliensis	Lamiaceae	A	<50	49
Phyllostegia macrophylla	Lamiaceae	C	100	100
Phyllostegia mannii	Lamiaceae	C	1	1
Phyllostegia mollis	Lamiaceae	A	2	2
Phyllostegia parviflora var. glabriuscula	Lamiaceae	A	50	50
Phyllostegia parviflora var. lydgatei	Lamiaceae	A	0	0
Phyllostegia parviflora var. parviflora	Lamiaceae	C	75	75
Phyllostegia pilosa	Lamiaceae	C	7	7
Phyllostegia racemosa	Lamiaceae	A	20	20
Phyllostegia renovans	Lamiaceae	A	30	30
Phyllostegia stachyoides	Lamiaceae	C	21	21
Phyllostegia velutina	Lamiaceae	A	55	55
Phyllostegia vestita	Lamiaceae	D	1000s	250
Phyllostegia waimeae	Lamiaceae	A	5	5
Phyllostegia warshaueri	Lamiaceae	A	3	3
Phyllostegia wawrana	Lamiaceae	A	13	13
Phytolacca sandwicensis	Phytolaccaceae	E	500	150
Pipturus albidus	Urticaceae	F	common	~1000
Pisonia sandwicensis	Nyctaginaceae	F	common	~1000
Pisonia umbellifera	Nyctaginaceae	F	common	~1000
Pisonia wagneriana	Nyctaginaceae	D	2000	250
Pittosporum argentifolium	Pittosporaceae	E	300	150
Pittosporum halophilum	Pittosporaceae	B	6	6
Pittosporum hawaiiense	Pittosporaceae	B	2	2
Pittosporum hosmeri	Pittosporaceae	G	common	~1000
Pittosporum napaliense	Pittosporaceae	E	180	150
Pittosporum terminalioides	Pittosporaceae	B	24	24
Planchonella sandwicensis	Sapotaceae	G	common	~1000

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Plantago hawaiensis	Plantaginaceae	D	300	250
Plantago princeps var. anomala	Plantaginaceae	A	75	75
Plantago princeps var. laxifolia	Plantaginaceae	C	50	50
Plantago princeps var. longibracteata	Plantaginaceae	D	3000	250
Plantago princeps var. princeps	Plantaginaceae	D	198	150
Platanthera holochila	Orchidaceae	C	42	42
Platydesma cornuta var. cornuta	Rutaceae	A	48	48
Platydesma cornuta var. decurrens	Rutaceae	D	284	250
Platydesma remyi	Rutaceae	A	40	40
Platydesma rostrata	Rutaceae	A	100	100
Platydesma spathulata	Rutaceae	F	common	~1000
Pleomele aurea	Asparagaceae	E	3000	150
Pleomele auwahiensis	Asparagaceae	E	1000s	150
Pleomele fernaldii	Asparagaceae	E	500	150
Pleomele forbesii	Asparagaceae	E	300	150
Pleomele halapepe	Asparagaceae	E	1000s	150
Pleomele hawaiiensis	Asparagaceae	E	300	150
Poa mannii	Poaceae	D	300	250
Poa sandvicensis	Poaceae	D	6000	250
Poa siphonoglossa	Poaceae	D	500	250
Polyscias bisattenuata	Araliaceae	A	37	37
Polyscias flynnii	Araliaceae	A	12	12
Polyscias gymnocarpa	Araliaceae	D	129	129
Polyscias hawaiensis	Araliaceae	D	1000s	250
Polyscias kavaiensis	Araliaceae	D	1000s	250
Polyscias lydgatei	Araliaceae	A	12	12
Polyscias oahuensis	Araliaceae	D	1000s	250
Polyscias racemosa	Araliaceae	D	114	114
Polyscias sandwicensis	Araliaceae	D	1000s	250
Portulaca molokiniensis	Portulacaceae	D	300	250
Portulaca sclerocarpa	Portulacaceae	D	3000	250
Portulaca villosa	Portulacaceae	C	100	100
Pritchardia bakeri	Arecaceae	A	2	2
Pritchardia beccariana	Arecaceae	D	1000	250
Pritchardia flynii	Arecaceae	D	275	250
Pritchardia forbesiana	Arecaceae	D	250	250
Pritchardia glabrata	Arecaceae	D	250	250
Pritchardia gordonii	Arecaceae	A	50	50
Pritchardia hardyi	Arecaceae	D	300	250
Pritchardia hillebrandii	Arecaceae	D	300	250

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Pritchardia kaalae	Arecaceae	D	185	150
Pritchardia kahukuensis	Arecaceae	A	50	50
Pritchardia lanigera	Arecaceae	D	150	150
Pritchardia lowreyana	Arecaceae	D	100s	250
Pritchardia maideniana (was affinis)	Arecaceae	A	51	51
Pritchardia martii	Arecaceae	D	1000s	250
Pritchardia minor	Arecaceae	D	500	250
Pritchardia munroi	Arecaceae	A	2	2
Pritchardia napaliensis	Arecaceae	D	157	150
Pritchardia perlmanii	Arecaceae	D	500	250
Pritchardia remota	Arecaceae	D	500	250
Pritchardia schattaueri	Arecaceae	A	13	13
Pritchardia sp. nov. (Maui)	Arecaceae	A	23	23
Pritchardia viscosa	Arecaceae	A	3	3
Pritchardia waialealeana	Arecaceae	D	1000s	250
Pritchardia woodii	Arecaceae	A	<50	49
Pseudognaphalium sandwicensium var. molokaiense	Asteraceae	D	1000s	250
Psychotria grandiflora	Rubiaceae	A	23	23
Psychotria greenwelliae	Rubiaceae	D	2000	250
Psychotria hexandra subsp. oahuensis var. oahuensis	Rubiaceae	A	8	8
Psychotria hobdyi	Rubiaceae	A	28	28
Psychotria wawrae	Rubiaceae	D	1000	250
Psydrax odorata	Rubiaceae	F	common	~1000
Pteralyxia kauaiensis	Apocynaceae	E	750	150
Pteralyxia macrocarpa	Apocynaceae	E	350	150
Pteris lidgatei	Pteridaceae	B	12	12
Ranunculus hawaiensis	Ranunculaceae	C	15	15
Ranunculus mauiensis	Ranunculaceae	D	170	150
Rauvolfia sandwicensis	Apocynaceae	F	common	~1000
Remya kauaiensis	Asteraceae	D	200	150
Remya mauiensis	Asteraceae	D	500	250
Remya montgomeryi	Asteraceae	A	37	37
Rhynchospora chinensis subsp. spiciformis	Cyperaceae	D	1000s	250
Rubus hawaiensis	Rosaceae	D	1000s	250
Rubus macraei	Rosaceae	D	1000s	250
Sadleria cyatheoides	Blechnaceae	G	common	~1000
Sanicula mariversa	Apiaceae	D	648	150
Sanicula purpurea	Apiaceae	D	150	150
Sanicula sandwicensis	Apiaceae	C	50	50

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Santalum ellipticum	Santalaceae	F	common	~1000
Santalum freycinetianum	Santalaceae	D	1000s	250
Santalum haleakalae var. haleakalae	Santalaceae	D	700	250
Santalum haleakalae var. lanaiense	Santalaceae	D	110	110
Santalum involutum	Santalaceae	A	75	75
Sapindus oahuensis	Sapindaceae	F	common	~1000
Sapindus saponaria	Sapindaceae	F	common	~1000
Scaevola coriacea	Goodeniaceae	D	150	150
Scaevola glabra	Goodeniaceae	F	common	~1000
Scaevola kilaueae	Goodeniaceae	D	500	250
Scaevola procera	Goodeniaceae	D	1000s	250
Scaevola taccada	Goodeniaceae	F	common	~1000
Schenkia sebaeoides	Gentianaceae	D	6000	250
Schiedea adamantis	Caryophyllaceae	A	21	21
Schiedea apokremnos	Caryophyllaceae	D	800	250
Schiedea attenuata	Caryophyllaceae	A	10	10
Schiedea diffusa subsp. difussa	Caryophyllaceae	C	50	50
Schiedea diffusa subsp. macraei	Caryophyllaceae	A	1	1
Schiedea globosa	Caryophyllaceae	D	1000s	250
Schiedea haleakalensis	Caryophyllaceae	D	250	250
Schiedea hawaiiensis	Caryophyllaceae	A	1	1
Schiedea helleri	Caryophyllaceae	A	57	57
Schiedea hookeri	Caryophyllaceae	D	500	250
Schiedea jacobii	Caryophyllaceae	A	0	0
Schiedea kaalae	Caryophyllaceae	A	28	28
Schiedea kauaiensis	Caryophyllaceae	A	7	7
Schiedea kealiae	Caryophyllaceae	A	100	100
Schiedea laui	Caryophyllaceae	A	23	23
Schiedea lychnoides	Caryophyllaceae	A	35	35
Schiedea lydgatei	Caryophyllaceae	A	55	55
Schiedea mannii	Caryophyllaceae	D	50000	250
Schiedea membranacea	Caryophyllaceae	A	90	90
Schiedea menziesii	Caryophyllaceae	D	5000	250
Schiedea nuttallii	Caryophyllaceae	C	10	10
Schiedea obovata	Caryophyllaceae	A	35	35
Schiedea pentandra	Caryophyllaceae	D	500	250
Schiedea perlmanni	Caryophyllaceae	A	10	10
Schiedea pubescens	Caryophyllaceae	C	50	50
Schiedea salicaria	Caryophyllaceae	D	750	250
Schiedea sarmentosa	Caryophyllaceae	D	1000s	250
Schiedea spergulina	Caryophyllaceae	D	200	150

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Schiedea stellarioides	Caryophyllaceae	D	300	250
Schiedea trinervis	Caryophyllaceae	D	324	250
Schiedea verticillata	Caryophyllaceae	D	1000	250
Schiedea viscosa	Caryophyllaceae	A	37	37
Schoenoplectus tabernaemontani	Cyperaceae	F	common	~1000
Sesbania tomentosa	Fabaceae	D	7200	250
Sesuvium portulacastrum	Aizoaceae	F	common	~1000
Sicyos albus	Cucurbitaceae	A	5	5
Sicyos cucumerinus	Cucurbitaceae	D	1000	250
Sicyos lanceoloideus	Cucurbitaceae	C	24	24
Sicyos macrophyllus	Cucurbitaceae	A	5	5
Sicyos waimanaloensis	Cucurbitaceae	D	1000s	250
Sida fallax	Malvaceae	F	common	~1000
Sideroxylon polynesicum	Sapotaceae	E	300	150
Silene alexandri	Caryophyllaceae	A	28	28
Silene hawaiiensis	Caryophyllaceae	D	30000	250
Silene lanceolata	Caryophyllaceae	D	1000	250
Silene perlmanii	Caryophyllaceae	A	0	0
Sisyrinchium acre	Iridaceae	D	1000s	250
Smilax melastomifolia	Smilacaceae	F	common	~1000
Solanum americanum	Solanaceae	F	common	~1000
Solanum incompletum	Solanaceae	C	83	83
Solanum nelsonii	Solanaceae	D	9500	250
Solanum sandwicense	Solanaceae	C	7	7
Sophora chrysophylla	Fabaceae	F	common	~1000
Spermolepis hawaiiensis	Apiaceae	D	7500	250
Sporobolus virginicus	Poaceae	F	common	~1000
Stenogyne angustifolia	Lamiaceae	D	5000	250
Stenogyne bifida	Lamiaceae	A	1	1
Stenogyne calycosa	Lamiaceae	D	1000	250
Stenogyne campanulata	Lamiaceae	A	0	0
Stenogyne cranwelliae	Lamiaceae	A	50	50
Stenogyne kaalae subsp. sherfii	Lamiaceae	A	0	0
Stenogyne kanehoana	Lamiaceae	A	1	1
Stenogyne kauaulaensis	Lamiaceae	A	3	3
Stenogyne kealiae	Lamiaceae	D	200	150
Stenogyne macrantha	Lamiaceae	D	500	250
Stenogyne purpurea	Lamiaceae	D	3000	250
Stenogyne rugosa	Lamiaceae	D	100s	250
Stenogyne scrophularioides	Lamiaceae	D	200	150
Streblus pendulinus	Moraceae	G	common	~1000

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Strongylodon ruber	Fabaceae	D	1000s	250
Syzygium sandwicensis	Myrtaceae	G	common	~1000
Tetramolopium arenarium var. arenarium	Asteraceae	D	350	250
Tetramolopium consanguineum subsp. consanguineum	Asteraceae	D	10000	250
Tetramolopium filiforme var. filiforme	Asteraceae	D	2974	250
Tetramolopium humile var. humile	Asteraceae	D	500	250
Tetramolopium lepidotum ssp. lepidotum	Asteraceae	C	75	75
Tetramolopium remyi	Asteraceae	C	3	3
Tetramolopium rockii var. calcisabulorum	Asteraceae	D	1000s	250
Tetramolopium rockii var. rockii	Asteraceae	D	174000	250
Tetramolopium sp. nov 2	Asteraceae	D	120	120
Tetramolopium sylvae	Asteraceae	D	50000	250
Touchardia latifolia	Urticaceae	F	common	~1000
Trematolobelia grandifolia	Campanulaceae	D	1000	250
Trematolobelia singularis	Campanulaceae	D	133	133
Trisetum inaequale	Poaceae	D	50000	250
Urera glabra	Urticaceae	F	common	~1000
Urera kaalae	Urticaceae	A	19	19
Vaccinium calycinum	Ericaceae	F	common	~1000
Vaccinium reticulatum	Ericaceae	F	common	~1000
Vicia menziesii	Fabaceae	A	18	18
Vigna o-wahuensis	Fabaceae	C	100	100
Viola chamissoniana ssp. chamissoniana	Violaceae	D	672	250
Viola helenae	Violaceae	A	29	29
Viola kauaensis var. kauaense	Violaceae	A	40	40
Viola kauaensis var. wahiawaensis	Violaceae	A	5	5
Viola lanaiensis	Violaceae	D	150	150
Viola oahuensis	Violaceae	D	297	250
Wikstroemia bicornuta	Thymelaeaceae	D	1000s	250
Wikstroemia monticola	Thymelaeaceae	D	1000	250
Wikstroemia oahuensis	Thymelaeaceae	F	common	~1000
Wikstroemia phillyreifolia	Thymelaeaceae	F	common	~1000
Wikstroemia sandwicensis	Thymelaeaceae	F	common	~1000
Wikstroemia skottsbergiana	Thymelaeaceae	A	10	10
Wikstroemia villosa	Thymelaeaceae	A	1	1
Wilkesia gymnoxiphium	Asteraceae	D	1000	250
Wilkesia hobdyi (CH)	Asteraceae	D	774	250
Xylosma crenatum	Salicaceae	A	28	28

Taxon	Family	Collection Group	Total Wild Mature Plants	Total Wild Mature Plants to Collect
Zanthoxylum dipetalum var. dipetalum	Rutaceae	D	1000s	250
Zanthoxylum dipetalum var. tomentosum	Rutaceae	A	13	13
Zanthoxylum hawaiiense	Rutaceae	D	550	250
Zanthoxylum kauaense	Rutaceae	D	100s	250
Zanthoxylum oahuense	Rutaceae	D	100s	250

APPENDIX B. Global Strategy for Plant Conservation Objectives and Targets 2011-2020

Objective I: Plant diversity is well understood, documented and recognized

- Target 1: An online flora of all known plants.
- Target 2: An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action.
- Target 3: Information, research and associated outputs, and methods necessary to implement the Strategy developed and shared.

Objective II: Plant diversity is urgently and effectively conserved

Target 4: At least 15 per cent of each ecological region or vegetation type secured through effective management and/or restoration.

Target 5: At least 75 per cent of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity.

Target 6: At least 75 per cent of production lands in each sector managed sustainably, consistent with the conservation of plant diversity.

Target 7: At least 75 per cent of known threatened plant species conserved in situ.

Target 8: At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Target 9: 70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge.

Target 10: Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded.

Objective III: Plant diversity is used in a sustainable and equitable manner

Target 11: No species of wild flora endangered by international trade.

Target 12: All wild harvested plant-based products sourced sustainably.

Target 13: Indigenous and local knowledge innovations and practices associated with plant resources maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care.

Objective IV: Education and awareness about plant diversity, its role in sustainable livelihoods and importance to all life on earth is promoted

Target 14: The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes.

Objective V: The capacities and public engagement necessary to implement the Strategy have been developed

- Target 15: The number of trained people working with appropriate facilities sufficient according to national needs, to achieve the targets of this Strategy.
- Target 16: Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy.

APPENDIX C. Hawaiʻi Strategy for Plant Conservation: Hawaiʻi Seed Bank Partnership Initiative

Hawaiʻi Seed Bank Partnership Initiative

Prepared for the National Tropical Botanical Garden and the Harold L. Lyon Arboretum

By Lauren Weisenberger and Matthew Keir

March 2013

Table of Contents

Introduction

The flora of the Hawaiian Islands has one of the highest rates of endemism in the world (89% for angiosperms, 71% for pteridophytes), with over half of all taxa at risk (Palmer 2003; Sakai et al. 2002; Wagner et al. 1999). Approximately 10% of the flora is extinct (Wagner et al. 1999), and over 30% (of 1352 species) is federally listed as threatened or endangered (USFWS 2010). The conservation of Hawai‘i's rare flora is necessary and challenging. Reasons for the decline of native species are numerous, often centered around the introduction of many invasive species, including other plants, invertebrates, and large ungulates, which can cause vast habitat degradation (Athens 2009; Cuddihy & Stone 1993; Diong 1982; Joe & Daehler 2008; Loope 1992; Loope et al. 1988; Weller et al. 2011). The need for conservation has been increasingly recognized for several decades. Even as most wild populations continue to decline and more of the flora is federally listed, continuous introductions of invasive species continue to assault Hawai‘i's threatened native ecosystems. The remaining small and fragmented populations are also faced with threats from dwindling genetic variation and reduced outcrossing as pollination services are lost (Frankham 1998; Kearns et al. 1998). Programs are active on every island to conserve native ecosystems and rare species. Federal, state, and county agencies, non-profit organizations, community groups, and private individuals are all involved in plant conservation. The species these conservation agencies work to protect are referred to here as ‘species of conservation importance' (SCI).

The first step towards preventing the extinction of threatened flora is to secure and maintain viable propagules (seeds, vegetative cuttings, living plants) in a "genetic safety net" using *ex situ* or "off-site" storage techniques (Havens et al. 2004). *Ex situ* collections are a critical propagule source for recovery efforts. Well-maintained *ex situ* collections are insurance against extinction while habitat restoration is proceeding. Restoring native habitats and excluding or reducing threats to native plants, including invasive ungulates and alien plant species (Weller et al. 2011), takes years or even decades. The rapid degradation of native ecosystems, recent commencement of recovery efforts and the looming threat from new alien species and climate change all contribute to a dynamic situation. It might not be possible to recover habitats in a timely manner to prevent the loss of many native plants. Collecting from SCI, prior and during habitat protection and threat removal efforts will provide a genetically diverse and representative pool of propagules for future reintroduction and recovery efforts. Creating and maintaining the *ex situ* "genetic safety net" is especially challenging given the high number of species in Hawai‘i in need of *ex situ* genetic representation. Conservation programs across Hawai‘i are engaged in all aspects of *ex situ* conservation including greenhouse propagation, tree nurseries, living collections in botanical gardens, field nurseries, micropropagation, cryopreservation and seed banking.

Conserving rare species utilizes all appropriate *ex situ* techniques to secure adequate plant material, replicate plants for restoration, represent sufficient genetic diversity via protecting and storing propagules, and ensure replication in collection locations. This work requires technical expertise regarding when and how to collect viable propagules and advanced horticultural and biological techniques in establishing and maintaining propagules in the best way feasible on a species-by-species basis. Initial *in situ* collections are necessary for conducting research to determine the best propagules and storage conditions to represent and propagate plants. Seed storage is cheaper, less detrimental to the wild plants, and captures a higher level of genetic variation in a single collection than other *ex situ* method (Havens et al. 2004; Weisenberger & Keir 2013). When viable, desiccation-tolerant, mature seeds cannot be obtained, clonal material, desiccation-sensitive seeds, or immature seeds can be harvested and secured using micropropagation techniques, cryopreservation, or propagation in nurseries or gardens.

A review of the inventories, capacity, and potential of 28 *ex situ* facilities in Hawai‘i (Assessment; Weisenberger & Keir 2013) was conducted in 2012. The Assessment determined that over half (54%, 724/1352) of native Hawaiian plants are of conservation importance, which supports the findings of Sakai et al. (2002), who estimated that half of Hawai‘i's flora is at risk of extinction. Collections of 528 SCI exist in the inventories of *ex situ* facilities across the state. Sixty-four percent of these 'secured' taxa are represented by collections from only ten percent or less of the remaining naturally occurring individuals. The Assessment also calculated that increasing the capacity for seed storage statewide is the most efficient way to expand *ex situ* services to secure all of Hawaiʻi's species of conservation importance (SCI). Long-term seed bank storage potential varied among taxa, but 78% of the 724 SCI are likely candidates for long-term seed storage. Since seed storage is the optimal *ex situ* method for most SCI, more investment is needed to build the capacity of the existing facilities on Kauaʻi, Oʻahu and Hawaiʻi Island. Access to seed storage should be improved and more information about the benefits and protocols of seed banking should be promoted to provide the best genetic safety net for more species as efficiently as possible.

There may be some initial concerns or misunderstandings regarding seed banking for *ex situ* storage. One concern with expanding and increasing *ex situ* services in Hawaiʻi is that it may divert resources from ongoing *in situ* restoration projects. This can be avoided by emphasizing that *ex situ* collections 1) are part of an overall strategy to conserving Hawaiian native plants, 2) are insurance policies that protect against extinction and unknown variables involved in conducting experimental restoration projects, and 3) provide time and a safe location to maintain representation of populations as habitat protection and threat management is conducted. Another concern is that once collections are secured, collectors and managers may assume that no further maintenance is needed and their collected taxa are indefinitely secured. Additional collections may be needed once the viability of the initial collections declines or, if initial collections are not highly representative (>75% on known plants or populations).

Lastly, seed bank collections are not adapting to climatic changes in habitat, and the collection is representative of a population at the time of the collection. If there are substantial environmental and climatic changes during the time the collection is banked, the resulting propagules that are reintroduced may be maladapted to the new conditions (Hamilton 1994). If seed banking is to be an insurance against extinction in the wild, multiple collections over time will be required to maintain this insurance. Seed banks, therefore, should carefully maintain and test the viability of collections, and seed bank managers must notify collectors when their collections need to be refreshed. Furthermore, collectors and land managers should update seed bank managers regarding the status of populations. Great changes in the population size and habitat changes should influence *ex situ* strategies for threatened species.

The current rate of progress in securing adequate *ex situ* representation for SCI is not fast enough to create an adequate genetic safety net in the next five years. To meet the goal of securing all SCI, support for both *ex situ* facilities and field collection efforts must be increased. The Assessment determined that much progress has been made in collecting from critically rare taxa. This effort should be expanded to secure collections of species estimated to have between 100 and 1000 naturally occurring individuals remaining. This expanded effort will require additional resources to support *in situ* collections, an increase in the capacity of *ex situ* facilities to research, store and maintain collections, and coordination among conservation agencies. Conservation programs in Hawaiʻi regularly partner with others to accomplish shared goals in protecting habitats and conserving native taxa. This informal network of programs includes the botanists surveying and making collections, the field crews conducting habitat protection and outplanting, and the *ex situ* facilities storing seeds, growing and maintaining plant collections. Each program has dedicated staff time and funding for collaborated efforts, which have resulted in successful plant conservation projects. To strengthen this network and expedite *ex situ* collections, a formal partnership should be created to represent the consortium of programs involved, and strengthen progress towards their shared conservation goals of successful restoration and rare plant recovery. Because seed banking is the *ex situ* service with the most potential to meet the needs of conservation programs across the state, these facilities should be the first to participate in a formal conservation network. A unified partnership of the existing seed banks, including the Lyon Arboretum Seed Conservation Lab (LASB), the National Tropical Botanical Garden (NTBG), Hawaiʻi Island Native Seed Bank (HINSB), and the Oʻahu Army Natural Resources Program (OANRP), in consultation with the National Center for Genetic

Resources Preservation (NCGRP), is necessary for increasing the *ex situ* representation of SCI.

A unified seed banking partnership in Hawaiʻi would increase the quality, replication, research, knowledge, and quantity of collections representing the native flora. It would also facilitate increased interaction between local *ex situ* facilities, conservation programs and specialists worldwide, to improve the quality of the banked collections and provide knowledge to reduce the concerns over seed banking. We propose the establishment of an official partnership of Hawaiʻi conservation agencies called the 'Hawaiʻi Plant Conservation Network' (HPCN) with an initial focus on fortifying a partnership of the current seed banks to increase capacity and secure Hawaiʻi's SCI. This initiative identifies the primary participants, describes network administration, quantifies the expenses and efforts needed to reduce limitations at each seed bank facility by recommending the equipment, staffing and coordination required for expanding seed banking and research. It details the steps necessary to standardize and streamline data management, prioritize research needs and standardize operational protocols. The initial seed bank partnership will serve as the foundation for the expanded network (HPCN) that will include more *ex situ* facilities, collectors, conservation groups and government agencies. Estimates for improving infrastructure, staffing and maintenance are provided below.

Seed Bank Partnership Organizational Summary

Each seed bank currently operates independently to serve a specific conservation region or group of agencies (Table 1). With participation from the four primary seed banks listed in Table 1, a single partnership can unify these efforts to address under-served regions and agencies. Collections held at VRPF, HALE and UCI should also be tracked by the network and replicated at the primary facilities In order to organize seed bank partners, the HPCN will initially hold meetings to plan collaborations on individual projects, draft standardized protocols, create a unified database system, and develop operating guidelines and an administrative framework for network activities. In the Assessment, each of these seed banks (Fig. 1) indicated its desire to increase communication, share collections, and establish standardized research-driven protocols. LASB will serve as the main repository for Oʻahu and Maui Nui collections, while NTBG should serve as the main repository for Kauaʻi and HINSB for Hawaiʻi Island. OANRP will store the species they are contracted to stabilize. Once protocols and data management are standardized, collections can be replicated at multiple facilities to reduce the risk of a single catastrophe eliminating entire collections of certain taxa or regions. The LASB and OANRP should continue to serve as the research facilities for all taxa in Hawaiʻi with unknown viability or germination and preferred storage conditions. Their research will be coordinated with NCGRP, which will serve as a mentor for research methods, especially related to cryopreservation.

The administration of HPCN projects can initially be contracted to independent consultants. An agreement to document the operating guidelines and contributions of the network partners including a long-term commitment to the security, staffing and maintenance of each seed bank facility is needed. This agreement will be the foundation for establishing the HPCN as an independent non-profit entity to represent the shared interests of the network participants and provide a mechanism for attracting and disseminating additional funding for conservation projects statewide. With sufficient financial support, staff positions could be created and a Board of Advisors formed to guide the network activities and expand to facilitate other *ex situ* conservation projects over time.

Table 1. Seed banks and their customers. The column ‘additional taxa to secure’ is an estimate of the number of taxa with less than 85% of the founders represented *ex situ*. LASB currently secures all Oʻahu and Maui Nui taxa, as they currently lack seed bank facilities. Acronyms are defined in Appendix A.

Seed Banks	Location	# SCI	# Additional Taxa to Secure	Collection/Conservation Programs Served
NCGRP	Fort Collins, CO	1 (12 from old collections)	Research and Replicates	NTBG
HINSB*	Hawaiʻi	18	~200	FWS, DOFAW
NTBG*	Kauaʻi	187	~300	NTBG, PEPP
LASB*	O`ahu	188	~550	PEPP, DOFAW, FWS, Navy, Private
OANRP *	O`ahu	41	33-43	OANRP, OPEPP, NARS-Oʻahu, PTA
HALE	Maui	13		HALE
PTA	Hawaiʻi	14		PTA
VRPF	Hawaiʻi	3		PEPP, DOFAW, NARS
UCI	Irvine, CA	2		OANRP, PEPP

*Primary seed bank partners. PTA will work in conjunction with OANRP. NCGRP will work on research collaborated with the partnership, and communication will be facilitated by HPCN..

<u>Seed Bank Partners</u>

The facilities that will be involved in the network have many characteristics necessary for a functional seed bank, but some equipment, staffing and infrastructure are lacking at each facility. Details regarding the equipment and operations of the seed banks are found in the Assessment (Weisenberger & Keir 2013). Understanding limitations of seed banks will allow the HPCN to determine the costs necessary to achieve fully operational seed banks that can hold viable collections of all SCI.

LASB is centrally located on Oʻahu, the affiliation with the University of Hawaiʻi (which provides opportunities for staffing, training and funding support), and proximity to the Lyon Arboretum Micropropagation Laboratory and other Lyon Arboretum conservation programs and administration. It has most of the equipment needed to conduct quality storage, germination and viability research and appropriate storage conditions, as well as a database capable of tracking the necessary data for storage collections and research. Some improvements are needed at LASB to meet the *ex situ* conservation goals for the SCI statewide. Additional space is needed for processing and to house the germination chambers, drying and storage units. Additional staff is needed for processing and to direct research efforts. Without additional staff, processing, research, records, and viability testing of older collections are limited. The LASB will be expanding into a larger space within the next few years; however, the building may need additional renovations to be suitable as a secure long-term location for the primary seed bank for Hawaiʻi’s native plants. The existing building is currently not reinforced to withstand hurricane-force winds. Additional equipment needed to expand services includes additional cool-storage units, growth chambers, and ultra-low temperature storage conditions for researching cryopreservation (a backup generator may be necessary if the current one is relocated to the new LAML facilities). The conditions for researching cryopreservation should be available in at least one seed bank in Hawaiʻi (Christina Walters, pers. comm. 2012). The database built under contract by the Hawaiʻi Biodiversity and Mapping Program currently has no outside support available for updates and staff indicates that there are improvements that could be made to queries and reporting.

The NTBG seed bank has space that may be available to house an expanded seed bank and a hurricane-proof structure that houses its storage units with an automatic backup generator for power outages. A nursery dedicated to propagating native plants and a clean room for processing and germination testing are available. There are some improvements needed at NTBG to be able to expand seed banking services. The NTBG seed bank has three refrigerator/freezer units that are currently at or near capacity and more are needed. Additional equipment needed includes germination chambers and drying units. It uses Excel spreadsheets to track inventory and germination trials, and can be linked to the NTBG databases that track provenance data by accession number. Database and IT support is available and is used to update the database systems and ensure provenance data are linked to accessions throughout the gardens. Additional experienced staff is needed to increase processing of new collections and to conduct viability testing and research.

The OANRP seed bank has room to expand, the equipment needed to conduct storage, germination and viability research and the conditions to store seeds for the SCI to its program. Its database can track the necessary data for storage collections and research and IT support is available. At this time, the facility has the financial support to secure the priority taxa covered in its conservation plans. An ultra-low freezer (-80C) is used for research and is provided free of charge by Bishop Museum. For OANRP, improvements to reinforce the building housing the seed bank are needed to secure it from hurricanes and an emergency power generator is needed and may be installed in 2014. The facility is currently also limited by the lack of equipment for cryopreservation research.

The HINSB currently provides the only repository for seeds collected from wild plants native to west Hawai‘i. Collections are meant to be stored for the short-term (<15 years) until used for restoration projects. It has one refrigerator to dry and store seeds. The equipment needed to process large quantities of fruit for collections of common taxa are used at HINSB. A larger walk-in 10’x10’ refrigerator may be available in the near future, as well as solar electrical power. HINSB, however, cannot increase storage capacity or handle more frequent collections without additional funding support and trained staff. In order to provide expanded seed banking services including long-term seed storage (>15 years) additional equipment and staff are needed. This may include freezers, drying equipment and growth chambers for seed viability tests.

The combination of these facilities under a unified network is the most practical approach to increasing collections in seed banks. For example, a single database structure or standardized fields that all seed banks use and share will simplify data entry and reporting. Once standardized, inventories can be combined with data from other plant databases to provide a complete statewide inventory for the SCI and collections can be prioritized for underrepresented taxa. Also, cryopreservation may be necessary for several species, but collections of these species could be sent to facilities trained to handle these techniques and provide these services, including NCGRP Thus, not every facility would need to have every service. Cryopreservation may be most appropriate for LASB and OANRP as the lead research facilities. There is currently no single facility in Hawai‘i that has the combination of a hurricane-resistant building with emergency back-up power, the equipment needed to conduct all research and provide for all storage conditions and enough staff to handle expanded services. To create a secure statewide repository, collections of each SCI should be held in such a facility. Hawai‘i needs a primary repository that is located in a secure building, fully equipped and adequately staffed.

The NCGRP is the leading genetic preservation facility in the nation and has all available equipment needed to conduct research. It serves as the primary repository for all USDA seed collections in the country. This facility could potentially serve two primary functions for *ex situ* conservation in Hawai‘i. The first is that secure long-term storage is available for seed collections that could serve as backup collections to collections held at Hawai‘i seed banks. These backup collections at NCGRP would be insurance against statewide natural disasters or other loss of important collections. Space is not a limiting factor for this service; however, the storage conditions are limited and do not necessarily equate to ideal storage conditions for all SCI. The CPC has collections held in this manner at NCGRP and several collections of Hawaiian plants are currently stored there. Ownership of these collections remains with the submitting group and all provenance data are kept secure. The second important function that NCGRP can serve is to collaborate with network partners on research to develop storage protocols for Hawaiian taxa. Research on collections submitted to NCGRP would be directed by a formal agreement with both parties. Currently, there is a lack of funding and statewide coordination for this research, though LASB, NTBG, and OANRP currently collaborate independently with NGCRP. One limiting factor to increasing the collaboration with NCGRP is transport of plant materials to and from Fort Collins, Colorado. Securely shipping collections can be difficult and would be an added expense. Data housed at NCGRP may be difficult to link to other databases without coordination. Propagules resulting from testing would not be easily returned to Hawaiʻi without changing protocols with NCGRP and creating and funding a reliable method of transport for delicate seedlings. This poses complications for incorporating these propagules into ongoing restoration efforts and having a predetermined ‘exit strategy’ when collections begin to loose viability. One of the services that the HPCN can provide is to be a liaison to the NCGRP, which could help guide all seed banking research. The HPCN can facilitate research results from NCGRP into protocols followed by the network facilities. This would also enable local staff to substantiate results through replication of methods developed at NCGRP.

Hawaiʻi Plant Conservation Network Service Description

The seed bank partnership is valuable in that the practices developed to improve collection and storage protocols at the research facilities can be shared with those that lack the capacity to conduct research. Examples of practices developed through research at the LASB and OANRP include 1) identifying fruit characteristics that indicate optimal harvesting time, 2) estimating seed set to instruct how may fruit should be collected, 3) maintaining a list of collection needs so that plants can be removed from the list once they are collected, and 4) determining storage conditions to prolong the viability of collections and re-collection intervals based on aging rates of stored seeds that will indicate when another collection is necessary to replace a particular naturally-occurring wild plant (NCGRP has assisted in some of this research). These practices can be adopted statewide through a network that would identify re-collection intervals for SCI.

In the Assessment, both collectors and seed bank staff indicated that better communication on fruit quality and quantity would improve efficiency of collections, and help to avoid making collections that are not likely to store well under the conditions available at the receiving facility. Many collections are received without any direction for a length of time to store them, whether or not storage testing can be completed, and identifying who has access to collections. A unified partnership could address these issues statewide and ensure that collections are submitted to the appropriate facilities with adequate documentation and plans.

Initially, HPCN staff will plan and facilitate regular meetings with the primary seed bank partners to begin the work recommended in the Assessment and Master Inventory (bulleted below; the Master Inventory is the spreadsheet produced by the Assessment of inventories from all *ex situ* facilities). These services are designed to increase capacity to store all SCI. The services described under urgent actions can start during the first several meetings among seed bank managers. The capacity building services can be developed once the network is more established and active in data collecting, site visits, and research.

Urgent Actions

- **Coordinate propagule transfer between seed bank facilities** to increase replication of important collections. During meetings, we can identify the collections of the highest conservation value, including collections of extinct or extremely rare taxa, collections from very remote, infrequently visited locations, and collections of single-island endemics. It can then be referenced using the Master Inventory to identify taxa that are represented at only one facility. These collections are good candidates for quickly establishing representation at more than one facility. If duplicate collections exist, seed bank managers can discuss if, how, and which facilities should house them. The network can also facilitate transport between collectors and *ex situ* facilities. It can establish transportation protocols that reduce the impact of transport on the viability of the propagules, by implementing proper handling and helping to determine the best facilities for storage.

- **Identify *ex situ* research needs** and identify researchers who can focus on resolving them. Develop a list of projects that can be conducted in partnership with NCGRP and seek funding to support that partnership. Facilitating meetings focused on research needs will allow the network to accelerate the research necessary to determine if and how taxa can be adequately represented in seed banks, as well as determining the most efficient, cost-effective manner to accomplish this. Collaborating and prioritizing questions among seed banks will help to disseminate information already known, as well as ongoing research. The network can also help determine where and how new research should be conducted.

- **Develop and implement standardized protocols** for collection, documentation, propagation and storage methods for native plants/propagules. Existing methods, data and protocols will be discussed by the seed bank partners and reviewed by HPCN. This will allow for the network to quantify progress in securing taxa, disseminate protocols that have been tested at some facilities to apply to others, and allow for summation reporting on a species level. HPCN administrators can visit facilities to ensure protocols are properly executed, assist with maintaining collections, entering data, conducting and analyzing research and improving infrastructure.

- **Assess the value of existing collections** by measuring viability and determining provenance. Determine what collections of desiccation-sensitive taxa have been stored to pull them for immediate propagation. Identify old collections that are in need of regeneration and/or re-collection.

- **Develop and implement sanitation protocols** for transferring plants between *ex situ* facilities. The network can coordinate surveys by experts to determine pests present at facilities and determine and disseminate control methods and sanitation protocols to clear propagules for transport following cleaning.

Capacity Building

- **Standardize record keeping for tracking provenance** of all SCI. Data management will be a long-term project necessary for the entire HPCN initiative, not just for the seed banks. Database designers will be contracted to modify existing seed bank databases at LASB and OANRP to be used statewide. The data fields used to track provenance between collectors, *ex situ* facilities and land managers must be unified. This will involve uniquely identifying every population for each taxon and utilizing this unique code from initial collection of a wild plant through its maternal line for generations, as propagules are grown. This will allow for determining how many founders of each taxon are actually represented across all *ex situ* facilities.

- **Manage a database to produce reports required for permits** and track the *ex situ* inventory of each SCI (including species found on multiple islands and managed by different agencies and stored at multiple *ex situ* facilities). This database will incorporate field observation records and *ex situ* inventories produced by each of the network partners to provide an annual statewide assessment of progress on meeting conservation goals.

- **Document and publish protocols as a resource for conservation programs**. Produce resources to help collectors in identifying mature fruit and optimal collection times. These protocols have been determined for taxa stored at OANRP, and the methodology can be available and applied to other species. The network can gather information from collectors, seed bank managers, and basic biology through fieldwork to make this information available for as many users and species as possible.

- **Sponsor workshops and trainings** in propagation and genetic storage protocols. Opportunities for training and technology transfer with the Millennium Seed Bank Partnership at Royal Botanic Gardens Kew and NCGRP can be coordinated by HPCN.

- **Seek funding** that can be used to fund network projects, infrastructure improvements and *ex situ* research and storage. Additional support for HPCN projects may be available through research grants, private funding and other sources. A unified network can represent the shared interests of the participants and may qualify for or attract additional support.

- **Assist conservation programs and land managers to develop detailed conservation plans** that include specific *ex situ* goals for all SCI. Once goals are in place, programs can be directed by funding agencies to establish genetically representative *ex situ* collections as a primary goal.

- **Unify and complete annual reporting requirements** for different conservation agencies (*i.e*. USFWS Controlled Propoagation Reports). Individual agencies and facilities could task out reporting needs and the governmental agencies requesting the information could benefit from consolidated reports that represent taxa or habitats in their entirety instead of reports from every individual program.

Cost Estimates for Expanding Seed Bank Services

Proper facilities, *ex situ* goals, and staff needs all contribute to costs for seed banks to increase capacity to store all SCI. A seed bank facility that is adequate for storing seeds should be housed in a building in a secured location that is structurally reinforced for natural disaster protection. The facility should have an automatic standby emergency power system in case of electrical power outages and have a reliable supply of clean water. The cooling units and environmental controllers must be kept in a temperature-controlled room with air conditioning capable of maintaining a temperature of 24C. The facility itself should be organized in a manner to provide a clean area for processing with ample room to allow for multiple staff. Preliminary cost estimates to equip a seed storage facility to process and store collections of rare taxa, conduct germination trials, and track viability of stored research collections are provided below, based on seed banking knowledge and interviews with staff on current seed banking operations at LASB and OANRP (Table 2). The facilities in need of additional staff, space, and hurricane hardening are provided in Table 3. Preliminary cost estimates for each of the primary seed banks to reach their functionality have been provided in Table 4.

Table 2. Preliminary Cost Estimates for equipping a fully operational seed bank

Infrastructure / Equipment	Notes	Costs ($)
Storage units	refrigerators and freezers	2,000/unit
Processing supplies	screens, tubs, tweezers, etc.	10,000
Fruit processing equipment	debearder, mechanical sorter	5,000
Office supplies	computer, software, desks, etc.	5,000
Propagation/ germination chambers	Percival Scientific environmental controllers	25,000
Drying cabinets	Hui Tong or glass desiccators, salts	3,000
Air-conditioning and dehumidifier units	wall AC units vs. central AC, dehumidifier if necessary (~$200)	5,000
Cryopreservation equipment	liquid nitrogen dewar	25,000
Labeling equipment	Labels, envelopes	3,000
Annual supply and maintenance costs	$70/yr/frig-freezer $100/yr/Percival	To be determined based on the number of units
Emergency generator		120,000
Hurricane hardening		To be determined based on the size and age of the structure

Table 3. Estimates for staffing, space, and hurricane hardening for each seed bank based on the amount of taxa each facility must secure.

Seed Bank	Current Staffing (FTE)	Additional Staffing Needed (FTE)	Additional Space Needed	Hurricane Hardening Needed
LASB	1	1	YES	YES
NTBG	1	1	NO	NO
HINSB	.5	1	NO	YES
OANRP	1.5	0	NO	YES

*An emergency generator may be needed if the current genset is moved when LAML moves to another building.

Using rough assumptions of costs (labor, processing supplies, maintenance) to test and store each collection, how many more plants need to be collected from, and how many collections can be processed by the seed banks per month, we are able to estimate how much it will cost, and project how long it will take to reach *ex situ* storage goals for the 724 SCI covered in the Assessment. These projections do not include any of the startup costs for equipment and infrastructure detailed in Table 2 and Table 4a-d. The number of staff used for these projections is the current total staff statewide. This is equivalent to four full-time seed bank staff. As HPCN grows and collections increase, expanding the seed banking staff statewide as shown in Table 3, will be necessary (Table 3). Preliminary cost projections are estimated below for meeting *ex situ* conservation goals for both rare and common taxa covered in the Assessment. Each of the seed banks have already committed to allocating funds to cover a portion of these costs. However, more support is needed to invest in seed bank facilities, increase staffing, and expand services statewide to expedite *ex situ* collections. The labor, supply and maintenance costs and processing capacity can be adjusted as staffing and capacity increase.

The costs for supplies ($5/plant), utilities and staff time to process, test and maintain collections to meet *ex situ* goals for the 86 common taxa from the Master Inventory are approximately $100/plant. The *ex situ* conservation goals for these taxa is to secure a well-sampled collection from every biogeographic region, following Price (2004) and Price et al. (2012). Two regions each were identified on Oʻahu, Molokaʻi, and Maui, one region for both Kauaʻi and Lanaʻi and a total of 8 regions for Hawaiʻi Island. Niʻihau, Kahoʻolawe, and the Northwest Hawaiian Islands are grouped into one single region for the purposes of the Assessment, yielding 17 regions in total. For regions with more than 250 individuals, approximately 25% of the mature plants should be sampled. No taxon, except for *Erythrina sandwicensis*, currently has *ex situ* representation from over ten percent of these regions. Only ten other common taxa have *ex situ* collections representing more than ten founders. This suggests that the large majority of these taxa still need more complete representation to be considered secure. Using these assumptions, cost projections can be made for securing these taxa. Excluding 14 desiccation-sensitive taxa and *E. sandwicensis*, there are 71 taxa from a maximum of 830 regions to represent. Considering the number of founders currently secured, a total of 46,000 plants will need to be stored. Thus, the total estimated cost ($100/plant) to secure the 46,000 remaining plants in seed storage is approximately $4 million.

For the remaining SCI that can be stored in seed banks (543 in the Master Inventory), the seeds are typically smaller, reducing costs to $75/plant. For these taxa that are not considered common, a collection from a maximum of 250 is needed to secure the taxon. For taxa with 250 or fewer plants remaining, all should be represented. Considering the founders already secured, we estimate that there are a total of 89,000 plants in need of collection. The estimated cost ($75/plant) to secure the 89,000 remaining plants in seed storage would be approximately $6 million. It is important to remember that maximum re-collection intervals, which take into account climate change and evolution, have yet to be determined or enforced in any capacity. For taxa with short generation times, it may be concluded, regardless of aging in seed banks, that collections should be replenished earlier as to not inflict strong selection for traits not longer suitable for a changing environment. More frequent collections may be needed to secure each taxon.

If we assume four full-time lab technicians who each process 50 collections every month, it would take 30-40 years to achieve the *ex situ* goals listed above. Increasing the number of plants processed to 100 per month, which is sometimes the case at LASB, will reduce goal attainment to 15 years. It is important to note, however, that the time required to make collections is the limiting factor for how long it will take to reach goals. The time to process and maintain collections is minor compared with the time to coordinate, plan and make the collections. With the proposed network intact, we would hope the expertise and progress of the network, in conjunction with additional funds, could further reduce the amount of time necessary. We assume even 15 years may be too long to secure these collections, due to threatened habitats, and collections will need to be prioritized to reduce loss of potential founders to be collected from.

<u>Additional Contracts</u>

Some contracted support will be needed to meet network goals. A contract for database design and support for keeping back-up versions and continuing updates on data management, report design and software upgrades will be necessary to standardize research and provenance data statewide. Also, IT support will be needed for basic networking, data security and software upgrades. Funding support will be required for research contracted to the NCGRP. Grants and matching funds may be used to meet some of these needs.

Projected Expenses for expanding capacity at each Seed Bank

Estimates are provided below for recommended improvements in infrastructure, equipment and staffing at each seed bank to expand services to participate in the HPCN and meet statewide conservation goals. All costs are given in dollars. Estimates for staff salaries were made on industry standards including overhead for managers ($75,000) and technicians ($40,000). Travel expenses would cover inter-island trips for HPCN meetings and a visit by LASB and OANRP staff in 2014 to NCGRP for training on cryopreservation equipment and use. Training costs would cover travel and expenses for workshops on *ex situ* protocols. Each seed bank currently has differing capabilities for data management and some may require more investment than others. Some database support as discussed above to standardize fields and create statewide inventories could be handled by a contract with HPCN for all network partners. Utility and maintenance costs were estimated using costs for expected power usage and extended warranties/maintenance contracts. All existing equipment will need to be replaced when needed. Building space and hurricane hardening are not included, and facilities in need of these features are listed in Table 3. All facilities will require funding for annual utilities and maintenance (estimated at approximately $20,000/yr.) in addition to these estimates. These are approximate estimates and are dependent on seed bank owners and a review of current equipment.

Table 4a**.** Lyon Arboretum Seed Conservation Laboratory Expenses

	Expense Details	Expense Covered by Lyon	Additional Support Needed	Start-up Costs	Year 1-3 Costs
Payroll	Seed Bank Manager		Yes	75,000	75,000
	Seed Bank Technician	Yes			
Expenses	Travel	Partial	Yes	2500	500
	Training	Partial	Yes	1000	1000
	Office Supplies	Yes			
	Database/IT support	No	Yes	10,000	10,000
Assets	Computer	Yes			
	Database, Software, etc.	Yes			
	Processing Supplies	Partial	Yes	750	750
	Percival (1)	Partial	Yes		10,000
	Refrigerator (3)	Partial	Yes	2,000	4,000
	Freezer (4)	Partial	Yes	4,000	4,000
	Drying Units (1)	Partial	Yes	500	
	Labeling equipment	Partial	Yes	500	
	Cryopreservation	No	Yes		20,000
	Equipment	Yes			
	Emergency Generator	Yes			
	Air Conditioning	Yes			
	Dehumidifier				
TOTAL				**96,250**	**125,250**

Table 4b. National Tropical Botanical Garden Seed Bank Expenses

	Expense Details	Expense Covered by NTBG	Additional Support Needed	Start-up Costs	Year 1-3 Costs
Payroll	Seed Bank Manager		Yes	75,000	75,000
	Seed Bank Technician	Yes			
Expenses	Travel	Partial	Yes	500	500
	Training	Partial	Yes	1000	1000
	Office Supplies	Yes			
	Database/IT support	Yes			
	Utilities & Maintenance	Yes			
Assets	Computer	Yes			
	Database, Software, etc.	Yes			
	Processing Supplies	Yes			
	Fruit processing equipment	No	Yes	5,000	
	Percival	No	Yes	15,000	
	Refrigerator (1)	Partial	Yes	2,000	
	Freezer (1)	Partial	Yes	2,000	
	Drying Units	Partial	Yes	2,000	
	Labeling equipment	Partial	Yes	500	
	Emergency Generator	Yes	No		
	Air Conditioning	Partial	Yes	2000	
	Dehumidifier	Yes			
TOTAL				**105,000**	**76,500**

Table 4c. Hawaiʻi Island Native Seed Bank Expenses

	Expense Details	Expense Covered by HINSB	Additional Support Needed	Start-up Costs	Year 1-3 Costs
Payroll	Seed Bank Manager (.5)	No	Yes		37,500
	Seed Bank Technician	Partial	Yes		20,000
Expenses	Travel	Partial	Yes	350	350
	Training	Partial	Yes	500	500
	Office Supplies	Yes			
	Database/IT support	No	Yes	5,000	5,000
Assets	Computer	No	Yes	1,500	
	Database, Software, etc.	No	Yes	500	
	Processing Supplies	Partial	Yes	750	750
	Fruit processing equipment	Yes			
	Percival	No	Yes		15,000
	Refrigerator (2)	Partial	Yes	2,000	2,000
	Freezer (3)	No	Yes	2,000	4,000
	Drying Units	No	Yes	1,000	2,000
	Labeling equipment	No	Yes	500	
	Emergency Generator	No	Yes		120,000
	Air Conditioning	Yes	Yes		5,000
	Dehumidifier	No	Yes	300	
TOTAL				**14,400**	**212,100**

Table 4d. Oʻahu Army Natural Resources Program Seed Bank Expenses

	Expense Details	Expense Covered by OANRP	Additional Support Needed	Start-up Costs	Year 1-3 Costs
Payroll	Seed Bank Manager	Yes			
	Seed Bank Technician	Yes			
Expenses	Travel	Partial	Yes	500	500
	Training	Partial	Yes	500	500
	Conferences	Yes			
	Office Supplies	Yes			
	Database/IT support	Yes			
	Utilities & Maintenance	Yes			
Assets	Computer	Yes			
	Database, Software, IT gear	Yes			
	Processing Supplies	Yes			
	Percival	Yes			
	Refrigerator (1)	Yes	Yes		2,000
	Freezer (2)	Yes	Yes	2,000	2,000
	Drying Units	Yes			
	Labeling equipment	Yes			
	Cryopreservation equipment	No		20,000	
	Emergency Generator	No		120,000	
	Air Conditioning	Yes			
	Dehumidifier	Yes			
TOTAL				**143,000**	**5,000**

Seed Bank Partnership Funding

Seed banking is a service that needs to be financially compensated in written contracts with users. A fee-for-service policy will help to document the costs accrued in keeping collections at optimal storage conditions and secure long-term support for those expenses. Access to seed storage should be improved and more information about the benefits and protocols of seed banking should be promoted in order to secure more collections in storage. There are many groups, including government agencies, private landowners and businesses, and non-profit companies, engaged in plant conservation work in Hawai'i. These groups are all potential users of the HPCN seed banks. Their projects to conserve and restore native habitats may likely involve outplanting and would benefit by having seed storage services available to hold seeds until they were needed for propagation. Services provided by the network for these groups should be compensated in contracts and agreements. This will improve overall efficiency of plant restoration projects and provide important information on seed dormancy, viability, and optimal germination conditions. There are several government statutes and official guidelines that mandate the use of *ex situ* facilities for conducting plant conservation work in Hawaiʻi. For mitigation and endangered species work, the U.S. Fish and Wildlife Service Recovery Plans entail securing *ex situ* collections. The Recovery Objective Guidelines from the Hawaiʻi and Pacific Plant Recovery Coordinating Committee list securing *ex situ* storage in the first stage in recovery, 'Preventing Extinction.' Most, if not all, mitigation plans for endangered plant species in Hawaiʻi require securing *ex situ* collections. There are many groups currently engaged in varying types of conservation work that could involve increased *ex situ* collections such as watershed protection, post-fire restoration, native plant landscaping, cultural education projects, and mitigation for land development. Grants and contracts with these groups could be pursued to support network services that would enhance their conservation projects and strengthen the HPCN.

Grants to conserve, protect, and restore native ecosystems are offered by many local and national agencies and several international groups. These could also be used to support the HPCN services and projects. The network could ascertain grants for making collections and supporting basic storage research. Additionally, portions of funding awarded from grants for restoration efforts could be distributed to the seed banks and HPCN for their roles in these projects. A fee for service contract should be negotiated with the potential seed bank users to compensate for the services provided for each accession. An example is provided in Table 5 that shows how a fee schedule for each submission to a seed bank could be negotiated to provide fair compensation for seed banking services. There may be several ways to structure these fees based on the size and frequency of collections. Expenses for viability monitoring could be based on the expected duration in storage (long-term vs. short-term). Once fees were negotiated with seed bank users, these expenses could be cited in grants to support collection maintenance or as in-kind donations for matching grants.

Table 5. Example of a Fee Schedule for Seed Banking Services. Fees to be determined by the Seed Bank Partnerships and the HPCN. Short-term storage is less than 10 years.

Accession Type & Size	Processing Fee	Initial Viability Assessment Fee	Short-term Storage Fee	Long-term Storage Fee	Return Seedlings Fee
Research Collection (>500 seeds)	*i.e.* $500-1500				
Store <500 Seeds					
Store <1000 Seeds					
Store <5000 Seeds					
Store <10,000 Seeds					

<u>Literature Cited</u>

Athens, J. S. 2009. *Rattus exulans* and the catastrophic disappearance of Hawai'i's native lowland forest. Biological Invasions **11**:1489-1501.

Cuddihy, L. W., and C. P. Stone 1993. Alteration of native Hawaiian vegetation; effects of humans their activities and introduction. University of Hawaiʻi Press, Honolulu.

Diong, C. H. 1982. Population biology and management of the feral pig (*Sus scrofa* L.) in Kipahulu Valley, Maui. University of Hawaiʻi, Honolulu.

Frankham, R. 1998. Inbreeding and extinction: island populations. Conservation Biology **12**:665-675.

Hamilton, M. B. 1994. Ex-situ conservation of wild plant-species - time to reassess the genetic assumptions and implications of seed banks. Conservation Biology **8**:39-49.

Havens, K., E. O. Guerrant Jr, M. Maunder, and P. Vitt. 2004. Guidelines for *ex situ* conservation collection management: minimizing risks. Pages 454-473 in E. O. Guerrant Jr, K. Havens, and M. Maunder, editors. *Ex situ* Plant Conservation. Island Press, Washington, DC.

Joe, S. M., and C. C. Daehler. 2008. Invasive slugs as under-appreciated obstacles to rare plant restoration: evidence from the Hawaiian Islands. Biological Invasions **10**:245-255.

Kearns, C. A., D. W. Inouye, and N. M. Waser. 1998. Endangered mutualisms: The conservation of plant-pollinator interactions. Annual Review of Ecology and Systematics **29**:83-112.

Loope, L. L. 1992. An overview of problems with introduced plant species in national parks and biosphere reserves of the United States. Pages 3-28 in C. P. Stone, C. W. Smith, and J. T. Tunison, editors. Alien Plant Invasions in Native Ecosystems of Hawaiʻi: Management and Research. University of Hawaiʻi Press, Honolulu.

Loope, L. L., O. Hamann, and C. P. Stone. 1988. Comparative conservation biology of oceanic archipelagoes: Hawaii and the Galápagos. BioScience **38**:272-282.

Palmer, D. D. 2003. Hawaiʻi's Ferns and Fern Allies. University of Hawaii Press, Honolulu.

Price, J. P. 2004. Floristic biogeography of the Hawaiian Islands: influences of are, environment and paleogeography. Journal of Biogeography **31**:487-500.

Price, J. P., J. D. Jacobi, S. M. Gon III, D. Matsuwaki, L. A. Mehrhoff, W. L. Wagner, M. Lucas, and B. Rowe. 2012. Mapping plant species ranges in the Hawaiian Islands - Developing a methodology and associated GIS layers. Page 34 in U. S. G. S. O.-F. Report, editor.

Sakai, A. K., W. L. Wagner, and L. A. Mehrhoff. 2002. Patterns of endangerment in the Hawaiian flora. Systematic biology **51**:276-302.

USFWS. 2010. Hawaiian Islands Plants: Listed and Candidate Species in U. S. F. a. W. Service, editor, Honolulu.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer 1999. Manual of the Flowering Plants of Hawaiʻi. University of Hawaiʻi Press & Bishop Museum Press, Honolulu.

Weisenberger, L., and M. J. Keir. 2013. A statewide assessment of the *ex situ* status, capacity and needs for the conservation of Hawaiian plants. Hauʻoli Mau Loa Foundation, Honolulu.

Weller, S. G., R. J. Cabin, D. H. Lorence, S. Perlman, K. Wood, T. Flynn, and A. K. Sakai. 2011. Alien plant invasions, introduced ungulates, and alternative states in a mesic forest in Hawaii. Restoration Ecology **19**:671-680.

APPENDIX D. Potential Partners in Laukahi: The Hawaiʻi Plant Conservation Network

Government Agencies
U.S. Fish and Wildlife Service- National Wildlife Refuges
U.S. Geological Survey
Department of Defense- Oʻahu Army Natural Resources Program
Department of Defense- Army Pohakuloa Training Area Natural Resources Program
Department of Defense- Lualualei Naval Reservation
National Park Service- Haleakala National Park
National Park Service- Hawaiʻi Volcanoes National Park
National Park Service- Kalaupapa National Historical Park
State of Hawaiʻi Department of Land and Natural Resources- Natural Area Reserve System
State of Hawaiʻi Department of Land and Natural Resources- Division of Forestry and Wildlife
State of Hawaiʻi Department of Land and Natural Resources- Hawaii State Parks
Kahoʻolawe Island Reserve Commission
Office of Hawaiian Affairs
U.S. Department of Agriculture- Forest Service
U.S. Department of Agriculture- National Center for Genetic Resources Preservation
U.S. Department of Agriculture- Natural Resources Conservation Service
Smithsonian Institute- Botany Department
U.S Bureau of Land Management- Seeds of Success
Conservation Alliances
Hawaiʻi Association of Watershed Partnerships
Plant Extinction Prevention Program
Hawaiʻi Conservation Alliance
Center for Plant Conservation
Hawaiʻi Silversword Foundation
Botanic Gardens Conservation International
Kew Millennium Seed Bank Partnership
Educational Institutions
University of Hawaiʻi at Manoa– Botany Department
University of Hawaiʻi at Manoa– Center for Conservation Research & Training
University of Hawaiʻi at Manoa- College of Tropical Agriculture and Human Resources
University of Hawaiʻi at Manoa- Curriculum Research and Development Group
Kamehameha Schools
University of Hawaiʻi at Hilo- Geography Department
University of Hawaiʻi at Hilo- Biology Department
Leeward Community College
Pacific Internship Programs for Exploring Science
Hawaiʻi State Department of Education
Hawaiʻi Environmental Education Alliance

APPENDIX D. Potential Partners in Laukahi: The Hawaiʻi Plant Conservation Network

Hawaiʻi Conservation Groups
Conservation Council for Hawaiʻi
Hawaiʻi Reserves Inc.
Pono Pacific
Landscape Industry Council of Hawaiʻi
Kokua Kalihi Valley
Kupu
Papahana kuaola
Ulupalakua Ranch
The Nature Conservancy of Hawaiʻi
Botanical Gardens
Bishop Museum- Amy Greenwell Ethnobotanical Garden
D.T. Fleming Arboretum
City and County of Honolulu- Honolulu Botanical Gardens
Harold L. Lyon Arboretum
Maui Nui Botanic Garden
National Tropical Botanical Garden
Waimea Botanical Garden
Conservation Nurseries
Agency Mid-Elevation Rare Plant Facilities (DOFAW-Kauai, Olinda Nursery, Pahole Rare Plant Facility, Volcano Rare Plant Facility)
Private Nurseries: Hui ku maoli ola, Native Nursery LLC, Laʻau Hawaiʻi, Dole (Lanai)
National Park Service: Haleakala, Volcano, Kalaupapa
Botanical Garden Nurseries: National Tropical Botanical Garden, Harold L. Lyon Arboretum
Pohakuloa Training Area Natural Resources Program
Oʻahu Army Natural Resources Program
Micropropagation
Harold L. Lyon Arboretum Micropropagation Laboratory
Cincinnati Zoo and Botanical Garden – Lindner Center for Conservation and Research of Endangered Wildlife
Hawaiʻi Seed Bank Partnership
State of Hawaii- Division of Forestry and Wildlife
Hawaiʻi Island Seed Bank
Harold L. Lyon Arboretum Seed Conservation Laboratory
National Center for Germplasm Resources Protection
National Tropical Botanical Garden
Oʻahu Army Natural Resources Program
Royal Botanic Gardens Kew- Millennium Seed Bank

APPENDIX E. Announcement – Hawai‘i Seed Bank Partnership, August 2013

Aloha!

Results of the '2012 Ex Situ Assessment' indicated ex situ facilities are at capacity but many more collections are necessary. In an effort to increase the quality and efficiency of seed banking in Hawai‘i without additional financial support, we initiated the Hawai'i Seed Bank Partnership, which is currently focusing on protocol development (fruit processing, curatorial management, seed spore and pollen storage, propagule transport...just to name a few!), compiling a list of species that cannot currently be stored in Hawaii's seed banks or need to be tested, and standardizing operations for the four (currently) participating seed banks. So far, it includes the Hawai'i Island Native Seed Bank (Jill Wagner), the National Tropical Botanical Garden (Margaret Clark), Lyon Arboretum (Tim Kroessig) and O'ahu Army Natural Resources Program. We plan to produce regular newsletters to update folks on highlights from the seed world.

The Partnership will be the 'radicle' of a larger Hawai‘i Plant Conservation Network (HPCN), a network that assessment participants and plant conservation stakeholders believe will benefit plant conservation efforts across the state and hopefully provide a viable method for increasing financial support. HPCN has another ongoing project to draft a statewide plant conservation plan to compile statewide goals and guide ex situ collection strategies. We will likely be contacting many of you during the next couple months for feedback and participation in creating this document. Mahalo to the Hau'oli Mau Loa Foundation for their continued support.

Please let us know if you have questions regarding the seed banking partnership or if you are storing seeds and want to be involved.

Mahalo!

Appendix F. Hawai'i Plant Conservation Species Plans

- **Critically Rare** (<100 plants)

A. Critically Rare Taxa with seeds that can be stored in conventional seed banks. This strategy will focus on representing the remaining founders and maintaining existing collections. The primary conservation group for these taxa is PEPP.

B. Critically Rare Taxa without seeds that can be stored in conventional seed banks. This strategy will focus on representing taxa in micro-propagation or living collections since seeds cannot be stored. The primary conservation group for these taxa is PEPP.

C. Critically Rare Taxa (<100 plants), with multi-island distribution (*Gardenia brighamii*). This strategy will focus on how a network could facilitate collaboration between collectors and ex situ facilities across multiple islands. The primary conservation group for these taxa is PEPP.

- **Imperiled** (>100 plants, but not common)

D. Imperiled Taxa with seeds that can be stored in conventional seed banks. This strategy will highlight the opportunity to secure many taxa that are not yet on the PEPP list with seed banking.

E. Imperiled Taxa with seeds that cannot be stored in conventional seed banks. This strategy will focus on representing taxa in micropropagation or living collections since seeds cannot be stored.

- **Common (**important for habitat, cultural use and watershed restoration)

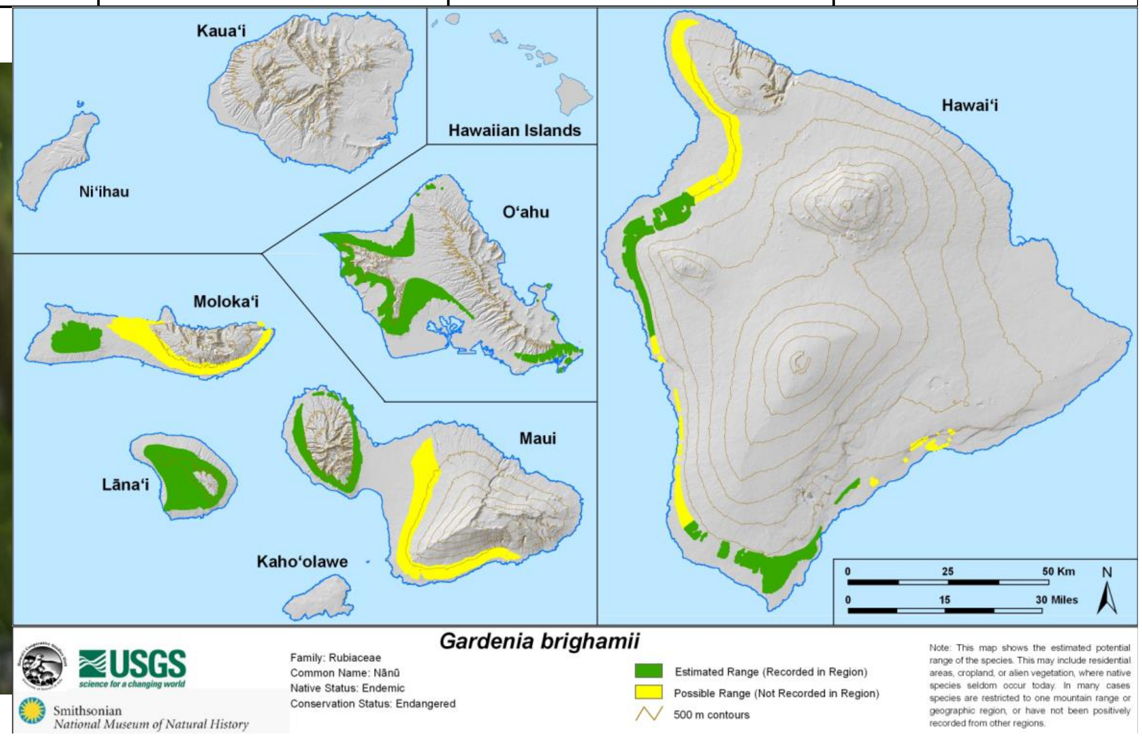
F. Common species with multi-island distributions that can be stored in conventional seed banks (*Acacia koa*). A collection strategy for common species will focus more on collecting propagules from a wide range of locations rather than collections from each individual wild plant. Efforts should focus on populations with no representation and increased collaboration between facilities will be needed.

G. Common species with multi-island distribution that cannot be stored in conventional seed banks. These taxa may require micropropagation, living collections, or additional research to secure ex situ.

1. **Species Description**: biology, distribution, habitat, conservation status and taxonomic notes
2. **Photo Gallery:** habitat, habit, morphology, size classes and stages of maturing fruit and seed, etc.
3. **Reproductive Biology**: phenology, suspected/known pollinator, pollinator syndromes, mating system, breeding system, seed biology
4. **Habitat Characteristics**: abiotic data and associated species from field observation forms
5. **Research**: ongoing, proposed and necessary studies on biology, ecology, threats and the researchers involved
6. **Populations**: to delineate groups of plants to standardize labeling of collections
7. **Population Structure & Estimates**: summary of population demography and number of plants reported on field observation forms and agency reports
8. **Threats and Control Methods**: from *in situ* observations and management reports
9. ***Ex Situ* Goals**: for the number of propagules needed to secure each plant and population
10. **Collection Protocols**: optimal harvest time, mature fruit characteristics, seed set and vegetative propagation methods, treatment and transport of the propagules
11. **Collection Sampling Strategy**: number of plants, population occurrences, and regions to collect
12. **Propagule Viability Maintenance**: optimal storage conditions, re-collection intervals, and regeneration strategies
13. **Restoration Outplanting**: reintroduction design, including the number of sites, number of plants, provenance of stock, number of founders, etc.
14. **Conservation Partners**: lead agency, collectors, land managers, landowners, *ex situ* facilities, etc.
15. **Logistical Considerations**: access to field sites, coordinating research, transporting propagules
16. **Estimated Time and Supplies**: staff, transportation, supplies, transferring propagules, data management, etc.
17. **Action Plan**: objectives involved, actions, timeline and measures of success

C. *Gardenia brighamii* (Mann) Wagner et al 1990, 1999 (Rubiaceae)					
Distribution (*=extirpated)	Federal Status	IUCN Rank	HPCN Collection Group	HPCN Conservation Status	Lead Agencies
Hawai‘i*, Maui*, Moloka‘i*, Lana‘i, O‘ahu	Endangered	Critically Rare	C	Critically Rare	PEPP

Photo: Tim Kroessig



Map Image: (Price 2012)

Population	Current Number of Populations	Current Number of Mature Plants	Current Total Plants (mature+juveniles)	Total Plants Secured *ex situ*	% of *ex situ* Goals	# of HPCN Facilities	Available for Restoration?
O‘ahu	1	1	1	3	100%	8	Yes
Lana‘i	1	5	5	~4	80%		Yes
Hawai‘i	0	0	0	3	100%	1?	No
Moloka‘i	0	0	0	1	100%	1?	No
Total Wild	2	6	6	11		13	Some
Total Outplanted	2 (+1 augmentation)	0	159	0			
TOTAL	4	6	170	11	More plants ex situ than in situ	13	Some

c. *Gardenia brighamii* (Mann) Wagner et al 1990, 1999 (Rubiaceae)

1. **Species Description**: *G. brighamii* is a small tree, up to five meters tall, endemic to Hawai'i, Maui, Moloka'i, Lana'i, and O'ahu. It is currently known from just a few wild locations on O'ahu and Lana'i.
2. **Photo Gallery:** (establish links here)
3. **Reproductive Biology**: dioecious?
4. **Habitat Characteristics**: dry forest
5. **Research:** An initial study is being conducted by HPCN to determine the sex of trees at Koko Crater Botanical Garden. Additional research on the breeding system and reproductive biology needs to increase and controlled breeding programs need to be established.
6. **Populations**: Only a few wild individuals remain on O'ahu and Lana'i
7. **Population Structure & Estimates**: No juveniles are known at the wild sites. There is estimated to be a single at one population on O'ahu and five trees on Lana'i.
8. **Threats (& Control Methods)**: Ungulates (fencing); low population size (hand-pollination); fruit predation of rodents; weeds that limit recruitment; amount of suitable habitat

Germplasm Type	Ex situ Facility	Minimum ex situ Goal	Total
Seeds	LASB	ALL Known Founders (11) x 50 seeds	550 Seeds
Seeds	NCGRP	ALL Known Founders(11) x 50 seeds	550 Seeds
Plants	HBG, MNBG, AGBG, WBG	Breeding Collection	100 Plants
Plants	PRPF, ORPF, VRPF	PEPP Restoration Outplantings	200 Plants

9. **Ex Situ Goals:** *G. brighamii* is held at thirteen ex situ sites, including gardens, seed banks, nurseries and in micropropagation. Collections from several of the now-dead trees have been in cultivation for decades. Conservation efforts managed by PEPP are ongoing to restore this taxon in its historic range, in living collections at botanic gardens, in conservation nurseries, and in public landscapes. Seeds can be stored using conventional techniques at the LASB and NTBG. This can be the primary method for securing representative collections as an ex situ genetic safety net. In addition, a living collection at several nurseries and/or gardens will be needed to provide propagules produced by controlled breeding to represent all of the remaining individuals. The primary ex situ goals that apply to this taxon are those listed in the USFWS Recovery Plan for Hawaiian Gardenia, HPPRCC guidelines for a critically rare plant and the PEPP program goals. To secure an adequate genetic safety net for this taxon, all remaining and subsequent wild founders, should be represented by at least three plants each in living collections at several gardens or nurseries statewide. These collections can be used for controlled breeding to secure seeds for restoration and to establish a genetic safety net in seed banks. At least 50 seeds from each of the fruit-producing individuals should be deposited and maintained at the LASB and NTBG seed banks. In addition, duplicate collections should be transferred to NCGRP for back-up storage.

C. *Gardenia brighamii* (Mann) Wagner et al 1990, 1999 (Rubiaceae)

10. **Collection Protocols:** For any known male trees, pollen will be collected and used to pollinate female trees to represent all paternal lines. At least three trees of each known founder should be represented clonally in at least two designated botanical gardens on separate islands, so that all lines are located in at least two locations. These living collections should be used to collect seeds from all maternal *x* paternal lines. Seed collections should be deposited at LASB with duplicate collections going to a secondary facility at NCGRP. Botanical gardens that are currently able to secure representation of this taxon include HBG (Koko Crater Facility), MNGB, AGEG, NTBG, and WBG. Fruit take months to mature, and cannot be collected when green.
11. **Collection Sampling Strategy:** All individuals should be collected and secured ex situ. Founders should be kept so that the wild-lines are preserved from each island.
12. **Propagule Viability Maintenance**: The optimal germplasm is mature viable seeds stored at -18C at 20% relative humidity, secured from living collections at botanical gardens. Re-collection intervals should be established for this taxon, though preliminary data from LASB suggests collections can maintain viability for at least ten years. Clones should be maintained at the gardens indefinitely, and these trees should serve as the source for re-collections as stored seed collections loose viability. Propagules generated by viability monitoring tests can be used in restoration efforts.
13. **Restoration Outplanting**: Outplanting plans are determined by PEPP and restoration plantings are ongoing. The number of plants still needed for these outplantings will be determined by PEPP.
14. **Conservation Partners:** PEPP (species lead manager), LASB (lead ex situ manager), State of Hawaiʻi Department of Hawaiian Home Lands (land owner), Lanaʻi (private landowner); and NTBG, LASB, PRPF, ORPF, WBG, MNBG, HBG, and AGEG (ex situ facilities). Partners would need extensive data management to construct maternal family lines and determine how many and which founders are represented at which facilities and how many generations removed from the wild plants all ex situ trees are. Currently, many known and unknown trees are located via seeds, seedlings, or clones across the state. Securing clones of all potential founder lines, and obtaining seed collections from the nursery and garden living collections on each island will require coordination between the PEPP programs and the ex situ facility staff to conduct the hand-pollinations needed for controlled breeding.
15. **Logistical Considerations:** Monitoring and securing collections from this taxon may require up to ten field days a year to visit the remaining plants and outplanting sites, five days for coordination and data management, and five additional days for controlled breeding of the living collections. No helicopter support is needed to visit the field sites and PEPP staff currently does this work.
16. **Estimated Time & Supplies**: Using estimates for up to twenty days of salary, field gear, supplies, and transport to off-island ex situ facilities, total cost for collections is estimated at approximately $17,000. Optimal seed storage conditions and protocols have been identified by LASB. Techniques for vegetative propagation are available to maintain clones in living collections at nurseries and gardens. Expenses for supplies and utilities to maintain a living collection of up to 100 plants at each of the existing facilities are estimated at $2000 per year. In order to process and maintain collections of up to 250 plants in seed storage, approximately $25,000 would be needed to secure collections of this taxon for up to 10 years. Support for a research project that determined the breeding system and sex of the remaining founders would enable conservation managers to plan controlled breeding and restoration strategies. Extensive work is needed to identify which founders are represented at each facility, complete the necessary cloning to establish all founders at the nurseries and botanic gardens, conduct hand-pollinations to collect the seeds for ex situ storage and for restoration projects.
17. **Action Plan**: The action plan for this species is determined by the lead agency (PEPP). HPCN efforts will focus on continuing research on the breeding system, identifying the gender of trees in the wild and in living collections, duplicating seed collections at NCGRP, facilitating access to stored collections for restoration outplantings, and compiling reports.

F. *Acacia koa* (A. Gray) Wagner 1990, 1999 (Fabaceae)

Distribution (*=extirpated)	Federal Status	IUCN Rank	HPCN Collection Group	HPCN Conservation Status	Lead Agencies
HI except Kaho'olawe & Ni'ihau	None	Least Concern	F	Common	DOFAW

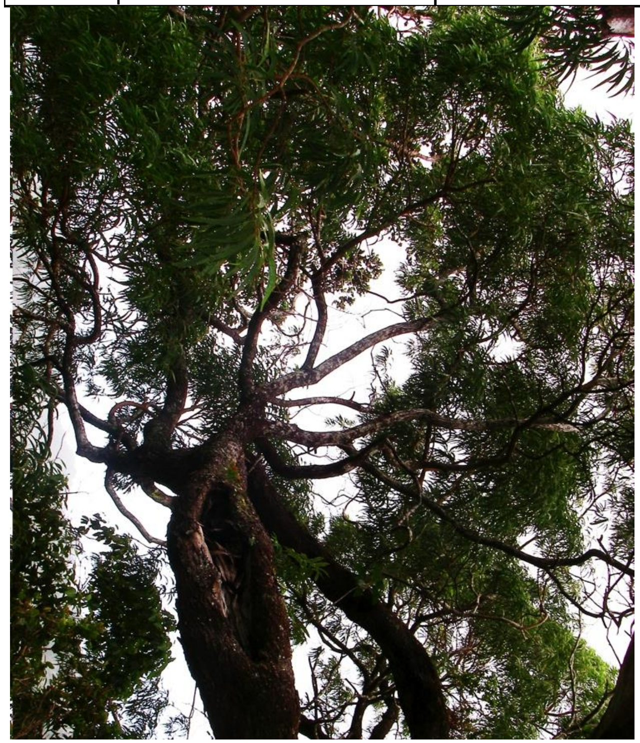


Photo: OANRP

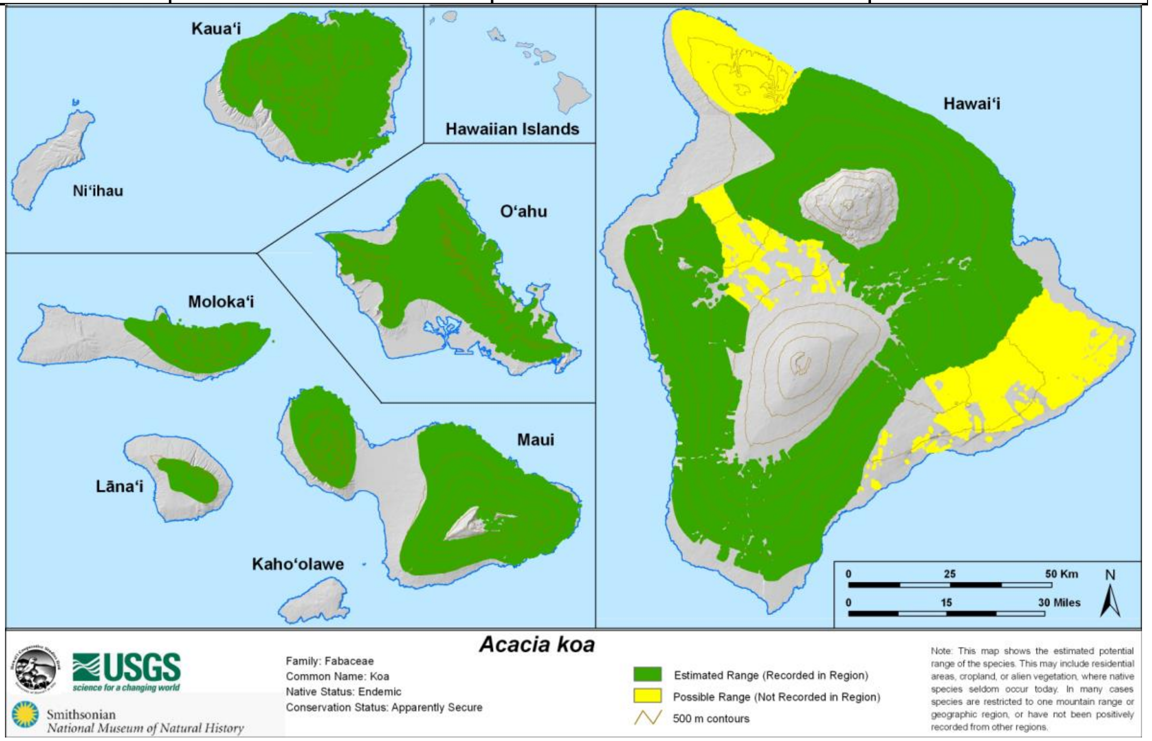


Image: (Price 2012)

Population	Current Number of Populations	Current Number of Mature Plants	Current Total Plants (mature+juveniles)	Total Plants Secured ex situ**	% of ex situ Goals	# of HPCN Facilities	Available for Restoration?
Kauai	1+	Common	Common	3	<10%	1	No
O'ahu	2+	Common	Common	21	<10%	4	Yes
Maui	2+	Common	Common	3	<10%	1	No
Moloka'i	1+	Common	Common	0	<10%	0	NA
Lana'i	1+	Common	Common	0	<10%	0	NA
Hawai'i	6+	Common	Common	5	<10%	1	No
TOTAL	13*	Common	Common	32	<10%	7	Few

*A minimum of 20 populations should be delineated. See discussion in the Collection Sampling section below.

**Rough estimates; a better evaluation of banked seed is necessary and other collections may exist at other facilites

F. *Acacia koa* (A. Gray) Wagner 1990, 1999 (Fabaceae)

1. Species Description: *A. koa* is a long-lived tree up to 35 meters tall found in nearly every bioregion in Hawaiʻi excluding Niʻihau and Kahoʻolawe. It is an important, dominant canopy tree in many native forests throughout Hawaiʻi (Wagner et al. 1999). It was identified as a species of conservation concern by the State of Hawaii Comprehensive Wildlife Conservation Strategy (http://www.state.hi.us/dlnr/dofaw/cwcs/) due to the 'Important Interaction' it has with native ecosystems.

2. Photo Gallery: establish links here and allow for uploads

3. Reproductive Biology: hermaphroditic, perfect flowers

4. Habitat Characteristics: "Often a dominant element of the vegetation of dry to wet forest from 60m-2060m elevation" (Wagner et. al. 1999)

5. Research: Research may be needed to better delineate populations based on genetics or ecological regions. Unique types should be identified and incorporated into collection strategies statewide. Research should identify seed zones within biogeographical regions to ensure representation of variation within the species.

6. Populations: Populations are delineated for thirteen biogeographical regions across the state. Throughout these regions, additional subregions need to be delineated. This will likely be based on elevational or rainfall gradients and other variation in morphological, habitat or environmental characteristics.

7. Population Structure & Estimates: Seedlings, immature plants, and mature plants are often observed within populations. Young seedlings are often seen in light gaps, both natural and following removal of invasive species. This, as well as the known physical dormancy of the seeds suggests a substantial soil seed bank is also established for this species. We are not aware of any statewide estimates for the number of *A. koa* trees, nor in any region.

8. Threats (& Control Methods): ungulates (fencing), seed borers, *A. koa* wilt, amount of suitable habitat, weeds that limit recruitment

Germplasm Type	*Ex situ* Facility	Minimum *ex situ* Goal (50 plants x 50 seeds OR 100 plants x 25 seeds)	Minimum Total Propagules
Seeds	HINSB	(6+ Populations x 50 plants x 50 seeds) x 2	15,000 Seeds
Seeds	NTBG	(1+ Populations x 50 plants x 50 seeds) x 2	2,500 Seeds
Seeds	LASB	(6+ Populations x 50 plants x 50 seeds) x 2	15,000 Seeds
TOTAL	3+ duplication	(20 populations x 50 plants x 50 seeds) x 2	100,000 Seeds

F. *Acacia koa* (A. Gray) Wagner 1990, 1999 (Fabaceae)

9. **Ex Situ Goals:** Mature seeds can be collected from wild trees and stored using conventional seed banking techniques (Weisenberger, pers. observ.). This can be the primary method for securing representative collections as an ex situ genetic safety net. Following SOS guidelines, a minimum of 20 populations will be represented to include all geographical regions. Unique populations or individuals should be represented ex situ. This may be especially true for populations that contain both *A. koa* and *A. koaia.* At least 25-50 seeds (without borer damage and able to sink in water) should represent every wild plant. All collections should be replicated at a backup facility for risk management. Populations or subregions should be delineated to meet the 20 population minimum. For example, Kauai has one geographical region, so several populations should be delineated to represent the known distribution on that and other islands. The seed bank facilities at HINSB should store seeds from trees on Hawai'i Island, NTBG from Kauai and LASB from the rest of the state. This will reduce transport costs.

10. **Collection Protocols:** Brown pods should be collected and handled in breathable (paper) bags and temporarily in plastic bags. Seeds should be removed from the pods immediately after collection to limit depredation by seed borers. Pods cannot be frozen to prevent seed borer predation as this kills the seeds by forming ice crystals within seed tissues. Collections should be scheduled in advanced with the seeds banks and assistance in processing by the collectors and species managers should be provided. Seed cleaning equipment is available at HINSB and should be used to clean large collections and an investment in this equipment for NTBG would allow for more efficient processing.

11. **Collection Sampling Strategy:** Areas of distinct populations should be identified and targeted for collection. These areas should represent all ecological clines, including ranges in temperature, rainfall, and elevation. They should also represent all proposed subspecies (Adamski et al. 2012). Following SOS guidelines, a minimum of 20 populations should be collected (50 seeds each from 50 plants or 25 seeds each of 100 plants) that include all geographical regions. Price et. al. (2012) recognized 13 distinct regions across the state. These should be further delimited so that 20 populations (seed zones) are identified across the state. These seed zones should be used to guide collection strategies so that any restoration outplantings occurring within those zones can utilize those collections. Additional seed zones should be identified with field botanists on each island. Collections should be prioritized for regions in which restoration is ongoing to encourage use of the collections for outplanting.

11. **Propagule Viability Maintenance**: Seeds should be floated in water to eliminate nonviable seeds prior to counting and preparation for storage. Seeds store conventionally at -18C and 20%RH and take approximately six weeks of drying at 43%RH at room temperature to achieve optimal RH. In addition to collections for genetic storage, additional seeds or collections can be used for restoration efforts, particularly post-fire restoration. Seed bank managers will need to track founder representation by region and population, and communicate with collectors when new collections will need to be ascertained. While it may not be necessary to re-collect from individual founders (given the large number of founders), regional collections will need to be refreshed when seed viability declines in storage, and they are likely long-lived.

12. **Restoration Outplanting**: Many restoration projects utilize this species across the state making securing collections a priority for wildlife habitat enhancement and watershed. In addition, agro-forestry projects are ongoing in many areas and these should be incorporated into this strategy. Research ongoing at institutions such as the Hawaii Agricultural Research Center and UH- Center for Tropical Agriculture and Human Resources should be incorporated into this strategy.

F. *Acacia koa* (A. Gray) Wagner 1990, 1999 (Fabaceae)

14. **Conservation Partners:** State Botanist (species lead manager), DOFAW (land owner), LASB, HINSB, NTBG, DTFA, and AGEG (ex situ managers).

15. **Logistical Considerations:** Kauai collections will go to NTBG for processing and storage. Maui and O'ahu collections will go to LASB until Maui. All Maui collections, however, should be processed prior to mailing collections to limit transporting pathogens and pests. Hawai'i Island collections will go to HINSB. Storage methods and protocols will be developed through research at LASB and other seed banks. Backup collections should be held at NCGRP or with the SOS program.

16. **Estimated Time & Supplies**: Collections should be gradual and incorporated into the daily operations of field staff. Collection supplies are minimal. Total cost of collections is difficult to estimate given the range and amount of individual trees to be collected from. An alternative approach would be to hire two full-time staff for several years to complete these and other collections of more common SGP for restoration and post-fire outplanting. Due to the size of the seeds and the amount of trees to be collected, it is estimated that maintenance costs of $100-200 per year per plant will be accrued for *A. koa*. Research collections need to be identified and ensured that enough seeds are present to test viability over a couple decades. Also, a suite of invasive species, including seed borers and fungal wilt, continuously assaults *A. koa*. If koa populations are documented to decline, control research may be necessary to combat these threats. Research on koa wilt is ongoing and critical to developing methods to successfully propagate mature trees from stored seed stock. If resistant trees are found to provide better success for restoration outplantings, stock from those trees should also be preserved in seed storage.

17. **Action Plan**: HPCN efforts will focus on securing seed collections from regions where restoration is ongoing, habitats that are fire threatened, and seed zones not currently represented. Methodology to efficiently transfer collections from the field to *ex situ* facilities, facilitate access to stored collections for restoration outplantings, build a workforce to make collections and compile reports on progress will be developed.

Photos: Forest & Kim Starr

APPENDIX G. Example- Collection guide for *Delissea waianaeensis*

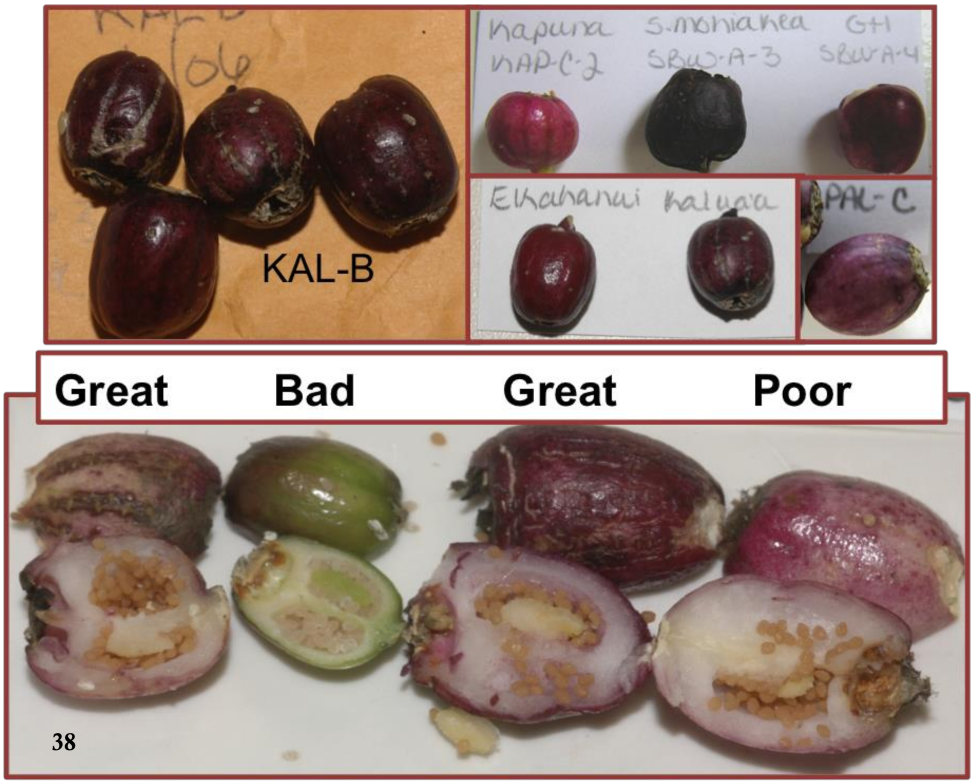


Fig. 1. Variety of coloring of mature fruit within a species, *Delissea waianaeensis*, and the appearance of mature and immature fruit. Developed and used by OANRP to guide collection efforts.

For this taxon, only mature fruit should be collected for ex situ storage. Fruit collected before maturity may be propagated immediately in nurseries or micropropagation.

APPENDIX H. Acronyms

AGEG- Amy Greenwell Ethnobotanical Garden Grounds
APGA- American Public Gardens Association
BGCI- Botanic Gardens Conservation International
CCH- Conservation Council for Hawai‘i
CCRT- Center for Conservation Research and Training at the University of Hawai‘i
CGAPS- Coordinating Group on
CPC- Center for Plant Conservation
DFTA- D.T. Fleming Arboretum
DLNR- Hawai‘i State Department of Land and Natural Resources
DOFAW- Hawai‘i State Division of Forestry and Wildlife
FWS- U.S. Fish and Wildlife Service
GSPC- Global Strategy for Plant Conservation
HALE- Haleakala National Park
HAVO- Hawai‘i Volcanoes National Park
HAWP- Hawai‘i Association of Watershed Partnerships
HBG- City and County of Honolulu- Honolulu Botanical Gardens
HCA- Hawai‘i Conservation Alliance
HDOE- State of Hawai‘i- Department of Education
HEEA- Hawai‘i Environmental Education Alliance
HINSB- Hawai‘i Native Seed Bank
HPCN- Hawai‘i Plant Conservation Network
HSBP- Hawai‘i Seed Bank Partnership
HSF – Hawai‘i Silversword Foundation
HSPC- Hawai‘i Strategy for Plant Conservation
IUCN- International Union for the Conservation of Nature
KANP- Kalaupapa National Park
KIRC- Kahoolawe Island Reserve Committee
KRPF- Koke’e Rare Plant Mid-elevation Facility
LAML- Lyon Arboretum Micropropagation Lab
LASCL- Lyon Arboretum Seed Conservation Lab
LCC- Leeward Community College
LICH – Landscape Industry Council of Hawai‘i
LYON- Harold L. Lyon Arboretum Greenhouse and Gardens
MNBG- Maui Nui Botanical Garden
MoRPF- Moloka‘i Rare Plant Facility
MSB – Royal Botanic Garden Kew Millennium Seed Bank
NARS- Hawai‘i State Natural Area Reserves System
NCGRP- National Center for Germplasm Resources Preservation
NPS- National Park Service
NTBG- National Tropical Botanical Garden: Seed Bank, Nursery and Gardens
OANRP- O‘ahu Army Natural Resources Program
OHA- Office of Hawaiian Affairs
ORPF- Olinda Rare Plant Mid-elevation Facility
PEPP- Hawai‘i Plant Extinction Prevention Program
PIPES- Pacific Internship Programs for Exploring Science
POP- Potentially a PEPP taxa with <100 known plants
PRPF- Pahole Rare Plant Mid-elevation Facility
PTA- U.S. Army Pohakuloa Training Area Natural Resources Program

APPENDIX H. Acronyms

ROI- Rare on Island (a PEPP designation for plants with >100 known but is rare on one or more island
SOC- Species of Concern a designation kept by State and Federal agencies
SOS- Save our Seeds- Bureau of Land Management
TNCH- The Nature Conservancy of Hawai‘i
UCI- University of California at Irvine
UH- University of Hawai‘i
UH-CRDG- University of Hawai‘i- Curriculum Research and Development Group
USDA- United States Department of Agriculture
VRPF- Volcano Rare Plant Mid-elevation Facility
WBG- Waimea Valley Hi‘ipaka LLC

APPENDIX I. List of pictures

APPENDIX J. Letter of support for Hawai'i Plant Conservation Network from Royal Botanical Garden, Kew

Wakehurst Place, Ardingly,
West Sussex, RH17 6TN, UK
Telephone +44 (0)1444 894 100
Facsimile +44 (0)1444 894 110
www.kew.org/msbp

MILLENNIUM SEED BANK PARTNERSHIP
Kew

Proposed Plant Conservation Network

Dear colleagues, 27-02-14

As part of RBG Kew's mission to *inspire and deliver science-based plant conservation worldwide*, the Millennium Seed Bank Partnership represents the largest ex situ plant conservation programme. Following the achievement in 2010 of banking seed from 10% of the world's flora this network of institutions is now working together to conserve the seeds of 25% of the world's flora and to make samples available for study. Key joint activities conducted by the Millennium Seed Bank Partnership include running training courses, undertaking joint seed collecting expeditions, facilitating collection data sharing and investing in capacity building.

As part of my work coordinating the Pacific Programme of the Millennium Seed Bank Partnership, I had the opportunity to meet and talk with some of the people working in the conservation of Hawaiian flora and I found that there is an interest in collaborating with Kew toward our common aim of conserving plant diversity. We are encouraged that the development of a Plant Conservation Network will help to deliver an effective combined response to the threats faced by native species. Kew is a cooperating organisation with the Plant Conservation Alliance http://www.nps.gov/plants/coop.htm which provided an umbrella for initiatives such as the Seeds of Success programme in the USA.

In close cooperation with our US partner the Center for Plant Conservation (copied) and their national initiative for critically imperilled and imperilled plant species, RBG Kew would be pleased to participate as a technical associate to your growing network of institutions, and individuals, working for the conservation of the Hawaiian flora. This suggestion would enable Kew to have a recognised route for communication about strategy development, technical issues or potential projects, and help us integrate with existing capacity in wild species seed banking. The resources necessary for Kew's participation would primarily come from our active projects dedicated to conservation of Pacific flora, but we remain interested in participating in new funding bids as opportunities emerge.

I would be pleased to hear how we could develop this relationship further,

Yours sincerely,

Peter Giovannini

Dr Peter Giovannini
Seed Conservation Department
Royal Botanic Gardens, Kew
Wakehurst Place
Ardingly
West Sussex RH17 6TN,
United Kingdom

APPENDIX K. Potential topics for Phase 2 of the Hawaiʻi Strategy for Plant Conservation: *in situ* habitat protection, restoration ecology and rare plant recovery

- Identification of limiting factors to plant population stability and reproductive success
- Prioritization of important areas in each ecological region for conserving plant diversity
- Review and prioritization of threat mitigation techniques (biological, physical, chemical) and research needs
- Identification of biosecurity measures
- Ecological restoration strategies
- Protocols for transferring germplasm between *ex situ* facilities and into restoration sites
- Identification of opportunities (or lack there of) to conduct restoration outplantings
- Reintroduction/outplanting design
    - Number of populations to represent (single vs. multi-sourced outplantings)
    - Number of wild plants to represent from each source population
    - Number of plants to plant to establish successful outplantings
- Monitoring methods and measures of success for habitat and restoration/reintroduction success (census, population viability analysis (PVA), data to collect)
- Conservation planning for impacts of climate change in Hawaiʻi
- Program and network development to strengthen and expand HPCN activities, identify funding needs for restoration work and securing agreements among network partners
- Workshop topics and work exchange opportunities
- Description of how national and international conservation efforts can support local projects