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Collaborative Conservation by Botanical Gardens: Unique Opportunities for Local to Global Impacts

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Abstract: Conservation organizations with common missions can find strength and synergy in collaboration. Collaboration can also be challenging, especially finding the right partnerships or organizations to lead. Within the “ecosystem” of conservation organizations, botanical gardens have a unique array of resources and expertise which make them ideal candidates for leadership or partnership in collaborative conservation efforts. We will explore this idea by examining four conservation initiatives at Desert Botanical Garden (Phoenix, AZ, USA) that approach collaborative conservation on regional, state, and international scales. On a regional scale, Metro Phoenix EcoFlora and the Central Arizona Conservation Alliance lead landscape-level conservation by providing a structure for more than 60 official conservation partners, by generating data, and through public engagement needed in a rapidly developing region. On the state scale, Great Milkweed Grow Out is an initiative for pollinator conservation that provides expertise, materials, and opportunities for a wide range of partners across Arizona. Desert Botanical Garden’s endangered plant species conservation efforts provide expertise and resources through horticulture and seed preservation for threatened and endangered plants across the US and internationally. We will share the structure of each program where applicable, how they came to fruition, and their successes. Through each case study, we will highlight the ways positioning within a botanical garden has benefitted the program and success in collaboration. We will also highlight unique challenges. Botanical gardens provide unique opportunities, and they should not be overlooked when seeking a conservation partner or leader.

Keywords: botanical gardens; conservation; collaboration; natural resource management; outreach; science communication; endangered species; pollinator; conservation horticulture; seed banking



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1. Introduction

Human impacts worldwide have generated the urgent need for conservation of natural resources. In modern times, this work has involved organizations of all kinds, including government agencies, academic institutions, NGOs and non-profits, industry, land managers/owners, and communities. While progress has been made to protect the environment through the individual efforts of these entities, the increasing rapidity and complexity of biodiversity loss has made it clear that collaborative conservation efforts are essential to effectively address this global threat. Collaboration, however, is a complex process that requires skilled and dedicated leaders for its successful implementation. Botanical gardens are uniquely suited as backbone organizers and leaders through the expertise, resources, and common ground that they represent. This paper will explore the role of botanical gardens in collaborative conservation through the close examination of several Desert Botanical Garden (Phoenix, AZ, USA) case studies.

1.1. Collaborative Conservation

Collaborative conservation includes efforts to preserve, protect, and/or sustainably manage natural resources by two or more entities explicitly working together, often includ-

ing shared goal setting, decision making, and implementation [1]. Joint efforts to manage natural resources equitably and sustainably go back to ancient times, but modern, Western conservation efforts have most often emphasized the centralized decision making of single organizations and top-down management until recently [2,3]. Increasingly, collaborative efforts are now acknowledged [4,5] as being essential to conservation due to their potential to address landscape-scale conservation needs that transcend management boundaries, include common pool resources and/or limited resources for management (e.g., funding and staff capacity), and the pressing need for diverse perspectives and knowledge types to support innovation [1,6,7].

A robust knowledge base has been developed that examines the complex process that collaborative conservation efforts entail and deepens our understanding of the factors that lead to success. In particular, two bodies of knowledge apply to the work represented here. The first is Ostrom's Design Principles [8], which define factors for success among efforts to jointly manage common-pool resources. These include defined boundaries; governance with fit-to-place, participatory decision making and the right to organize; monitoring of resources; graduated sanctions; access to conflict resolution; and the presence of nested networks [9]. While we will not be delving into this framework in this paper, several of the case studies presented concern common-pool resources and implicitly include consideration of the design principles in their structure. More explicit is the integration of the collective impact framework into the efforts of the Central Arizona Conservation Alliance (CAZCA), which is considered among the case studies. Collective impact focuses on the structures necessary for effective collaborative effort including (1) backbone staff to facilitate the collaborative efforts, (2) a common agenda among partners, (3) shared measurement of results, (4) mutually reinforcing activities throughout the collaboration, and (5) open and continuous communication [10].

1.2. Botanical Gardens and Conservation

Botanical gardens and arboreta (henceforth jointly referred to as botanical gardens) around the world display living plants and provide opportunities for visitors to learn about and enjoy them. They also contribute to plant conservation on all scales—local to global. In most cases, these living plants serve as collections for ex situ conservation. It is estimated that 25–30% of plant species are accessioned in living collections of botanical gardens globally [11–14]. Seed banks house collections that exceed 55,000 plant species from around the world, which is valuable for the preservation of genetic diversity [15,16]. Botanical garden herbaria provide depositories of plant specimens for documentation and research totaling more than 140 million specimens worldwide [17]. They contain valuable data on plant diversity, distribution, and historical records that can serve as a baseline for studies of climate change and species assessments. Scientists and staff at botanical gardens and collaborating institutions use living collections, seed banks, and herbaria to study all levels of botany, including taxonomy, plant biology, physiology, ecology, and conservation [17,18]. Scientists serving botanical gardens often also participate in in situ conservation [19,20].

Beyond research and collections, botanical gardens can support or lead conservation efforts through public education [14,21,22]. Programs, visitor centers, and classes can teach learners of all ages about plants, ecosystems, and climate change while countering “plant invisibility” [21–24]. They can also engage people in the appreciation of plants through community science initiatives that encourage participants to seek out flora while providing crucial data to scientists [14,25,26].

Botanical gardens have key resources and qualities that enhance their ability to serve as centers for collaborative conservation. This paper will highlight some of these benefits and give examples through case studies of four programs or initiatives at Desert Botanical Garden (DBG). Each case study will describe the development of the collaboration, key successes and quantifiable results, and how positioning within DBG has fostered these

successes. The discussion will explore some of the challenges faced by collaborative botanical garden conservation efforts.

2. Materials and Methods

The focal institution examined in this paper is the Desert Botanical Garden (DBG), located in Phoenix, AZ, USA. As of 2022, DBG manages 140 acres of Sonoran Desert habitat with over 50,000 arid ecosystem plants. These plants consist of more than 4800 taxa, over 500 of which are of conservation concern [27]. DBG has a growing base of skilled staff, hundreds of volunteers, and welcomes an average of 450,000 visitors a year.

DBG was founded in 1939 to conserve desert plants and habitat in a rapidly expanding city and has maintained this commitment to conservation. In 1985 it became a charter member of the Center for Plant Conservation, in 2012 it was a founding member of the Central Arizona Conservation Alliance (CAZCA), and in 2017 DBG completed the Hazel Hare Center for Plant Science (HHCPs). Its most recent strategic plan also carries the mission forward with an entire section focused on environmental sustainability and plant conservation [28].

The focus of this paper will be on the collaborative initiatives and projects of DBG that demonstrate the role of botanical gardens in local, regional, national, and international collaborative conservation efforts. These include the Metro Phoenix EcoFlora (MPE), CAZCA, Great Milkweed Grow Out (GMGO), and DBG's endangered plant conservation program and efforts (Table 1).

Table 1. Summary of DBG case study programs/projects.

Program/ Project Name	Conservation Focus	Scale	No. of Collaborators	Types of Partner Organizations
EcoFlora	Urban biodiversity, alleviating plant invisibility, open-access data and information	Local—Metro Phoenix area	40+	Non-profits, academic, municipal agencies, societies, professional scientists, local experts, community members
CAZCA	Habitat connectivity, restoration, outreach, collaborative coordination	Regional—Maricopa County and associated HUC watersheds	70+	Federal, state and municipal agencies, non-profits, academic institutions, industry
GMGO	Pollinators, native plant materials, research, outreach	State	60+	Federal and state agencies, non-profits, academic institutions, community members, K-12 schools
Endangered Species Plant Conservation	Rare, threatened, and endangered plant conservation ex situ and in situ	International	70+	Federal and state agencies, IUCN, other botanical research institutions

2.1. EcoFlora

EcoFlora is an initiative of the New York Botanical Garden (NYBG) created in 2016. The program is focused on understanding urban biodiversity, increasing access to biodiversity data and information, and alleviating plant invisibility. Simultaneously, the project bolsters herbarium collections, documents plants and their associated organisms, and engages with the public. Observations are recorded by community scientists using iNaturalist (<https://www.inaturalist.org/> accessed on 15 February 2022), a free and open-source, web-based platform and app that is a joint initiative by the California Academy of Sciences

(San Francisco, CA, USA) and the National Geographic Society (Washington, DC, USA). iNaturalist engages users by functioning as a digital field guide, suggesting identifications and providing taxon information, while also serving as a database that includes images and geospatial data. EcoFlora engages the public through presentations, training, events, educational resources, and communications.

In 2019, a National Leadership Grant from the Institute of Museum and Library Services was awarded to NYBG to expand the program within the United States, and four partner botanical gardens were selected to implement the EcoFlora model in their respective locations. DBG was selected, along with Chicago Botanic Garden, Denver Botanic Gardens, and Marie Selby Botanical Gardens. The projects are collectively known as the EcoFloras of North America. Each garden operates their EcoFlora project autonomously, while collaborating under the guidance of NYBG.

The EcoFlora program at DBG is known as the Metro Phoenix EcoFlora (MPE). It began in February 2020 and operates within the CAZCA initiative (Section 2.2). The study area includes metro Phoenix (AZ, USA) and is estimated to cover 2700 square miles (4300 square kilometers) (Figure 1). MPE prioritizes community engagement and collaboration, emphasizing that awareness is the first step in increasing appreciation of plant life and environmental literacy, thereby fostering public involvement in conservation [29]. The project collaborates with scientists, organizations, and community members in events, communications, resources, and data collection. Additionally, the iNaturalist observations and information gathered in the metro Phoenix area complement existing floristic data in the Southwest Environmental Information Network (SEINet; <https://swbiodiversity.org/seinet/> accessed on 15 February 2022) and the DBG herbarium collections.

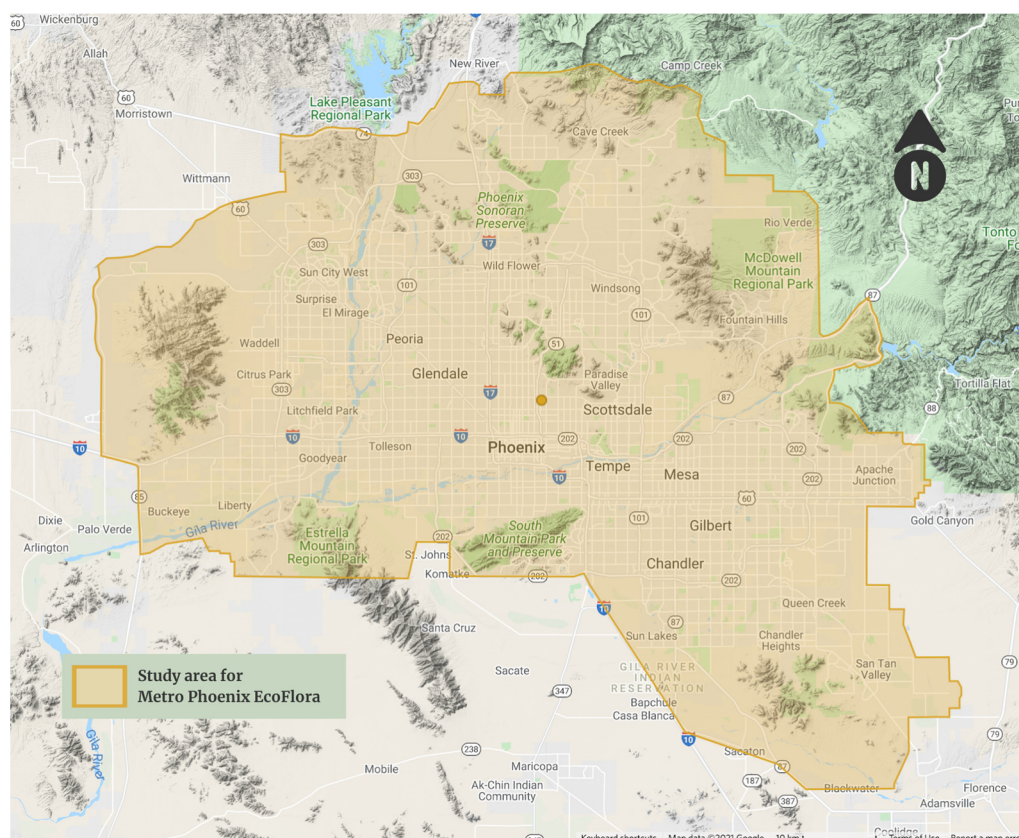


Figure 1. Study area for the Metro Phoenix EcoFlora project created with iNaturalist, using Google Maps data.

2.2. Central Arizona Conservation Alliance

CAZCA is an initiative of DBG designed to lead regional conservation collaboration through strategic planning and convenings, as well as programmatic work. The initiative was founded in 2012, with leadership from DBG along with Arizona State University, Maricopa County Parks and Recreation Department, and others. The motivation for this effort was the rapid population growth in Maricopa County and associated biodiversity loss due to development practices [30,31]. It was believed that collaborative leveraging of limited resources and sharing of expertise through CAZCA would support the increased flexibility, adaptability, and scale of conservation efforts necessary to protect ecosystem health while balancing the needs of a growing population. CAZCA's primary spatial focus is on Maricopa County in Arizona, USA, with additional areas for associated Hydraulic Unit Code (HUC) 10 watersheds (Figure 2) to increase the ecological relevance of CAZCA's work [32].

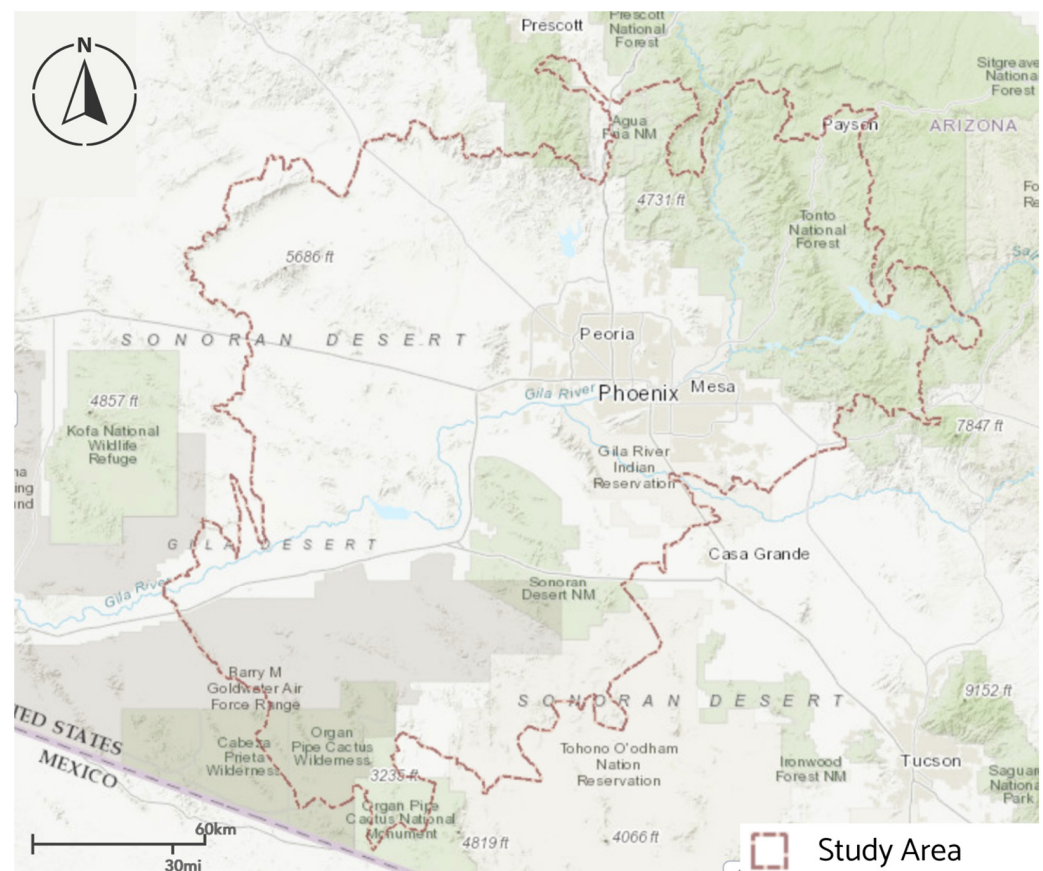


Figure 2. Map of the CAZCA study area in Arizona, USA.

Structurally, CAZCA follows the Collective Impact model [10], with DBG serving as the backbone organization that houses the staff dedicated to the collaborative work of the initiative. At the time of writing this article (2022), CAZCA had a staff of two, a program director and an engagement coordinator, three dedicated volunteers, and annual contracted expertise. The initiative is further supported and advised by a steering committee with representation from six organizations from among the 70+ partner organizations that make up the Alliance.

The work of the initiative is guided by the Regional Open Space Strategy for Maricopa County (ROSS). The ROSS was the first major CAZCA project and was developed through 18 months of iterative discussion among 73 participating organizations (Appendix A). The focus of these convenings was to develop goals and objectives that would be necessary to attain the shared vision of a regional network of natural open spaces across Maricopa

County. This network of natural open spaces, as envisioned, would be structured and managed to support biodiversity and human well-being. This resulted in a finalized document published in 2018, with four primary goals outlined by the partner organizations [33]:

1. Protect and Connect—Ensure a robust network of habitat blocks and connections to sustain native plant and animal communities, provide opportunities for recreation, support clean air and water resources, and improve resilience to drought, extreme heat, and flooding.
2. Sustain and Restore—Identify and engage best practices in land management and restoration to sustain and enhance native biodiversity, positive recreational experiences, and socio-economic benefits connected with the Sonoran Desert.
3. Love and Support—Build champions and constituency of support and action for Sonoran Desert conservation by raising awareness and connecting people with nature.
4. Coordinate and Elevate—Build upon the CAZCA foundation to ensure and amplify regional open space collaboration, coordination, management, and conservation successes.

Since 2018, CAZCA has shifted its focus to accomplishing the objectives outlined by the ROSS. This work is carried out through two methods: (1) facilitating and supporting continued and targeted convenings; and (2) innovative, collaborative project incubation. In both cases, the initiative staff consult with partner organizations on the identification of priority activities, groups are formed to plan for activities from among the partners, and projects are carried out with shared capacity.

2.3. Great Milkweed Grow Out

GMGO is an initiative of DBG started in 2016 to support the conservation of monarch butterflies and other pollinators. Monarch butterflies have faced drastic declines in their two US migratory flyways over the last three decades [34–36]. While there are likely multiple causes of decline, most authorities agree that habitat loss is a major contributor and that habitat restoration is a key conservation tool [35,37]. Of particular concern is the loss of monarch breeding habitat, which includes milkweed plants (*Asclepias* spp.) and nectar-producing plants as its primary components [38–40]. Monarchs can benefit from small habitats in urban areas [41,42], so urban plantings provide a direct method through which individuals can help protect a beloved butterfly species.

Native plants are essential to monarch survival and, with expertise in native plants, botanical gardens can serve as leaders in monarch conservation. At DBG, monarch conservation messages have been shared with visitors for many years through exhibitions and volunteer interactions, largely through the Jonathan and Maxine Marshall Butterfly Exhibit and the newer Butterfly Exhibit opened in 2017. Visitors are encouraged to create habitat for monarchs with the use of native plants, but historically this call to action was hard to execute. Native milkweeds were not often available in plant nurseries and there was a general lack of understanding of how monarchs interacted with milkweeds in the region [43,44]. This need for plants and a greater understanding of butterfly–plant interactions led to the development of GMGO as an internal collaboration between the Exhibits Department, with their butterfly expertise in the Butterfly Pavilion, and the Research, Conservation, and Collections Department, with research and native plant propagation expertise. GMGO has since expanded to include three full-time staff with seasonal interns who collaborate with a variety of partners statewide.

The structure of GMGO was developed to combine the basic needs of monarch conservation in Arizona with the strengths of DBG. It has three major activities that are all intertwined and integral to success: plant propagation, ecological research, and community outreach. Propagation of native milkweeds provides the basic resources needed for habitat plantings, outreach, and researching monarch–milkweed interactions. GMGO focuses propagation efforts on plants that are not common in commercial wholesale nurseries and thus often require some experimentation with seed germination and growing protocols to efficiently produce viable plants from wild-collected seed. Scientific research into monarch–

milkweed interactions fills essential knowledge gaps and provides the information needed to use limited resources most effectively. Outreach facilitates the distribution of milkweed plants throughout the Phoenix area while sharing the importance of native plants with the public. Combining these activities into one conservation initiative allows for enhanced conservation outcomes via the integration of key activities and the joint leveraging of partner resources and expertise, leading to more engagement and conservation action, as well as more chances for collaboration.

2.4. Rare, Threatened, and Endangered Species Conservation

The threats to plants and their associated ecosystems are numerous and ever-increasing. In the US and Canada there have been an estimated 65 vascular plant taxa lost to extinction since European colonization [45]. Focused on plants found in the Southwest, cacti, and succulents, DBG is conserving plants to avoid future extinctions. Threatened and endangered plant species are maintained at DBG in long-term storage in the seed bank and as part of the living collection, both on public display and in cultivation in the state-of-the-art facilities within the HHCPs.

In 2019, the Ahearn Desert Conservation Laboratory (DCL) opened as part of the HHCPs. Key features of this new facility are a seed bank and seed lab that houses growth chambers used for testing seed viability, developing germination protocols, and in vitro propagation through tissue culture. In addition to the long-term preservation of rare species, the seed collection is also used to enhance the living collection for research, seed amplification, and in situ restoration efforts. DBG also employs personnel with extensive experience in collection, horticulture, and seed germination research.

Researchers realized early in the history of the Garden that to effectively manage the ever-growing list of threatened species, collaboration would have to be a key strategy of DBG's plant conservation efforts. DBG is a charter member of the Center for Plant Conservation (CPC), which coordinates a network of 71 botanical institutions that work collectively to conserve over 2200 of the most imperiled species of North America, referred to as the "CPC National Collection of Endangered Plants" [46]. DBG currently manages 62 taxa within the national collection that spans seven states and ranges geographically from California to Florida. Under a similar agreement, in 2018, DBG signed an MOU with the North American Orchid Conservation Center, founded by the Smithsonian Institute and U.S. Botanic Garden [47]. This agreement gave the Garden the distinction of becoming the regional seed bank for the more than 30 orchid taxa that inhabit the Southwestern region [48]. As the designated seed bank, the aim is to work with other regional partners to collect and preserve every taxon throughout the Southwest.

DBG also contributes to rare plant conservation by supporting government agencies that are mandated to manage sensitive species on public lands. Since over 75% of lands in Arizona are estimated to be managed by the federal government, Native American tribes, or the state [49], this can be an overwhelming challenge. Adding to this challenge, agencies often lack sufficient funding and, as a result, staff dedicated to managing rare plants on these lands. For these reasons, they often rely on the expertise and resources available at botanical gardens and other botanical institutions to help manage rare species that fall under their jurisdiction. This is illustrated by two projects: one to salvage the endangered Arizona hedgehog cactus (*Echinocereus arizonicus*) impacted by the construction of a new bridge and another to survey and propagate an endangered orchid, the Canelo Hills ladies' tresses (*Spiranthes delitescens*), on the brink of extinction.

Another collaboration in the conservation of plant species is DBG's participation in the International Union for the Conservation of Nature (IUCN). In 2015, DBG became the host institution for the IUCN Cactus and Succulent Specialist Group (CSSG) as part of the Species Survival Commission. As of 2021, DBG employs a Red List Authority Coordinator that oversees the completion and publishing of Red List species assessments and the CSSG Programme Officer. DBG also contributes staff expertise to this group to assess and guide cactus and succulent conservation efforts worldwide.

3. Results

3.1. EcoFlora

Metro Phoenix EcoFlora (MPE) emphasizes engagement and collaboration as a key pathway to public participation in science and conservation. As of 11 June 2022, the project has 460 members with 339 active observers and has collaborated with at least 40 organizations, professional scientists, local experts, and community members. MPE has hosted over 40 events and trainings, with approximately 440 attendances since August 2020. These events have been primarily virtual. Attendees of virtual events have been located throughout Arizona, other US states, and other countries. In-person events have included iNaturalist training, birding, moth lighting, hikes, and social events.

In September 2021, the project collaborated on an event with local artist Aimee Ollinger (<https://www.aimeeollinger.com/> accessed on 15 February 2022), whose abstract work often includes nature viewed at a microscopic scale. Attendees were given a short lesson in plant identification and were then taught how to use a microscope. This increased attendees' botanical knowledge and equipped them with a new scientific skill. Collaborating with community members from varying fields outside of science can reach people that previously may not have been interested in plants or plant science.

EcoQuests are month-long projects that ask community scientists to observe specific species and/or ecological relationships. EcoQuestions are presentations by guest speakers followed by question-and-answer sessions that relate to the monthly EcoQuest topic. In total, 24 EcoQuests and 16 EcoQuestion sessions have been hosted by MPE (as of 15 February 2022). Both of these provide opportunities for participants to increase their environmental knowledge, contribute to conservation efforts, and connect with organizations, professional scientists, and community members.

In April 2021, the project collaborated on an EcoQuest with Dr. Tania Hernandez, New World Succulents and Cactus Scientist at DBG, which asked community scientists to observe as many cacti (*Cactaceae*) as possible. This provided preliminary data (1674 observations of 74 species) for research on wild and urban cactus populations and related implications for genetic and urban conservation. In May 2022, a collaborative EcoQuest was hosted with both Dr. Hernandez and a Girl Scout Gold Award project that searched for saguaros (*Carnegiea gigantea*) and engaged the public to document them on iNaturalist, including details on their health and providing location data for future sampling. The EcoQuest resulted in 8497 saguaro observations, more than doubling the amount of existing observations and resulting in a total of 12,593 observations in the metro Phoenix area. The observations also included digital information about saguaro size, hydration, and general health.

Social media and digital communications can effectively contribute to biodiversity knowledge and conservation efforts [50,51]. MPE virtually engages people through social media on Instagram (Menlo Park, CA, USA), Facebook (Menlo Park, CA, USA), and Twitter (San Francisco, CA, USA), with a combined total of 1317 followers. The majority of followers are in the United States, but others come from around the world. The project has had a combined reach of 15,102 unique accounts who saw content at least once from May 2020 to 14 February 2022 (accessed on 14 February 2022). One Facebook post in March of 2021 reached 2000 people with information concerning how extreme drought in Arizona may have been affecting wildflowers. EcoQuestions sessions and other resources are recorded and posted for viewing on YouTube (San Bruno, CA, USA) and have amassed 2232 views (accessed on 11 June 2022). The Metro Phoenix Field Guide is the digital monthly project newsletter that includes EcoQuest information, project events, volunteer opportunities, and project resources. The newsletter also provides a way for collaborators to share events and research efforts. There were 1631 contacts on the newsletter mailing list as of 14 February 2022.

iNaturalist observations provide a wealth of data and information at a scale not achievable by professional scientists alone [52]. Since February 2020, project members have made 64,702 observations of 2990 species, with plants accounting for 40,333 observations of 1365 species (Figure 3, accessed on 11 June 2022). MPE project member observations

make up 39% of the total number of observations of all taxa in the metro Phoenix area. For comparison, there are 32,653 plant occurrence records in metro Phoenix in SEINet, dating to the 1800s (accessed on 7 March 2022). The observations made on iNaturalist are currently being compared to the occurrence records in SEINet to understand more about plant biodiversity. A checklist of species has been created by combining SEINet occurrence records with species that also have observations on iNaturalist in the metro Phoenix area (<https://swbiodiversity.org/seinet/checklists/checklist.php?clid=24132&emode=0> accessed on 7 March 2022).

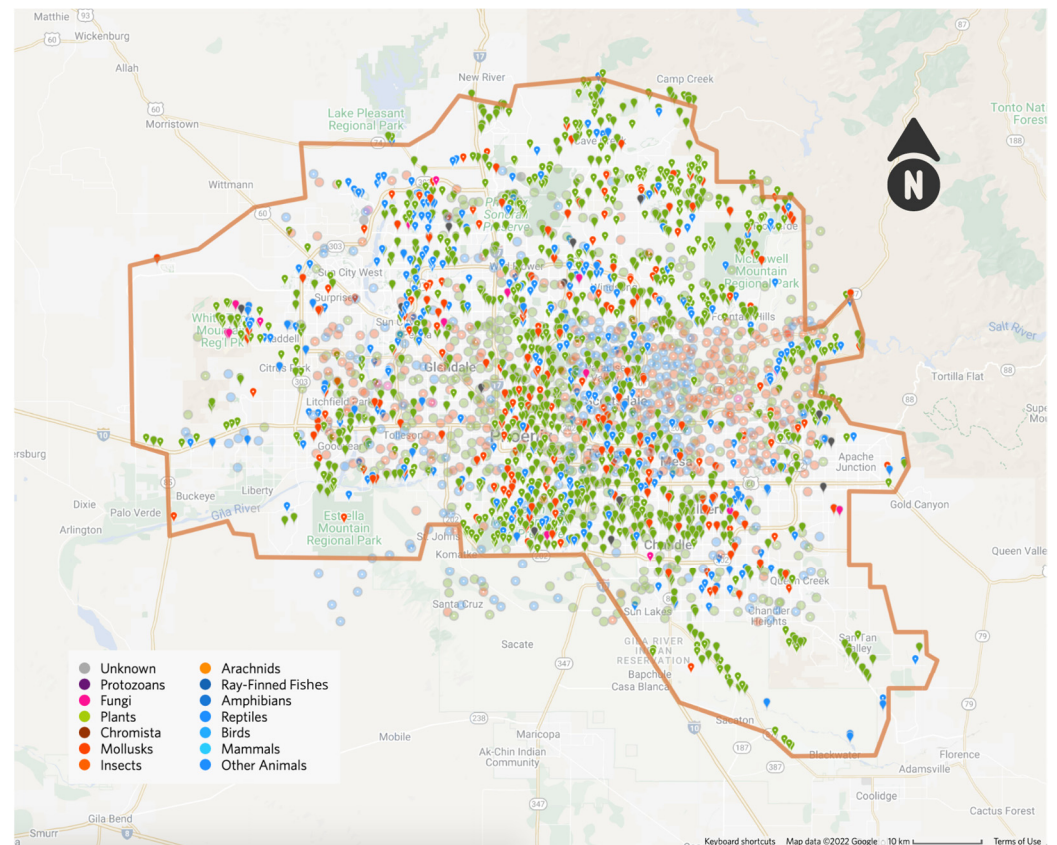


Figure 3. iNaturalist project observations within the MPE study area since February 2020 created using iNaturalist and Google Maps data.

3.2. Central Arizona Conservation Alliance

The first major outcome of the Central Arizona Conservation Alliance (CAZCA) has been the joint production of a regional, shared vision for conservation in the region. Since then, CAZCA has been the successful convener of a variety of projects necessary for the accomplishment of the shared vision and has played a pivotal role in shifting the collaborative environment of Central Arizona conservation.

The shared vision is encapsulated in the Regional Open Space Strategy for Maricopa County (ROSS; Section 1.2), which outlines the vision itself (for a regional network of natural open spaces that serve both environmental and community needs) and the objectives that the partner organizations outlined as necessary to realize that vision [33]. Through CAZCA, DBG served as the primary facilitator and organizer of the collaborative process that produced the ROSS. This included 18 months of stakeholder processes involving more than 80 meetings with 30+ partner organizations. The first phase of the ROSS planning process involved the identification of regional goals (Figure 4), and the second phase involved the planning team breaking into goal-focused groups that created the underlying objectives (Figure 5). The goal teams met more than 30 times, and the larger planning

group met more than 40 times during this process. Since its completion, the ROSS has led to regional planning and collaboration outcomes, including: (1) the development of tools from shared resources; (2) increased collaboration around large-scale challenges, such as habitat connectivity and land acquisition; and (3) the successful launching of regional conservation efforts, such as landscape-scale mapping and management of invasive plant species.

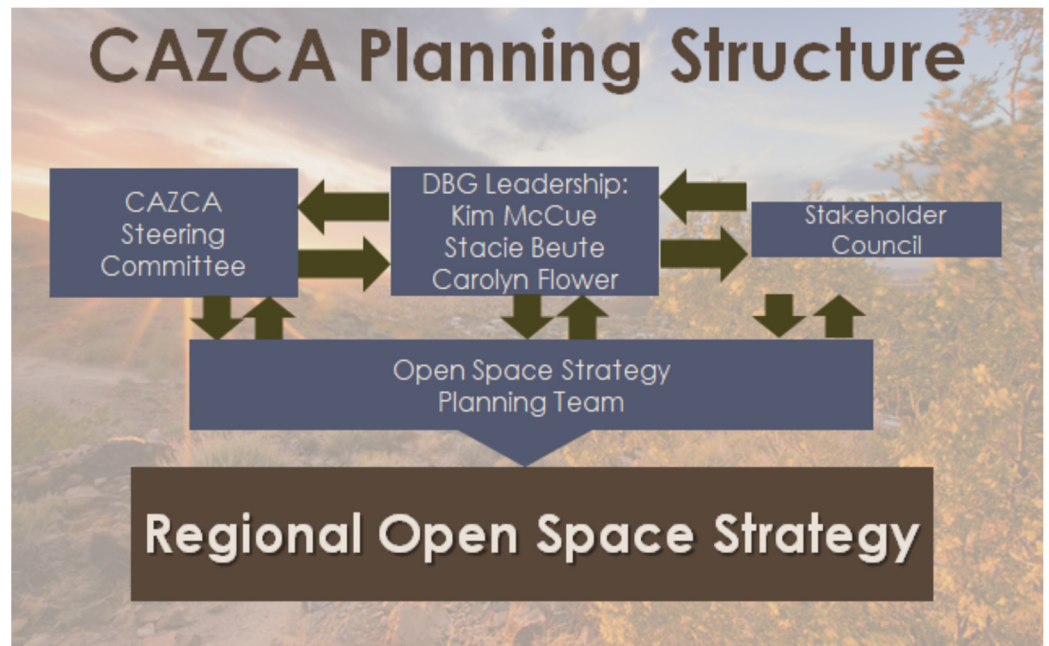


Figure 4. Phase one of the structure that CAZCA utilized in planning the ROSS.



Figure 5. Phase two of the structure that CAZCA utilized in planning the ROSS.

CAZCA has also provided facilitation and organizational support to partner organizations, as well as a neutral space for professionals to collaborate on the creation of tools

that will benefit the region. In many cases, without the backbone support of CAZCA, these products would not have been possible.

The first of the tools developed is a natural infrastructure viewer called the Greenprint (accessible at https://web.tplgis.org/cazca_plan/ accessed on 1 February 2022); this includes data on natural resources across Maricopa County, from water to habitat quality, as well as data relevant to urban planning and habitat preservation, such as parcel-level data and heat vulnerability information, among many other elements. This is called for in the ROSS, in Objective 1.1, and its development required in-depth partner collaboration. A team of technical experts was assembled by CAZCA to determine what data to include and to vet the tool in a cyclical development process that was led by the Trust for Public Land. The Greenprint was successfully unveiled to the partner organizations in 2019 and has been utilized by a variety of regional planning and grassroots efforts since then, including Maricopa County's Parks 2030 plan.

CAZCA was also the facilitating and convening force in the creation of a collaborative plan for habitat connectivity in Central Arizona. The process of developing the plan involved iterative gatherings of an advisory team and a larger regional stakeholder meeting which involved 35 partner organizations (see Appendix B for a full list). The focus of these meetings was on synthesizing spatial data and expert knowledge in order to identify what were termed Conservation Opportunity Areas (COAs). COAs were large, natural areas identified by the stakeholders as important to conservation and practical for preservation as rapid urban development continues in the region.

In conjunction with the planning and tool development described above, CAZCA has been instrumental in the creation of a more collaborative environment in Maricopa County for efforts related to biodiversity conservation and nature-based community well-being. This includes CAZCA's direct collaborative project work and the general increase in collaborations across the region post-ROSS development. First, the Sonoran Seed Collaborative project involves eight partner organizations in the development and study of genetically appropriate native plant materials for habitat restoration. To date, it has produced two annual reports tracking the scientific outcomes of the project, it has funded and carried out habitat restoration at Papago Park and Piestewa Peak in Phoenix, AZ, and the group hosted a 2022 Sonoran Seed Summit that supported expert exploration of how to increase production of native plant materials in Central Arizona.

CAZCA also runs a collaborative project called Desert Defenders, which involves seven partner organizations and focuses on the management of nine invasive plant species. The project trains community scientists to map invasive plants on trails with their smartphones, has created a public map of this spatial data, and serves as a platform for sharing knowledge on invasive plant management strategies among partners. From 2018 to 2022, it has mapped hundreds of acres and identified 6532 invasive plant occurrences.

Finally, when CAZCA was founded in 2012, it was with the realization among partner organizations that collaboration was lacking in Central Arizona but sorely needed due to the rapidity of habitat loss and degradation in the region. Since this time, and since the iterative convenings of the ROSS, many collaborative networks have formed in Central Arizona, illustrating a change in the environment for collaboration here. As of 2022, some of the primary collaboratives in Central Arizona, aside from CAZCA itself, include the Lower Gila Collaborative, Rio Reimagined, and the North Valley Outdoor Network. Organizations such as White Tank Mountains Conservancy and McDowell Sonoran Conservancy have also become leaders in collaborative work, and both are CAZCA partners.

3.3. Great Milkweed Grow Out

Great Milkweed Grow Out (GMGO) was well positioned at its inception to collaborate with federal agencies and monarch conservation organizations to carry out projects that would directly benefit monarch conservation. Monarch butterflies are captivating and have inspired conservation action within the community and interest from many potential partners. From 2016–2019, GMGO's propagation work focused on milkweeds (*Asclepias*

spp.). GMGO collaborated with the federal Bureau of Land Management (BLM) to grow and distribute milkweeds and collect seeds from wild populations. In that time, more than 6000 milkweeds were propagated and distributed to agencies, non-profits, and members of the general public. Milkweeds quickly sold out at plant sales and were popular giveaways at events. GMGO developed growing protocols for three species of native milkweeds from wild-collected seed. GMGO successfully demonstrated the demand for native milkweeds and shared these growing protocols. Since 2016, local wholesale growers have begun to grow and offer more native milkweed taxa, making milkweeds and monarch habitat even more prevalent within the region.

In the following years, GMGO broadened the scope of propagation, outreach, and research to include other pollinators that are also facing significant population declines [53,54] and thus to grow and distribute plants beyond milkweeds. GMGO has propagated and developed replicable propagation protocols for a range of native plants valuable to pollinators, including *Aristolochia watsonii*, *Acourtia wrightii*, *Cephalanthus occidentalis*, *Conoclinium greggii*, and *Ageratum corymbosum*. Since 2019, GMGO has propagated and distributed more than 1500 non-milkweed plants and continues to grow at least 1500 milkweeds per year. To further increase plant material availability, GMGO has worked with BLM to collect milkweed and other native nectar plant seeds under BLM's Seeds of Success Protocol. GMGO's seed collections and propagation efforts were recognized on a national scale in the 2018 National Seed Strategy Making Progress Report [46].

In addition to distributing plants, GMGO creates pollinator gardens in schools and community centers in the Phoenix area, planting 22 pollinator gardens since 2016. These pollinator gardens are a collaboration with BLM and were featured in their 2015–2020 National Seed Strategy Progress Report [55]. GMGO has also donated plants to more than 25 partner organizations to facilitate habitat creation and has given more than 20 presentations to community groups, schools, non-profit organizations, and corporate groups. Three larger areas of habitat have been created in partnership with the US Fish and Wildlife Service's (USFWS) Partners for Fish and Wildlife Program.

GMGO has significantly contributed to our understanding of milkweeds and monarch behavior and ecology through a variety of research projects. In 2020, GMGO published a study on the egg-laying preference and larval performance of monarch butterflies on native milkweed taxa [44]. The research showed higher preference and survival for one native species (*Asclepias angustifolia*) compared to another (*A. linaria*). This directly influenced recommendations for plantings within the region and influenced the focus of GMGO milkweed propagation. GMGO has also researched the pollinators, parasites, and predators that visit milkweed and could benefit milkweed populations or endanger growing monarch caterpillars (manuscript in progress). In 2018, GMGO initiated a number of research projects still ongoing in collaboration with the University of Arizona on milkweed physiology relating to host–pollinator interactions and climate shifts in order to guide habitat plantings in the future. In February 2022, GMGO launched a community science project in collaboration with the USA National Phenology Network to gather data on monarch behavior and milkweed phenology in the winter months in Arizona [56]. This will also contribute to community engagement by offering monarch enthusiasts a chance to be more involved.

Through all these activities, GMGO has worked closely with other organizations interested in monarch and pollinator conservation to have the greatest impact. Since 2015, DBG has been working with Monarch Joint Venture (MJV), an international partnership of agencies, NGOs, and academic institutions. As a partner in MJV, DBG has benefited from significant knowledge transfer and a framework for conservation priorities [57]. Statewide, GMGO has been active in the Arizona Monarch Collaborative (AMC). Created in 2019, AMC has brought together approximately 70 different partners across the state [58]. Partners include state agencies, local representatives of federal agencies, non-profits, energy companies, tribes, and universities. DBG has been active since the start, providing expertise on monarchs in Arizona and the plants that support them. As of March 2022, DBG has

one staff member on the steering committee and staff members leading the plant materials and restoration and the research and monitoring committees. DBG staff serve as experts within this group and have shared growing protocols and knowledge of local plant species and monarch biology with AMC partners. This has led to the development of conservation goals for the state in support of the Western Association of Fish and Wildlife Agencies' Monarch Conservation Plan [59] and a variety of resources being made available on the website to wide audiences [60].

3.4. Rare, Threatened, and Endangered Species Conservation

DBG's participation and leadership role within the Center for Plant Conservation (CPC) has led to the conservation of numerous imperiled species. The DBG seed bank currently houses over 5300 seed accessions, 2500 from plants of conservation concern. Since 1984, DBG has made 708 seed collections of 52 CPC National Collection species and currently maintains 566 accessions in the DBG seed bank. During that period, over 400 duplicates of these collections have been backed up at the United States Department of Agriculture's National Laboratory for Germplasm Resource Preservation in Ft. Collins, Colorado, through an agreement with CPC. Since partnering with North American Orchid Conservation Center (NAOCC), DBG has contributed 38 accessions of 13 taxa towards the goal of banking seeds of all orchid species of the Southwest. In addition, 30 root samples have been provided to the Smithsonian Environmental Research Center (SERC), which has led to the successful identification of several fungal symbionts associated with these orchids.

In support of both CPC and NAOCC, DBG is working under a USFWS-funded grant to develop methods to propagate the endangered orchid *Spiranthes delitescens* (the Canelo Hills ladies' tresses orchid) for use in future seed amplification and restoration projects. In 2016 and 2021, seeds were collected from the two extant populations and have been banked and used to successfully propagate plants in vitro. These seedlings have since been moved into potting media for further growth to maturity. In addition, SERC has been able to culture and identify its symbiotic fungus. This fungus can then be used to inoculate seeds to allow for plants to be propagated using common horticultural methods [61].

Due to the cryptic nature of many native terrestrial orchids, plants can be difficult to locate in the wild given their size, shape, and ability to blend with surrounding vegetation. Added to this, many of the rarer species, such as *S. delitescens*, exist in small communities. To aid in locating these plants, DBG, with the support of USFWS, has enlisted a professional dog trainer experienced with using dogs for ecological purposes. The goal is to train dogs to detect these orchids in situ to locate additional plants at known sites and relocate populations at historical sites. In June 2022, collections of 13 living plants were made of a congener of *S. delitescens*, *S. infernalis* (Ash Meadows ladies' tresses), currently being used as a proxy for training the dogs off-site. Early results have shown that the dogs are able to detect this related species which should lead to successfully locating the target orchids in the wild. These projects would not be possible without cooperation between federal agencies, private landowners, and private businesses.

In 2018, DBG was contracted by the Arizona Department of Transportation (ADOT) to conduct a salvage and reintroduction of the endangered *Echinocereus arizonicus* (Arizona hedgehog cactus) to make way for a new bridge construction over Pinto Creek, near Superior, Arizona. The salvage consisted of 34 mother plants that were collected from the construction site surrounding Pinto Creek. Due to the steep, rocky terrain, the salvage required extreme physical effort, including rock climbing and rappelling, and care in delicately extracting the plants from their habitat. Each cactus was documented and transported back to the Garden, where they were cared for and allowed to rehabilitate in the Hazel Hare Center for Plant Science facilities. While housed at DBG, the plants were hand-pollinated, and seeds were collected for banking, testing, and propagation. This resulted in 12 additional seed accessions of known parentage containing thousands of seeds, hundreds of seedlings produced, and a collection of cuttings still maintained at DBG.

In March 2022, after the completion of the bridge, the same team of staff returned to the heavily impacted construction site to reintroduce 61 plants consisting of mostly original mother plants along with cuttings propagated from those same plants. Care was taken to transplant the cacti within the right microsites. They were given ID tags, measured, and provided with supplemental water. Under the agreement, DBG will monitor these plants for two years and augment the population as necessary using plant material still maintained at DBG. Although funding was provided by ADOT, this project was a partnership between DBG, federal agencies, and private businesses and has been an incredible achievement in collaborative conservation.

DBG has also had considerable success working with private landowners. This collaboration is particularly important since federally listed plants are not granted the same protection as animals on private lands under the Endangered Species Act [62]. As part of the CPC, NAOCC, and USFWS collaboration to conserve *S. delitescens*, DBG has been working with private landowners to locate new and historic populations. The orchid was historically known to only exist in four locations in Arizona. Three locations were on privately owned cattle ranches and another on a preserve managed by the Nature Conservancy. DBG was able to assess these historical populations by working with private landowners.

The participation of the Garden in the IUCN Cactus and Succulent Specialist Group as part of the Species Survival Commission has allowed for greater scientific and media attention to the dire status of cacti and succulents and the threats to their populations. DBG scientists worked with other cactus succulent specialists around the world to complete Red List Assessments. Of the 1478 evaluated species of cacti, nearly 31% were found to be at risk of extinction [63]. DBG is currently working with other members of the Cactus and Succulent Specialist group to assess 300 species of aloes and yuccas, with most of the assessments completed and published by the Red List [64].

4. Discussion

4.1. EcoFlora

The EcoFlora program is a compelling and dynamic tool that illustrates the importance of science communication and community science for collaborative conservation at any scale. The Metro Phoenix EcoFlora (MPE) is an inherently collaborative project, from its inception at New York Botanical Garden, to its shared implementation by partner gardens, to working with partner organizations and community scientists. The objectives of both the joint EcoFlora program and the local MPE project are largely achieved through collaboration and engagement, along with the provision of accessible resources and open-source data. Botanical gardens can play a unique role and engage and support projects that are invested in collaborative conservation efforts in numerous ways.

The established communication channels and built-in audiences with DBG, Central Arizona Conservation Alliance (CAZCA), and iNaturalist provided the opportunity for initial awareness raising as well as supporting communication, sharing resources, and sustaining engagement in the MPE project (Figure 6). DBG, specifically, is a well-known organization that has strong support and enthusiasm from the public and is visited by nearly half-a-million people on an annual basis. MPE's association with DBG is in itself a draw for the public to join the project as well as attend classes and events. In-house marketing and design professionals at botanical gardens can assist with broad engagement and graphic communications. The Marketing Communications team at DBG provides essential support for and promotion of MPE, including project branding for all five partner gardens and the national program, designing collateral and materials, website design and hosting, and email and social communications.

Metro Phoenix EcoFlora Awareness Channels

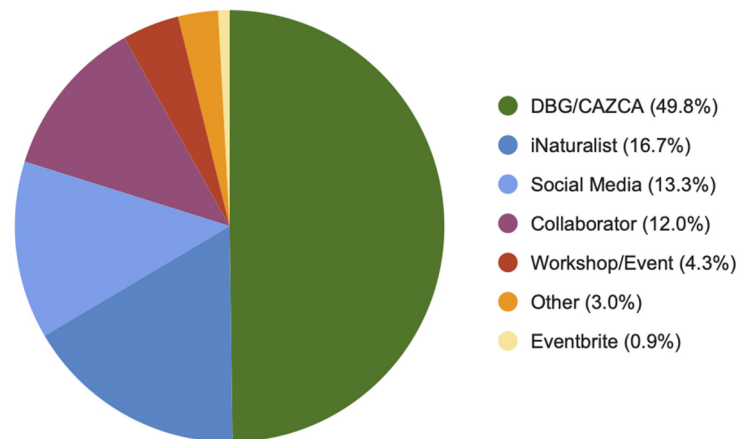


Figure 6. Channels of MPE project awareness as of 10 March 2022 according to MPE newsletter responses.

Events, classes, and resources created by MPE are free and open to project members and the public, with an overall result of increased awareness and knowledge of biodiversity and plant life. DBG provides the space for events and classes, requiring fewer resources, lessening the burden on MPE to find, schedule, reserve, and finance spaces outside of DBG. MPE creates and collaborates on resources that can be used by other projects and organizations. For example, MPE worked on educational videos with McDowell Sonoran Conservancy's Conservancy Kids program, teaching younger audiences about biodiversity and observing nature. Numerous educational resources that have been created by MPE are available through the iNaturalist project journal. DBG email lists and social media provide a way to share these resources widely.

Botanical gardens are uniquely situated to combine modern observations with existing floristic data. A deliverable of the EcoFlora project is to synthesize iNaturalist observations with existing herbarium records through Symbiota (<https://symbiota.org/> accessed on 10 March 2022), the biodiversity data management software that hosts the SEINet portal. A collective Symbiota portal will be created for the EcoFlora partner gardens, linking out to checklists and information for each garden and the flora that can be found in their respective locations. Utilizing SEINet and the herbarium resources and expertise at DBG, MPE has identified 40 non-cultivated plant species that have not been previously documented in the metro Phoenix area. Furthermore, iNaturalist can be used to compliment herbarium vouchers by adding a QR code to labels. The QR code can link to iNaturalist observations that can include photos of the live specimen and other information. iNaturalist, Symbiota, and SEINet are open-source platforms, and botanical gardens and scientists around the world can access and use EcoFlora project data and information, contributing to conservation efforts locally and at large.

Finally, botanical gardens and other organizations across the United States have expressed interest in applying the EcoFlora model, while others have already begun to do so, adding to local and national conservation efforts. MPE provided the foundational materials and support for the Maricopa County Parks and Recreation's Eco-BLITZ program, which focuses on observations in Maricopa parks (Arizona, USA). The project also inspired the Fire Followers program from the California Native Plant Society (CNPS, California, USA). Jose Esparza, Community Science Coordinator for CNPS, states: "The Metro Phoenix EcoFlora project on iNaturalist was truly inspirational to me during the launch of our own CA Fire Followers Project. It is amazing to see other participatory science projects on iNaturalist be community-driven and characterized by place-based knowledge and social learning, collective action and empowerment." In June 2022, the EcoFloras of North America created an instructional toolkit [65] that can be shared with botanical gardens

interested in implementing an EcoFlora or similar program. The toolkit is specifically designed with the capabilities and resources that botanical gardens can provide for an EcoFlora project.

4.2. Central Arizona Conservation Alliance

The Central Arizona Conservation Alliance (CAZCA) provides insight into the strategic benefits of botanical garden leadership in collective impact backbone organizations and has illuminated the challenges of this kind of collaborative conservation as well.

First, while some botanical gardens, such as DBG, have strong conservation commitments [28], they can nonetheless serve as neutral facilitators and provide neutral convening spaces for partners that might otherwise hesitate to collaborate with one another. This is ideal for the collaborative process, and such resources can assist organizations in building social capital and supporting essential governance formation for the collective effort [8,65]. They also provide welcoming and non-threatening spaces for new collaborators, particularly those representing groups that might not traditionally be involved in conservation work but whose participation is now understood to be essential [66]. Such neutral spaces strengthen collaborations and their related conservation outcomes through the support of inclusive decision making and resulting shared buy-in [67]. Gardens also have physical infrastructures for convenings and uniquely attractive spaces for large and small gatherings which implicitly encourage stakeholder involvement [68]. The organization of large, diverse groups in the creation of CAZCA's Regional Open Space Strategy, Greenprint, and Conservation Opportunity Areas demonstrate this strength.

Botanical gardens can also serve as a natural bridge between conservation professionals and the public because the gardens themselves are designed as spaces for public immersion and connection with nature, and many gardens have internal marketing, communication, and outreach expertise [69]. In terms of collaborative efforts, CAZCA has illustrated the benefit of a botanical garden serving as a backbone organization through its successful awareness-raising campaigns and public engagement efforts.

Finally, botanical gardens have resources from their admissions revenues, grants, and donor support to provide the needed capacity for collaborative conservation efforts. Dedicated staff and expertise have been found to have strong positive impacts on collaborative, landscape-scale outcomes [10]. When considering the conservation challenges created by plant invisibility, having garden staff in leadership roles in collaborative efforts can help elevate and communicate the importance of plants in biodiversity work-at-scale, increasing the longevity of positive conservation outcomes [70]. CAZCA's regional impacts on the collaborative environment as well as its impacts on plant-focused conservation efforts have underlined these advantages.

4.3. Great Milkweed Grow Out

The success of Great Milkweed Grow Out (GMGO) as a conservation initiative is due to a variety of factors, such as dedicated staff and volunteers, incorporation of a charismatic animal, and a wide variety of collaborators in our state and region. Some of these are due to GMGO's positioning at a botanical garden.

While monarch and pollinator conservation programs exist in many communities and institutions on many scales, one factor that has made GMGO successful is the plant expertise provided by DBG. With native plants at the heart of monarch conservation, this expertise is essential for actions such as seed germination, planting schedules, plant mixes, responsible native seed collection, milkweed diversity, and large-scale propagation [71–73]. With a staff that includes horticulturalists, propagators, research botanists, and conservation experts, DBG is uniquely positioned among its partner organizations to provide this information. Expertise in pollinator and butterfly biology was also available due to DBG's investment in the Butterfly Exhibit and having a full-time butterfly expert on staff to oversee the health and welfare of the butterflies. Botanical gardens often hold a wealth of knowledge on many different ecological topics, and collaborative conservation efforts can benefit from this.

The blend of floral and faunal focus has also allowed the program to benefit from varied funding sources. Funding from botanical and horticultural interests have funded propagation, internships, and seed collection. Organizations and programs with an interest in monarchs and pollinators have funded school gardens, habitat plantings, and research. Portions of the program are funded by plant and seed sales through DBG's bi-annual plant sale and Garden Shop, which attract gardeners from the greater Phoenix area.

GMGO has been able to effectively share important conservation messages that inspire action by reaching a wide variety of audiences through DBG. GMGO gives DBG the opportunity to share impactful messages about the importance of native plants with guests that connect more with monarchs and other animals than with plants. This is an audience DBG may not have reached otherwise. Similarly, DBG attracts many avid gardeners that seek out unique cacti, succulents, and other desert plants and admire their beauty. By sharing the importance of monarch conservation, many dedicated gardeners have begun seeking milkweed and other nectar plants to support monarchs and pollinators. Pollinators are bridging the gap between flora and fauna and inspiring collaboration and action.

The second major factor in GMGO's success in collaborative conservation has been the resources available at DBG. The most important of these resources is their volunteer force. DBG hosts and manages a large, dedicated volunteer group, generally maintaining close to 800 active volunteers that assist with a wide variety of programs. GMGO worked to engage these volunteers from the beginning of the initiative, and most propagation tasks are carried out by dedicated DBG volunteers led by staff. Since 2016, GMGO has worked with over 330 volunteers contributing more than 4500 h to propagation, outreach, and research projects (as of February 2022). GMGO would not be as successful without this volunteer base.

Another set of key factors is space and facilities. Locations not actively cultivated or open to the public exist within DBG's footprint that can be used for propagation and experimental plots, including greenhouse and garden space, and butterfly husbandry facilities. GMGO uses roughly 6000 square meters of outdoor space for propagation of plants in one-gallon plots. GMGO also built experimental beds to test hypotheses about monarch and queen visitation to different milkweed species [44] and characterize the wide variety of beneficial insects supported by milkweeds. DBG's property size also allowed for the development of a $\frac{1}{4}$ -acre fenced experimental plot to test the effects of drought due to climate change on milkweeds. This area and another nearby also serve as seed amplification plots for harvesting known-source milkweed seeds to share with various partners for habitat restoration. Finally, the Butterfly Exhibit has served as a space for controlled larval rearing experiments and studies of behavior.

The last major factor that allows for success is the name recognition of DBG. DBG is recognized throughout the region as an expert in local natural resources. This lends credibility to GMGO's conservation actions, and facilitates outreach, as most has been the result of word-of-mouth contacts. GMGO did not have to spend time and effort seeking opportunities to interact with the community or schools that wanted a butterfly garden.

4.4. Rare, Threatened, and Endangered Species Conservation

Plant conservationists recognize that saving plants cannot be achieved in isolation. The threats to habitats and ecosystems are simply too great and one institution alone cannot single-handedly keep up with the increasing rate of species loss. Conservation efforts at DBG have benefited greatly by working collaboratively alongside government agencies, businesses, and private landowners.

The success of collaborative conservation is partially due to the extensive resources at DBG and the status of DBG as a non-governmental organization (NGO). DBG has made considerable investment in plant care facilities, such as the Hazel Hare Center for Plant Science, and in the development of a robust research and conservation department with extensive knowledge and expertise, which has benefited the conservation of rare species. The position of Conservation Collections Manager at DBG, for example, oversees the seed

bank, rare plants in cultivation, and conducts research on rare and endangered plants. This position is also tasked with obtaining and managing permits, acting as a conduit between the Garden and outside entities.

For decades, DBG has partnered with the US Fish and Wildlife Service (USFWS) and the Bureau of Land Management in the conservation of endangered plants and protection of rare species. Since agencies often have limited staff, resources, and expertise for managing or mitigating the loss of rare species, they have turned to outside organizations, such as botanical gardens, to fulfill these requirements. As demonstrated in the case studies, DBG has had a history of successful partnerships with federal and state agencies, and without the assistance of botanical institutions, the capacity for conservation by federal agencies would be greatly reduced.

When rare plants occur on private lands, collaboration with landowners is necessary. DBG's status as a non-governmental organization allows for a bridge between federal or state governments and private landowners. Landowners may be skeptical of the motives of government agencies, resulting in distrust and unwillingness to cooperate in conservation efforts. The reputation of DBG as a respected institution has been valuable in opening lines of communication with landowners. In several cases, DBG has been able to access private land to monitor imperiled species, where the same luxury may not have been afforded to government officials.

4.5. Challenges to Collaboration

While there are many demonstrated benefits of botanical garden leadership and involvement in collaborative conservation efforts, there are also a variety of challenges that should be taken into consideration. First, collaborative conservation efforts require resources in the form of funding and staff capacity, particularly for any institutions attempting to lead or serve as a backbone organization [10]. Leading and coordinating successful collaborative conservation efforts is complicated, dynamic, and difficult; sufficient resources over the long-term are essential [1,74]. In the case of gardens, staff capacity may also be shared between collaborative responsibilities and duties related to garden operations, even for those staff members with positions primarily focused on collaborative efforts. Collaborative conservation may have the benefit of combining resources across institutions and can be a great way to leverage capacity and funds across institutions. Gardens themselves may have more flexibility than agencies or other institutions to accept types of funding or add staff positions to their rosters. Gardens may also have resources through alternate streams of funding that most other partner organizations cannot take advantage of via ticket and membership sales, event-space rentals, etc. However, this kind of revenue, widely related to tourism, whether local, domestic, or international, can be heavily impacted in times of economic strain or uncertainty [75]. Without sufficient, long-term funding, collaborations are unlikely to be successful.

Additionally, collaboration with multiple agencies and private landowners takes time and sometimes negotiation skills to navigate conflict. Conservation efforts may be time-sensitive due to seasonality of plant phenophases or schedules of planned development. Working on federal, state, and municipal lands but not being a related agency requires the acquisition of permits, which can take months or longer to process. In addition, culturally diverse, minoritized, and under-resourced communities are understandably more likely to engage with community-based organizations than with scientific and informal science-education institutions and organizations, and understanding the values, priorities, and boundaries of communities should be prioritized to ensure their autonomy and balance of power [76].

Collaborative efforts are, by nature, more complex than conservation initiatives that are primarily or entirely designed and managed by a single entity. They require the cooperation of at least two partners and the coordination of their personnel and resources. This complexity leads to increased need for capacity and related funding requirements, the potential need for long-term work beyond the time horizons of typical funders, and

additional skills needed for collaborative teams related to trust-building and working across institutional boundaries. These are challenges that must be taken into account but which can be overcome.

5. Conclusions

There are many benefits to collaborative conservation with botanical garden partners. Botanical gardens have access to an immense amount of botanical knowledge that is not widely available elsewhere. Many botanical gardens are non-profit institutions that have unique, diverse revenue streams via admissions, committed donors and members, and a variety of public and private grants [77–79]. Botanical gardens have the ability to secure funding for a wide variety of project types, including research and restoration activities, educational programming, and trail renovation. Diversity of funding and project types makes these institutions more resilient to funding challenges and also creates many opportunities for partnership. Many botanical gardens also utilize volunteers to assist with conservation projects [80]. Botanical gardens often house their own marketing, communication, and design professionals who can provide effective tools for outreach and conservation efforts. [74].

For botanical gardens that are looking to lead conservation, these case studies provide key takeaways. First, forming relationships with local and federal agencies, NGOs, and academic institutions is imperative to the success of conservation programs. This is also something important for agencies to keep in mind—to look to the expertise and experience that botanical gardens may hold. Second, ideas for impactful conservation programs can emerge from the creativity of staff below leadership level. Staff imagination and ambition, with institutional support, can lead to impactful and profitable programs. Investing in staff who have relevant experience, expertise, and relationships is important to leading collaborative conservation. Third, careful planning around collaborative projects is necessary, even when the need for collaborative efforts is clear. It is imperative that realistic timelines are developed, long-term funding needs are addressed, and the well-being and collaborative skills of backbone staff and active partners are inventoried and maintained. Conservation programs involve direct connections to community and partner groups that bring value and recognition to their host institutions and, with proper internal support and respect, provide ample opportunities for the pursuit of further institutional as well as collaborative goals.

The role of botanical gardens in conservation has evolved over time, and it is clear that these institutions are essential components of the effort to slow and stop the rapid loss of global biodiversity through the direct protection of plant species and the species that rely on them [14]. As the importance of collaboration in conservation is becoming more clear, botanical gardens have and will continue to serve as leaders in collective efforts to manage natural resources. Understanding the benefits and challenges related to this leadership, as reflected in the case studies explored here, can assist botanical gardens and partners of botanical gardens in starting and maintaining the successful collaborations that are increasingly needed to preserve and cultivate healthy ecosystems.

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Appendix A. CAZCA Partners and Collaborators in 2018

Desert Botanical Garden
Arizona Alliance for Liveable Communities
Arizona Association for Environmental Education
Arizona Columbine Garden Club
Arizona Center for Nature Conservation
Arizona Department of Transportation
Arizona Department of Water Resources
Arizona Game and Fish Department
Arizona Native Plant Society
Arizona Parks and Recreation Association
Sonoran Desert Museum
ASU—Arizona Sustainable Cities Network
ASU—Biomimicry Center
ASU—CAP LTER
ASU—Design School
ASU—Global Institute of Sustainability
ASU—School of Community Resources and Development
ASU—School of Life Sciences
ASU—UREx Sustainable Research Network
Audubon Arizona
B3.8
Bureau of Land Management
Bureau of Reclamation
Catalyst Collective
Center for Biodiversity Outcomes
Center for the Future of Arizona
City of Buckeye Community Services Department
City of Glendale Community Services Department
City of Peoria Community Services Department
City of Phoenix Parks and Recreation Department
City of Scottsdale Parks and Recreation Department
Cultivate South Phoenix—Spaces of Opportunity
Desert Foothills Land Trust
Desert Foothills Community Foundation, Desert Awareness Committee
Friends of Daisy Mountain Trails
International Union for Conservation of Nature
Keep Phoenix Beautiful
Local First Arizona

Logan Simpson & Associates
Maricopa Association of Governments
Maricopa County Parks and Recreation Department
Maricopa Trail and Parks Foundation
McDowell Sonoran Conservancy
National Park Service—Saguaro National Park
North Mountain Visitor Center
Northern Arizona University
Okanogan Trail Construction, Inc.
Phoenix College
Phoenix Fire Department
Phoenix Parks Foundation
Phoenix Union High School District
Phoenix Weedwackers
Pima County Natural Resources, Parks, and Recreation
Pinal County Open Space and Trails
PLANet
Plant Atlas Project of Arizona
Salt River Pima—Maricopa Indian Community
Save Our Mountains Foundation
Signature Botanica
Sonoran Institute
South Mountain Environmental Education Center
Southwest Seed Partnership
Southwest Society of Botanical Artists
Superstition Area Land Trust
Tovrea Carraro Society
The Center for Native and Urban Wildlife
The Nature Conservancy
The Phoenix Mountains Preservation Council
The Trust for Public Land
USGS—Western Ecological Research Center
USFS—Tonto National Forest
Vitalyst Foundation
White Tank Mountains Conservancy

Appendix B. List of Participating Organizations in the Stakeholder Consultation Meetings for the Conservation Opportunity Area Identification

Arizona Army National Guard
Arizona Game and Fish Department
Arizona Office of Tourism
APS
Arizona State Parks and Trails OHV
Arizona Water Company
Arizona Wilderness Coalition
ASU School of Community Resources and Development
ASU School of Landscape Design
ASU Sustainable Cities
Bureau of Land Management
Circle G Development
City of Apache Junction
City of Avondale
City of Buckeye
City of Mesa

City of Peoria
 City of Phoenix
 Copper State Consulting Group
 Desert Foothills Mountain Bike Association
 El Dorado Holdings
 Goodyear Recreation Board
 GPEC
 Maricopa County Planning
 Maricopa Farm Bureau
 Maricopa Trails and Park Foundation
 MBAA
 Town of Cave Creek
 Town of Surprise
 State Historic Preservation Office
 Superstition Area Land Trust
 Valley Partnership
 Vitalyst Health Foundation
 Retired Supervisor of Maricopa County (Individual)
 Landscape Architect (Individual)

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