National Leadership Grants for Museum

Sample Application MG-60-19-0064-19
Project Category: Collections Care and Public Access
Funding Level: Project Grant $50,000-$1,000,000

Chicago Botanic Garden

Amount awarded by IMLS:	$731,633
Amount of cost share:	$734,301

Attached are the following components excerpted from the original application.

- Abstract
- Narrative
- Schedule of Completion

Please note that the instructions for preparing applications for the FY2020 National Leadership Grants for Museums program differ from those that guided the preparation of FY2019 applications. Be sure to use the instructions in the FY2020 Notice of Funding Opportunity for the grant program and project category to which you are applying.

TITLE: Improving ex situ plant conservation: Extending zoo pedigree management approaches to rare, exceptional plant species in botanic gardens

Lead Organization: Chicago Horticultural Society (operating as Chicago Botanic Garden)

The Chicago Botanic Garden, working with the Chicago Zoological Society (operating as Brookfield Zoo), Botanic Gardens Conservation International, and three U.S. botanic gardens (National Tropical Botanical Garden, Montgomery Botanical Center, Atlanta Botanical Garden), will scale up the zoo community's pedigree-based management approach to conserve threatened, "exceptional" plant species (i.e., species that cannot be seed banked and therefore must be curated as living collections) at gardens. This project directly addresses an increasingly critical need in the botanic garden conservation community: how to manage living collections of threatened plants across multiple institutions to maintain maximum genetic diversity and demographic viability, and therefore their potential to support reintroduction efforts over the long term. The zoo community has developed a comprehensive approach to manage captive animals that minimizes the risk of genetic loss by using multi-institution studbooks that track the origin and source of all captive individuals and software that enables a pedigree-based approach to make scientifically-informed breeding and curation decisions.

In a three-year project, we propose to expand the core components of the zoo-based management approach to enable botanic gardens to cooperatively manage collections of threatened plant species. We will 1) collect demographic and genetic information on all known ex situ collections of six threatened exceptional plant species, and use this information to develop pedigrees for all individuals in all collections. Species selected for inclusion in this project will represent a range of life histories and breeding systems to ensure applicability to a wide variety of other plant species. We will then 2) build the digital infrastructure to manage individual-level information necessary to make pedigree-based breeding and curation decisions. This includes developing a "pedigree management module" for Botanic Gardens Conservation International's PlantSearch database—currently the only freely available, web-based platform for information sharing across the botanical community. It will also include creating a new pedigree analysis package, "PMxceptional", with algorithms that are based on but also considerably extend the zoological community's population management software, PMx. PMxceptional will read the information coming from the PlantSearch pedigree module, updating the tools in PMx to accommodate plant life-history traits. We will test this digital infrastructure to 3) establish multi-institution, pedigree-based management plans for all six focal species. Finally, to ensure the digital infrastructure and expertise developed through this project is available to all gardens and for all species, we will 4) create a manual on how to scale up this approach to other plant species, as well as a guide to where we think the approach is most useful to help with species prioritization, and disseminate these tools widely through the BGCI network, publications and presentations.

Performance measures include completion of these digital tools, production of the manual and guidelines, metrics related to completion of training modules, and ultimately the number of gardens adopting pedigree management approaches. This project leverages existing resources rather than creating tools de novo. **It will revolutionize how living collections of threatened plants are maintained in gardens, greatly improving their genetic management and chances for long-term survival.**

Improving *ex situ* plant conservation: Extending zoo pedigree management approaches to rare, exceptional plant species in botanic gardens

Background: Botanic gardens currently curate more than 30% of all known plant species, including over 41% of known threatened species (Mounce et al., 2017). With the rapid loss of species in the wild (Pimm and Raven, 2000), these collections are increasingly important to avoid extinction and support future reintroduction efforts. However, many *ex situ* collections are neither genetically diverse nor secure, and this can hinder species conservation efforts. For example, a study in 2010 found that, of the 844 plant taxa identified as extinct in the wild at that time, 9% were being curated in botanic garden collections, while an additional 5% had been in collections but subsequently lost (Govaerts, 2010). The cause of these losses was not reported but may likely be related to a lack of genetic diversity and/or random loss of plants (e.g., unexpected collection loss due to hurricanes or other extreme weather events, pests or disease, etc.). Regardless, it is clear that a coordinated management approach is needed to effectively conserve threatened plant species *ex situ*.

For some plant species, *ex situ* conservation is most effectively implemented through seed banking, where collection protocols ensure that large, genetically diverse *ex situ* populations are maintained for decades or even centuries (Guerrant et al., 2004). This minimizes the immediate need for a coordinated management approach to ensure long-term collection viability. However, for "exceptional" plant species that either do not produce seeds, or produce seeds that cannot be dried and frozen, seed banking is not an option (Pence, 2013). For the estimated one-third of threatened flowering plant species that are exceptional (Wyse et al., 2018), living plant collections represent the best available *ex situ* conservation option. Yet curating living collections presents many challenges when attempting to ensure their long-term genetic diversity and viability. For example, living collections of a single species are often held at multiple institutions and managed at an accession rather than at an individual level. They may also be of cultivated or unknown origin, without detailed provenance information. This makes it difficult to know how many genetically unique individuals are represented, and how to approach maintaining genetic diversity over multiple generations and institutions. The abbreviated lifespans of plants in living collections also hinder the ability to preserve unique lineages and genetic diversity through time (Griffith et al., 2017).

The curation challenges faced by the botanical community closely parallel those faced by the zoo community's conservation efforts with captive animal populations (Lees and Wilcken, 2009). In response to these challenges, the zoo community has developed a comprehensive approach to manage captive animals that minimizes the risk of genetic loss within the *ex situ* population (Ballou et al., 2010). They achieved this through the maintenance of multi-institution studbooks that track the origin and source of all captive individuals, and the development of software that enables a pedigree-based approach to making scientifically-informed breeding and curation decisions and to maintaining genetic diversity and population viability (Lacy, 1994). In one prominent example, this approach was used to successfully reintroduce 3,500 black-footed ferrets (*Mustela nigripes*) to the wild after they were reduced to only 18 remaining individuals (Shoemaker et al., 2014). **Here, we propose a project that expands the core components of the zoo pedigree-based management approach to enable botanic gardens to cooperatively manage *ex situ* collections of threatened plant species, particularly those that are "exceptional".**

A. PROJECT JUSTIFICATION

What do you propose to do?

We propose to scale up the zoo community's pedigree-based management approach to conserve exceptional threatened plant collections at botanic gardens. For this, we will (1) collect demographic and genetic information on all known *ex situ* collections of six threatened exceptional plant species (see Supporting Document 1 for a list of species, their conservation status, and reasons for inclusion in the project). This information will be used to develop pedigrees for all individuals in all collections. Species selected for inclusion in this project will represent a range of life histories and breeding systems to ensure applicability to a wide variety of other plant species. We will then (2) build the digital infrastructure to manage individual-level information necessary to make pedigree-based breeding and curation decisions for threatened species maintained across multiple institutions. This includes developing a "pedigree management module" for Botanic Gardens Conservation International's (BGCI) PlantSearch database as a plant collections data hub comparable to the zoo studbooks that will allow us to collect and manage demographic and pedigree information at the individual plant level, which is not typically done at botanic gardens. It will also include creating a new pedigree analysis package, "PMxceptional", with algorithms that are based on the zoo community's population management software, PMx, and also considerably extend its capabilities. PMxceptional will read the information coming from the PlantSearch pedigree module, updating the tools in PMx to accommodate plant life-history traits. We will test this digital infrastructure to (3) establish multi-institution, pedigree-based management plans for all six focal species. Finally, to ensure the digital infrastructure and expertise developed through this project is available to all gardens and for all species, we will (4) create a manual on how to scale up this approach to other plant species, as well as a guide to where we think the approach is most useful to help with species prioritization.

This project recognizes the critical role that botanic gardens play in the curation and conservation applications of living plant collections, and utilizes the invaluable expertise resident within the zoo community to build an infrastructure for more effective conservation management. We aim to engage gardens across the country to build and test a cloud-based infrastructure for multi-institution, pedigree-based management. Once completed, our study species will serve as the foundation for the inclusion of a growing number of species and gardens.

The Chicago Horticultural Society (operating as the Chicago Botanic Garden) has a proven track record of effective collaboration and engagement of gardens nationally and globally. We have collaborated with National Tropical Botanical Garden (NTBG) on numerous genetic analyses to inform their ex situ collections, including those of *Brighamia insignis*, and have worked with the global botanic garden community to acquire collections information and leaf tissue to enable the development of pedigrees for all known curated plants. This collaboration led to an ongoing IMLS-funded project (*Safeguarding our plant collections*) awarded to Montgomery Botanical Center (MBC), which supported work by the Garden, Chicago Zoological Society (CZS) and Species Conservation Toolkit Initiative (SCTI), BGCI, and NTBG on the first tests of plant data in PMx. This project directly informed the needs identified and addressed by this project. Additionally, the Garden is a collaborator on a current IMLS-funded project (*Establishing the exceptional plant cryo bank, award* to Cincinnati Zoo and Botanical Garden 2018-2020) aimed at advancing research on endangered exceptional plant species with BGCI, NTBG, and Atlanta Botanical Garden. It was through this collaboration that we identified focal species for inclusion in this project at Atlanta Botanical Garden.

What need, problem, or challenge will your project address, and how was it identified?
This project directly addresses an increasingly critical need in both the botanic garden and plant conservation communities: how to manage living collections of threatened plants across multiple institutions to maintain maximum genetic diversity and demographic viability, and therefore maintain their potential to support reintroduction efforts, over the long-term. The number of wild founders will determine the maximum genetic diversity of a collection. Consequently, botanic gardens have focused increasingly on ensuring that *ex situ* collections capture sufficient genetic diversity from the wild (Griffith et al., 2015). However, as an *ex situ* collection ages, some loss of diversity is inevitable. Unfortunately, management decisions for maintaining and distributing this diversity to slow the rate of decline are not prioritized by, or even possible for, many institutions. This is particularly an issue for "exceptional" species that cannot be seed banked, and are maintained solely as living collections. Minimizing losses will require distributing founding diversity across multiple institutions, to ensure redundancy, and careful tracking of lineages within any single institution. Currently, the botanic garden community has no infrastructure to track founding individuals, to manage this diversity across multiple institutions, to make informed decisions about which plants to breed to minimize losses of diversity and prevent inbreeding, or how best to invest limited resources in resulting progeny. This means that even large and genetically diverse collections are susceptible to genetic loss and even demographic collapse.

The critical need for this project was made clear in our collaborative work with *Brighamia insignis* (Campanulaceae), an endemic Hawaiian plant species with only one remaining individual in the wild. This species is often used as an *ex situ* conservation success story, with hundreds of plants in curated *ex situ* collections at botanic gardens around the world. Because it is relatively short-lived (10-20 years) and the seeds of this species lose viability rapidly over time, this species in maintained in *ex situ* collections through the continual production of new individuals. The NTBG in Kauai, Hawaii currently curates the largest collection of *B. insignis*. Recent studies by NTBG have demonstrated increasingly poor pollen viability and low seed set in the remaining individuals (likely due to genetic issues, including inbreeding).

These deficiencies were addressed as part of an IMLS-funded project (*Safeguarding Our Plant Collections* to Montgomery Botanical Center, 2017-2019). For this, the Garden and NTBG developed a pedigree of *ex situ* collections of this species which revealed the disappearance of five unique genetic lineages from NTBG's collection (random losses) and an increase in levels of inbreeding. Fortunately, because this species is cultivated *ex situ* in at least 57 other botanical collections around the world, we were able to identify sources of genetic diversity lost at NTBG residing in plants curated at other botanic gardens. Using this data, we identified genetically unrelated individuals to perform test crosses that resulted in an increase in plant vigor and restoration of pollen viability within the collection. Without the infrastructure provided by this previously-funded project to plan and implement the long-term management approach for *B. insignis*, this species may have faced extinction within a generation. From this work we have demonstrated that **there is an urgent need for a science-based management infrastructure to plan and prioritize breeding and exchange of important genetic information if we are to maintain the genetic diversity and demographic viability of our *ex situ* collections and support future reintroduction efforts** (Fant et al. 2016).

The same IMLS grant that supported our work with *B. insignis* also supported our first formal collaboration with experts in the zoo community related to the pedigree management software,

PMx. The development of PMx was also supported in part by IMLS (*Pedigree reconstruction to sustain populations*, Chicago Zoological Society, 2005-2007), and the software is now at the core of all decisions made by zoos to breed and manage animal collections across sites. Using *B.insignis* and *Zamia lucayana*, we piloted PMx software as a tool to determine breeding and management decisions for these threatened plants. A large part of our project involved identifying common fields and gaps in functionality when entering genetic and demographic information for plants into this animal-specific software.

Through this process, we identified two key approaches that will create necessary infrastructure supporting *ex situ* plant conservation: 1) expand BGCI's PlantSearch database, creating a repository of pedigree data for threatened plant species held in collections, and 2) adapt PMx to make it more useful and effective for plant species. The expanded BGCI PlantSearch database—currently the only freely available, web-based platform for sharing collections information across the botanical community—will provide critical information about *ex situ* plant collections for analysis with the new PMxceptional software to be developed by this project. The proposed development of a new software package, PMxceptional, will build on the current animal-focused software and incorporate fields that accommodate the wide range of plant life histories and breeding systems.

How will the museum field benefit from your project?

This project is explicitly designed to support the needs of the botanic garden community to efficiently and effectively manage *ex situ* collections for long-term maintenance of their conservation value. We will build capacity and expertise among the four botanic gardens that participate directly in this project. And because the tools/infrastructure developed will be freely available to all gardens (maintained and distributed by BGCI and the Species Conservation Toolkit Initiative [SCTI]), complete with a user guide and case studies, it will allow any botanic garden wishing to engage in building and managing the conservation value of their collections to do so. This will propel the botanic garden and plant conservation communities into the 21st century. Moreover, this project will build additional conservation capacity in the zoo community because PMxceptional will be useful for managing animal groups that are not strictly dioecious, e.g. some invertebrates and fishes.

How will your project address the goals of the NLG for Museums and align with the project category you have chosen?

The botanic garden community has adopted plant conservation as one of its primary goals (BGCI, 2016). Maintaining the genetic diversity represented in *ex situ* collections is one of the biggest challenges in meeting conservation goals. This project will provide the tools to allow gardens to maintain diversity more efficiently and effectively, advancing conservation practices for botanical institutions nationally and globally. **Our project aligns with the NLG Building Capacity goal and the Collections Care and Public Access category.** In particular, we will be adapting and applying tools used in the zoo community to the *ex situ* collection management of plants, and expanding functionality of the only global database of botanic garden collections to create a dynamic, two-pronged system. This scaling up of conservation management approaches leverages what we have learned from previous IMLS-supported work with *Brighamia insignis* that addresses the challenges identified when attempting to collect and use the necessary data from plant collections to create pedigrees. We also address the problems identified with modifying plant data in order to use an animal-focused pedigree management software program, PMx. We have worked closely with collaborators in the zoo community to determine what changes are needed to adapt their software program for plants. We have collaborated with BGCI and gardens around the world to test and

visualize an accessions module for the PlantSearch database. **This project will revolutionize how living collections of threatened plants are maintained in gardens, greatly improving their genetic management and their long-term chances of survival.**

B. PROJECT WORK PLAN

What activities, including evaluation and performance measurements, will you carry out?

We propose to replicate our approach with *Brighamia insignis* with six other species of conservation concern (see Supporting Document 1 for taxa list, information, and justification). The ultimate goals are to 1) demonstrate the effectiveness of this approach in a wide variety of plant groups; 2) to secure six species in a diverse range of collections; 3) to build capacity for the implementation of this approach at partner botanic gardens, and; 4) to create a replicable process and toolkit to extend this approach throughout the botanic garden community for additional threatened plant species. The project has several components:

1. Compile individual-level accession data of all curated plants of focal taxa

In conservation, the value of a curated plant increases when its wild provenance is known. BGCI's PlantSearch is the only global database of living botanical collections, which currently holds only taxon-level information for over 500,000 taxa curated by more than 1,000 institutions around the world, including over 160,000 taxa curated by nearly 300 institutions in the U.S. alone. Our goal will be to use PlantSearch to connect with each institution that holds, or has held, one of our focal taxa, and to collect any available data on wild source location, possible exchanges among institutions, and parental sources of seeds produced in cultivation. Any information we can gather on focal plants, both living and dead, will allow us to track movement of accessions following wild collection events to their current locations, and build a preliminary pedigree for each species. Because most plants are curated at the accession level, rather than by individual, and typically have uncertain parentage, we expect to have incomplete pedigrees. To increase pedigree accuracy we will use genetic analysis (Step 2) to fill information gaps. PMx software currently has functionality to assess the completeness of pedigrees, and these metrics will also be built into PMxceptional so that they can be used to evaluate our progress for this part of the project. Additional performance measures include number of accession records compiled and number of wild provenance individuals identified. At this point, we have do not know how many records or founders exist, but are aiming for pedigrees that are at least 90% complete (75% complete is usable; 90% or higher is ideal).

2. Conduct genetic analyses to determine or confirm pedigrees

Once we have identified all living plants in collections, we will request a small amount of dried leaf material be sent to Chicago Botanic Garden for genetic analysis. Genetic analysis, using microsatellite markers, will be used to determine (or confirm) the lineage of each curated plant back to the original founding plants of the *ex situ* collection. This will allow us to 1) assign a likely wild source to each curated individual, which is desirable for guiding future reintroduction efforts; and 2) determine how many of the original founders brought into cultivation are still present in collections or represented by living descendants. This information is essential for development of a breeding and management program that will ensure that the genetic diversity of plants that originally founded the ex situ collection is maintained and represented as equally as possible across collections and institutions. The SCTI is currently working with researchers at San Diego Zoo Global to add a tool to PMx to identify the specimens for which molecular genetic information would do the most to fill important gaps in the population pedigree, and this tool would be available also for use in PMxceptional. Performance measures include number of accessions analyzed, number of unique

lineages identified, and number of redundant lineages identified.

3. Update BGCI's PlantSearch database to support collaborative pedigree management

One challenge to using PMx or other pedigree analysis software for plant conservation is that botanic gardens currently do not have a studbook management database (such as SPARKS or ZIMS used by zoos), so pedigree management must be done manually (Step 1). Therefore, we will develop a "PlantSearch pedigree management module" that emulates the zoo community's studbook databases. For this, we will use information gathered in Step 1 to test the data collection form functionality and ensure future data contribution from botanic gardens is streamlined. We will also use guidance from Step 4 to ensure that data managed in PlantSearch can be directly imported to the new "PMxceptional". Once complete, all data collected from Steps 1-2 will be entered into the new PlantSearch pedigree module, and all institutions that curate focal species will be asked to help test functionality. Performance measures include the addition of an online data entry form and number of species and accessions added to the pedigree management module.

4. Create population management software to better accommodate plants

PMx was designed by the zoo community for animals and currently does not accommodate many important life-history traits specific to plants. With prior IMLS funding, we identified numerous components of the software that need to be adapted or improved for plants, including allowing for clonal reproduction, self-fertilization, monoecious breeding systems, sex-change, and the use of demographic models that are stage or size-based rather than age-based. The plant-specific requirements identified during our previous IMLS project will be used to design a new software package using the existing PMx framework. Our focal taxa represent a wide variety of life-histories and breeding systems, affording the opportunity to iteratively adjust software functionality as we progress through the project and data from each taxa become available through Steps 1-3. The focal species' diversity increases the likelihood that the new software package will be able to accommodate most plant taxa upon completion of the project. Although not a direct goal of this project, the PMxceptional pedigree analysis software will also be valuable for the many animal species (e.g., many invertebrates, fishes, amphibians, and reptiles) that have more diverse life histories than do the mammals and birds that have been the primary focus of cooperative breeding programs at zoos to date. We will measure progress as 1) completion of each item identified during initial software design; 2) identification of new issues arising from testing with data from the six focal species; and 3) completion of issues identified during testing. Throughout the design and build process, we will be evaluating the format of the data file exported from the PlantSearch pedigree module developed in Step 3 to ensure that all information needed for population management is accessible by the new PMxceptional software.

5. Develop pedigree management plans for all focal species

Using the new PMxceptional, pedigree management plans for all focal species will be developed. This will involve working with all institutions that curate each focal species, and ensuring that they utilize the new PlantSearch pedigree module (Step 3) to update and manage data on all associated plants curated in collections. Outputs from PMxceptional will be used to determine optimal breeding and transfer plans to maintain genetic diversity and identify any individuals that are redundant and not a high priority (and possibly detrimental) to include in future crosses. Performance measures include completing the management plans and number of recommendations from those plans carried out.

6. Disseminate results, invite participation, justify and support future expanded use

To ensure that the botanical community is easily able to access the new resources this project creates, we will develop a manual on how to use the PlantSearch pedigree module and PMxceptional. This manual, along with the software and database, will be made freely available online, communicated at professional conferences, and distributed through botanic garden networks, including BGCI. SCTI is in the process of developing on-line training materials for components of PMx using Articulate 360, a comprehensive suite of on-line authoring tools for building custom interactive modules, screencasts, and responsive web courses. We will develop similar materials for PMxceptional and make them freely available via a conservation tools training section that is being implemented on SCTI's new website (soon to be unveiled at http://scti.tools). We will evaluate course effectiveness and gain insight into learning behaviors by tracking metrics related to module completion rates, learner performance, and learner satisfaction. The training section of the SCTI website will also host dynamic forums in order to allow new users of these tools to engage and learn from each other. We will also develop a guide outlining when a pedigree-based management approach will be most useful to inform species prioritization. Finally, to help support and justify future expanded use, we will explore: 1) how effectively diversity in collections can be maintained long-term using a pedigree-based management approach versus business as usual (e.g. typical botanic garden curation practices that do not involve crossing individuals between institutions); and 2) when it is necessary to incorporate genetic analyses into this approach. To accomplish this, we will create two separate pedigrees for each species which will allow us to compare management recommendations based on accession data only, as well as genetic and accession data combined. Additional performance measures include production of the manual and guidelines, metrics related to completion of training modules, and number of gardens adopting pedigree management approaches. Success at this scaling stage would be 50 gardens using these tools by the end of the grant period.

What is your project's maturity level?

This project is at the scaling stage. We have piloted the approach with plant species in a previous IMLS-funded project, the results of which show great promise for further application across the botanic garden community (see "what need does your project address?"). Over 1,100 gardens around the world currently provide collections data to BGCI's PlantSearch database. Testing of an accessions-level module for PlantSearch over the past two years has prepared BGCI for implementation. The tools for pedigree management using PMx are well developed (also previously IMLS-funded) in the zoo community. With some adaptation, this existing asset can be augmented to improve plant collection management, capitalizing on the initial investment and avoiding duplication of effort and federal resources.

What are the risks to the project and are they accounted for in the work plan?

The work we propose here is quite straightforward and we do not anticipate problems in completing the outlined tasks. There are inherent risks in developing existing software to perform new functions, however both the PlantSearch and PMx teams have been involved in tests using accessions-level plant data. The next steps beyond this project, e.g. mainstreaming its use globally, may be more difficult. The zoo community maintains approximately 1,000 studbooks for animals on a largely voluntary basis. We anticipate some 25,000-50,000 plant species could benefit from this approach, but the garden community will need to carefully prioritize which species to manage this way to avoid being overwhelmed by the task. Part of our task with this project is to demonstrate concretely the benefits of this approach (versus the status quo), and to create buy-in among the botanic garden community by disseminating the data through professional conferences and botanic

garden networks and publications, including BGCI's member network and journal.

Who will plan, implement, and manage your project?

The following personnel will plan, implement, and manage this project. Their biosketches (or job decriptions for new positions to be filled) are included in the Resumes attachment. Organizational letters of support are available in Supporting Document 2. Descriptions of their project roles are in the Project Staff document.

Chicago Botanic Garden
Kayri Havens – Senior Director of Ecology and Conservation and Senior Scientist, co-PI
Jeremie Fant – Conservation Scientist, Genetics, co-PI
Andrea Kramer – Conservation Scientist, Restoration
Bianca Rosenbaum – Conservation Data Manager

Botanic Gardens Conservation International, U.S.
Abby Meyer – Executive Director
Meirion Jones – Head of IT at BGCI-global

Chicago Zoologicial Society (CZS) and Species Conservation Toolkit Initiative (SCTI)
Taylor Callicrate – Conservation Scientist & Programmer
Sara Sullivan – SCTI Training Specialist
Conservation Scientist (to be hired by CZS in early 2019)
Post-doctoral Fellow – Species Conservation Methods (to be hired in 2019)

SCTI Project Advisors
Robert Lacy – Senior Conservation Scientist Emeritus, CZS. Together with Jon Ballou, was the developer of PMx and the originator of many of the methodologies now used for guiding management of animal breeding programs. Will continue to consult with and assist the SCTI team after his retirement from CZS.
Jon Ballou – Research Scientist Emeritus, Smithsonian. A pioneer in the field of population management, including an author on multiple influential books. Retired, but continues to collaborate with SCTI.

Partnering Gardens
Each of the gardens below will provide all available accessions data and tissue of their chosen taxa for genetic analysis (see Supporting Document 1). This includes samples from plants held in their collection and samples obtained from all other documented living collections. They will assist the Chicago Botanic Garden team in developing a pedigree for their taxa based on collections records and the genetic results. They will also help with testing data entry and functionality of the PlantSearch pedigree module and PMxceptional tools.
Atlanta Botanic Garden – Emily Coffey and Andrew Bunting
Montgomery Botanical Center – Patrick Griffith

National Tropical Botanic Garden – Seana Walsh

When and in what sequence will your activities occur?
This project will take three years to complete. A schedule of activities and the timing of their completion is available in the attached Schedule of Completion.

What time, financial, personnel, and other resources will you need to carry out the activities?
Financial resources and time commitments of key personnel are provided in the budget and budget justification. The Chicago Botanic Garden will carry out the genetic analyses with the assistance of a laboratory technician to be hired. They will also develop the PlantSearch pedigree module with a programing technician to be hired. BGCI will implement and test needed PlantSearch developments in collaboration with the programmer based at CBG. Chicago Botanic Garden science and data management staff all have office and laboratory space in the Daniel F. and Ada L. Rice Plant Conservation Science Center. This nearly 40,000 sq. ft. facility features a series of work spaces and nine laboratories, including labs centered on plant genetics, plant ecology, population biology, seed conservation, and more. All the equipment needed for this work is already in place.

The SCTI team will carry out all software design and development tasks for PMxceptional. SCTI is hosted by the Chicago Zoological Society, which provides office space at the Brookfield Zoo and collaboration tools for remote team members. A laptop workstation will be needed for the new Postdoctoral Fellow. No additional software or hardware will be needed for the existing SCTI staff who will be working on this project.

How will you track your progress toward achieving your intended results?
The project team will meet annually in person and quarterly via skype to monitor progress toward our quantifiable goals outlined in the logic model (Supporting Document 1). With much of the project team residing in Chicago, additional meetings will be scheduled as needed. The SCTI team building the PMxceptional software will meet with key partners about every 6 months to design, test, and refine components of the new software tools as they are developed.

How and with whom will you share your project's results?
This project will be shared widely with the botanic garden community through presentations at professional conferences including the American Public Gardens Association annual meeting and Botanic Gardens Conservation International's Global Botanic Gardens Congress, as well as through publications in their member newsletters and magazines. In addition, results will be shared through scientific publications and presentations. We will share all software, manuals, and other user tools free of charge, through online portals at BGCI and SCTI.

C. Project Results

Performance Measures

Our project falls under the "Build Capacity" goal. For the IMLS performance measures, we will create and administer a survey for people who undertake the SCTI training modules. We will evaluate course effectiveness and gain insight into learning behaviors by tracking metrics related to module completion rates, learner performance, and learner satisfaction. Using a 5-point scale, we will ask learners the questions below and report number of participants, total responses, responses per answer option, and non-responses:

- My understanding has increased as a result of this program/training
- My interest in this subject has increased as a result of this program/training
- I am confident I can apply what I learned in this program/training

How will the knowledge, skills, behaviors, or attitudes of the audience change?

Plant living collection managers who learn about the pedigree-management approach from our network outreach, presentations, and publications will be encouraged to take the SCTI training modules. Through this training, they will understand the benefits of this approach for minimizing genetic loss and will be empowered to enter their threatened species collection data into the PlantSearch Pedigree Module and to use PMxceptional. Additionally, the public will benefit from more effective and efficient conservation of endangered plants. While it is impossible to know what benefits society may gain from these and other threatened plant species, it is clear those benefits will be lost if these species are extinct.

What tangible products will result from your project?

Tangible products and performance measures are outlined in our logic model (Supporting Document 1). Tangible products include the PlantSearch Pedigree Module, PMxceptional software, pedigrees and management plans for the six focal taxa, training modules for PMxceptional (that include our survey questions), an online manual, 3-4 publications and at least 4 presentations at relevant conferences. Project success is defined as the adoption of pedigree management by 50 gardens by the end of the grant period. We expect that once plant conservation practitioners better understand the benefits of this approach, and have digital resources and an infrastructure in place to support it, they will be eager to incorporate it into their conservation programs.

How will you sustain the project?

Both BGCI and CZS are committed to keeping the software useful and usable and have a long record of doing so with PlantSearch and PMx respectively through their operational budgets. General ongoing maintenance is institutionally supported. The project team will work through BGCI to disseminate information about the project and its benefits throughout the botanic garden community.

Literature Cited:

References for the literature cited in this proposal are provided in Supporting Document 3.

Appendix 3: Schedule of Completion (CBG: Improving ex situ plant conservation)