ATLANTA BOTANICAL GARDEN

Synecology

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COVER STORY: Conserving and restoring Southern Appalachian bogs

From the Vice President

As we look back at the remarkable year we have had, it is essential to reflect on our journey and our successes. Unlike previous years marked by outward expansion, in 2023 we turned our focus inward, assessing and improving our strengths, and identifying key areas for growth and development. We have focused on introspection and reflection, and what we found was both enlightening and promising.

One of the most profound aspects of this year was our commitment to team development. Our strength as an institution comes from the talent of our people, and how we come together as a well-rounded, knowledgeable, and cohesive team. This year we committed ourselves to team development, expanding opportunities for training and collaboration. Our field biologists enriched their skills through specialized training; our seed bank curator ventured to the renowned Millennium Seed Bank, coordinated by the Royal Botanical Gardens, Kew, for an unparalleled learning experience; our scientists presented at various conferences nationwide, not only to showcase our groundbreaking research, but also to obtain valuable feedback from, and maintain connections with, other subject matter experts.

In the spirit of continuous learning and alignment, we carved out time for a strategic retreat and renewed our 4-year strategic plan. We recalibrated our objectives, rekindled our collective passion, and fortified our vision for the future.

It has also been a year of continuing to support and deeply engage with our networks. The Southeastern Plant Conservation Alliance (SE PCA) and the Global Conservation Consortium for Magnolia (GCCM) uphold our ongoing commitment to plant conservation regionally and globally. These alliances exemplify the importance of collaborative endeavors in addressing pressing environmental challenges. By concentrating on specific areas, each network offers targeted strategies, research, and on-the-ground conservation actions, providing a robust framework for capacity building in biodiversity hotspots. The synergistic approach of these networks amplifies conservation efforts, enabling a broader and more effective response to the challenges facing our planet's rich tapestry of life.

While looking inward, we've realized that the Southeastern Center for Conservation's expertise and resources would be adrift without our shared sense of purpose, both within and beyond our organization. Each of us, from the field biologists to the research scientists to the leadership, is united by a singular passion: conserving our planet's irreplaceable plant biodiversity. This goal that we share with all regional and global partners helps propel our conservation community forward with clarity and purpose.

To all of you – thank you. Your steadfast support and shared dedication are the foundation of our successes. Despite the many challenges ahead, we look forward with a renewed sense of hope and determination.

With the most profound appreciation and warmest wishes for 2024,

Emily Coffey, PhD
Vice President, Conservation & Research
Atlanta Botanical Garden

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Land Acknowledgement

The Southeastern Center for Conservation humbly acknowledges the Indigenous Peoples and Tribal Nations of our focal region. We are working on the homelands of many Tribes and Indigenous Communities, 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 Center recognizes the many impacts of colonialism and the irreparable losses that have been endured by the region's original inhabitants–including humans, animals, plants and stones–and the land itself. We aim to provide access to resources and opportunities for an informed alliance while we participate in building bridges, expanding perspectives, honoring Indigenous Knowledge, and weaving together our respective approaches.

To learn more about Tribes in the Southeast, visit the Southeast Climate Adaptation Science Center Tribal Story Map (secasc.ncsu.edu/tribal-resources/) and the Native Land Digital (www.native-land.ca) interactive online 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.

cover story

ATLANTA BOTANICAL GARDEN

NAVIGATING NEW WATERS

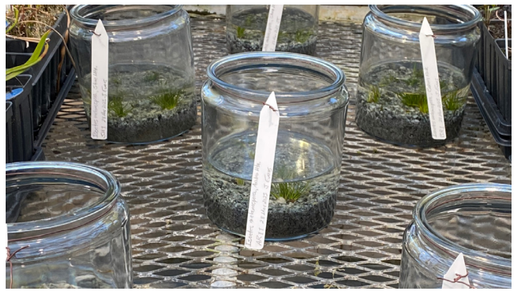
Experimenting on ways to safeguard rare aquatic quillworts

by John Evans, MSc
Conservation Horticulture Manager

Newly constructed Hoop House at the Conservation Safeguarding Nursery in Gainesville, GA

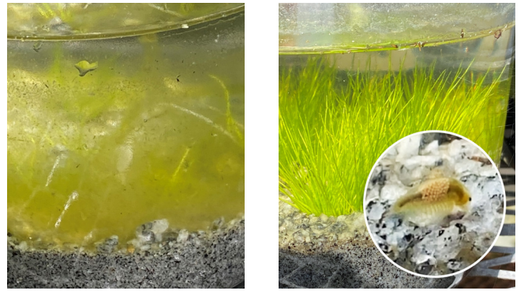
Quillworts (genus *Isoetes*) are rather unassuming little plants. Small and grasslike, living in aquatic or semi aquatic environments, most people would pass them over without noticing. Nevertheless, quillworts are fascinating and have an ancient lineage. Modern quillwort species spread around the globe in the relatively recent past, though they still look virtually identical to fossils from the Jurassic period [1]. Most quillworts are rare, with extremely narrow distributions. The Garden's Southeastern Center for Conservation has recently begun safeguarding in its Conservation Collection three critically imperiled quillwort species unique to the southeastern United States.

Safeguarding aquatic quillworts presents several novel challenges. For a plant collection to be of high conservation value, we need to be able to preserve its genetic diversity by housing and tracking different genetic lineages separately [2]. This is fairly easy with land-dwelling plants or aquatic plants with reproductive structures that emerge above the water surface. Unfortunately, aquatic quillworts grow submerged and reproduce by releasing microscopic spores into the water. These free-floating spores would muddle attempts to maintain clear genetic lineages within the collection. As such, wild-collected *Isoetes* must be housed in separate containers, each deep enough to prevent splashing between containers during irrigation. The solution: candy jars!



Candy jars are used to isolate quillworts from different populations.

In March 2023, Center staff joined botanist Gemma Milly from the Georgia Department of Natural Resources to collect specimens of two rare quillworts of the Georgia Piedmont: black-spored quillwort (*Isoetes melanospora*) and mat-forming quillwort (*I. tegetiformans*). Both species are endemic to ephemeral pools on granitic rocky outcrops. The quillworts were planted in several large candy jars, which are an affordable and space-efficient way to house them in our Conservation Greenhouse.



Quillwort jars with clam shrimp (right) have much less algae than those without (left). The use of biological control to manage weeds and pests is a cornerstone of Integrated Pest Management (IPM).

Of course, jars of water sitting in a warm, sunlit greenhouse develop a very predictable problem: algae. Within two weeks, the jars of quillworts were smothered with algae, all except for two. Why were these two jars different? A closer examination revealed a happy accident. Freshwater clam shrimp had hitched a ride on some of the quillwort specimens and had settled quite comfortably in these two jars. These native shrimp ate the algae and kept the water crystal clear. We have since purchased clam shrimp eggs to help control algae in the quillwort collection.

We are also currently developing methods to safeguard a third endangered quillwort. In early 2023, it was discovered that the Tennessee quillwort (*I. tennesseensis*) was under threat by severe habitat degradation in the Hiwassee River. While efforts to remedy the issue are ongoing, the Center has begun investigating how to grow this species in captivity, should a rescue of the population prove necessary.

But Tennessee quillwort presents yet another novel horticultural challenge: it is adapted to grow in fast-flowing, cold water. We were permitted to collect two specimens of this plant to experiment ways to grow it in captivity. We set up a 10-gallon glass tank under grow lights, in an air conditioned work area, with a water pump to simulate the turbulent waters of the Hiwassee River. Seven weeks later, the plants were thriving and also reproducing! This suggests that an *ex situ* safeguarding collection of the Tennessee quillwort is possible. The equipment needed to replicate the unique requirements of the species at a larger scale will require space. Fortunately, we will be able to do this very soon, in our new 2300 sq ft Conservation Hoop House, located at the Conservation Safeguarding Nursery in Gainesville, Georgia.

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Urgent Action

Southeastern botanists identify the region's most threatened plants in need of conservation action

by Sarah Norris, MSc
Conservation Partnerships Assistant

The southeastern United States is a biodiversity hotspot with over 11,000 native plant species, 30% of which are only found in this region [1]. The Southeastern Plant Conservation Alliance (SE PCA) has partnered with the Atlanta Botanical Garden's Southeastern Center for Conservation, NatureServe, Terwilliger Consulting Inc., the Southeastern Association of Fish and Wildlife Agencies, and authors of *Flora of the Southeastern United States*, to create the nation's first 'Regional Species of Greatest Conservation Need' (RSGCN) list for plants. This list highlights plant species of the southeastern U.S. that are in most urgent need of conservation action, to help decision makers prioritize conservation actions. Plants included on this list are from Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Due to limited data availability, species from Puerto Rico and the U.S. Virgin Islands could not be included in this iteration of the list.

RSGCN lists are useful when states or Tribal Nations are creating Wildlife Action Plans, the primary means by which threatened species are prioritized for funding. Although RSGCN lists have existed since the 1990s, they previously included only animals. Plants were thus often excluded from Wildlife Action Plans, since there were no official guidelines or standards for defining which plant species are in urgent need of conservation actions. Furthermore, states experienced difficulty including plants on their Wildlife Action Plans that are rare in their state, but not rare regionally or globally. The Southeastern Plants RSGCN now provides a credible source for informing plant Wildlife Action Plans for the region.

The Southeastern Plants RSGCN was made publicly available in May 2023 (se-pca.org/southeastern-plants-rsgcn). The list includes each species' Level of Conservation Concern based on G-Rank (global rarity), S-Rank (state rarity), threats, population trends, and species' conservation needs. States and Tribal Nations can now cite the list to make their case when applying for conservation funding. The success of the Southeastern Plants RSGCN has encouraged other regions in the United States to begin creating their own.

We are constantly working to update and enhance the utility of the Southeastern Plants RSGCN. In October 2022, the Garden's Southeastern Center for Conservation hosted a workshop, facilitated by NatureServe, to discuss southeastern U.S. species that may need G-Rank updates. Botanists from state wildlife organizations and natural heritage programs gathered to discuss these species. Plans for the next ranking workshop in February 2024 are already underway. Moving forward, we aim to finalize adding habitat information, or 'Ecological Systems,' of each species to the RSGCN. To this end we are collaborating with Alan Weakley, author of *Flora of the Southeastern United States*, and Alex Loomis, an Oak Ridge Institute for Science Education (ORISE) Rare Plant Climate Impacts Postdoctoral Research Fellow. This will help substantiate the conservation of not only threatened plant species, but also their vital habitats.

The finalization of the Southeastern Plants RSGCN marks a significant advancement for the nation and will continue to enhance efficiency, capacity, and awareness for plant conservation. Funding for the Southeastern Plants RSGCN was provided by the U.S. Fish and Wildlife Service.

Help to save plants on the Southeastern Plants RSGCN!

34% of plant species in the United States are at risk of extinction. You can support plant conservation today, by simply contacting your senator and telling them to pass the Recovering America's Wildlife Act (RAWA). This Act will provide extra funding for states and Tribal Nations to support imperiled wildlife, including plants.

For more information, scan the QR code or visit se-pca.org/recovering-americas-wildlife-act.

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Building Bridges

Working together to conserve magnolias in Mexico and Central America

by Jean Linsky, MSc
GCC Magnolia Coordinator

Yaro, *Magnolia yoroconte*

The Garden's Southeastern Center for Conservation seeks to build regional and international collaborations to help conserve plants worldwide. Through our leadership of the Global Conservation Consortium for Magnolia (GCCM), we aim to ensure that no wild *Magnolia* species goes extinct. A geographical region of priority for the GCCM is Mexico and Central America, which are particularly rich with *Magnolia* species. Some 72 *Magnolia* species have been described in this region, with 79% assessed as threatened. Numerous local botanical gardens, NGOs, and government agencies are striving to conserve the region's magnolias. The GCCM seeks to foster more international collaboration to further improve conservation outcomes for this region.

In May 2023, the GCCM participated in the IX World Magnolia Symposium in Siguatepeque, Honduras. This symposium was co-organized by Universidad Nacional de Ciencias Forestales, Instituto Nacional de Conservación Forestal, Mancomunidad de Municipios del Parque Nacional Montaña de Celaque, Celaque Asesores, Universidad de Guadalajara - CUCBA, and the GCCM. The event celebrated the science, conservation, and culture of magnolias through workshops, presentations, and field trips. Participants from ten countries (Mexico, Guatemala, Honduras, Dominican Republic, Costa Rica, Colombia, Ecuador, USA, China, and Thailand) joined the symposium both in person and virtually. We were glad to be able to financially support the participation of GCCM members from Colombia and Costa Rica.

During the symposium, our Center staff worked alongside GCCM Steering Committee Member Marcela Serna (Tecnológico de Antioquia - Institución Universitaria) to lead a conservation workshop. One of the sessions at the workshop encouraged organizations to develop conservation metacollections. A metacollection is a group of coordinated collections of an endangered plant, maintained by multiple botanical gardens that share plant material and provenance data. This allows several organizations to share the cost and effort of maintaining comprehensive collections of a threatened species in captivity. Another session at the workshop focused on conservation planning. Participants were introduced to the steps of developing species conservation plans, by analyzing quality information, creating well-defined and achievable objectives, incorporating multiple perspectives, and establishing common goals. This guidance is drawn from the IUCN Species Survival Commission Conservation Planning Specialist Group, another international network that the Garden's Southeastern Center for Conservation is involved in. Finally, workshop participants also worked in small groups to identify *Magnolia* species in the region to prioritize conservation actions. These discussions were fueled by other exciting presentations at the symposium on genetic studies, habitat restoration, and *ex situ* conservation of specific *Magnolia* species.

The GCCM aims to continue building collaborations in Mexico and Central America in the near future. Our specific aims include publishing species conservation assessments, supporting actions that help protect wild *Magnolia* species, and encouraging the inclusion of Magnolia species into agroforestry and reforestation in the region.

About the GCCM

The Global Conservation Consortium for Magnolia is a network of institutions and experts working collaboratively to develop and implement comprehensive conservation strategies to prevent the extinction of magnolias worldwide. Launched in 2020, the Consortium has grown to include 49 participants from 17 countries. Current projects include the conservation of species within the U.S. (read more about our conservation genetics work with *M. fraseri* and *M. pyramidata* on page 18), as well as abroad (e.g. *M. polyhypsophylla* in Colombia, *M. banghamii* in Indonesia). For more information, visit globalconservationconsortia.org.

Magnolia yoroconte is being trialed as a shade tree for growing cacao in Honduras.

Participants of the IX Magnolia Symposium toured a farm where *Magnolia yoroconte* is grown for timber.

COVER STORY: Conserving and restoring Southern Appalachian bogs

DNA DIVERSITY

Using modern population genetics to evaluate past conservation actions

by Amanda Carmichael, MSc
Conservation Genetics Lab Manager

photo by Alan Cressler

The Atlanta Botanical Garden has been involved in the conservation of mountain purple pitcher plant *(Sarracenia purpurea* var. *montana)* for decades. This imperiled variety of pitcher plant is endemic to Appalachian bogs of Georgia, South Carolina and North Carolina. Due to low population numbers and threats to its habitat, the mountain purple pitcher plant was petitioned for listing under the Endangered Species Act in 2011. In Georgia, there is only one remaining natural population, and in the 1990s, urgent conservation action was taken to protect it. Seeds were collected from the lone population and grown to maturity, so that 500 new plants could be outplanted at seven other mountain bogs within the state.

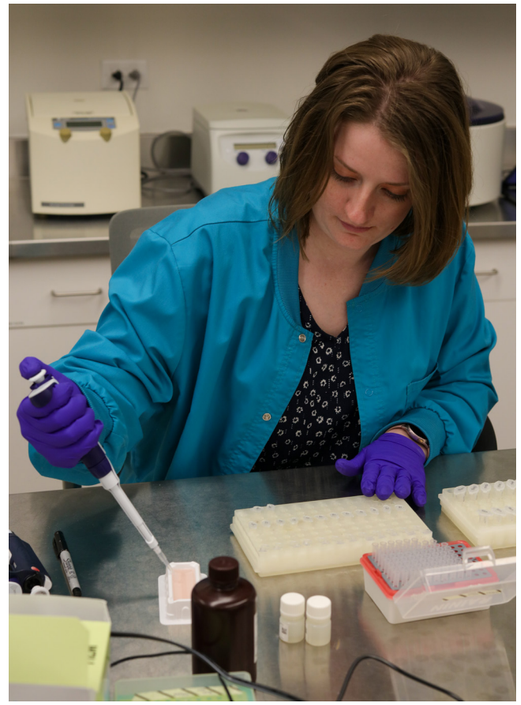
Five of the newly created pitcher plant populations eventually produced wild seedlings. However, there were concerns over the genetic diversity of these new populations, as they were grown from seeds collected from just a few wild plants from the original natural population. Their low genetic diversity could result in inbreeding - the repeated mating of siblings and cousins that results in weaker plant populations over time.

We recently examined the genetic diversity of Georgia's mountain purple pitcher plant. Leaf tissue was collected from 189 wild individuals, from the natural population, as well as from three of the largest populations that were created in the 1990s. It is extremely challenging to extract quality DNA from members of the genus Sarracenia, but we were able to develop a modified CTAB extraction method. The genomic DNA was converted into nextRAD genotyping-by-sequencing libraries and sequenced on a Novaseq 6000 with one lane of 122 bp reads by SNPSaurus at the University of Oregon.

As expected, we found that the genetic diversity of the original natural population is the most diverse (points cover the widest area in the principal components analysis of Figure 1). Genetic diversity within the created populations was relatively low, comprising a fraction of that of the natural population (points of created populations cover a fraction of space occupied by points of the natural population). Clonal analyses showed that plant individuals that were spatially distant in the field were often very closely related, implying that they are the product of inbreeding.

Potential population inbreeding may be remedied by strategically supplementing with genetically unique plant material grown from seeds sourced from the natural population. Since all the wild plants that provided DNA for this study were marked using plant tags and geo-located, we can identify genetically suitable individuals from the natural population from which to grow seeds for outplanting.

These findings highlight the importance of considering population genetics in plant conservation actions. With advances in science and technology, plant conservationists are able to improve on past management actions and refine future practices to improve efficiency and effectiveness. Today, the Garden's Southeastern Center for Conservation adopts a variety of evidence-based approaches to improve management success. These range from conducting and reviewing ecology and population genetics studies, to maternal line tracking of all our collections and outplants. Our team has learned much over the decades, and we hope to remain adaptable to new and diverse perspectives that will benefit rare plant conservation long-term.



Amanda Carmichael measured DNA concentrations with a fluorometer after isolating them from mountain purple pitcher plant samples.

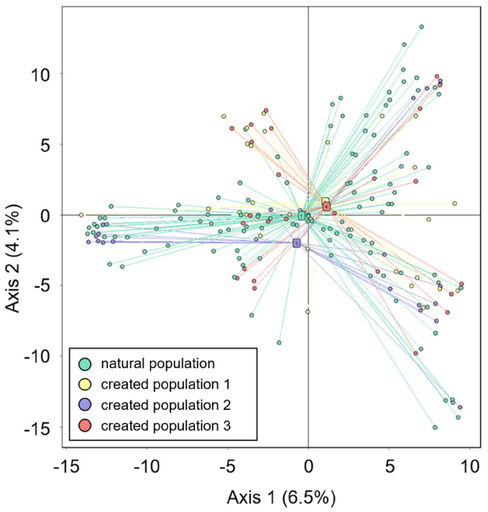


FIGURE 1: Principal components analysis of the genetic makeup of the DNA isolations obtained from 189 mountain purple pitcher plant. Each point represents an individual plant with colors representing the four populations. Points that are close together represent plants that are more genetically similar than points that are farther apart.

Saving Pink from the Brink

The plant that started our mission to save Georgia's Appalachian bogs

by Carrie Radcliffe
Director of Conservation Partnerships

It is the 1940s in northeast Georgia, and botanist Wilbur Duncan is perusing a mountain bog, one of the rarest habitats in the Appalachian Mountains. He lays eyes upon a curious plant that he has never seen in the state, with rose-pink florets and bright blue anthers - a swamp pink (*Helonias bullata*). Today this population of swamp pink remains the only recorded natural occurrence of this wildflower in Georgia. Although the swamp pink's range extends to New York, research has revealed that the southernmost populations are a rich source of genetic diversity, making them crucial to the species' long-term survival and persistence.

Even at its discovery, the future of Georgia's lone population of swamp pink was uncertain. Farming activities close to the population's bog habitat threatened to drain the wetland site. Despite years of monitoring the population, swamp pink seedlings were never found, suggesting a lack of natural recruitment. It seemed that the swamp pink was at risk of extirpation in Georgia.

Fortunately, high-quality Appalachian bogs habitats, where swamp pink could potentially thrive, exist on public lands in other parts of north Georgia. In the 1990s, the Atlanta Botanical Garden launched efforts to safeguard swamp pink and other rare Appalachian bogs plants, such as the mountain purple pitcher plant. This led to the formation of the Georgia Plant Conservation Alliance (GPCA). Working together with other GPCA founding members, we sought to reduce the risk of swamp pink going extinct in Georgia by propagating new plants from seeds collected from the wild population. Since 1997, over 400 swamp pink plants have been planted in wild mountain bogs in the northeast corner of the state. Since 2011, several of these reintroduced populations have produced multiple generations of offspring, a sign that they are becoming self-sustaining in the wild.

Thanks to advances in science and technology, today the Garden's Southeastern Center for Conservation is able to use new tools and resources to improve our approach to plant conservation. Leaf tissue samples have been collected from the reintroduced swamp pink populations in hopes of evaluating the genetics of all current wild populations (for more on our population genetics research on outplantings of mountain purple pitcher plant, see page 10). We now also safeguard swamp pink populations of North Carolina in our Conservation Seed Bank and as seed-grown plants. These *ex situ* safeguarding collections have already proven invaluable. We were recently able to provide the North Carolina Plant Conservation Program with swamp pink plants grown from seed originally collected from a North Carolina population that was unexpectedly wiped out by road construction.

Together with other GPCA founding members, we continue to restore Georgia's mountain bogs and protect their unique biodiversity. Management activities have included the control of invasive exotic plants, application of prescribed fire to maintain the open sunny conditions typical of mountain bogs, and the exclusion of feral hogs that damage wetland habitats. These actions have increased the health and reproduction of swamp pink and other rare mountain bog plants. The restoration of mountain bog habitats also supports the conservation of rare mountain bog animals, such as the critically endangered southern bog turtle. The GPCA's ongoing efforts to protect, restore and manage Georgia's mountain bogs now serve as models of success for other conservation organizations, such as the regional Bog Learning Network (BLN) and the Southeastern Plant Conservation Alliance (SE PCA).

highland wetland

A closer look at a Southern Appalachian mountain bog

1 **APPALACHIAN MOUNTAIN BOGS** are home to some of the most endangered plants and animals of the southeastern United States. A quintessential part of the Appalachian landscape, these wet, sunny clearings are found nestled within denser forests. Mountain bogs are typically small in area but rich in biodiversity

2 **MOUNTAIN BOG ECOSYSTEMS** are complex and variable. They typically form where subsurface rock and soils hold groundwater and rain. Their sparse tree canopies promote sun-loving plants, including abundant peat moss and wildflowers.

3 **BEAVERS** likely helped create many mountain bogs in the past. Their dams and tree-felling activities create sunny ponds, which age into wetlands when the animals move on. The bogs eventually become overgrown with trees, until the beavers return to start the cycle anew. Today, beavers are far less abundant and mountain bogs have become rare.

4 **UNUSUAL WILDLIFE** found here include threatened plants like the mountain purple pitcher plant, swamp pink, and white fringeless orchid. Bog animals include a variety of amphibians, birds, fish, mammals, and reptiles, such as the critically endangered southern bog turtle.

5 **THREATS TO MOUNTAIN BOGS** began after European colonization. These bogs were historically more widespread and interconnected, but most have been destroyed for settlement and drained for agriculture. Humans continue to illegally poach rare bog plants and animals. Invasive feral hogs wallow and dig in bogs, killing vegetation and further altering hydrology.

6 **RESTORATION AND PROTECTION** of mountain bogs is challenging due to their unusual ecology. Fortunately, many high-quality habitats remain on public and protected lands. The Southeastern Center for Conservation and its partners conduct habitat management to simulate historic natural disturbances like fire and beaver activity. Barriers made of local natural materials or wire fencing are used to protect habitats and rare plants from feral hogs. The Center helps to safeguard endangered bog plants in its *ex situ* conservation collections.

Illustration by Loy Xingwen

CITES certified

The Southeastern Center for Conservation awarded CITES Certificate of Scientific Exchange

by Maria Vogel, MSc
Scientific Executive Assistant to the
Vice President of Conservation and Research

Emily Coffey, PhD
Vice President of Conservation and Research

Xylobium leontoglossum

In December 2022, the Southeastern Center for Conservation received a Certificate of Scientific Exchange (COSE) under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is a cooperative agreement between governments that helps regulate the international trade and exchange of species [1]. It helps protect rare plants and animals by enforcing international permits for trade or use. The commercial trade of animal and plant products — including medicines, skins, seeds, fruits, tourism gifts, and more — generates billions of dollars. CITES enforces varying degrees of protection to more than 40,000 species of animals and plants. For example, all orchid species are protected by CITES, and CITES permits are needed to legally transport them between countries. This helps prevent wild orchids from being overexploited for international trade and protects them in their natural habitats.

The Center's new COSE certification highlights the caliber of its research, staff, and facilities for rare plant conservation. It allows the Center to loan or exchange rare plants to other COSE institutions. Safeguarding rare plants in conservation collections is sometimes necessary because many are threatened by habitat destruction and climate change. These *ex situ* (out of the wild) conservation collections provide insurance against plant extinction in the wild. COSE allows the Center to safeguard particularly vulnerable plants and facilitates partnerships with other conservation organizations.

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Small things matter

Using micropropagation to safeguard endangered woody plants

By Qiansheng Li, PhD
Research Scientist, In Vitro Conservation

Micropropagation uses tiny pieces of plant tissue (sometimes tiny seeds, as in orchids) and grows them under sterile *in vitro* laboratory conditions to produce new plants. This is useful for the conservation of endangered woody plants for which seeds are hard to obtain or difficult to store. The tiny lab-grown plants, called *in vitro* propagules, can be kept alive in test tubes or flasks. These take up little space and are more efficient to store than fully grown plants. To prolong storage, the growth of *in vitro* propagules can be slowed using low temperatures or special growing media. Long-term storage is even possible with cryopreservation - carefully freezing the propagules to preserve them for extended periods.

For an endangered plant species to be stored as *in vitro* propagules, we must first develop an effective micropropagation protocol. However, some woody plants are very difficult to grow *in vitro*. This is a problem in the conservation of rare oaks and magnolias, which also have seeds that are nearly impossible to store long-term. As the leader of the Global Conservation Consortium for Magnolia (GCCM) and a partner in the Global Conservation Consortium for Oak (GCCO), the Southeastern Center for Conservation is determined to make headway in the *in vitro* conservation of magnolias and oaks. We are pleased to report that in the spring of 2023, we successfully established aseptic cultures of three endangered magnolias (*Magnolia ashei*, *M. stellata*, and *M. zenii*) and three endangered oak species (*Quercus georgiana*, *Q. boytonii*, and *Q. hinckleyi*). Our lab has also made great progress in culturing other endangered woody plants endemic to the southeastern United States, such as *Rhododendron chapmanii*. We hope to create or improve *in vitro* propagation protocols for more species. We also aim to collect and propagate more endangered species for *in vitro* safeguarding and for producing mature plants to return to the wild.

Georgia oak, *Quercus georgiana*

SEPARATE ENTITIES

Genetic evidence for species delimitation of *Magnolia fraseri* and *M. pyramidata*

by Lauren Eserman, PhD
Research Scientist, Genetics

How do we define a species? The ways in which we should delimit similar species are often debated. This has real-world impacts on species conservation. Categorizing the world's biodiversity into discrete units is necessary for conservation planning. Species delimitation is a field of research that uses genetics, morphology, geography, ecological niche, and other evidence to determine whether individuals form one or multiple species.

A long-standing question among botanists in the southeastern United States is whether the Fraser magnolia (*Magnolia fraseri*) and the pyramid magnolia (*M. pyramidata*) are truly two separate species, or one and the same. The two plants are similar in morphology, except that *M. fraseri* tends to be larger. They also occupy distinct geographic areas: *M. fraseri* is found in the Appalachian Mountains and *M. pyramidata*, in the Coastal Plain. Recently, *M. pyramidata* was ranked on the International Union for Conservation of Nature (IUCN) Red List as 'Endangered', with fewer than 80 known occurrences and declining populations. However, if *M. pyramidata* and *M. fraseri* were combined into a single species, they would be much more abundant and require less urgent conservation attention.

We set out to determine whether *M. pyramidata* and *M. fraseri* are genetically distinct. This work was funded by the Institute of Museum and Library Services (IMLS), and in collaboration with researchers at the Morton Arboretum in Lisle, Illinois and Sungshin Women's University in Seoul, South Korea. We examined tissue samples collected from 217 wild plants, botanical garden collections, and herbarium specimens. For each sample, we sequenced 748 genes using two complementary target capture bait sets. DNA isolations from samples and DNA sequencing libraries were generated in the Conservation Genetics Laboratory at the Atlanta Botanical Garden by our Conservation Genetics Laboratory Manager Amanda Carmichael. We built a phylogenetic tree, which is a branching diagram that depicts the evolutionary relationships among organisms.

A common criterion for delimiting species is monophyly - all individuals of a single species must have descended from a single common ancestor. Our phylogenetic tree (Figure 1) showed that all wild-collected *M. fraseri* samples form a monophyletic group. Likewise, all wild-collected samples of *M. pyramidata* form another monophyletic group. There were only three trees from botanical garden collections that were identified as *M. pyramidata* but fall within the *M. fraseri* group – we are investigating whether these could be hybrids that formed in captivity or potential misidentifications. Overall, it is clear that *M. fraseri* and *M. pyramidata* form separately evolving, monophyletic lineages. These two species fit the criterion of monophyly, providing genetic evidence that they are indeed separate species.

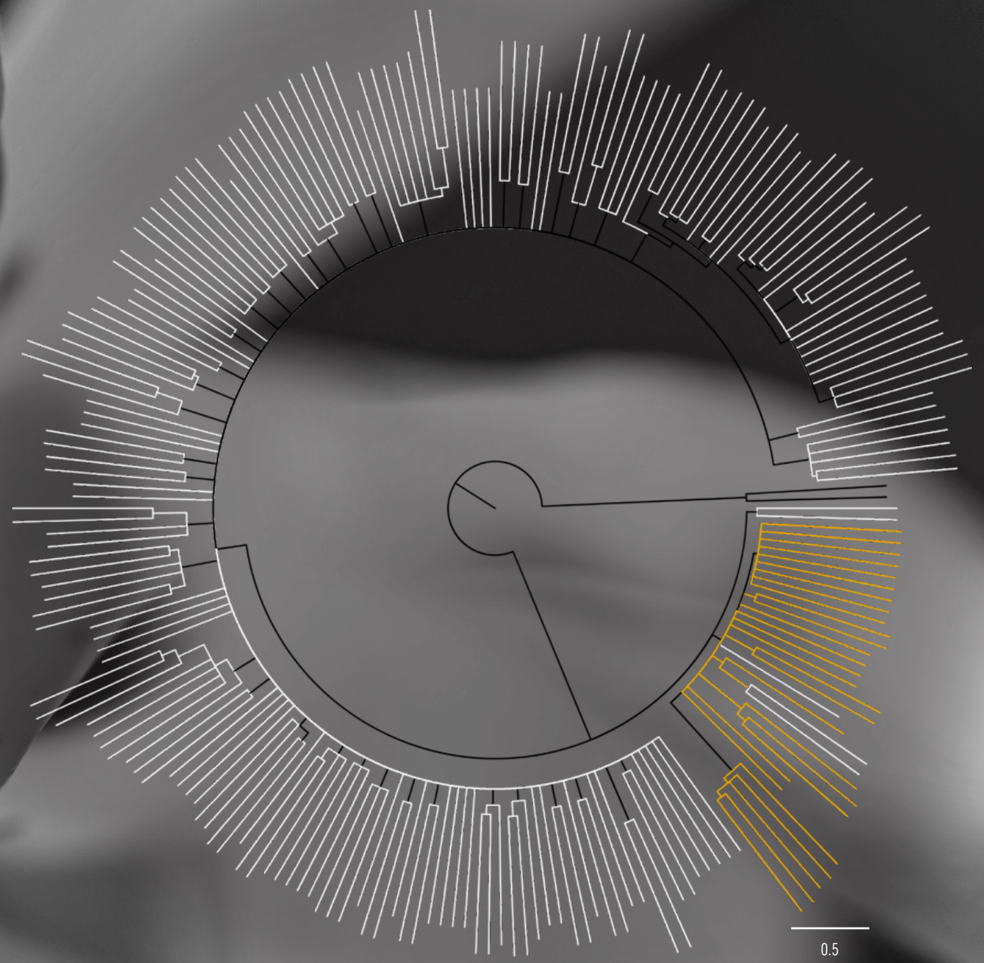

Figure 1. Phylogenetic tree of 217 *Magnolia fraseri* and *M. pyramidata* samples generated using ASTRAL-III. All nodes in the tree with bootstrap support less than 50% are collapsed. Tips of the tree colored in white are samples of *M. pyramidata*, and gold tips are *M. fraseri*. Three samples identified as *M. pyramidata* fall within the *M. fraseri* group.

Living Library

Building an online database of the Garden's botanical collections

by Sathid Pankaew
Plant Digitization Assistant

Sarracenia species

Established in 1973, the Atlanta Botanical Garden has cultivated a rich collection of plants from around the world. A little known fact is that the Garden's vast plant collections are available to members of the global research, education, conservation, and horticulture communities. With permission, interested parties can obtain samples from the Garden's plant collection.

The application process to request samples from the Atlanta Botanical Garden's collection is fairly simple. However, relatively few external parties make requests. Of the 873 botanical samples that the Garden provided to external parties in the last five years, over half of them were requested by a single researcher. A fifth of all the requests for plants and plant samples for educational purposes were to one institution. The Garden's immense botanical resources should be utilized by more external researchers and educators.

A solution is to create a searchable, digital database that can be accessed and browsed online. In this way, our collections can function more effectively as a living library. In 2022, the Garden was awarded funds from the National Science Foundation to begin creating a searchable online database of its collections. The database will catalog and show photo vouchers of the Garden's accessioned plants. We are currently prioritizing plants for the database that are listed as imperiled, based on assessments by the International Union for Conservation of Nature (IUCN) and NatureServe. We are also focusing on the Garden's several collections that are nationally accredited by the American Public Garden Association's Plant Collections Network (PCN), such as *Gongora* and *Stanhopea* orchids, *Sarracenia* pitcher plants, magnolias and maples.

Documenting the Garden's immense plant collection is an inter-departmental effort. Directing the project is Conservation Research Scientist Dr. Lauren Eserman, working closely with Conservation Database Coordinator Jonathan Gore and the Garden's Plant Documentation Manager Wade Enos. We are transforming the Garden's existing database into a new, more user-friendly format. In close collaboration with Garden horticulturists, I am leading the photography and mapping of plant collections in the Garden by coordinating our digitization technicians (in 2023 these included Billie Fraser, Isabelle Grovenstein, Tiana Scott, and Will Johnson). Over 2000 accessions across 1000 species have been documented so far. We aim to photograph and digitize 5000 accessioned plants and map 2000 plants within three years.

When the updated database is officially launched online, it will be announced on social media and in the press, as well as directly to relevant academic societies such as the Botanical Society of America, American Society of Plant Taxonomists, and the American Society of Plant Biologists. We will also notify universities of this teaching and research resource. We hope that this will increase effective use of our botanical collections, facilitate plant research, and allow more people to learn about plants in our collections.

Digitization technicians taking photos of trees in the Tropical Rotunda.

Flower of *Paphiopedilum acmodontum*.

A color correction card helps ensure photos accurately capture colors in real life, while a ruler provides a size scale.

BORN TO BE WILD

Pilot study on the low reproduction rates of wild Georgia asters

by Loy Xingwen, PhD
Research Scientist, Ecology

A native of southeastern United States, Georgia aster (*Symphyotrichum georgianum*) has the largest blooms of its genus, with ray petals that are a deep and brilliant purple. In a garden setting, Georgia aster spreads easily by seed. In the wild, however, the species seems to struggle to produce seeds and seedlings.

To help solve this paradox, we obtained funding from the USDA Forest Service to conduct a pilot study of Georgia aster's low seed production in the wild. Pilot studies are used to test the feasibility of study methods, in preparation for more comprehensive future research. In Georgia's Chattahoochee National Forest, we found that Georgia aster blooms from late September to early November. We found that we could readily identify Georgia aster in the spring, by its stems and foliage alone. This will be helpful for tracking the abundance of non-reproductive plants in future demography studies. We found that seed production was variable but usually low. We located 13 populations on National Forest lands that are suitable for conducting more detailed demography studies.

In timed pollinator observations, we found that pollinator visitation rates varied greatly among Georgia aster populations. Male and queen eastern bumble bees (*Bombus impatiens*) were the most common flower visitors, even though bumble bee colonies are usually dominated by worker bees (that are always female). This is likely because in the late fall, when bumble bee colonies start to decline, they begin producing more male bees and young queen bees instead of workers. When the old queen bees die in winter, it is the young queens that will hibernate to begin next year's colonies. Because Georgia aster blooms well into November, when few other plants are still flowering, it may be a valuable food source for young bumble bee queens preparing to hibernate.

We are only just beginning to understand the ecological role that Georgia aster plays in its ecosystem. Although Georgia aster is easy to grow in captivity, the ultimate goal of plant conservation is for species to be self-sustaining in the wild, where they can grow and evolve as part of natural ecosystems. We are hopeful for opportunities in the near future to better understand and protect this charismatic wildflower.

Garden Graduates

Our recent Emory University Master's graduates share their experiences

by Kelly Coles, MSc
Gulf Coast Projects Manager

Joe Stockert, MSc
Field Biologist

Why did you choose to pursue graduate studies with the Atlanta Botanical Garden?

Kelly: I'd worked in ecological restoration for more than six years and I was seeking a way to deepen my botanical knowledge. One day, I was reading the Georgia Plant Conservation Alliance newsletter, and learned about an amazing graduate assistantship at Emory University funded by the Atlanta Botanical Garden and the Jones Center at Ichauway (a 12,000+ hectare longleaf pine reserve in southwest Georgia). I had worked as a research technician at Ichauway before! It was where I had first fallen in love with the species that would become the focus of my Master's research – it was the opportunity of a lifetime! My Master's mentors were Dr. Emily Coffey, Dr. Lance Gunderson (Emory University), and Lisa Giencke (Jones Center at Ichauway).

Joe: I'm from Atlanta originally but in 2020, I went to work at Dutch Harbor, Alaska, as a fisheries biologist. I moved after the COVID-19 pandemic halted research at the Georgia Tech lab where I was a technician. After months away, homesickness was calling me back to the Southeast. The maritime plant communities in Dutch Harbor are wildly different from Atlanta – I began to appreciate the way that plants color and define a place. Also, the visible impacts of climate change on livelihoods in the fishing community fostered my desire to pursue a career in conservation. I saw a posting for a graduate assistantship on the Garden website one day and my course was set from there. For my Master's, I was mentored by Dr. Emily Coffey and Dr. Lance Gunderson (Emory University).

Tell us a bit about your Master's research projects.

Kelly: I conducted research on American chaffseed, *Schwalbea americana*. This rare, Southeastern, hemiparasitic plant is threatened by habitat loss and fire suppression. I wanted to know its environmental needs, whether it associates with fungi that affect its survival, and whether we could find unrecorded populations with a habitat suitability model. I found that the ground near *Schwalbea* populations tended to have higher pH readings than the surrounding land, so soil acidity might be a limiting factor for the dispersal of this species. I also examined fungal DNA in *Schwalbea* roots. The most frequent fungal species was *Curvularia protuberata*, which is known to be beneficial in helping some grass species survive high temperatures. Fungal pathogens were also identified, suggesting that fungal disease could be an issue. Finally, I built a habitat suitability model to guide searches for populations of *Schwalbea*. Unfortunately, I did not find any new populations for the record, but we did find potentially suitable habitat! I'll continue to fine-tune the model, to include factors like fire frequency.

Joe: I studied a characterful Southeast endemic plant: the Miccosukee gooseberry, *Ribes echinellum* (which we refer to simply as '*Ribes*'). *Ribes* occurs in just two locations worldwide: near Lake Miccosukee in Florida, and near Stevens Creek in South Carolina – that's 240 miles apart. In each state, I measured the population's age structure, recruitment rate, and mortality rate to construct a demographic model. This is an effort to understand how environmental factors in each state, such as herbivory by deer, constrain *Ribes* population growth. Demographic models require large amounts of data, but thanks to support from Garden staff and partners, I was able to collect

two season's worth of data from both states. Contrary to what was thought, I found that *Ribes* recruitment rates exceeded mortality rates in both states – a hopeful sign of stability. But the fruit set was very low in Florida. Exclusion fences (to keep out deer) in South Carolina seem to benefit *Ribes* growth. I'm hoping that a third year of demographic data, which we will collect in February of 2024, will clarify some of these preliminary findings to inform the management of this species.

How was a Garden graduate program valuable to you?

Kelly: Being a graduate student with the Garden provided the opportunity to conduct research not just for research's sake, but to generate findings that address practical concerns in plant conservation. Working with Dr. Coffey shaped my graduate training in a way that prioritized applied research and allowed me to learn from and network with working professionals. It gave me the chance to see conservation in action, and to learn from geneticists, horticulturists, and field biologists.

Joe: I really appreciated the Emory University community, and being in an enclave of environmentally-minded folks in the Environmental Science Department. But I also really enjoyed working and training with the Garden, especially the fieldwork at Stevens Creek and Lake Miccosukee. It helped me hone my observational skills, practice field techniques, learn to use new equipment, experience an ecologically unique habitat, and work with professional plant conservationists – I think it was the most valuable experience of my graduate education.

ACROSS THE POND

Visit to The Royal Botanic Gardens' Millennium Seed Bank

by William Grant Morton, PhD
Conservation Seed Bank Curator

We are honored to have been invited to the Seed Conservation Techniques Course hosted by The Royal Botanic Gardens' Millennium Seed Bank in Wakehurst, United Kingdom. Seed banking is a critical tool for plant conservation, global food security, and research. The Millennium Seed Bank (MSB) is one of the world's largest seed banks, driven by a global mission to conserve plant diversity, support conservation initiatives, advance scientific knowledge, and contribute to agricultural and ecological sustainability. The MSB provides training, technical advice, and equipment to partners to support their seed banking efforts. The Seed Conservation Techniques Course, which I attended in October 2022, is MSB's largest course, spanning two weeks, and provided to select partner seed banks.

The course brought together global conservation experts in seed banking, fostering knowledge exchange and standardization of methodology. We delved into the practical and theoretical aspects of seed conservation such as seed collection, processing, storage techniques, moisture content assessment, germination testing, seed moisture relations, storage behavior, storage life prediction, and the complexities of seed bank management and design. I gained valuable insights into seed processing tools, the innovative application of fluorescent staining for orchid seed viability testing, and other techniques, which I look forward to testing out in our facility in Atlanta.

The Atlanta Botanical Garden's Conservation Seed Bank is one of the largest in the Southeast, with more than 3,700 accessions comprising over 550 taxa, over a hundred of which are globally rare or endangered. Just last year alone, over 300,000 seeds were deposited in our seed bank. Our seed collections are used for safeguarding the genetic diversity of wild plant populations, propagating new plants for revegetation and population augmentation, and for research.

New Faces

Meet the new members of our team

Melissa Natividade

she/her
Conservation Outreach and Education Assistant, NSF RaMP

Melissa coordinates the Rare Plant RaMP Network, a project funded by the National Science Foundation to support research and professional experiences for demographics historically excluded from STEM. Melissa acquired her Bachelor's of Science in Environmental Sciences from The College of New Jersey.

Qiansheng Li, PhD

he/him
Research Scientist, In vitro

Qiansheng develops plant tissue culture protocols and cryopreservation programs to support plant conservation. He is now working on several rare and endangered species of the genus *Magnolia*, *Quercus*, *Rhododendron*, *Taxus*, *Torreya*, and orchids. Qiansheng holds a PhD in horticultural sciences from Nanjing Agricultural University, and did postdoctoral research at the University of Florida and Texas A&M University.

Madison Ohmen

she/her
Conservation Horticulturist

Madison joined the Atlanta Botanical Garden in November 2022 and is based at the Conservation Safeguarding Nursery in Gainesville, Georgia. She assists with the daily management of the nursery and supports the curation of *ex situ* conservation collections of rare and endangered plants. Madison graduated from North Carolina State University with a Bachelor's of Science in Horticultural Science.

Climbing Fetterbush, *Pieris phillyreifolia.* Photo by Will Hembree.

ATLANTA BOTANICAL GARDEN

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