

Ex situ Gap Analysis of High Priority Plant Taxa of Conservation Concern in the Southeast U.S.

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July 2022



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The Atlanta Botanical Garden has more than 30 years of experience in the conservation and recovery of rare and threatened plant species through research, propagation, collaborative restoration and habitat management. Through conservation of imperiled species and natural communities across the southeastern United States, Caribbean, and Ecuador, the center protects the natural heritage of one of North America's most biodiverse regions. Through its Southeastern Center for Conservation & Research, Atlanta Botanical Garden advances the science of conservation through research, collaborations, and native species recovery programs that include conservation collections at the garden and applied conservation activities that support preservation of species in their native habitats. Conservation programs, training, and capacity building derived from the activities of the Southeastern Center for Conservation support the Garden's commitment to serving the needs of the community and making the connection between people and plants. <https://atlantabg.org>



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Botanic Gardens Conservation International (BGCI) is a global network representing some 600 institutional members in nearly 100 countries that exists to ensure the worldwide conservation of plant diversity. BGCI-US connects conservation interests, best practices, and information with botanic gardens and conservation partners to secure threatened plants in North America and around the world. We aim to support and empower our members and the wider conservation community, so that our knowledge and expertise can be applied to reversing the threat of extinction facing plants. Our vision is a world in which plant diversity is valued, secure and supporting all life, and our mission is to mobilise botanic gardens and engage partners in securing plant diversity for the well-being of people and the planet. <https://bgci.org>



For nearly 50 years, NatureServe has been the authoritative source for biodiversity data throughout the Americas. To protect threatened biodiversity, NatureServe works with nearly 100 organizations and over 1,000 conservation scientists to collect, analyze, and deliver standardized biodiversity information, providing comprehensive spatial data to meet both regulatory and conservation needs. NatureServe and its network partners develop and manage data for over 100,000 species and ecosystems, answering fundamental questions about what exists, where it is found, and how it is doing. <https://natureserve.org>



The Southeastern Plant Conservation Alliance (SE PCA) is currently coordinated by members of the Atlanta Botanical Garden's Southeastern Center for Conservation & Research, with participation from partners at the state, regional, and national levels. The SE PCA bridges local and national efforts while collaborating to restore and prevent the loss of plant diversity. This is achieved by building capacity, facilitating novel partnerships, and leveraging shared resources to stimulate collective success in our region. This work is unique, cost effective, and can be accomplished in no other way. There are more than 120 individual members representing government agencies, land managers, botanical gardens, university programs, plus other experts and professionals; 20+ leaders make up our steering committee and there are 50+ task team members; our footprint includes 17 U.S. states and territories. <http://se-pca.org>



Acknowledgements

The Southeastern Plant Conservation Alliance (SE PCA) humbly acknowledges the indigenous people of our focal area. We are working on the homeland of many tribes, and it is with gratitude and appreciation that we seek to conserve species and natural systems that were nurtured by those stewards possessing unparalleled relationships with these lands since time immemorial. The SE PCA recognizes the many impacts of colonialism and the irreparable losses that have been endured by the original inhabitants - including humans, animals, plants, and stones - and the land itself. To learn more about tribes in the Southeast, you can visit the [Southeast Climate Adaptation Science Center \(SECASC\) Tribal Story Map](#) and the [Native Land Digital](#) interactive maps. *These are on-going works in progress that are not meant to represent official or legal tribal boundaries; to learn about definitive areas, please contact the nation(s) in question.*

The analyses presented here would not have been possible without the support of many botanic gardens, seed banks, and other botanical institutions and collections, who responded to our requests for collections data. Thank you to the 50+ institutions who updated their taxa list in BGCI's PlantSearch database, and a special thank you to the 158 institutions who responded to our accession-level survey of *ex situ* living collections (Appendix E). Curating, exporting, and formatting accessions data can be an unseen task. We hope the results presented here will help further plant conservation objectives and provide evidence of the continued importance of the dedicated work of individuals and institutions each day.

Funding support for this project was provided by the Atlanta Botanical Garden on behalf of the Southeastern Plant Conservation Alliance.

Recommended citation: Beckman Bruns, E., Coffey, E., Treher Eberly, A., Frances, A., Meyer, A., Radcliffe, C. (2022). *Ex situ Gap Analysis of High Priority Plant Taxa of Conservation Concern in the Southeast U.S.* San Marino, California: Botanic Gardens Conservation International U.S.

Cover photo: *Sarracenia leucophylla* in Deer Lake restoration area (photo by Jeff Talbert, 2020).



Table of Contents

Background	5
Southeastern Plant Conservation Alliance	5
Objectives	6
Priority Southeast U.S. Taxa of Conservation Concern	6
Ex situ Gap Analysis	9
Approach and Objectives	9
Taxon-level PlantSearch Analysis	11
Wild-origin Accessions Survey	15
Overall Findings	18
Taxon-specific Case Studies	21
American Chaffseed (<i>Schwalbea americana</i>)	22
Carolina Birds-in-a-nest (<i>Macbridea caroliniana</i>)	23
Georgia Rockcress (<i>Arabis georgiana</i>)	24
Miccosukee Gooseberry (<i>Ribes echinellum</i>)	25
White Fringeless Orchid (<i>Platanthera integrilabia</i>)	26
Whorled Sunflower (<i>Helianthus verticillatus</i>)	27
Final Remarks	28
References	30
Appendices	31
Appendix A. High priority plant taxa in the Southeast U.S. and <i>ex situ</i> survey results	31
Appendix B. Genus-level summary of <i>ex situ</i> survey results	32
Appendix C. Family-level summary of <i>ex situ</i> survey results	32
Appendix D. NatureServe conservation status rank definitions	33
Appendix E. List of institutions who provided <i>ex situ</i> collections data	34
Supplemental Materials	36



Background

Southeastern Plant Conservation Alliance

The Southeast U.S. is a biodiversity hotspot – an area rich in unique habitats and plants that, because of anthropogenic influences and climate change, is at increased risk of loss (Cartwright & Wolfe, 2016; Knapp et al., 2020). The region is home to over 11,000 native plant species, 30% of which are endemic (Noss et al., 2015). Of the 65 plants that have vanished in North America since European settlement, nearly 40% (25) are from the Southeast U.S. Of an additional seven plants assessed as extinct in the wild (only known in *ex situ* living collections), four are from the Southeast U.S. The majority of federally threatened and endangered species are plants – yet they receive less than 5% of federal & state recovery funding (Negrón-Ortiz, 2014). Nearly one third of plant species in the U.S. are at risk of extinction, but only 11% are protected by the Endangered Species Act (Antonelli et al., 2020).

The Southeastern Plant Conservation Alliance (SE PCA) is a public and private partnership of professionals bridging gaps between local and national plant conservation efforts and collaborating to prevent and restore the loss of plant diversity in the Southeast U.S. The Alliance is tailored to multiple interests to provide training opportunities, fill information gaps, identify conservation needs, prioritize efforts, and work collaboratively to conserve imperiled plants. The goals of the SE PCA are being achieved by promoting best practices (Center for Plant Conservation, 2019), adapting successful models, novel partnerships, and creative solutions to challenges while leveraging shared resources.

Preliminary strategic planning has outlined the following action items for the SE PCA:

- Develop a list of species of greatest conservation need for the Southeast U.S.
- Identify and conduct conservation status assessments for priority species
- Secure 60–75% of Southeast U.S. rare plants in seed banks and cultivated (*ex situ*) living collections (Botanic Gardens Conservation International, 2016)
- Implement recovery and restoration programs that return 10–15% of *ex situ* material to the wild (*in situ*) within 4–6 years (Botanic Gardens Conservation International, 2016)



Objectives

In an effort to pursue the SE PCA’s strategic goals, the SE PCA, in partnership with the Atlanta Botanical Garden, Botanic Gardens Conservation International U.S., and NatureServe conducted an *ex situ* living collections survey in early 2021. The analyses presented in this report provide a framework for assessing current *ex situ* representation and gaps for high priority Southeast U.S. plants of greatest conservation need.

Priority Southeast U.S. Taxa of Conservation Concern

Based on NatureServe’s taxonomic backbone and distribution data, a taxa list was compiled in late 2020 by NatureServe, in consultation with project collaborators, for all vascular plants native to any portion of the Southeast U.S. The geographic scope followed the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) definition of the Southeast U.S. which includes the following 15 states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Puerto Rico and the Virgin Islands were not included due to insufficient data, but will be incorporated in a future iteration. Taxa with the majority of their distribution within the Southeast U.S. and a NatureServe Conservation Status Rank of G1/T1 (Critically Imperiled), G2/T2 (Imperiled), or GH/TH (Possibly Extinct) were then selected as high priority (NatureServe, 2020). See Appendix D for a table with definitions of the NatureServe Conservation Status Ranks. This list was further refined to exclude non-standard taxa (e.g., sp. 1, var. 2) and non-standard taxonomic duplicates, *resulting in a final list of 703 “high priority” taxa of greatest conservation concern in the Southeast U.S.* (Appendix A). The list includes over 600 taxa ranked by NatureServe either as Imperiled or as Critically Imperiled, and a small number (22) of taxa ranked as Possibly Extinct (Table 1). The taxonomy used in the list follows NatureServe’s taxonomic backbone at the time of compilation in 2020, therefore further iterations of the list may update names or remove taxa.

Table 1. Number of high priority plant taxa of conservation concern in the Southeast U.S. (703 total), by NatureServe Conservation Status Rank. See Appendix D for NatureServe Global Conservation Status Rank definitions. Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020).

NatureServe Global Conservation Status Rank	Number of high priority taxa
GH/TH (Possibly Extinct taxa)	22
G1/T1 (Critically Imperiled taxa)	305
G2/T2 (Imperiled taxa)	376

Some states in the Southeast U.S. contain more high priority taxa than others, which can help to quantify the issues faced within each state and prioritize where the greatest conservation impact could be realized (Table 2). Florida and Texas hold the greatest number of high priority taxa of conservation concern, with a total of 240 and 213, respectively. All states have more Imperiled taxa than Critically Imperiled taxa. Texas has by far the most Possibly Extinct taxa (8), followed by Florida and Georgia (3 taxa each). Missouri and Oklahoma, located at the western extent of the Southeast U.S., have the fewest high priority taxa of conservation concern.

Table 2. Number of high priority plant taxa of conservation concern native to each Southeast U.S. state, by conservation status; counts per state based on NatureServe distribution data. See Appendix D for NatureServe Global Conservation Status Rank definitions. States are ordered by the total number of high priority taxa occurring in each state (highest to lowest). Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020).

State	NatureServe Global Conservation Status Rank		
	GH/TH (Possibly Extinct)	G1/T1 (Critically Imperiled)	G2/T2 (Imperiled)
Florida	3	107	130
Texas	8	89	116
Georgia	3	44	93
Alabama	1	34	83
North Carolina	1	34	73
South Carolina	2	19	57
Tennessee	1	27	43
Virginia	0	21	38
Arkansas	1	7	23
Louisiana	1	1	23
Mississippi	0	4	20
Kentucky	0	5	18
West Virginia	3	5	15
Missouri	2	5	12
Oklahoma	0	1	16

These state-level taxon richness data can also be viewed as a heat map, to visually identify areas of conservation need in the Southeast U.S. Following Florida and Texas with the most high priority taxa are Georgia, Alabama, and North Carolina, each with >100 high priority taxa (Figure 1). Although the states with high numbers of priority species are targets for further resources based on this diversity, it's important to note that states with lower numbers of high priority taxa could include populations with unique genetic diversity not represented elsewhere in the Southeast, and therefore populations in these states still require attention.

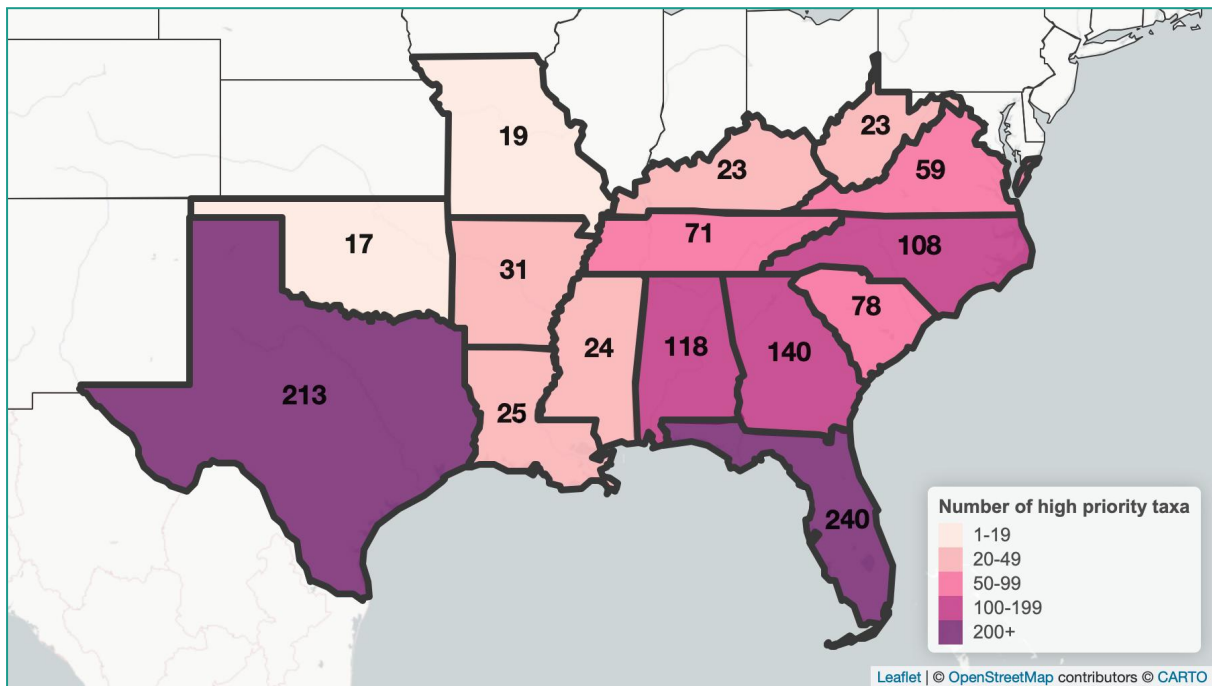


Figure 1. Number of high priority taxa of conservation concern (703 total) in each Southeast U.S. state, based on NatureServe distribution data and a 2020 list of high priority species of conservation concern (NatureServe, 2020).

Ex situ Gap Analysis

Approach and Objectives

Ex situ plant conservation is the maintenance and care of living plant material outside a species' natural habitat, in the form of whole plants, seeds, pollen, tissues, and other viable germplasm. With growing environmental threats to wild plant populations, *ex situ* conservation is often of vital importance for long-term species survival.

Botanic gardens and similar organizations such as arboreta, academic institutions, nurseries, and government agencies play a unique and important role in the conservation of plants. In addition to providing a safe haven to prevent a species' complete extinction, *ex situ* living collections support awareness-building for millions of botanic garden visitors and students each year by providing important and relevant plant conservation information. *Ex situ* collections also help to advance research in genetics, breeding, propagation, and evaluation. Through propagation, *ex situ* collections can increase supply of highly-desirable species, thereby reducing pressure on wild populations. When produced from wild and genetically diverse material, *ex situ* plants can also supply material for reintroduction programs.

However, with limited staff, space, and time, it is essential for *ex situ* sites to strategically develop and promote broader use of their living collections for conservation and research. *Ex situ* plant collections should, when possible, focus on genetically representative collections of species of conservation concern, and especially exceptional species (species unable to be seed banked long-term) to achieve the greatest conservation impacts (Pence et al., 2022). Metacollections – the combined holdings of a group of collections that are stewarded collaboratively for research and conservation purposes – allow broader access to greater diversity, dilute risk of loss, and reduce overall costs across all institutions involved (Griffith et al., 2019). The closer alignment of *ex situ* efforts through metacollections offers greater conservation success at the species level.



Newly-found individual of Torreya taxifolia in the wild (photo by Atlanta Botanical Garden).

BGCI's PlantSearch database is the only global database of plants, seeds, and tissues maintained in botanic garden living collections. BGCI uses PlantSearch to track progress toward the Global Strategy for Plant Conservation Target 8, which is focused on *ex situ* conservation. According to PlantSearch, more than one-third of all plant species on Earth are maintained by botanic gardens and similar *ex situ* organizations, including more than 40% of globally threatened species. BGCI and partners are working to scale up and expand gene and species diversity across *ex situ* collections as a vital safety net against extinction. To that end, BGCI conducts *ex situ* gap analyses for priority plant groups to gauge *ex situ* representation and identify gaps to guide *ex situ* conservation action.

To assist the SE PCA in furthering the strategic goals of the network, BGCI-US conducted an *ex situ* living collections survey of high priority plant taxa of conservation concern in the Southeast U.S. In February and March 2021, a call for taxa lists from *ex situ* collections was sent out to the SE PCA network of more than 120 conservation organizations. A direct email was also sent to over 300 botanic gardens and similar organizations known by BGCI to be located in the Southeast U.S. Through



Symphyotrichum georgianum in Georgia (photo by Carrie Radcliffe, Atlanta Botanical Garden).

this data call, new and updated taxa lists were added to BGCI's PlantSearch database by over 50 institutions. In April 2021, the PlantSearch database was queried for records matching the 703 high priority taxa of conservation concern in the Southeast U.S. or their synonyms (BGCI PlantSearch, 2021), which was provided by NatureServe. Institutions that had last updated their taxa list in PlantSearch prior to 2010 were excluded from these results to increase confidence.

The resulting list of institutions reporting high priority taxa to PlantSearch was used to send direct email requests from BGCI for accession-level plant records data for wild-origin material currently in their living collections. A total of 158 institutions responded to this data call, including 146 who provided

accession-level data for high priority taxa of conservation concern for the Southeast U.S. Once accession-level plant records were received from respondent institutions, these records were compiled and standardized using R (R Core Team, 2021). Overall, taxon name, number of individuals, provenance type, and wild collection site latitude and longitude were standardized. Six taxa were chosen for taxon-level case studies that compare the taxon's full native distribution to wild localities represented in collections. For these target taxa, wild-origin *ex situ* accessions were manually geolocated for mapping if a locality description was provided but geographic coordinates were not.

Taxon-level PlantSearch Analysis

A wide variety of institutions across the world maintain Southeast U.S. high priority taxa of conservation concern in their *ex situ* living collections. Overall, 321 institutions in 36 countries reported one or more high priority taxa to PlantSearch, including 170 (53%) institutions in the U.S., of which 69 (21%) are located in the Southeast U.S. (Figure 2). Of the 321 institutions that report high priority taxa, 17 are seed banks. Ten (59%) of these seed banks are located in the Southeast U.S. and only one is found outside the U.S.

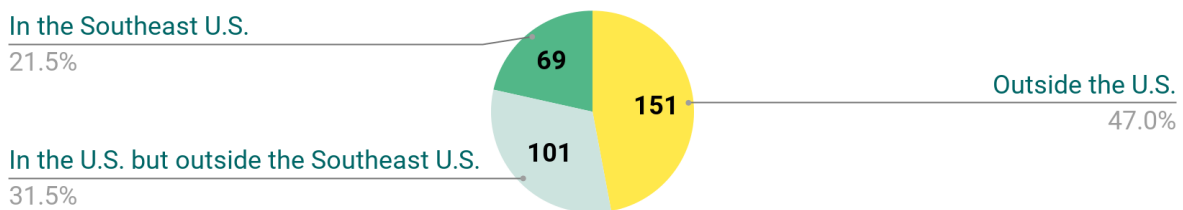


Figure 2. Number of *ex situ* living collections reporting Southeast U.S. high priority taxa of conservation concern, by institution location. Based on collections data reported to BGCI's PlantSearch database as of April 2021.

In total, *ex situ* living collections reported 382 (54%) Southeast U.S. high priority taxa to PlantSearch (Figure 3). *This shows fantastic progress for the Southeast U.S. and is above average when compared to other regional ex situ analyses recently completed by BGCI. It is also very encouraging to see that 377 (99%) taxa are reported by ex situ collections in the U.S. and 308 (81%) taxa are reported by ex situ collections in the Southeast U.S.* This demonstrates the valuable work of *ex situ* institutions in the Southeast U.S. and the excellent momentum gained by the SE PCA. These findings also highlight the *ex situ* material around the world that, in some cases, may be important sources of some of the last known genetic diversity for these high priority taxa. It is clear, however, that few high priority taxa are held *only* by *ex situ* collections outside the U.S., and most high priority taxa are maintained in *ex situ* collections within the Southeast U.S.

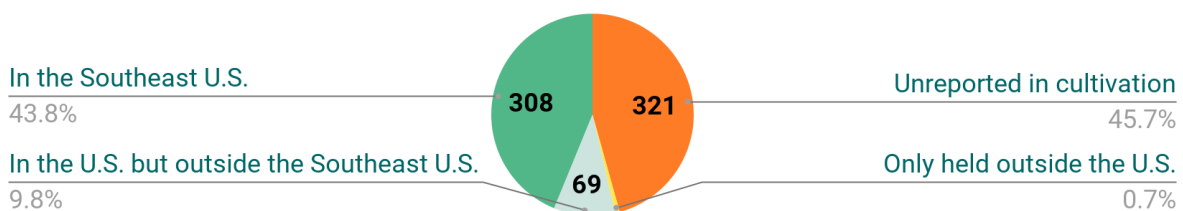


Figure 3. Number of Southeast U.S. high priority taxa of conservation concern (703 total) reported in *ex situ* living collections, by institution location. Based on collections data reported to BGCI's PlantSearch database as of April 2021.

Many of the most common Southeast U.S. high priority taxa maintained in living plant and seed collections are well-represented in *ex situ* collections in the Southeast U.S. (Table 3). This includes many ornamental taxa common in cultivation – including the widely grown *Franklinia alatamaha* which historically originate from a single plant – but also some taxa that are not as charismatic and are highly threatened. For the latter group especially, this demonstrates that botanic gardens and other *ex situ* institutions have been actively collecting and distributing germplasm of these threatened taxa. *There are a number of very dedicated and capable seed banks in the Southeast U.S., and our results highlight opportunities to build even more genetically representative seed bank accessions within the region.* This can be achieved by sharing or propagating material that exists outside the Southeast U.S., in addition to making new collections from wild populations.

Table 3. Southeast U.S. high priority taxa reported by more than 20 *ex situ* living collections, outside and in the Southeast U.S. Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020) and collections data reported to BGCI's PlantSearch database as of April 2021.

Taxon name	Outside the Southeast U.S.		In the Southeast U.S.	
	Number of plant collections	Number of seed banks	Number of plant collections	Number of seed banks
<i>Franklinia alatamaha</i>	82	2	17	0
<i>Dionaea muscipula</i>	79	1	8	1
<i>Abies fraseri</i>	79	3	3	1
<i>Tsuga caroliniana</i>	54	1	15	1
<i>Torreya taxifolia</i>	43	2	16	0
<i>Paxistima canbyi</i>	52	1	5	0
<i>Sarracenia oreophila</i>	38	1	7	2
<i>Echinacea tenesseeensis</i>	30	4	9	1
<i>Betula uber</i>	33	1	9	0
<i>Illicium parviflorum</i>	19	0	22	0
<i>Viburnum bracteatum</i>	26	2	8	0
<i>Spiraea virginiana</i>	18	3	10	1
<i>Rhododendron chapmanii</i>	16	1	12	1
<i>Quercus acerifolia</i>	23	2	4	0
<i>Elliottia racemosa</i>	15	0	11	0
<i>Hamamelis ovalis</i>	15	2	8	0

<i>Sarracenia jonesii</i>	19	1	3	2
<i>Chionanthus pygmaeus</i>	11	2	9	1
<i>Sarracenia alabamensis ssp. alabamensis</i>	19	0	3	0
<i>Taxus floridana</i>	12	1	8	0
<i>Echinocereus viridiflorus var. davisii</i>	17	2	2	0

There are also many Southeast U.S. high priority taxa that are still under-represented in *ex situ* living collections. This includes 319 (45%) taxa that are completely absent from *ex situ* collections and 135 (19%) are in four or fewer collections (Appendix A). These absent taxa could use additional attention for appropriate *ex situ* collection building. One exception is the 20 taxa absent from collections that are ranked as Possibly Extinct; these need targeted survey efforts aimed at rediscovery in the wild – and in some cases further taxonomic clarification – before they can be prioritized for *ex situ* conservation. It’s also possible some of these taxa are held by institutions who did not provide collections data in our survey, or that additional information could identify unique genetic resources that should be prioritized for duplication and distribution to multiple *ex situ* locations. In addition, there are 94 taxa reported only by plant collections, and further attention should be directed toward seed banking genetically representative samples for these taxa.

It is also valuable to consider the type of germplasm stored in *ex situ* collections, to help inform next-steps for conservation. *Notably, 288 high priority taxa (75% of the taxa in collections) are reported by seed banks. Because seed collections often capture greater genetic diversity than plant collections, this demonstrates the powerful conservation work that has been accomplished for Southeast U.S. high priority taxa.* Estimating or assessing genetic representativeness of those seed accessions across each taxon is an important step as well. There is also a growing role for *ex situ* plant collections to maintain and manage genetically representative and long-term groves of long-lived exceptional species, which cannot be seed banked (Pence et al., 2022).

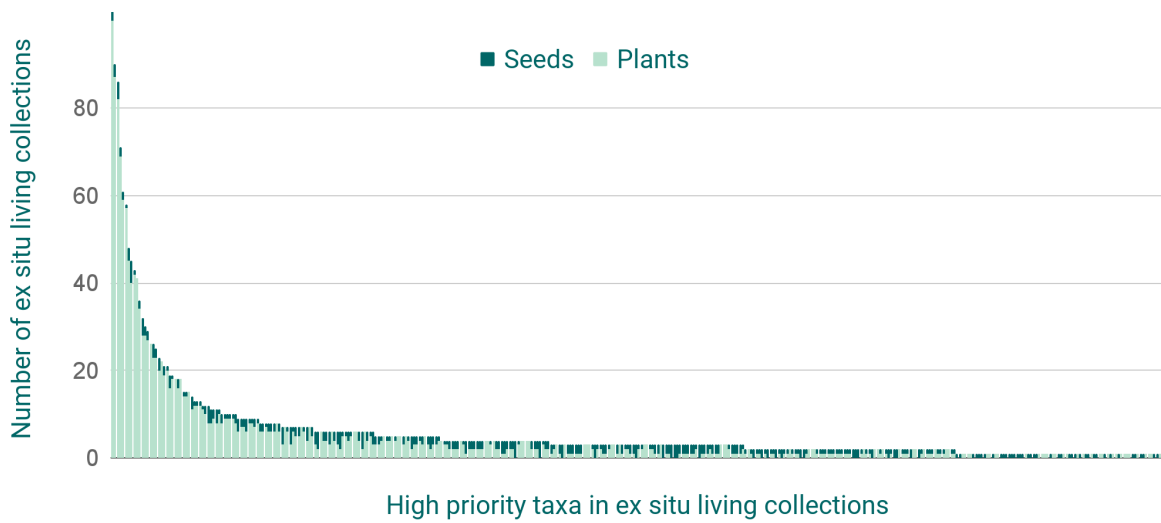


Figure 4. Number of ex situ living collections reporting 382 of 703 high priority plant taxa of conservation concern in the Southeast U.S., categorized by germplasm type (plants or seeds). Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020), collections data reported to BGCI’s PlantSearch database (2021), and an ex situ survey of wild-origin accessions as of April 2021.



Quercus acerifolia growing at The Morton Arboretum in Lisle, Illinois (photo by Deb Brown, The Morton Arboretum).

Wild-origin Accessions Survey

With the ability to pinpoint which institutions maintain high priority taxa of conservation concern in the Southeast U.S., an accession-level (plant records) survey was distributed. In total, 158 *ex situ* living collections responded to a follow-up direct email request for accessions data, including 79 (50%) institutions in the U.S. and 28 (18%) in the Southeast U.S. Of these, 77 (49%) reported wild-origin material for high priority taxa, including 53 (34%) in the U.S. and 21 (13%) in the Southeast U.S.

Of the 703 high priority taxa, 223 (32%) are reported to have documented, wild-origin material in *ex situ* living collections (Figure 5). *This is an above-average finding at the regional level when compared with similar studies carried out by BGCI, and demonstrates significant ex situ progress for the Southeast U.S.* Thirty (4%) taxa are represented by 20 or more accessions of wild- or propagated-from-wild- origin and likely include genetically representative sample sizes (though not necessarily complete; Table 4). However, 616 (88%) taxa are represented by five or fewer accessions of wild-origin and likely have insufficient genetic sampling.

Regarding the number of institutions holding taxa, only 11 taxa are reported by more than five institutions. A further 125 taxa represented by wild-origin material are reported by only single institutions, and 56 of those taxa are represented by a single wild-origin accession. Overall, Critically Imperiled (G1/T1) and Imperiled (G2/T2) taxa are distributed fairly evenly across the curve of number of wild-origin accessions for each high priority taxon (Figure 5). It is noteworthy that a small number of Extinct in the Wild (GH/TH) taxa are reported, and those should certainly be investigated further.



Platanthera integrilabia in Alabama (photo by Ian Sabo, Atlanta Botanical Garden).

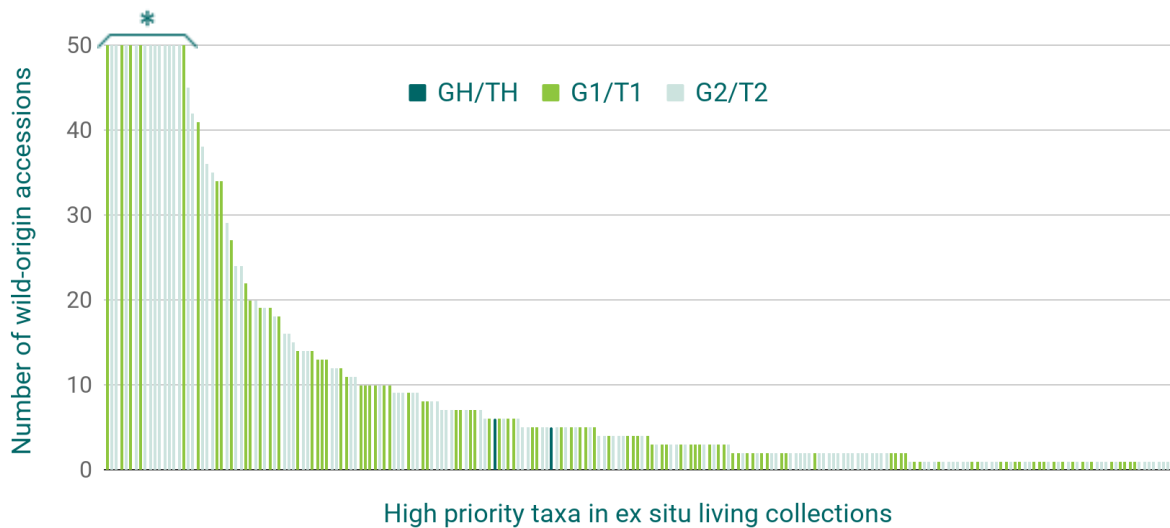


Figure 5. Number of wild-origin accessions reported for 223 Southeast U.S. high priority taxa of conservation concern, categorized by NatureServe Global Conservation Status Rank. Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020), and living collections data reported during an April 2021 ex situ survey of wild-origin accessions. *Please note that numbers of accessions greater than 50 have been cropped here to maximize data visibility; reference Table 4 for exact values greater than 50. See Appendix D for NatureServe Global Conservation Status Rank definitions.

A different strategy should be followed for the 11 taxa held by five or more institutions and 17 taxa represented by 50 or more wild-origin accessions (Table 4). These taxa are represented by some of the strongest *ex situ* conservation collections that are known currently, and the institutions collectively maintaining these taxa could explore opportunities such as broader metacollection coordination, assessing levels of genetic sampling, and exchanging information on cultivating or banking a taxon.

Table 4. High priority taxa of conservation concern in the Southeast U.S. represented by more than 50 wild-origin accessions and/or reported by five or more institutions. Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020), and living collections data reported during an ex situ survey of wild-origin accessions in April 2021.

Taxon name	Total number of wild-origin accessions reported	Number of institutions reporting wild-origin <u>plant</u> accession(s)	Number of institutions reporting wild-origin <u>seed</u> accession(s)
<i>Torreya taxifolia</i>	829	19	1
<i>Abies fraseri</i>	148	21	3
<i>Platanthera chapmanii</i>	125	3	1
<i>Astragalus bibullatus</i>	123	1	1
<i>Sarracenia oreophila</i>	109	8	1
<i>Quercus acerifolia</i>	106	13	1
<i>Boltonia decurrens</i>	100	1	1
<i>Hibiscus dasycalyx</i>	100	1	0
<i>Tsuga caroliniana</i>	88	11	2
<i>Geocarpon minimum</i>	71	1	1
<i>Platanthera integrilabia</i>	63	3	1
<i>Echinacea laevigata</i>	62	5	2
<i>Chloris texensis</i>	61	1	0
<i>Spiraea virginiana</i>	56	8	1
<i>Dalea foliosa</i>	56	0	2
<i>Dionaea muscipula</i>	54	2	3
<i>Dirca decipiens</i>	51	1	0
<i>Sarracenia jonesii</i>	45	4	1
<i>Taxus floridana</i>	42	5	0
<i>Echinacea tennesseensis</i>	38	3	2
<i>Quercus boyntonii</i>	34	8	1
<i>Hamamelis ovalis</i>	29	9	1
<i>Helianthus verticillatus</i>	14	3	2
<i>Betula uber</i>	13	7	0
<i>Crataegus harbisonii</i>	10	3	2
<i>Robinia viscosa</i> var. <i>hartwegii</i>	9	6	1

Overall Findings

Ex situ living collections with Southeast U.S. high priority taxa of conservation concern are distributed around the world, which demonstrates the global importance of the Southeast U.S. flora and the potential genetic diversity held by institutions in and outside of the Southeast U.S. (Figure 6). The majority of accessions for high priority taxa are held by institutions in the U.S., Europe, Asia, and Oceania. Wild-origin material is reported by 77 *ex situ* collections located in the U.S., Canada, New Zealand, and 11 countries in Europe, with the majority (68%) located in the U.S. Based on our accession-level survey, only two taxa have wild-origin material held exclusively outside the U.S.: *Aquilegia chrysantha* var. *chaplinei* (held in Canada and Sweden) and *Sophora gypsophila* var. *guadalupensis* (held in Sweden).

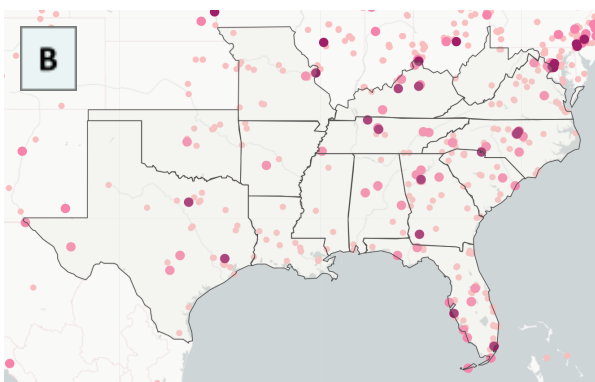
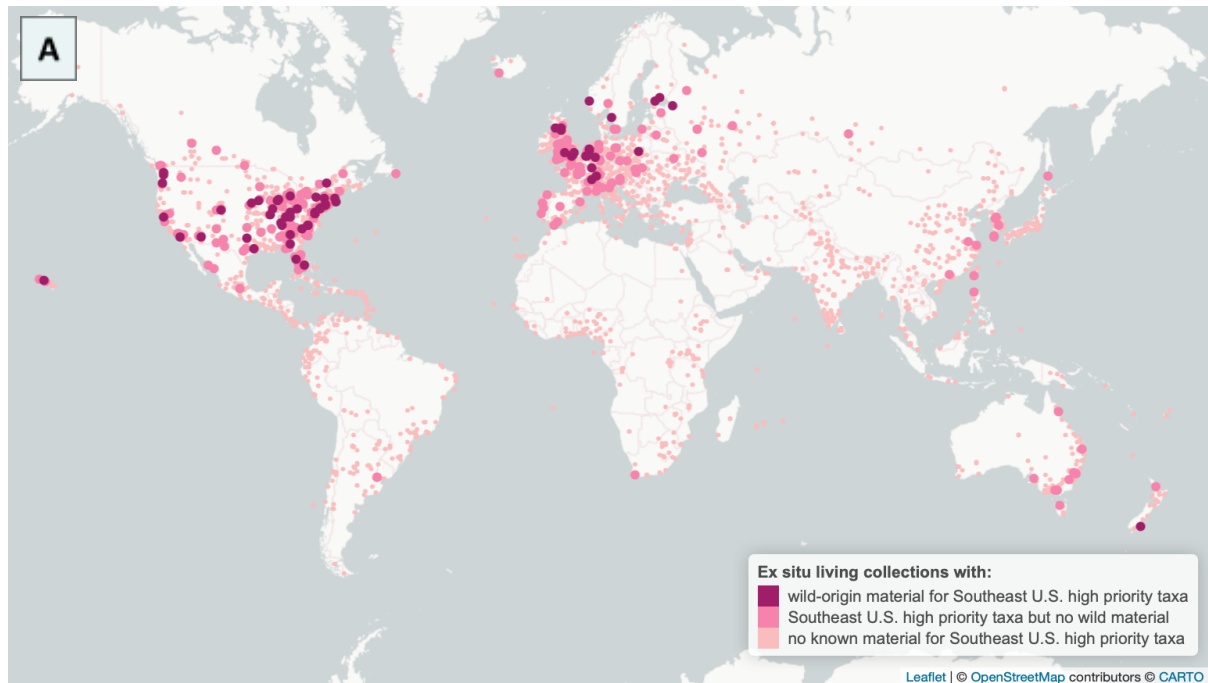


Figure 6. (A) Global *ex situ* living collections (institutions) categorized by presence of Southeast U.S. high priority taxa of conservation concern; and (B) Closeup of over 300 *ex situ* collections in the Southeast U.S. region (outlined). Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020), *ex situ* location data from BGCI's GardenSearch database (2021), results from the taxon-level PlantSearch analysis (2021), and the *ex situ* survey of wild-origin accessions in 2021.

Of the 703 high priority taxa of conservation concern in the Southeast U.S., wild-origin provenances for 223 (32%) taxa are reported, while provenances for another 161 (23%) taxa in *ex situ* living collections are not reported (Figure 7). A fairly even balance of wild provenance material is reported for Critically Imperiled (G1/T1) and Imperiled (G2/T2) ranked taxa, and provenances for two Extinct in the Wild (GH/TH) taxa are even reported. *Information about which high priority taxa are reported or unreported in ex situ collections – and which collections have wild provenance material – is a crucial starting point for catalyzing conservation action and prioritizing next steps for specific taxa (Figure 7).* Overall, additional institutions documenting and sharing information about their collections, as well as new, scientifically-informed wild collections being made and documented appropriately will increase *ex situ* representation for these high priority taxa of conservation concern.

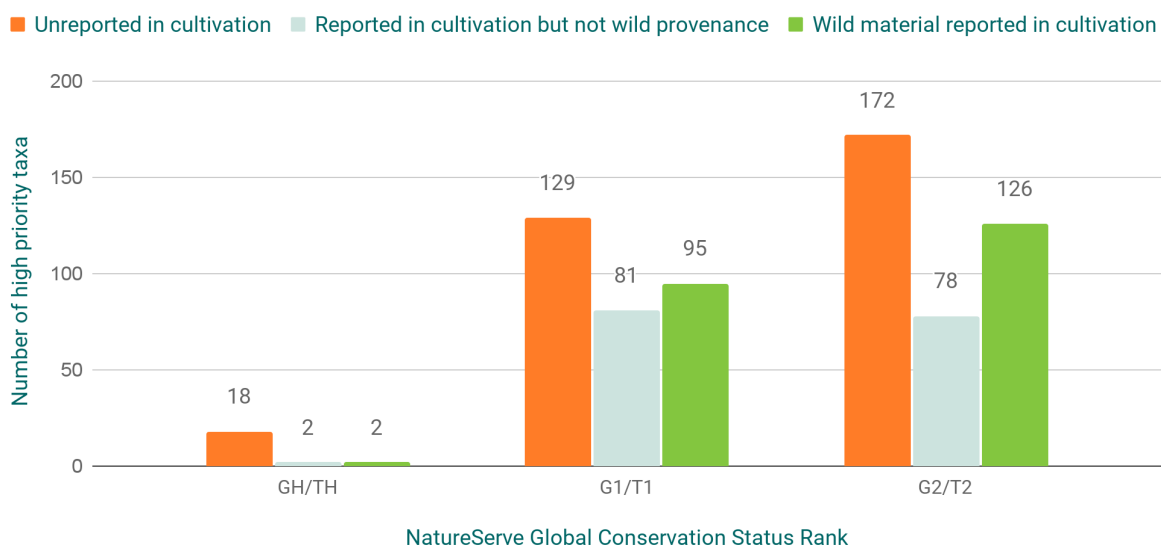


Figure 7. Number of Southeast U.S. high priority plant taxa reported and unreported by *ex situ* living collections, by conservation status. Based on a 2020 list of high priority species of conservation concern (NatureServe, 2020), collections data reported to BGCI’s PlantSearch database (2021), and an *ex situ* survey of wild-origin accessions as of April 2021. See Appendix D for NatureServe Global Conservation Status Rank definitions.

The number of high priority Southeast U.S. taxa of conservation concern held in *ex situ* living collections can also be analyzed at the state level. Here, we provide a region-wide, taxon-level view of the number of native taxa in each state that are reported or unreported in cultivation (Figure 8). This overview highlights which states have the most Southeast native taxa represented in collections, however, due to multiple-state species distributions, does not necessarily pinpoint which states have the highest need for additional *ex situ* collecting. Further analyses could examine endemic species per state, and also the wild provenance of *ex situ* living collections of each target taxon to identify on a state level the taxa that have wild-origin material collected from each state.

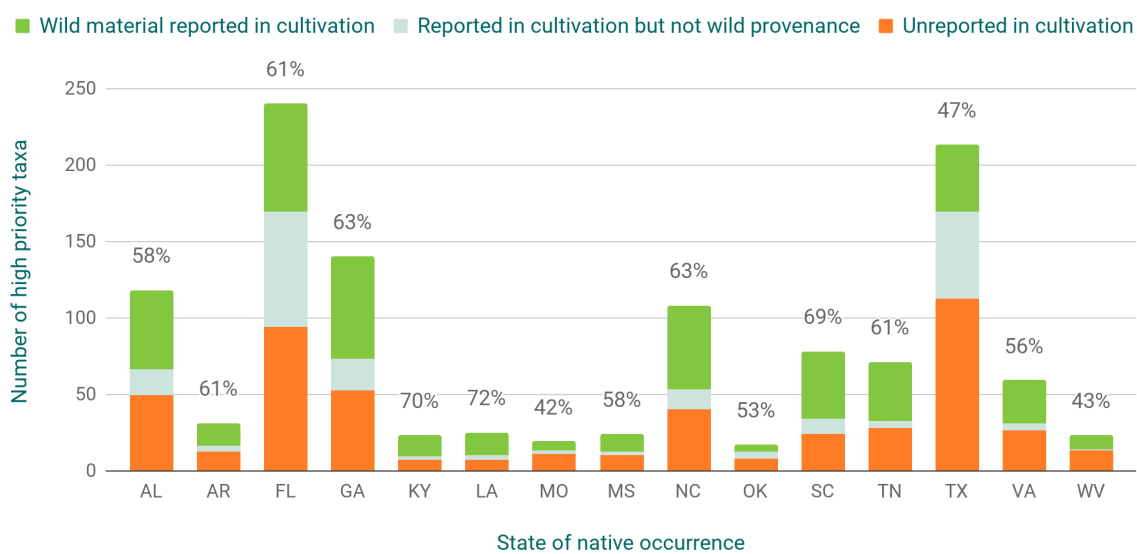


Figure 8. Number of Southeast U.S. high priority plant taxa reported and unreported by *ex situ* living collections, by state of native occurrence. Number above each bar gives the total percent of high priority taxa found in *ex situ* collections. Results based on a 2020 list of high priority species of conservation concern (NatureServe, 2020), collections data reported to BGCI’s PlantSearch database (2021), and an *ex situ* survey of wild-origin accessions as of April 2021, in addition to NatureServe state-level distribution data.

Taxon-specific Case Studies

To demonstrate some of the geographic gap analyses that are possible using the accessions data compiled for this report, we selected six priority species as case studies. The Southeast U.S. high priority taxa with *ex situ* accessions data from the 2021 survey were cross-referenced with the 2016 Southeastern Partners in Plant Conservation planning list, which included species protected by or petitioned for listing under the Endangered Species Act. Taxa overlapping all three lists were chosen for mapping. *Ex situ* accessions data for these taxa were then examined to identify records with no source latitude and longitude provided for wild-origin accessions. If a wild collection locality description was provided for these records and gave a location at the county-level or finer, the latitude and longitude were manually filled using Google Maps to identify the location.

An *ex situ* representation map was created for each target taxon by overlaying NatureServe *in situ* occurrence points with wild collection sites reported in the *ex situ* accessions survey. We estimate that areas where an *ex situ* wild collection site does not overlap with the *in situ* distribution of the taxon could be caused by a gap in NatureServe *in situ* occurrence points, misidentification of the taxon in the wild, incorrect geolocation by the *ex situ* collectors, or the wild population could have been from occurrences that are now historical (extirpated). These results can be used to estimate *ex situ* genetic representation and create targeted surveying or collecting plans by identifying populations that are under-represented or not yet represented in *ex situ* living collections.



American Chaffseed (*Schwalbea americana*)

Species conservation status and distribution in the Southeast U.S.

NatureServe Global Conservation Status: G2 (Imperiled)

State-level distribution and NatureServe statuses within the Southeast U.S.:

Alabama (S1), Florida (S1), Georgia (S2), Kentucky (SH), Louisiana (S1), Mississippi (SH),
North Carolina (S1), South Carolina (S2), Tennessee (SX), Virginia (SH)

U.S. Endangered Species Act: Endangered (9/29/1992)

Summary results from the *ex situ* living collections surveys

Number of institutions reporting the taxon to BGCI PlantSearch: 6 (5 [83%] in the Southeast U.S.)

Number of accessions reported in our survey: 133 (20 wild-origin)

Number of wild-origin accessions geolocated and mapped: 14 (70%)



Map source: NatureServe (2020); wild collection locations added by BGCI-US

Legend



Carolina Birds-in-a-nest (*Macbridea caroliniana*)

Species conservation status and distribution in the Southeast U.S.

NatureServe Global Conservation Status: G2 (Imperiled)

State-level distribution and NatureServe statuses within the Southeast U.S.:

Alabama (SNR), Florida (SNR), Georgia (S1), North Carolina (S2), South Carolina (S3)

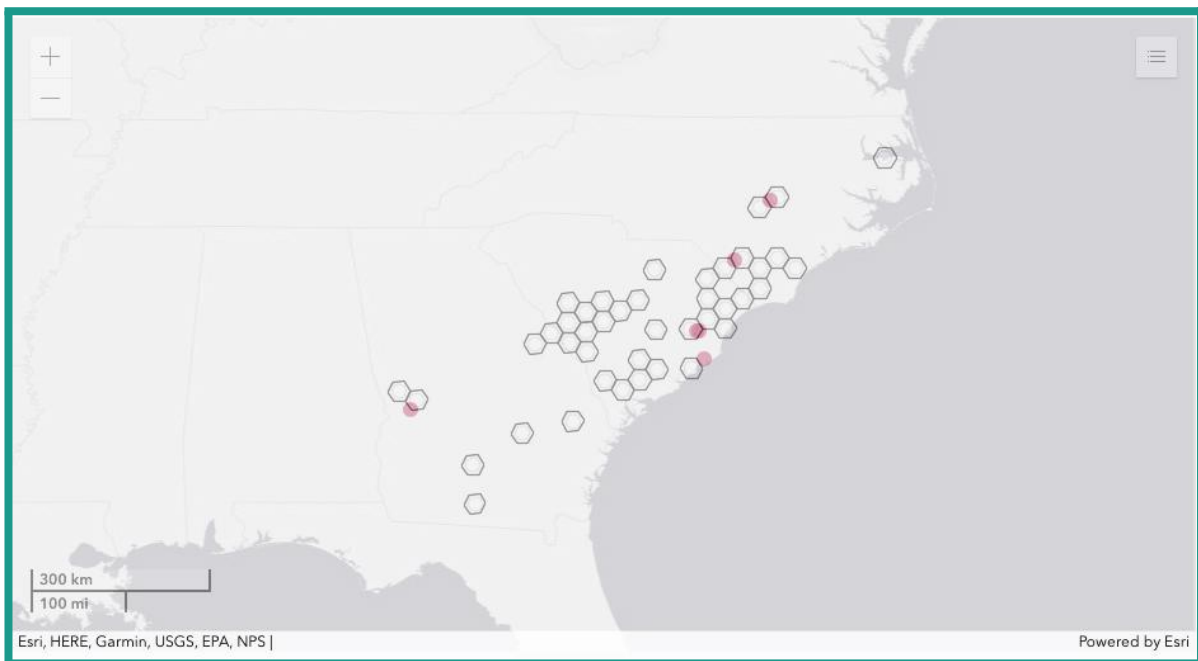
U.S. Endangered Species Act: Under Review (9/27/2011)

Summary results from the *ex situ* living collections surveys

Number of institutions reporting the taxon to BGCI PlantSearch: 10 (8 [80%] in the Southeast U.S.)

Number of accessions reported in our survey: 17 (7 wild-origin)

Number of wild-origin accessions geolocated and mapped: 6 (86%)



Legend



Georgia Rockcress (*Arabis georgiana*)

Species conservation status and distribution in the Southeast U.S.

NatureServe Global Conservation Status: G1 (Critically Imperiled)

State-level distribution and NatureServe statuses within the Southeast U.S.:

Alabama (S1), Georgia (S1)

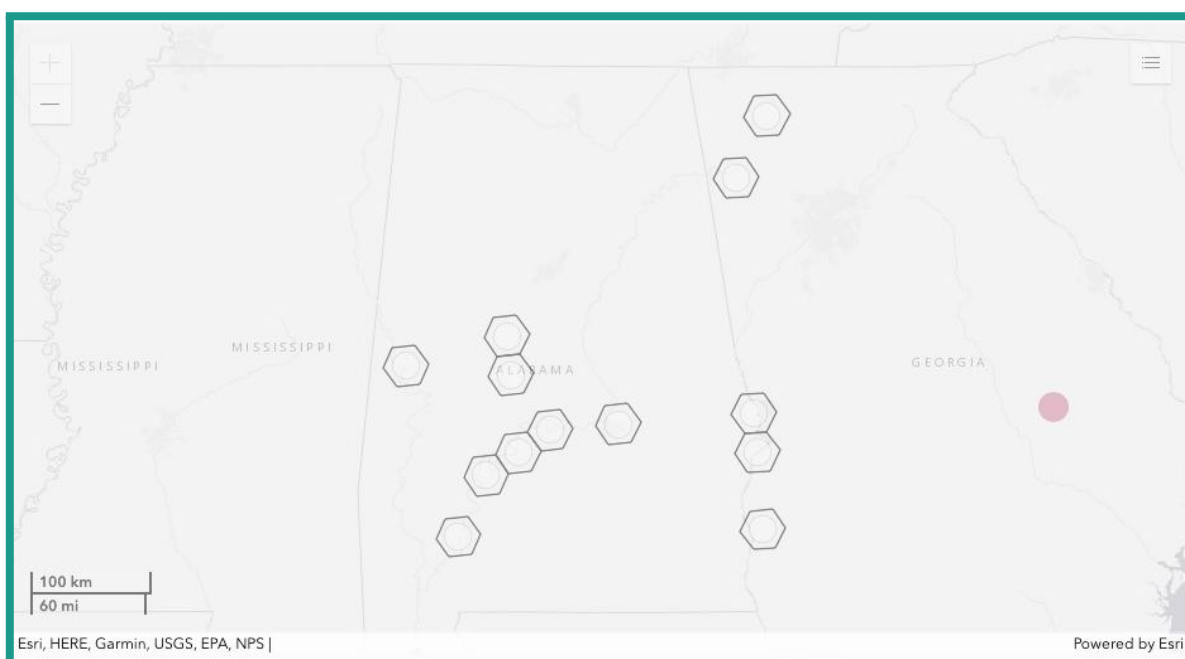
U.S. Endangered Species Act: Threatened (9/12/2014)

Summary results from the *ex situ* living collections surveys

Number of institutions reporting the taxon to BGCI PlantSearch: 4 (4 [100%] in the Southeast U.S.)

Number of accessions reported in our survey: 5 (2 wild-origin)

Number of wild-origin accessions geolocated and mapped: 1 (50%)



Legend



Miccosukee Gooseberry (*Ribes echinellum*)

Species conservation status and distribution in the Southeast U.S.

NatureServe Global Conservation Status: G1 (Critically Imperiled)

State-level distribution and NatureServe statuses within the Southeast U.S.:

Florida (S1), South Carolina (S1)

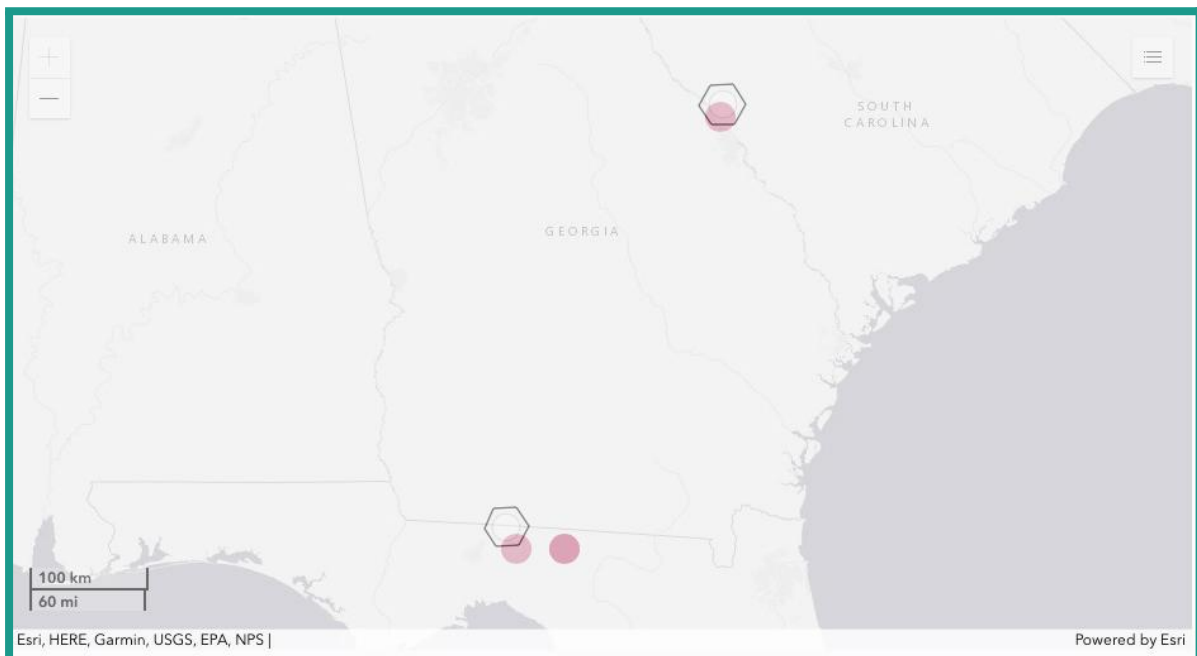
U.S. Endangered Species Act: Threatened (7/18/1985)

Summary results from the *ex situ* living collections surveys

Number of institutions reporting the taxon to BGCI PlantSearch: 10 (6 [60%] in the Southeast U.S.)

Number of accessions reported in our survey: 8 (5 wild-origin)

Number of wild-origin accessions geolocated and mapped: 4 (80%)



Map source: NatureServe (2020); wild collection locations added by BGCI-US

Legend



White Fringeless Orchid (*Platanthera integrilabia*)

Species conservation status and distribution in the Southeast U.S.

NatureServe Global Conservation Status: G2 (Imperiled)

State-level distribution and NatureServe statuses within the Southeast U.S.:

Alabama (S2), Georgia (S1S2), Kentucky (S1), Mississippi (S1), North Carolina (SH), South Carolina (S1), Tennessee (S2S3)

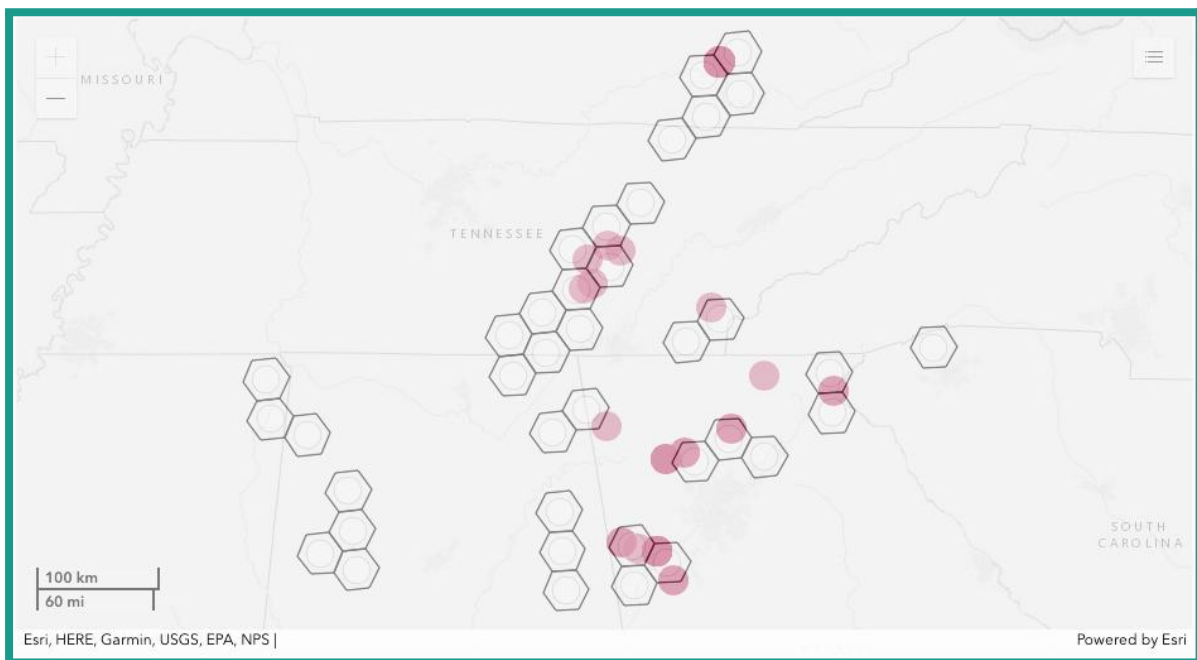
U.S. Endangered Species Act: Threatened (9/13/2016)

Summary results from the *ex situ* living collections surveys

Number of institutions reporting the taxon to BGCI PlantSearch: 5 (4 [80%] in the Southeast U.S.)

Number of accessions reported in our survey: 97 (63 wild-origin)

Number of wild-origin accessions geolocated and mapped: 60 (95%)



Map source: NatureServe (2020); wild collection locations added by BGCI-US

Legend



Whorled Sunflower (*Helianthus verticillatus*)

Species conservation status and distribution in the Southeast U.S.

NatureServe Global Conservation Status: G1 (Critically Imperiled)

State-level distribution and NatureServe statuses within the Southeast U.S.:

Alabama (S1), Georgia (S1), Mississippi (S1), Tennessee (S1)

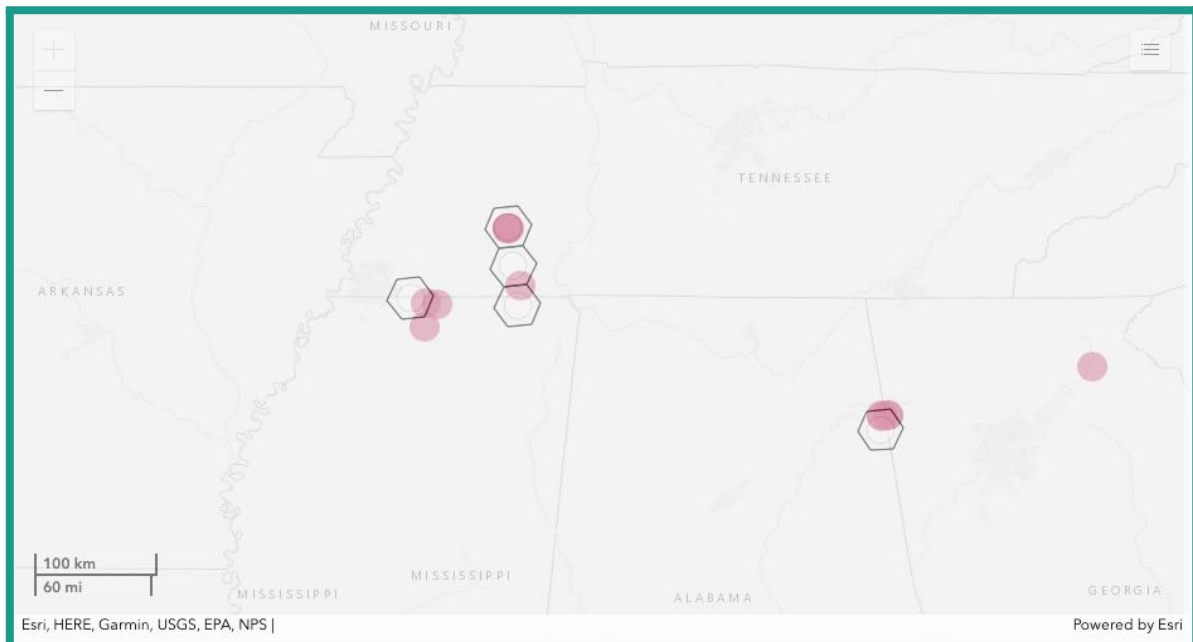
U.S. Endangered Species Act: Endangered (8/1/2014)

Summary results from the *ex situ* living collections surveys

Number of institutions reporting the taxon to BGCI PlantSearch: 8 (6 [75%] in the Southeast U.S.)

Number of accessions reported in our survey: 16 (13 wild-origin)

Number of wild-origin accessions geolocated and mapped: 13 (100%)



Legend



Distribution (Where available)

343 mi² / 888 km²
Hexagon



BOTANIC GARDENS
CONSERVATION INTERNATIONAL

Results from 2021 *ex situ* accession-level survey

Source locality for wild-origin *ex situ* accessions; the darker the circle, the more accessions



Final Remarks

This *ex situ* gap analysis is intended to be a useful step toward identifying conservation priorities for the SE PCA, building on existing *ex situ* living collections and targeting gaps, and identifying collaborative opportunities across institutions including the dynamic management of species-focused metacollections. *Collections and accessions data contributions require valuable time on the part of collectors and ex situ collection managers, and for that we are grateful.* We hope the data and analyses here will inform efforts throughout the Southeast U.S. to further prioritize conservation action, provide justification for funding applications, and further connect partners and allied organizations focused on individual species.

We acknowledge that *ex situ* efforts represent one of many valuable tools that support plant conservation. While seed banking and cultivation of material from wild populations using best practices is powerful, the conservation of natural communities through land preservation and management are essential. Combined with ongoing biological research and efforts to increase awareness about the importance of plant biodiversity, we can gain a better collective understanding and make greater strides towards sustaining wild plants and our future on Earth.

Limitations of this gap analysis include the quality of the taxon-level data provided to BGCI's PlantSearch database and the accession-level data provided by those institutions that were able. As living collections are dynamic, it is worth noting the importance of regularly sharing and updating data, and tracking progress.



Macbridea caroliniana at the North Carolina Botanical Garden (photo by Cornusflorida, 2017).

It is also vital to reiterate that a goal for this and other related efforts is to establish and sustainably maintain genetically appropriate *ex situ* collections of these high priority taxa of conservation concern. This assessment is just one step toward this mission, and the continued commitment of the SE PCA and *ex situ* collection partners is required to maintain and build on this assessment. *It is hoped that the SE PCA can maintain and update the aggregated accessions data through time for high priority taxa.* This analysis will be updated through future iterations and aims to further inspire and guide conservation action for our regional network, which includes many stakeholders.

Next steps and ideal actions for the SE PCA network include the following:

- Utilize the dataset compiled in this *ex situ* gap analysis to *map the geographic coverage of ex situ collections for additional high priority taxa* (see taxon-specific case studies presented above). Further review and refinement of the dataset could allow greater mapping capabilities, and could identify unique wild populations not previously documented by NatureServe or others.
- *Identify and connect with those ex situ institutions that have globally unique collections* and look for opportunities to back up, propagate, and share that material and associated information for greater conservation impact. Verification of the Extinct in the Wild (GX/GH) collections identified in the analysis would be of interest.
- *Guide appropriate and scientifically-informed wild collecting activities* by:
 - *Increasing population-level representation and taxon-level genetic diversity* in *ex situ* collections;
 - *Facilitating metacollection development* to ensure genetically representative collections are shared and backed up across the regional network;
 - *Building well-documented and genetically diverse ex situ collections*, particularly for species in areas where *in situ* habitat loss and climatic threats are greatest; and
 - *Compiling updated ex situ collections data* (accession-level, focused on wild provenance material) on a regular basis, *documenting ongoing conservation efforts*, and *identifying needs* (reintroduction, propagation, research, etc.) for priority taxa
- *Continue promotion of cross-sector networking and collaboration* by identifying gaps in information and action to ensure species conservation.
- *Develop a formal regional species prioritization list* to focus funding, field work, data collection, *ex situ* collections development, *in situ* restoration and recovery, and other conservation action among stakeholders with related contexts and objectives.

The diversity of habitats and plant species in the Southeast U.S. and the ecosystem services they provide offer critical resiliency in the face of our changing climate. But these natural resources are largely overlooked, underfunded, and are vulnerable to multiple ongoing threats, which will lead to additional and irreplaceable losses. Therefore cohesive action in the Southeast can prevent the further extinction of plant species and provide security and momentum for the entire U.S. This gap analysis is a crucial step toward assessing and facilitating efficiency in our continued efforts to conserve rare plant species.

References

- Antonelli, A., Fry, C., Smith, R. J., Simmonds, M. S. J., Kersey, P. J., Pritchard, H. W. ... Zhang, B. G. (2020).** *State of the World's Plants and Fungi 2020*. Royal Botanic Gardens, Kew. doi: 10.34885/172
- BGCI GardenSearch. (2021).** GardenSearch online database. Botanic Gardens Conservation International: Richmond, U.K. Available at www.bgci.org/plant_search.php
- BGCI PlantSearch. (2021).** PlantSearch online database. Botanic Gardens Conservation International: Richmond, U.K. Available at www.bgci.org/plant_search.php
- Botanic Gardens Conservation International. (2016).** *North American Botanic Garden Strategy for Plant Conservation, 2016-2020*. Illinois, USA: Botanic Gardens Conservation International U.S.
- Cartwright, J. M., & Wolfe, W. J. (2016).** *Insular ecosystems of the southeastern United States—A regional synthesis to support biodiversity conservation in a changing climate*. U.S. Geological Survey Professional Paper 1828, 162. doi: 10.3133/pp1828
- Center for Plant Conservation. (2019).** *CPC Best Plant Conservation Practices to Support Species Survival in the Wild*. Center for Plant Conservation: Escondido, CA. Retrieved from <https://saveplants.org/wp-content/uploads/2020/12/CPC-Best-Practices-5.22.2019.pdf>
- Griffith, M. P., Beckman, E., Callicrate, T., Clark, J., Clase, T., Deans, S., ... Wood, J. (2019).** *TOWARD THE METACOLLECTION: Safeguarding plant diversity and coordinating conservation collections*. San Marino, USA: Botanic Gardens Conservation International- US.
- Knapp, W. M., Frances, A., Noss, R., Naczi, R. F. C., Weakley, A., Gann, G. D., ... Gluesenkamp, D. (2020).** Vascular plant extinction in the continental United States and Canada. *Conservation Biology*, 35(1), 360-368. doi: 10.1111/cobi.13621
- NatureServe. (2020).** NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available at <https://explorer.natureserve.org/>. Accessed November, 2020.
- Negrón-Ortiz, V. (2014).** Pattern of expenditures for plant conservation under the Endangered Species Act. *Biological Conservation*, 171, 36-43. doi: 10.1016/j.biocon.2014.01.018
- Noss, R., Platt, W. J., Sorrie, B. A., Weakley, A. S., Means, D. B., Costanza, J. K., & Peet, R. (2015).** How global biodiversity hotspots may go unrecognized: Lessons from the North American Coastal Plain. *Diversity and Distributions*, 21(2), 236-244. doi: 10.1111/ddi.12278
- Pence, V. C., Beckman Bruns, E., Meyer, A., Pritchard, H. W., Westwood, M., Linsky, J., ... Beech, E. (2022).** Gap Analysis of Exceptional Plant Species — Using a Global List of Exceptional Plant Status to Expand Strategic Conservation Action Beyond Seed Banking. *Biological Conservation*, 266. doi: 10.1016/j.biocon.2021.109439
- R Core Team (2021).** R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at <https://www.R-project.org/>.



Appendices

Appendix A. Table of high priority plant taxa of conservation concern in the Southeast U.S. and results from two April 2021 ex situ surveys. Taxa are listed in alphabetical order. The table below provides a preview of the full list of all 703 taxa, which can be downloaded here: <http://www.se-pca.org/ex-situ-gap-analysis/>

Taxon name	Family	NatureServe Global Conservation Status Rank	NatureServe state-level distribution and S-Ranks	Number of ex situ living collections reporting the taxon in BGCi's PlantSearch database as of April 2021					Number of ex situ living collections reporting wild-origin material in April 2021 accessions survey				
				Total	In the U.S.	In the South-east U.S.	Plants	Seeds	Total	In the U.S.	In the South-east U.S.	Plants	Seeds
<i>Agalinis caddoensis</i>	Scrophulariaceae	GH	LA(SH)	0	0	0	0	0	0	0	0	0	0
<i>Agalinis flexicaulis</i>	Scrophulariaceae	G1	FL(S1)	0	0	0	0	0	0	0	0	0	0
<i>Agalinis georgiana</i>	Scrophulariaceae	G1	FL(S1), GA(S1)	0	0	0	0	0	0	0	0	0	0
<i>Agalinis pseudaphylla</i>	Scrophulariaceae	G1	AL(S1), MS(SNR), TN(SNR), TV(SNR)	0	0	0	0	0	0	0	0	0	0
<i>Agave neglecta</i>	Agavaceae	G2	FL(SNR)	4	3	2	4	0	0	0	0	0	0
<i>Allium elmendorfii</i>	Liliaceae	G2	TX(S2)	0	0	0	0	0	0	0	0	0	0
<i>Allium keeverae</i>	Liliaceae	G2	NC(S2)	0	0	0	0	0	0	0	0	0	0
<i>Allium oxyphilum</i>	Liliaceae	G2	VA(S1), WV(S2)	0	0	0	0	0	0	0	0	0	0
<i>Allium speculae</i>	Liliaceae	G2	AL(S2), GA(S2), TV(SNR)	2	2	1	2	0	0	0	0	0	0
<i>Amsonia tharpii</i>	Apocynaceae	G1	NM(S1), TX(S1)	5	5	0	3	2	0	0	0	0	0
...													

Appendix B. Genus-level summary of April 2021 ex situ survey results for high priority plant taxa of conservation concern in the Southeast U.S. Genera are listed in alphabetical order. The table below provides a preview of the full list of 315 genera, which can be downloaded here: <http://www.se-pca.org/ex-situ-gap-analysis/>

Genus	Number of high priority taxa				Proportion of high priority taxa	
	Total	Unreported in cultivation	Provenance not reported	Wild provenance	Unreported in cultivation	Wild provenance
<i>Abies</i>	1	0	0	1	0%	100%
<i>Abronia</i>	1	0	0	1	0%	100%
<i>Aeschynomene</i>	1	0	0	1	0%	100%
<i>Agalinis</i>	5	4	0	1	80%	20%
<i>Agave</i>	1	0	1	0	0%	0%
<i>Allium</i>	4	3	1	0	75%	0%
<i>Alnus</i>	1	0	0	1	0%	100%
<i>Amorpha</i>	3	0	0	3	0%	100%
<i>Amphianthus</i>	1	0	0	1	0%	100%
<i>Amsonia</i>	1	0	1	0	0%	0%
...						

Appendix C. Family-level summary of April 2021 ex situ survey results for high priority plant taxa of conservation concern in the Southeast U.S. Families are listed in alphabetical order. The table below provides a preview of the full list of 99 families, which can be downloaded here: <http://www.se-pca.org/ex-situ-gap-analysis/>

Family	Number of high priority taxa				Proportion of high priority taxa	
	Total	Unreported in cultivation	Provenance not reported	Wild provenance	Unreported in cultivation	Wild provenance
Acanthaceae	6	4	2	0	67%	0%
Agavaceae	5	2	1	2	40%	40%
Aizoaceae	1	1	0	0	100%	0%
Alismataceae	5	2	1	2	40%	40%
Anacardiaceae	1	0	0	1	0%	100%
Annonaceae	4	1	0	3	25%	75%
Apiaceae	10	6	2	2	60%	20%
Apocynaceae	8	3	4	1	38%	13%
Aquifoliaceae	1	0	0	1	0%	100%
Aristolochiaceae	3	1	0	2	33%	67%
...						

Appendix D. NatureServe conservation status rank definitions.

Global (G) Conservation Status Ranks	
GLOBAL RANK	DEFINITION
GX	Presumed Extinct (species) — Not located despite intensive searches and virtually no likelihood of rediscovery
	Presumed Collapsed (ecosystem) — Collapsed throughout its range, due to loss of key dominant and characteristic taxa and/or elimination of the sites and ecological processes on which the type depends
GH	Possibly Extinct (species) or Possibly Collapsed (ecosystem) — Known from only historical occurrences but still some hope of rediscovery. Examples of evidence include (1) that a species has not been documented in approximately 20-40 years in human-dominated landscapes despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species or ecosystem has been searched for unsuccessfully, but not thoroughly enough to presume that it is extinct or collapsed throughout its range.
G1	Critically Imperiled — At very high risk of extinction or collapse due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2	Imperiled — At high risk of extinction or collapse due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
G3	Vulnerable — At moderate risk of extinction or collapse due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
G4	Apparently Secure — At fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5	Secure — At very low risk of extinction or collapse due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.

Appendix E. List of institutions who provided ex situ living collections data for high priority Southeast U.S. plants of greatest conservation need, either through BGCI's PlantSearch database and/or our April 2021 ex situ survey of wild-origin accessions.

Ambler Arboretum of Temple University, The • Arboretum at Kutztown University • Arboretum at Regis University, The • Arboretum at the University of California, Santa Cruz • Arborétum Borová hora • Arboretum Freiburg-Günterstal • Arboretum Mustila • Arboretum National des Barres (et Fruticetum Vilmorinianum) • Arboretum Oudenbosch • Arboretum Wespelaar • Arboretum Zampach • Arboretum-Pinetum Lucus Augusti • Arlington National Cemetery Memorial Arboretum • Arnold Arboretum of Harvard University, The • Association for Biodiversity and its Conservation • Atlanta Botanical Garden • Auckland Botanic Gardens • B.M. Kozo-Polyansky Botanical Garden of Voronezh State University, The • Baker Arboretum • Bamboo Brook Outdoor Education Center • Barnes Arboretum at SJU, The • Bartlett Tree Research Laboratories Arboretum • Bayard Cutting Arboretum • Bedgebury National Pinetum & Forest • Benmore Botanic Garden • Bergen Botanical Garden • Bernheim Arboretum and Research Forest • Betty Ford Alpine Gardens • Bickelhaupt Arboretum • Bicton Park Botanical Gardens • Birmingham Botanical Gardens and Glasshouses • Bishop Museum, Cultivated Plants of Hawai'i • Blue Mountains Botanic Garden, Mount Tomah • Bok Tower Gardens • Bok Tower Gardens Conservation Program • Boone County Arboretum • Botanic Garden of Petrozavodsk State University • Botanic Garden, Lund University • Botanic Gardens at Kona Kai, The • Botanic Gardens of South Australia • Botanical Garden of Klaipeda University • Botanical Garden of Moscow Palace of Pioneers • Botanical Garden of Tartu University • Botanical Garden of the Carinthian Botanic Center (Landesmuseum Kärnten) • Botanical Garden of the University of Bern • Botanical Garden of Vilnius University • Botanical Garden, Natural History Museum of Denmark • Botanical Research Institute of Texas • Botanicá zahrada, Univerzity Pavla Jozefa Šafárika • Botanische Gärten der Universität Bonn • Botanischer Garten der Carl von Ossietzky-Universität Oldenburg • Botanischer Garten der Friedrich-Schiller-Universität • Botanischer Garten der Johannes Gutenberg-Universität Mainz • Botanischer Garten der Justus-Liebig Universität Giessen • Botanischer Garten der Technischen Universität Dresden • Botanischer Garten der Universität Osnabrück • Botanischer Garten der Universität Potsdam • Botanischer Garten der Westfälischen Wilhelms-Universität • Botanischer Garten Frankfurt am Main • Botanischer Garten und Botanisches Museum Berlin • Botresearch USA Seed Bank and Research Collection • Bowman's Hill Wildflower Preserve • Boyce Thompson Arboretum • Brenton Arboretum, The • Brisbane Botanic Gardens • Brookgreen Gardens • Brooklyn Botanic Garden • Brookside Gardens • Cairns Botanic Gardens, The • Cambridge University Botanic Garden • Cape Fear Botanical Garden • Catalogue of Medicinal Plants of Ukrainian Botanic Gardens and Parks • Centennial Museum and Chihuahuan Desert Gardens • Center for Plant Conservation (USA) • Château Pérouse • Cheekwood Botanical Garden • Chelsea Physic Garden • Chicago Botanic Garden • Chihuahuan Desert Nature Center & Botanical Gardens • Cincinnati Zoo and Botanical Gardens • Cleveland Botanical Garden • Coastal Maine Botanical Gardens • Connecticut College Arboretum • Conservatoire et Jardin botaniques de la Ville de Genève • Conservatoire Genétique des Arbres Forestiers USC ONF-INRA • Cornell Botanic Gardens • Cox Arboretum & Gardens • Dawes Arboretum, The • Dawyck Botanic Garden • Dendrological garden of the Silva Tarouca Research Institute for Landscape and Ornamental Gardening • Denver Botanic Gardens • Denver Zoological Gardens • Desert Botanical Garden • Die Flora, der Botanische Garten Köln • Dixon Gallery and Gardens, The • Dominion Arboretum and Central Experimental Farm • Donald E. Davis Arboretum • Dow Gardens • Dr Cecilia Koo Botanic Conservation Center • Duke Biology Plant Teaching and Research Facility • Duke Farms • Dunedin Botanic Garden • Eddy Arboretum, Pacific Southwest Research Station • Eden Project, The • Elisabeth C. Miller Botanical Garden • Fairchild Tropical Botanic Garden • Fanshawe College Botanical Gardens, The • Fellows Riverside Gardens • Fernwood Botanical Garden and Nature Preserve • Finnish Museum of Natural History, Helsinki University Botanic Garden • Florida Botanical Gardens • Forest Preserve District of DuPage County • Forstbotanischer Garten der Technischen Universität Dresden • Fort Worth Botanic Garden • FossilPlants • Frank A. Waugh Arboretum • Franklin Park Conservatory • Frederik Meijer Gardens & Sculpture Park • Frelinghuysen Arboretum • Fullerton Arboretum • Gabis Arboretum at Purdue Northwest • Gainesway Farm • Gardens of the Big Bend: Magnolia Garden • Garvan Woodland Gardens • Giardino Botanico "Caplez" • Gibraltar Botanic Gardens • Glasgow Botanic Gardens • Gothenburg Botanical Garden • Green Spring Gardens • Green-Wood Cemetery • Greenwood Gardens • Harlow Carr • Henry Schmieder Arboretum • Hershey Gardens • Hidden Lake Gardens • Hof ter Saksen Arboretum • Holden Arboretum, The • Honeysuckle Farm and Gardens • Hortus Botanicus Amsterdam • Hortus Botanicus Reykjavíkensis • Hoyt Arboretum • Hungarian Academy of Sciences Botanic Garden • Huntington Library, Art Museum and Botanical Gardens, The • Hyde Hall • Institute of the Volga State Technological University Botanical Garden • Instituto de Botanica 'Gonçalo Sampaio' • International Conifer Conservation Programme • Jangheung Natural Arboretum • Jardí Botànic Marimurtra • Jardim Botânico da Universidade de Coimbra • Jardim Botânico da Universidade de Lisboa • Jardín Botánico "Lucien Hauman" • Jardin Botanic Benjamin F. Johnston • Jardin Botanic Culiacán • Jardín Botánico de la ciudad de Buenos Aires "Carlos Thays" • Jardin Botanic del Instituto de Biología (UNAM) • Jardin Botanic Facultad de Estudios Superiores Cuautitlan UNAM • Jardin Botanic-Historico "La Concepcion" de Malaga • Jardin Botanique Alpin de la Jaýsinia • Jardin botanique de l'Université de Fribourg • Jardin Botanique de la Ville de Caen • Jardin Botanique de la Ville de Lyon • Jardin botanique de Paris • Jardin Botanique Exotique " Val Rahmeh " • Jardin Botanique Yves Rocher • Jardin des Plantes • Jardin des Plantes de Paris et Arboretum de Chevreloup • Jardins botaniques du Grand Nancy et de l'Université de Lorraine • JC Raulston Arboretum • Jeju Botanical Garden, Yeomiji • Jones Center at Ichuaway, The • Kalmthout Arboretum • Kee-chung-san Botanic Garden • Key West Tropical Forest & Botanical Garden • Lady Bird Johnson Wildflower Center • Lakes Park Botanic

Garden • Landis Arboretum • Lauritzen Gardens • Les Jardins Suspendus • Lewis Ginter Botanical Garden • Lincoln Park Zoo • Living Desert Zoo & Gardens State Park • Living Desert Zoo and Gardens • Logan Botanic Garden • Longwood Gardens • Lurie Garden: Millennium Park, Inc. • Main Botanical Garden, Russian Academy of Sciences • Marie Selby Botanical Gardens • Mead Botanical Garden • Meadowlark Botanical Gardens • Meise Botanic Garden • Memorial University Botanical Garden • Mercer Botanic Gardens • Millennium Seed Bank • Minnesota Landscape Arboretum • Missouri Botanical Garden • Montreal Botanical Garden (Jardin botanique de Montréal) • Moore Farms Botanical Garden • Morden Arboretum Research Station • Morris Arboretum, The • Morton Arboretum, The • Mount Auburn Cemetery • Mountain Top Arboretum • Mt. Airy Arboretum • Mt. Cuba Center • Museum of Life + Science Magic Wings Butterfly House • Nanjing Botanical Garden Mem. Sun Yat-sen • Naples Botanical Garden • Nashville Zoo • National Arboretum Canberra • National Botanic Garden of Wales • National Plant Germplasm System (USDA-ARS-NGRL) • National Rhododendron Garden • National Tropical Botanical Garden • Native Plant Trust, Garden in the Woods • Nebraska Statewide Arboretum • Ness Botanic Gardens (University of Liverpool) • Neuer Botanischer Garten der Universität Göttingen • New Brunswick Botanical Garden • New York Botanical Garden, The • Newport Arboretum, The • Niagara Parks Botanical Gardens and School of Horticulture, The • North Carolina Arboretum, The • North Carolina Botanical Garden • Northwestern University Ecological Park and Botanic Gardens • Novosibirsk Dendropark • Oak Park Conservatory • Oklahoma City Zoo and Botanical Garden • Orto Botanico dell'Università degli Studi di Padova • Orto Botanico di Torino • Orto Botanico di Torino • Oxford University Botanic Garden & Arboretum • Paignton Zoo Environmental Park • Panama City Field Office, US Fish & Wildlife Service • Patterson Garden Arboretum • Peter the Great Botanical Garden of the V.L. Komarov Botanical Institute • Pinetum Blijdenstein • Polly Hill Arboretum, The • Purdue Arboretum, The • Pyunggang Botanical Garden • Quercus Multi-site Collection, Plant Collections Network • Real Jardín Botánico Juan Carlos I • Reiman Gardens • Rhododendron Species Foundation and Botanical Garden • Rio Grande Botanic Garden • Rogerson Clematis Collection • Rogów Arboretum of Warsaw University of Life Sciences • Rosemoor • Rotterdam Zoological and Botanical Gardens • Royal Botanic Garden Edinburgh • Royal Botanic Gardens Kew, Wakehurst • Royal Botanic Gardens Sydney • Royal Botanic Gardens, Kew • Royal Botanic Gardens, Victoria • Royal Botanical Gardens, Ontario • Sakhalin Botanical Garden • San Antonio Botanical Gardens • San Diego Botanic Garden • San Diego Zoo Safari Park • Sanghyo Botanical Garden • Sarah P. Duke Gardens • Scott Arboretum of Swarthmore College • Seeds of Success • Sentier de Decouverte • Shanghai Chenshan Botanical Garden • Shaw Nature Reserve of the Missouri Botanical Garden • Sheffield Botanical Gardens • Sherwood Fox Arboretum • Sir Harold Hillier Gardens, The • Sister Mary Grace Burns Arboretum • Smith-Gilbert Gardens • Smithsonian Gardens • Smithsonian National Museum of Natural History Botany Greenhouses • South China Botanical Garden, CAS • Southeastern Grasslands Initiative • Spring Grove Cemetery and Arboretum • St. Andrews Botanic Garden • Starhill Forest Arboretum • State Arboretum of Virginia (Orland E. White Arboretum) • State Botanical Garden of Georgia, The • State Botanical Garden of Kentucky, The Arboretum • Stellenbosch University Botanical Garden • Stoneleigh: a natural garden • Sukkulenten-Sammlung Zurich • Tasmanian Arboretum Inc • Tatton Garden Society, The Lovell Quinta Arboretum • Toledo Botanical Garden • Toronto Botanical Garden • Treborth Botanic Garden • Trees Atlanta • Trinity College Dublin Botanic Garden • Trompenburg Gardens & Arboretum • Tyler Arboretum • U.S. National Arboretum • UConn Plant Biodiversity Conservatory and Research Center • United States Botanic Garden • United States Capitol Grounds and Arboretum • United States National Arboretum • University Botanic Gardens Ljubljana • University of Alabama Arboretum • University of Alberta Botanic Garden • University of British Columbia Botanical Garden • University of California Botanical Garden at Berkeley • University of Guelph Arboretum • University of Idaho Arboretum & Botanical Garden • University of North Carolina at Charlotte Botanical Gardens • University of Oslo Botanical Garden • University of Tennessee Arboretum, The • University of Tennessee Gardens • University of Washington Botanic Gardens • Utrecht University Botanic Gardens • Vanderbilt University Arboretum • VanDusen Botanical Garden • Von Gimborn Arboretum • W. J. Beal Botanical Garden • Waimea Valley Arboretum and Botanical Garden • Westonbirt, The National Arboretum • Willowood Arboretum • Wisley • Yew Dell Botanical Gardens



Supplemental Materials

These data are owned by Atlanta Botanical Garden and Botanic Gardens Conservation International U.S., and have been kept private to protect rare taxa and honor collections' privacy. Data subsets can be shared confidentially upon request to facilitate conservation planning and activities. Please contact coordinator@se-pca.org to request data via SE PCA.

Supplemental materials include [file names in brackets]:

- Results from the April 2021 query of high priority plant taxa of conservation concern in the Southeast U.S. reported to BGCI's PlantSearch database [SE PCA Ex situ Gap Analysis 2022 - Supplemental Materials: PlantSearch Taxon-level].
- Results from the April 2021 accession-level survey of *ex situ* living collections holding high priority plant taxa of conservation concern in the Southeast U.S. [SE PCA Ex situ Gap Analysis 2022 - Supplemental Materials: Accession-level Survey].
- R script for creating interactive maps of the wild source localities of accessions reported in the *ex situ* survey. This script was used to map the *ex situ* layer in the taxon-specific case studies presented above [SEPCA_ExSituGapAnalysis2022_CaseStudyMaps_Supp.R]

