

Case Report

The Arnold Arboretum's Campaign for the Living Collections: A Case Study in Living Collection Development

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Abstract: In 2015, the Arnold Arboretum of Harvard University began an ambitious plant acquisition program: The Campaign for the Living Collections. Prior to the initiative's launch, the Arboretum underwent several years of strategic planning to assess the values, strengths, and gaps within its renowned living collection of temperate woody plants and then set goals that would profoundly shape the collection and its research and conservation potential for decades if not for centuries. Core genera, conservation value, phylogenetic breadth, biogeography, and climate change responses were among the priority themes used to generate a targeted list of 395 desiderata to acquire from wild populations. In only a few years, the Campaign's 26 formal expeditions and other acquisition efforts have yielded 631 accessions of 263 highest-priority desiderata, representing 66.6% of the overall goal. This venture represents one of the most transformative and deliberate collection development activities at the Arnold Arboretum and among botanical gardens in the current era. These successes are due to a combination of factors that include visionary yet realistic strategic planning and goal setting, adherence to high standards of documentation and reporting, and authentic relationship building among collaborators.

Keywords: plant exploration; plant introduction; ex situ plant conservation; curation; collections development; museum planning



Citation: Dosmann, M.S.; Schwartz Sax, M. The Arnold Arboretum's Campaign for the Living Collections: A Case Study in Living Collection Development. *J. Zool. Bot. Gard.* **2024**, *5*, 119–130. <https://doi.org/10.3390/jzbg5020008>

Academic Editors: Donald Rakow and Christopher P. Dunn

Received: 27 February 2024

Revised: 14 March 2024

Accepted: 26 March 2024

Published: 28 March 2024



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1. Introduction

Museums are central to society: they interpret our natural and constructed world to visitors, foster a sense of discovery, educate all ages, and preserve specimens for future generations' use. Botanical gardens (hereafter gardens, including arboreta) are vibrant members of the museum community, dedicated to research, education, preservation, and public service [1]. Living plant collections, beyond possessing incredible aesthetic beauty, are curated to serve essential research, conservation, and education purposes [2–5].

For many reasons, living plant collections are far more dynamic than those curated within most other museums, and the most fundamental is, by definition, that living objects eventually die, and without a pipeline of new material, the collection shrinks [6]. Without proper governance and oversight to guide the replacement plants, collections may be unthoughtfully developed and, in turn, fail to best serve and honor the garden's mission. A singular way to avoid this is the adherence to a collections policy and subsequent collections development plan [1]. Whereas the collections policy typically outlines the scope and priority of the collections, the plan establishes the specifics related to the actual collection building.

Collections are built through acquisition, and new plant material can come through a variety of sources such as purchase, exchange with other gardens, or withdrawal from seed banks or germplasm repositories. Plant exploration to collect or introduce germplasm directly from wild populations has been another longstanding portal to build garden collections. While gardens may be known as historical "introduction centers", the need to continue introducing germplasm from the wild is great due to the litany of current global

change challenges [3]. In particular, as the biodiversity crisis continues to unfold, plant exploration has become essential to preserve species threatened with extinction [7].

2. The Arnold Arboretum and Its Living Collection

The Arnold Arboretum of Harvard University, founded in 1872, is the oldest public arboretum in North America. It is located in Boston, Massachusetts, and occupies 114 hectares. Since its inception, this museum of temperate woody plants has simultaneously been a research and conservation collection, teaching laboratory, display garden, and beloved Boston park that is free and open to the public daily [8]. Like other gardens, the Arnold Arboretum uses an accessioning system to document and organize the plants within the living collection. An accession considered the basic unit of a museum collection, is defined at the Arnold Arboretum as a single taxon derived from one source/place at one point in time and through one mode of propagation. Each accession is assigned a unique accession number at the time of registration, and an individual accession typically comprises multiple plants (i.e., seedlings A, B, C, etc.).

As of 31 December 2023, The Arnold Arboretum's permanent (i.e., non-nursery) living collection comprises 15,932 plants belonging to 10,392 accessions. Taxonomically, it represents 114 families, 402 genera, and 2173 species, as well as 1894 infraspecific cultivars, subspecies, varieties, and formae (almost exclusively woody). With respect to the provenance of the accessioned plants, 45.1% are of wild origin (direct or indirect), and 27.4% are of garden origin. The remaining 27.5% are of uncertain origin, and most of these (2680 accessioned plants) correspond to individuals growing in natural/naturalized regions whose provenance cannot be confidently ascertained. The dynamic living collection is always in flux, and between 2007 and 2022, an average of 391 (2.4%) plants were removed, and 337 (2.1%) were added each year [6].

During its first century, the Arboretum aspired to grow every potential taxon of temperate woody plant in the living collections (i.e., to be comprehensive). Modes of acquisition included direct field collection from wild populations, donation, and exchange of germplasm from sister institutions, as well as purchase from commercial nurseries. In 1979, only a few years after its centennial year, institutional planning yielded A Feasibility Study for Restoration [9], which in part addressed the development of the living collections in a formal way. To "complete" the collections (at least from a taxonomic perspective), the Arboretum would need to acquire some 2500 botanical taxa (known as desiderata, plural, or desideratum, singular). The plan was to put forward an ambitious goal to collect from the wild or obtain through other means (index semina or clones from other gardens) 1500 of these desiderata within the first five years. Although the plan did not indicate an end year, the decade to come represented vigorous exploration activities and yielded many high-value acquisitions, particularly those collected in eastern Asian countries like China, which re-opened in 1980 [10]. By 1991, a new long-range plan for the living collections [11] continued the 1979 plan's comprehensive scope and expanded the list of desiderata to almost 3000 individual botanical taxa.

Shortly after its publication in 1991, a re-evaluation of collections development activities led to a pause. In retrospect, while in 1979 and 1991, the plan's goals were noble at the time and measurable progress was made, they were too ambitious to be realistically achieved. Among other reasons, this was due to limitations in staffing, facilities, and (notably) space in the permanent collections—long-lived woody perennials (i.e., trees) take up a lot of room [8]. Exploration activities did not cease after this time, however, and from the early 1990s until the launch of the Campaign for the Living Collections in 2015, the Arboretum conducted many expeditions to acquire germplasm of value. Most expeditions targeted floristically rich regions like Hubei, China [12]; however, a few focused on single species, like the northernmost (and potentially winter-hardy) populations of *Quercus virginiana* in Virginia, USA [13].

This article profiles the Arnold Arboretum's Campaign for the Living Collections (hereafter Campaign), an ongoing initiative that serves as a case study in collection development.

It provides an overview of the Campaign, insights into how the initiative was developed, and measurements of its success. Since its launch, there have been multiple publications that describe in detail expedition execution [14], the propagation and production stage [15], placement and maintenance of plants in the permanent collections [16], as well as the Campaign’s pivotal role in serving plant conservation needs [17]. Publishing these types of articles along with procedural documentation like The Arnold Arboretum Expedition Tool Kit [18] is customary at the Arnold Arboretum. They create opportunities to share our methods with the garden community, and they create an archive of institutional initiatives.

3. The Campaign for the Living Collections

3.1. Envisioning and Planning the Campaign

The Arboretum’s living collections policy governs all facets of the management of the collections, particularly the scope of collections which in turn affects acquisition priorities [19]. The current scope of collections is no longer comprehensive. Rather, the collections policy identifies core collections of priority genera, as well as themes of importance such as biogeography and conservation [20]. After several years of strategic planning, in 2015, the Living Collections Advisory Board (which comprises both Arnold Arboretum staff and experts from other universities and gardens) put forward a visionary living collections development plan known as the Campaign for the Living Collections [21]. This plan applied the living collections policy to identify a number of priority values and themes that, in turn, were used to generate a targeted list of acquisitions or desiderata.

An important theme was a focused core collection of seventeen priority genera (Table 1). At the time, the Arboretum curated six genera (*Acer*, *Carya*, *Fagus*, *Stewartia*, *Syringa*, and *Tsuga*) accredited through the Plant Collections Network, PCN [22]. These already represented some of the richest ex situ collections of their kind on Earth, characterized by high species diversity and usually multiple wild-origin accessions within each taxon. With only a bit more emphasis and focus (maximized species diversity and three to five wild-sourced populations within each taxon), these collections—already great—would become exemplary. A second group of genera (*Carpinus*, *Forsythia*, *Ginkgo*, and *Ostrya*) was also prioritized, with goals to again achieve maximum species diversity but from fewer documented populations. Rather than species diversity, the priority for monotypic *Ginkgo biloba* was on the few remaining wild populations in China as well as unique cultigens. The intention was that, in time, these four genera would receive National Accreditation, and since the launch of the Campaign, *Ginkgo* and *Forsythia* have been accredited [23].

Table 1. Progress on seventeen priority genera targeted in the Campaign.

Priority Genera	Taxa on the List of Desiderata			Currently Living in the Permanent Collections ¹			
	Sought	Acquired	Acquired Accessions	Acquired Campaign Taxa	Living Campaign Plants	Total Plants within Genus ²	Percentage from Campaign (%) ³
<i>Acer</i>	53	36	63	17	50	576	8.7%
<i>Carpinus</i>	5	4	11	2	6	98	6.1%
<i>Carya</i>	12	10	32	8	57	209	27.3%
<i>Cornus</i>	7	7	23	5	27	302	8.9%
<i>Fagus</i>	11	7	17	3	13	125	10.4%
<i>Forsythia</i>	5	2	2	1	3	89	3.4%
<i>Ginkgo</i>	1	1	1	0	0	77	0.0%
<i>Hamamelis</i>	4	4	8	2	16	145	11.0%
<i>Hydrangea</i> ⁴	6	3	1	1	3	164	1.8%
<i>Magnolia</i>	5	2	3	2	5	206	2.4%
<i>Ostrya</i>	1	1	2	1	2	41	4.9%
<i>Stewartia</i>	7	6	44	1	5	49	10.2%
<i>Syringa</i>	21	10	19	5	27	407	6.6%
<i>Taxus</i>	3	3	9	1	10	168	6.0%
<i>Tsuga</i>	10	8	39	3	91	1546	5.9%
<i>Viburnum</i>	20	12	22	2	5	304	1.6%
<i>Weigela</i>	3	1	1	0	0	75	0.0%

¹ Excludes living plants in the greenhouse and nursery, as well as Campaign plants that were planted into the permanent collections and later perished. ² All plants in the living collections within a genus, including those collected for the Campaign. ³ The percentage of living plants within each genus that resulted from the Campaign. ⁴ Includes species within the genera *Cardiandra*, *Decumaria*, *Deinathe*, *Platy crater*, as well as *Hydrangea sensu stricto*.

The third theme was that of biogeography, and eight genera (*Cornus*, *Hamamelis*, *Hydrangea sensu lato*, *Magnolia*, *Taxus*, *Viburnum*, and *Weigela*) with strong evolutionary histories in Eastern Asia and Eastern North America were selected. Note that *Weigela*, endemic to East Asia, is sister to North American *Diervilla*, a genus already well represented in the Arboretum's collections and with little need for additional collection development. We did not seek comprehensive species diversity within each of these genera, so to maximize phylogenetic breadth, we used recently published phylogenies to select at least one species that would represent each of the well-supported clades within each genus. In the end, 174 of the taxa on the final list of desiderata belonged to one of the seventeen priority genera.

A goal of synoptic breadth—representation of as many temperate and woody genera as possible—led to the selection of some 40 genera that were completely absent from the collections at the time. The addition of only one accession of one species in each would fill in a notable synoptic gap. There were several other themes that stood on their own, as well as cut across the earlier themes. For example, almost 100 marginally hardy species that previously had evaded cultivation in Boston would be attempted again (or for the first time). Many of these were added based on anticipated climate shifts. Lastly, because of the importance of ex situ conservation, over 50 species threatened with extinction were included on the list. Although many also occurred in priority genera, other additions were woody plant species native to North America with a significant IUCN or NatureServe conservation ranking. This aligned with Target 8 of the Global Strategy for Plant Conservation: at least 75% of threatened plant species in ex situ collections, preferably in the country of origin [24].

Benchmarking the above themes against the extant living collections inventory yielded a list of 395 taxa (almost all species; however, a few infraspecific taxa were included) belonging to 145 genera and 68 families (for the complete list, consult Friedman et al. [21]). Unless otherwise noted, the goal was to obtain each desideratum directly from documented wild populations, and while some of these desiderata could be marked off the list with only a single acquisition, other taxa would require multiple distinct provenances to obviate the requirements.

To acquire nearly 400 taxa by the end of the 10th year (the goal of the *Campaign*), the Arboretum would mount multiple expeditions annually (almost exclusively in autumn) populated by Arboretum staff with field experience, as well as those new to the process. We would also rely on other garden and academic contacts and networks to make collections on our behalf or to donate existing germplasm to us. For instance, with respect to China, we would leverage our longstanding collaboration with other member gardens of the North America–China Plant Exploration Consortium, NACPEC, to collect and share germplasm [25].

To standardize practice across all acquisitions and to assist in training new explorers and contracted collectors, we issued a resource known as The Expedition Toolkit [18], which included guidelines, advice, requirements, and protocols related to planning, documenting, and executing expeditions. In order to best document acquisitions associated with the Campaign, we used specific coding within the living collections database and ran periodic audits to track progress.

The initiative was led by the senior author, with assistance during the first three years from two short-term staff (Living Collections Fellows) to create acquisition plans and individual species audits and participate in fieldwork. In 2023, the Arboretum received external funding to create a new position to oversee the Campaign, which led to the appointment of the junior author. Ten additional staff in the living collections departments of the Arboretum also participated in expeditions, most of which also had representation from staff from other universities and gardens.

3.2. Progress Report on the Campaign

While in the final stages of the Campaign's planning (including developing the final list of desiderata), the Arboretum undertook an expedition to Arkansas between 1 and

8 October 2014. Even though it occurred before the official launch, because many of the Campaign's themes (and target taxa) were part of this expedition's goals, we include it here. Between 1 October 2014 and 31 December 2023, the Arboretum embarked on 26 official expeditions and received germplasm from another 56 sources (e.g., expeditions conducted by sister institutions and donations from professional colleagues). Most Arboretum expeditions targeted a particular region known to house many priority desiderata, such as the recent 2023 Expedition to Honshu and Kyushu, Japan [26]. However, a few were specific to only one taxon, such as the 2015 NACPEC Expedition that focused on *Acer griseum* throughout most of its entire range in central China [27].

Most (76.5%) new accessions were acquired as seeds, but 11.9% came in as plants and 11.6% as clonal propagules (e.g., cuttings or grafts). These last two categories were typically donations from other gardens and repositories, although a few were directly from wild populations. Almost all (96.8%) of the acquisitions are of documented wild origin derived from 19 different countries (Figure 1), and the majority were from the United States (62.5%), China (18.0%), and Japan (11.3%).



Figure 1. Collection points of wild-origin acquisitions (red circles) and their countries of origin (heavy shading).

We have acquired 263 (66.6%) of the 395 target desiderata, with annual acquisitions of new desiderata ranging from as many as 48 (2015 and 2016) to as few as 2 (2020) per year (Figure 2). These represent 110 genera and 61 families. These 263 desiderata are represented by 631 distinct accessions or acquisitions. The number of accessions per desideratum was as low as one for 117 (44.5%) individual taxa and as high as 26 in one heavily collected species (*Stewartia ovata*). A total of 117 of the desiderata acquired belong to the 17 priority genera. *Acer*, which had the greatest number of initial desiderata, also had the greatest number of acquired taxa and accessions (Table 1). Five genera (*Cornus*, *Ginkgo*, *Hamamelis*, *Ostrya*, and *Taxus*) acquired all their targets, although these had modest goals to begin with. Although not listed as a priority genus, *Quercus* has been heavily sampled, with eight out of nine desiderata acquired via 34 distinct accessions.

As Enzenbacher and Alexander [15] describe, propagation is the most crucial (and often most challenging) stage. At the taxon level, so far, 196 (74.5%) of the 263 acquired desiderata are (or were, see below) represented by living plants, meaning that they were successfully propagated or accessioned as plants initially. Looking at the accession level, 437 (69.3%) of the 631 accessions made it to this living plant stage. No doubt, both of these statistics will increase as many of the 60 accessions acquired in 2023 are still under their various propagation treatments and will germinate in months to come. While the

two percentages (74.5% and 69.3% for taxa and accessions, respectively) are only slightly different, the variance demonstrates that collecting an individual taxon multiple times increases the likelihood of success. In other words, if only 69% (the percentage at the accession level) of the taxa had “become plants”, there would be 14 fewer taxa alive.

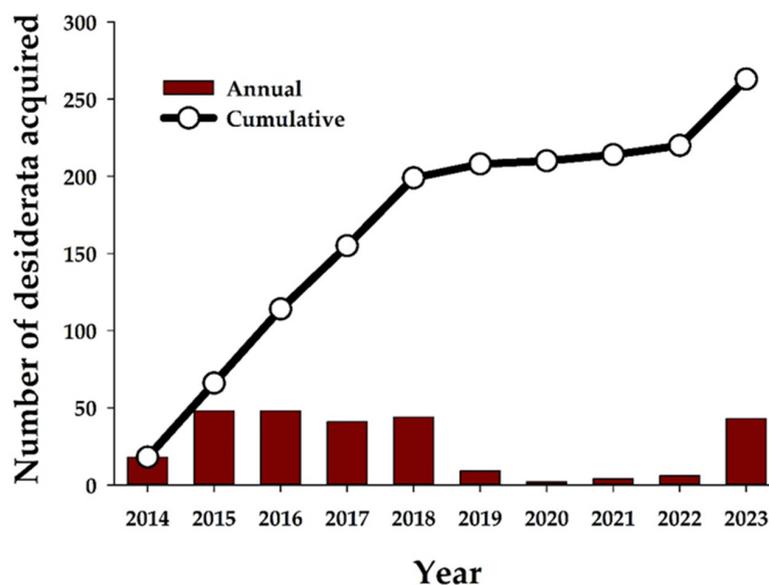


Figure 2. Annual (bars) and cumulative (line) desiderata acquired. Note that while many desiderata were acquired multiple times, only the year of first acquisition is shown.

After three to seven years, most young plants are large enough to be transplanted into permanent collections [16]. So far, a total of 894 plants (recall that a given accession usually comprises multiple plants) have been sited into the Arboretum landscape, and 705 (78.6%) of them are still alive (Figure 3). An attrition rate of about 20% is not surprising, considering the vagaries of plant establishment and environmental conditions. The Arboretum landscape experienced a record low temperature of $-24.2\text{ }^{\circ}\text{C}$ on 4 February 2023, which eliminated some marginally hardy species. Although the Arboretum provides supplemental irrigation for young plants in the nursery and after transplanting, drought conditions in 2016, 2020, and 2022 also affected the establishment and performance of some individuals. Attrition is always assumed, and whenever possible, we plant extra plants within an accession across multiple years. While it is unfortunate that some accessions and taxa are no longer represented by living plants, that does not negate the value of their acquisition. The passport data, photographs, and herbarium vouchers that accompany them at the point of collection are invaluable records in service to biodiversity science. And, because many of those accessioned were distributed to sister institutions, many collections live elsewhere (see below).

Although these 705 Campaign plants represent only 4.4% of the permanent collections, they have had a transformative impact. They represent 130 different taxa, including 50 species (and six genera) that would not be living in the permanent collections if not for the Campaign. With respect to the priority genera (Table 1), one of the most dramatic effects can be seen in *Carya*, where 27.3% of the current permanent collections—57 living plants—were acquired as part of the Campaign. This includes one species completely new to the collection (*Carya aquatica*) and many new populations of species already represented (as many as six with *Carya tomentosa*). As a raw number, the addition of 91 new *Tsuga* to the collections is also significant, but because the total collection includes over 1500 individuals, the new plants represent only 5.9% of the total. Most of the new additions to the landscape represent wild-sourced *Tsuga canadensis*, some of which may possess resistance to hemlock woolly adelgid (*Adelges tsugae*), an insect pest severely affecting natural populations in the Northeastern USA.

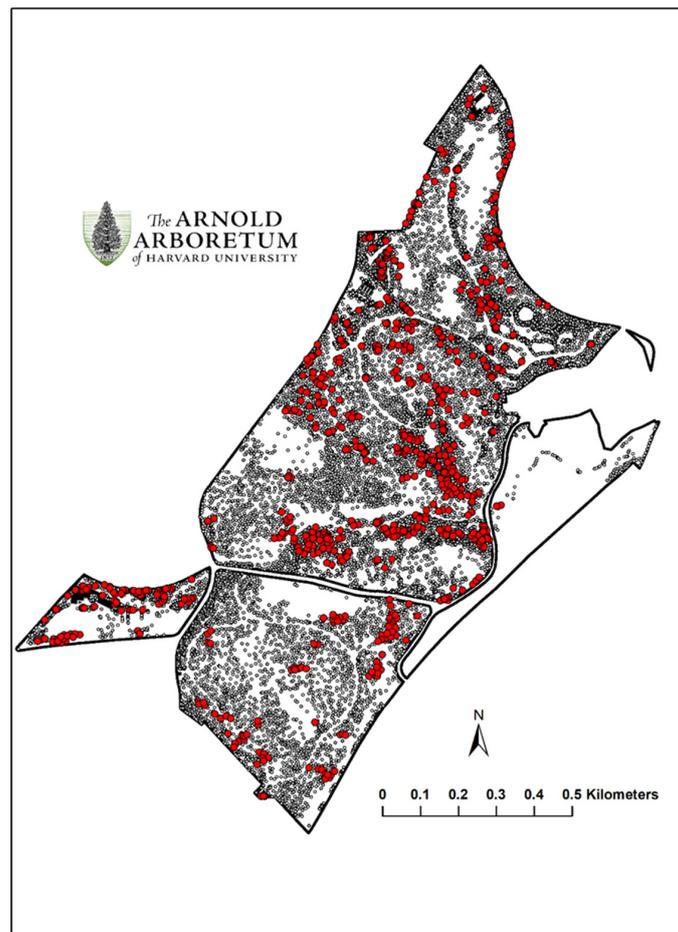


Figure 3. The distribution of all living accessioned plants in the permanent collections across the Arnold Arboretum landscape. Accessions comprise 705 plants collected as part of the Campaign (red circles) and 15,227 non-Campaign plants (black circles).

Thirty-two of the newly acquired taxa are threatened with extinction, and 166 individual plants of conservation concern have been planted. They represent 6.3% of all the plants of conservation concern growing in the collections, a percentage that increases annually. Over 1000 Campaign plants (many still small seedlings) remain in the greenhouse and nursery, including 49 new taxa not yet growing in the permanent collections. We anticipate the ongoing transformation of the collections as these existing plants and those from yet-to-be-acquired desiderata are added over the years to come.

To accommodate the new germplasm, most additions were sited within the Arboretum's traditional collection areas, which are grouped by genus. However, in a few instances, we created new collection areas or nodes for genera that have outgrown their historic boundaries. Of little surprise, one of the genera affected the most is *Carya*, where 65 plants of eight different taxa were planted into the permanent collections. While some of these were sited within the traditional *Carya* section in the Arboretum's landscape, many were placed in brand new collection areas developed for "upland" and "lowland" hickories based on the Arboretum sites' hydrology and edaphic properties and the various species' tolerances. Another example is *Quercus acerifolia*, where most of the sixteen additional plants grow in a new grove reserved for this species of conservation concern.

Another measurable impact is the service these collections have provided to those outside and beyond the Arnold Arboretum. From the launch of the Campaign in 2015 through 2023, there have been 855 distinct distributions of the Campaign material for the purposes of collections development and scholarship (Figure 4). Almost all of the 682 distributions used for collection development (comprising 197 accessions of 131 different taxa) went to

38 other gardens and germplasm repositories. Many were seed distributions immediately after the expedition, although others were surplus seedlings grown specifically for this purpose. Perhaps one of the most important lessons learned after the 1980 Sino-American Botanical Expedition was how tenuous plant introduction was and how important it was to share germplasm in order to preserve ex situ lineages [10]. Since this time, gardens and their networks (particularly NACPEC) have become more systematic in their distribution and tracking of these valuable, wild-collected accessions [28]. And due to the expanding array of global change challenges, distribution is even more essential to ex situ conservation, particularly when the germplasm must be maintained as living plants [29].

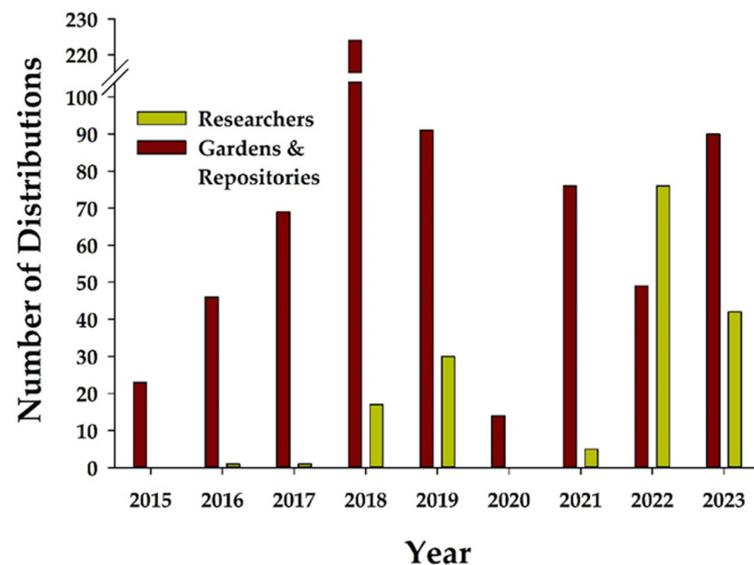


Figure 4. Distribution of Campaign acquisitions to other gardens and repositories for collection development (red) and to scholars for research (greenish–yellow) purposes.

The Arboretum’s living collection has long served the scholar [30], and for this reason, collections-based, woody-plant scholarship was recognized as one of the four essential tenets that anchored the Campaign’s strategic plan [21]. Although most scholarly usage of the collections has been on non-Campaign plants, between 2016 and 2023, there were 172 distinct distributions or uses of the Campaign material for research (Figure 4). Twenty-five different research projects (most making use of fresh or silica-dried leaves for subsequent analyses) accessed 76 different accessions representing 41 different species. Due to the influx of new genetic material acquired from the species’ ranges, it was not surprising that the two genera with the most plants added to the collection (*Carya* and *Tsuga*, Table 1) were also the two most heavily sampled for research. Interestingly, one marginally hardy species (*Gordonia lasianthus*) was used in a research project right before succumbing to winter injury and death. This demonstrates the value of plant acquisition even when individual accessions are short-lived in the landscape.

4. Lessons Learned from the Campaign

Although several years remain before the Campaign is completed, we already deem it a success and attribute success to several reasons. To begin with, the development plan was fully aligned with our mission-bound collection policy. It was embraced fully by institutional leadership to receive prioritization and resource allocation, which included outside philanthropic support. In contrast to earlier initiatives at the Arboretum, the Campaign’s goals were ambitious yet realistic and based on available staff, facility, and spatial resources to acquire, propagate, and cultivate new germplasm in the permanent collection. We could not have accomplished this alone, and collaboration has been key to our success, working fully within the Arboretum and our networks (including a number of new collaborations). As the adage goes, “many hands make light work”.

Although there was considerable planning before launching the Campaign, for each acquisition and expedition, we learned to be flexible and adjust plans as needed. After 4.5 years of success (with at least 10% of the desiderata acquired newly each year), we paused and conducted only three formal expeditions in 2019 that yielded only nine new taxa, including one conservation-status Japanese species (*Acer pycnanthum*) whose fruits dispersed in May and required a special spring expedition. The expectation was that following this recovery year, 2020 would be routine with four or five full-scale expeditions. However, the arrival of COVID-19 significantly affected domestic and international travel and access for several years, and consequently, few new acquisitions were added (Figure 2). Full recovery (with 43 new desiderata acquired) did not occur until 2023. Although we intended the Campaign to be a decade-long endeavor, ending in 2025, we now expect it to conclude in 2028.

Flexibility comes in other forms, too. There were times when we encountered a species in the field that, while not one of the official desiderata would obviate an original desideratum's contribution to the Campaign. For instance, the goal was to have one wild-collected accession within the genus *Helwingia*, and *Helwingia japonica* was selected as the desideratum to acquire. However, during the 2016 expedition to Sichuan, China, fruit-bearing plants of *Helwingia chinensis* were found in the field. We made the field decision to collect this species instead and catalog it as an official post-launch desideratum that was collected again in 2018 in Hubei, China. It is important to recognize that the goal was not a list of names but what each of those taxa qualitatively represent. Ironically, in 2020, we finally acquired *H. japonica* as a donation from another garden.

Although the 631 Campaign accessions may represent the most important acquisitions during this period, in quantity, they are a minority relative to others registered at the Arboretum. Between 2015 and 2023, the Arboretum added between 257 and 885 (average of 467) new accessions annually, which included nursery purchases, the asexual repropagation of valuable lineages already existing in the collections, targeted Campaign desiderata, and other acquisitions made while on expedition. With respect to non-target or opportunistic collections made during the expedition, some represent lineages that are too important not to collect. For instance, the Japanese endemic *Cercidiphyllum magnificum* was a discrete desideratum collected in 2018, but the more common species from Japan and China (*Cercidiphyllum japonicum*) was left off the target list because it was already well-represented in the Arboretum's living collections. Yet, during the 2017 expedition to Sichuan, China, trip participants encountered the exact tree from which the type specimen of *Cercidiphyllum japonicum* var. *sinense* (no longer an accepted taxon) was collected by Ernest Wilson in 1910. Without hesitation, the explorers collected seed and herbarium vouchers from this tree and others in the population [31]. Another unplanned but important collection was *Hypericum swinkianum*, which was a high-priority target for the 2022 Expedition to the Great Lakes in the US, despite the fact that the species was not one of the initial desiderata. It was described as new to science in 2016, after the Campaign's launch, and had the taxon been known at the time, it almost certainly would have been listed as a targeted desideratum like its close relative, *Hypericum kalmianum*, which was also collected on that expedition [32]. These two examples demonstrate that although it is important to maintain focus to avoid dilution of your stated goals, flexibility combined with sound judgment can yield valuable acquisitions.

5. The Campaign as a Model for Other Gardens

Although Heywood [3] found that plant introduction by gardens "has been remarkably successful", he noted the process "...with a few exceptions, has been described as largely a random, poorly organized, insufficiently collaborative, badly publicized and inefficiently followed through process". When it comes to success, we concur: plant introduction among gardens has been successful when you look back to see what was acquired through time and how individual garden collections have expanded and changed. However, we find it difficult to assess the success of specific collection development plans simply because few

exist that set goals in the first place. Or if a garden established specific goals a priori, there was little to no follow-up assessment afterwards.

This is one reason why we find the Campaign to be unusual, if not fully unique, among botanical institutions and hard to compare with other initiatives. It is distinctive because it meets four criteria that allow for internal as well as external assessments and evaluations: (1) vision setting; (2) defined goals; (3) documentation and evaluation; (4) and published reporting. Vision setting refers to articulating an overall scope and purpose of the development plan, ideally rich in the qualitative description that inspires and justifies the initiative. In the case of the Campaign, this included defining a set of four core principles and six themes that would serve as the foundation for the bold plan and guide the subsequent goal-setting and definition [21]. Using the ideas generated through the vision-setting process, realistic and specific goals were set that defined which taxa to include as desiderata (and why), as well as time-bounding the initiative to ten years. Documentation included capturing data during the plant acquisition phase as well as throughout the collection development process. This allowed for ongoing evaluation and calibration. Lastly, reporting is critical both internally and externally to communicate what the collections development plan is trying to achieve and how it progresses. It also forces the institution to be honest about the successes as well as failures, which are critical when evaluating the short- and long-term impacts. Thus, we feel the Campaign to be one of Haywood's [3] few successful exceptions because it has been intentional, organized, highly collaborative, well-publicized, and possessed efficient follow-through.

Like the Arnold Arboretum, many gardens and germplasm repositories have statements regarding collection visions and priorities, and many have built tremendous collections—the best of their kind—over time. However, in trying to compare their development plans to the Campaign, with few notable exceptions, most lack precisely defined goals that were set from the beginning, details of how they planned to achieve their visions or provide mid-point or after-the-fact reporting of success.

However, one positive example comes from the United Kingdom National Tree Seed Project, which set out to establish a genetically diverse seed bank of native species across the UK [33]. The goals were to first develop an understanding of the genetic diversity of native tree species, capture georeferenced localities of target species, and then learn how to optimize seed storage and germination procedures. They developed a nationwide sampling strategy, targeted locally adapted traits through sampling regional provenance, and determined how many seeds were required to capture rare alleles from maternal lines. After seed collection was completed, they tested the acquired germplasm to determine if the sampling strategy successfully met modeled expectations. Data from the project have been captured for posterity and are available to the research community. Research publications generated from the findings and a website have further communicated the project to stakeholders, including the public.

Another model that meets the criteria comes from the United States Department of Agriculture (USDA) Apple (*Malus*) germplasm repository in Geneva, New York, USA. National Plant Germplasm System collections are maintained across the USA by the USDA, with a primary focus on economically important plant species, cultivars, and crop wild relatives. These collections are maintained for conservation, characterization, and basic and applied research, particularly as a genetic resource for plant breeding. Between 1989 and 1996, a series of targeted acquisition trips were planned and executed to Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan) to acquire a diverse sampling of *Malus sieversii*, a wild relative of the domesticated eating apple (*Malus domestica*). The vision and goals for these trips were to sample across the range of the species and bring the germplasm into cultivation for characterization and conservation. In addition to many scientific papers, these well-documented trips and characterizations were summarized in a full volume of Horticultural Reviews [34].

As a final example, in recent years, there has been a trend for gardens to form multi-institutional collaborations that focused on developing priority collections of genera across

multiple sites, also known as metacollections [35]. Similarly, Global Conservation Consortia (GCC) are hosted by Botanic Garden Conservation International and led by individual institutions to bring together organizations, experts, and enthusiasts to champion an individual group (typically a genus) of plants. The goal of these consortia is to promote global conservation efforts. GCC groups have been formed for *Acer*, *Erica*, *Magnolia*, *Nothofagus*, *Quercus*, and *Rhododendron*, as well as Cycadales and Dipterocarpaceae. Activity varies by group, but each actively engages with research and conducts assessments that capture information on the current conservation status of species. Using *Quercus* as an example, this GCC has identified operational regions and leaders to champion conservation efforts in those respective areas. Publishing The Red List of Oaks [36] and a Conservation Gap Analysis of Native US Oaks [37] not only lists and describes rare oak species and their status in nature (including distribution, ecology, and threats) but also addresses the needs to acquire them in ex situ collections. Publications and progress reports serve as powerful tools for targeted plant acquisition plans and create blueprints for the development and refinement of metacollections.

Although these examples do not strictly adhere to the four criteria of the Campaign, they demonstrate visionary and successful collections development plans that are well documented, assessed, and evaluated. We believe that other gardens or consortia—particularly those with active plant exploration programs—can benefit by approaching collections development like we have at the Arnold Arboretum. Our approach can be applied to an entire living collection or smaller sub-collections like a core genus. And, while our focus has been on germplasm of documented wild provenance, there is no reason why it cannot be applied to reference cultivar collections or others where thoughtful development is warranted.

At the end of the published vision document, Friedman and colleagues [21] note, “The Campaign for the Living Collections does not just consider the long term, it focuses on it. . . The impact will resonate for decades, if not centuries, to come”. Without question, these acquisitions have had an immediate impact. We look forward to further assessing the Campaign’s measurable and meaningful effects upon its completion. And, in the historic annals of the Arnold Arboretum, we hope that this pulse reverberates for many years, decades, and centuries to come.

Author Contributions: Conceptualization, M.S.D. and M.S.S.; methodology, M.S.D. and M.S.S.; formal analysis, M.S.D.; data curation, M.S.D. and M.S.S.; writing—original draft preparation, M.S.D.; writing—review and editing, M.S.S.; visualization, M.S.D. and M.S.S.; supervision, M.S.D. and M.S.S.; project administration, M.S.D. and M.S.S.; funding acquisition, M.S.D. All authors have read and agreed to the published version of the manuscript.

Funding: This initiative was funded, in part, by numerous private donors to the Arnold Arboretum of Harvard University and, specifically, the Fondation Franklinia and the Harvard China Fund.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The dataset is available on request from the authors.

Acknowledgments: For their help in collection data management, we thank Kyle Port, Kathryn Richardson, and Ali Schade, particularly Kyle Port for his assistance in cartography. We thank Robert Dowel and Terry Huang, two curatorial fellows, who helped with the Campaign’s initial launch. This initiative would have been impossible without the contributions from countless collectors and associates who participated in fieldwork and the staff at the Arnold Arboretum involved with their curation, documentation, propagation, and cultivation.

Conflicts of Interest: The authors declare no conflicts of interest.

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