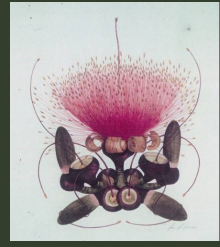


Gifford Arboretum Newsletter

Spring 2015

Volume 10, Issue 2



Dr. Dennis Stevenson, 2015 Gifford Arboretum Lecturer

We are pleased to welcome this year's John C. Gifford Arboretum Lecturer: Dennis Wm. Stevenson, Ph.D. Dr. Stevenson is the Vice President of Laboratory Research at the New York Botanical Garden (NYBG), one of the largest and most respected botanical research institutions in the world. He has been a researcher, curator, and administrator at NYBG since 1980. In addition, Dr. Stevenson serves as adjunct professor at the City University of New York, Universita di Napoli, New York University,

Yale University, Columbia University, and Cornell University.

Dr. Stevenson received his B.S. and M.S. in Botany from Ohio State University, and then earned his Ph.D. in Botany at the University of California, Davis in 1975. He was a postdoctoral researcher at Fairchild Tropical Garden in 1975-76 and again from 1978-80. Today, he continues to collaborate with both Fairchild and Montgomery Botanical Center here in Miami.

His current research focuses on the evolution and classification of cycads (Cycadales), and he studies many aspects of cycad biology, including reproductive biology, anatomy, cytology, and molecular systematics. He produces taxonomic treatments of Neotropical cycads, and he leads a highly collaborative research program working with researchers from around the world on cycad taxonomy.

Dr. Stevenson has an active field program that studies natural populations of cycads, as well as members of the order Gnetales, and he works to save these plants from extinction through ex-situ conservation. As part of the Plant Genomics Consortium, he is working to understand the origins and development of seeds. He is also conducting research on the molecular biology of a nonprotein amino acid implicated in Guam Dementia, and he is interested in the systematics of commelinids, a large group of monocots.

In addition to his research, Dr. Stevenson has served in advisory positions for many worldwide conservation organizations, such as the World Wildlife Fund and the International Union for Conservation of Nature. He has authored and coauthored numerous articles and research papers, as well as several books, including textbooks and gardening books.

Dr. Stevenson will present a lecture entitled "Yes Bobby, Gardens and Arboreta are Relevant to the Molecular World" on Thursday, April 2, 2015 at 7:00 PM in Cox Sciences Center, Room 126. This promises to be an enlightening lecture on the continued and vital importance of living collections to botanical science.

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Director's Message from Steve Pearson

I want to THANK all Gifford Arboretum supporters who have made gifts to the Arboretum recently. Your support is much appreciated and needed, and together we are making the Arboretum better! If you are not already part of this select and important group, please join by sending your donation today.

Also, a big THANK YOU to Montgomery Botanical Center for again cohosting our Lecture by providing housing for our speaker. Finally, THANKS to Dr. Janos for his fine article. Enjoy!

Can Root-Inhabiting Fungi Save the World?

Summary of a Cooper Fellow lecture by Professor David P. Janos of the University of Miami Department of Biology



At present, you are one of 7.1 billion people on Earth, a population that is predicted to increase to between 9.6 and 12.3 billion by the year 2100¹. Because of population growth and also because of loss attributable to salinization of irrigated lands and other soil degradation, the amount of arable land per person, 0.2 hectare in 2012 according to the World Bank, is less than half its 1961 value of 0.5 hectare. In other words, right now your share of land for food production is a bit less than half the size of an American football field (excluding the end zones). What will your share be in 35 years, in the year 2050?

Pressure on arable land is worsened by people shifting their diets to increased protein, and by diversion of crops such as corn in the United States and sugar cane in Brazil to biofuel production. If you eat beef, pork, or poultry, it takes 7, 4, and 2 kilograms of feed grain, respectively, to produce one kilogram of meat – a bit more than two pounds. At current rates of improvement, yields of maize, rice, wheat, and soybean, which together account for two-thirds of agricultural calories, are unlikely to achieve the doubling predicted to be needed by 2050².

Gains in agricultural production that compensate for the diminishing share of land per person come chiefly because of fertilization. Fertilizers not only enhance crop growth but also replace mineral nutrients removed in harvested materials. Those bananas you ate because your mother told you they would provide potassium, represented potassium export from wherever the bananas were grown.

When you buy any container of fertilizer, it will have three numbers listed prominently on it. Those are the concentrations of nitrogen, phosphorus, and potassium that it contains. Always listed in that order, plants must acquire these three elements from the soil in the largest amounts. So, in order to sustain – not to mention, increase – current crop yields, we need to ask how long the world's supplies of these elements will last.

The International Fertilizer Industry Association forecasts that for 2017/18 world agriculture will consume slightly more than 116, 45, and 33 million metric tons (Mt) per year of nitrogen, phosphorus, and potassium, respectively³. Fortunately for us, as long as we can afford the energy required for the conversion, we can produce nitrogenous fertilizer from the effectively unlimited supply of nitrogen in the air. But phosphorus and potassium must be mined, and readily-accessible world reserves are estimated to be 5079 Mt of phosphorus (as P₂O₅)⁴ and 8300 Mt of potassium (as K₂O)⁵. Simple long-division suggests that if our rate of fertilizer use remained constant at 2017/18 levels, readily-accessible potassium would last 250 years. Additionally, there is a similar amount of difficult and expensive to extract reserve that could double the time to potassium exhaustion.

In contrast, phosphorus is a major concern for future fertilizer needs because at current

rates of use we have only 112 years' worth of easily-accessible phosphorus. Typically, however, extraction of mineable natural resources such as phosphorus (and oil) reaches a peak, and then, as extraction becomes increasingly difficult and expensive, annual production diminishes until the reserve is exhausted. For phosphorus, peak production might come as early as 2033⁴, or sooner if rates of fertilizer use continue to increase.

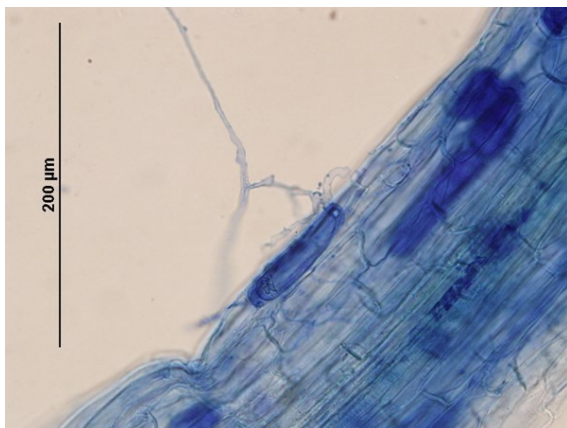


Figure 1. Magnified view (the scale bar is about one-fifth the thickness of a dime) of a blue-stained plant root and its accompanying root-inhabiting fungus which is visible as bumpy, threadlike filaments outside the root and darkly-stained fungus storage structures within the root. Photo by J. Weremijewicz

change of phosphorus from the fungi in return for energy-rich carbon compounds from host plants. Threadlike filaments of the fungi extend beyond roots to provide an extensive, better-distributed and less energy-expensive absorptive network than roots and root hairs. Root hairs are extensions of single epidermal cells and rarely exceed the diameter of a penny in length, but the external filaments of arbuscular, root-inhabiting fungi can extend 'tens of pennies' beyond roots. Thus, the fungi can gather and transport phosphorus to roots especially efficiently.

Of course, if phosphorus is abundant and readily available in the soil, the help of root-inhabiting fungi is irrelevant to plants which can do fine on their own. But, when phosphorus is limited, the fungi can substantially improve plant growth (Figure 2). Such growth improvement is known as the 'responsiveness' of a plant species or crop variety to root-inhabiting fungi^{7,8}.

As phosphorus availability in soil increases, plant responsiveness diminishes. That has led crop scientists to think that deliberately breeding crop varieties to take best advantage of fertilization inadvertently might reduce their capacity to benefit from root-inhabiting fungi. A new analysis⁹, however, suggests this need not happen. Nevertheless, crop breeders should try intentionally to produce varieties capable of maximizing the yield advantage to be gained from association with root-inhabiting fungi, which so far has not been attempted.

Having crop plants that efficiently use phosphorus proffered by root-inhabiting fungi brings with it a second challenge which is the need to make sure that the fungi are present and available to associate with roots. Unfortunately, so far no one knows how

What can we do about this impending phosphorus crisis?

Because the amount of phosphorus on Earth is finite, the only option for its sustainable utilization is to limit consumption to an amount that can be satisfied by recycling – a considerable challenge in the face of an expanding human population and diminishing arable land. Although technologies exist to minimize fertilizer over-application and consequent loss, most of the world's farms lack access to them. Moreover, even technological economies lack infrastructure for phosphorus recovery and recycling from waste streams. To presage such approaches which will be needed eventually, can we enhance the efficiency of phosphorus uptake and use by plants?

The answer may lie in the Gifford Arboretum, just as it does in most native vegetation worldwide. If you microscopically examine the roots of more than 80 % of the world's plant species, you would find them associated intimately with fungi (Figure 1) belonging to a unique, ancient group, the Glomeromycota⁶. Within root cortical cells, Glomeromycotan fungi form tiny, bush-like, much-branched structures called 'arbuscules' that facilitate ex-

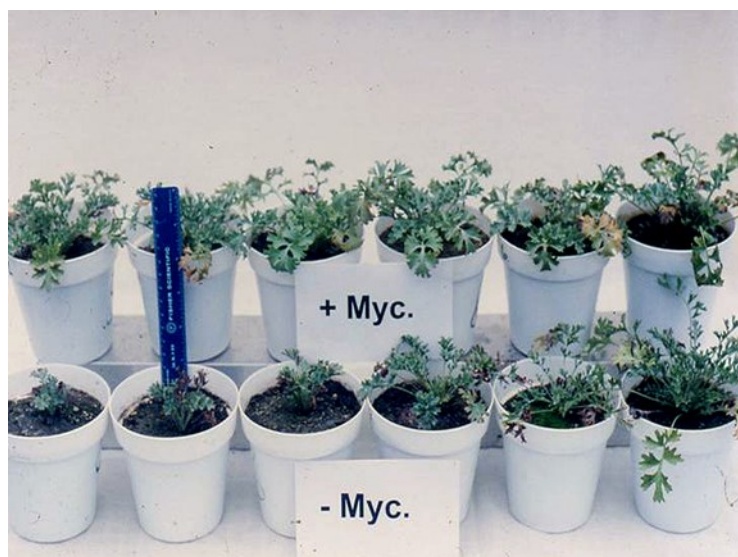


Figure 2. *Pyrethrum chrysanthemum* (*Tanacetum cinerariifolium*) plants grown with (+ Myc.) and without (- Myc.) beneficial, root-inhabiting fungi across a range of phosphorus fertilization from low (left) to high (right). 'Myc.' abbreviates 'mycorrhiza' which literally translates as 'fungus root,' the name given to the absorptive organ jointly formed by roots and ancient, Glomeromycotan fungi. Photo by D. Janos

to grow the fungi cheaply in pure cultures, although there are several commercial enterprises, for example in Colombia, India, France, and the United States, that produce inoculum somewhat laboriously and expensively by growing the fungi on living roots. An alternative is to learn how to manage the fungi in the field – as nature has done for millennia – to ensure their abundance.

Ways of maintaining the fungi in the field include avoiding tillage which disrupts their filamentous networks, cover cropping, and using companion plants that ‘nurse’ the fungi. That is possible because the fungi have nearly unrestricted host ranges. The same fungus species that associate with corn also may associate with Tulip tree (*Liriodendron tulipifera*, Magnoliaceae), and those hosts are as distantly-related as can be. So, not only can one plant make the fungi available to another, but additionally, the fungi can persistently physiologically interconnect multiple plants belowground. The fungus is sort of like a cable TV network or the Internet, to which many plant ‘households’ hook-up. Just as with cable and the Internet, however, there might be ‘cable piracy’ (a plant getting more than its fair share of phosphorus for the amount of energy it pays) or even the equivalent of an Internet denial-of-service attack if one plant can preempt all the fungus’ phosphorus.

Plants interconnected by root-inhabiting fungi can compete more strongly with one another than if they were not connected¹⁰. That presents a dilemma for agronomists because while close-spacing and consequent networking may most effectively promote abundance of the fungi, generally crops are grown with sufficient spacing to minimize the negative effects of adjacent plants on one another. Fortunately, even though networked plants in dense monocultures can compete across root-inhabiting fungus networks, improvement of phosphorus or other limiting mineral nutrient uptake that enhances the growth of the largest plants at the expense of the smallest nevertheless can increase total yield¹¹.

When two or more crops (such as the traditional corn, beans and squash polycultures of meso-America) feasibly can be grown together in the same field as an ‘intercrop,’ different times to maturity and complementary root attributes especially might help to maintain root-inhabiting fungi. Even though maintaining the fungi, however, intercropping also might diminish their benefit because increasing overall plant density often diminishes the average per plant benefit gained from the fungi. Notwithstanding, several combinations of two plant species have been found that increase both species’ responsiveness at the plants’ highest joint density¹². What we don’t know is why they do so!

Satisfying the growing human population’s need for food without running out of phosphorus fertilizer is likely to become an increasingly expensive and acute problem by or before 2050. The problem can be mitigated by crop breeding, by improving commercial production of beneficial root-inhabiting fungus inocula, and by devising farming systems to manage the fungi. Pursuing those options, however, will take much additional investigation, and time – like phosphorus – is running-out.

Footnotes:

1. Bradshaw & Brook. 2014. Human population reduction is not a quick fix for environmental problems. PNAS 111:16610-16615.
2. Ray, et al. 2013. Yield trends are insufficient to double global crop production by 2050. PLOS One 8(6): e66428.
3. Heffer & Prud’homme. 2013. Fertilizer outlook 2013-2017. International Fertilizer Industry Association.
4. Cordell, Drangert, White. 2009. The story of phosphorus: global food security and food for thought. Global Environmental Change 19:292-305.
5. Roberts. 2008. Global potassium reserves and potassium fertilizer use. International Plant Nutrition Institute.
6. Exceptions would be pines and oaks, which have a different type of mycorrhiza – ectomycorrhizas – in association with “higher” fungi.
7. Janos. 2007. Plant responsiveness to mycorrhizas differs from dependence upon mycorrhizas. Mycorrhiza 17:75-91.
8. Nodulated legumes associated with effective strains of rhizobia tap atmospheric nitrogen directly. Interestingly, most legumes will not nodulate with the bacteria until and unless they first form arbuscular mycorrhizas. Both the processes of nodulation and especially nitrogen fixation by bacteroids in the nodules are energy-intensive, and because phosphorous (as ATP) mediates energy transformations, the legumes need for phosphorous takes precedence over the need for nitrogen.
9. Sawers, et al. 2010. Characterizing variation in mycorrhiza effect among diverse plant varieties. Theoretical and Applied Genetics 120:1029-1039.
10. Janos et al. 2013. Arbuscular-mycorrhizal networks inhibit *Eucalyptus tetrodonta* seedlings in rain forest soil microcosms. PLoS ONE 8(2): e57716.
11. Weremijewicz & Janos. 2013. Common mycorrhizal networks amplify size inequality in *Andropogon gerardii* monocultures. New Phytologist 198:203-213.
12. Schroeder-Moreno & Janos. 2008. Intra- and inter-specific density affects plant growth responses to arbuscular mycorrhizas. Botany 86:1180-1193.

Elegantly Stated:

Biodiversity is a simple way to describe the complex and beautiful web of life that has made our planet capable of supporting us and all other living beings.

- Jon Letman, from “Walking in Time” in The Bulletin of the National Tropical Botanical Garden, Fall, 2014

ARBORETUM EVENTS SINCE LAST NEWSLETTER

December 6th, 2014: This **Annual Picnic** featured the 123 fruit and other edible plants of the Gifford Arboretum and the main event was a tour of most of these plants that was led by Chris Rollins, the soon-to-be-retired Director of the Redland Fruit and Spice Park, and Arboretum Director Steve Pearson. Chris Rollins is one of the world's foremost authorities on tropical fruit and, after a break for a fun and delicious lunch, the tour continued until almost 4 PM! During lunch we were pleased to present Mr. Rollins with a plaque commemorating and thanking him for his many years of service to this community and his introduction of many new and tastier fruits.



January 21th, 2015: Jazz guitarist Russ Spiegel and trombonist Javier Nero kicked off **Music in the Arboretum** for the spring semester with an hour of lively jazz, including original compositions. The audience was impressed by the proficiency and creativity of both of these musicians, and felt privileged to have heard them.



February 4th, 2015: **Dr. Thomas Lodge**, Everglades ecologist and author of *The Everglades Handbook: Understanding the Ecosystem*, presented "**Everglades Tree Islands: Kinds, Origins, Ecology, and Problems**" to a packed house. It was a fascinating and instructive presentation about how the Everglades works and evolves. Dr. Lodge shared an alarming connection between sulfate use in sugar agriculture and elevated mercury levels in fish and other Everglades animals. We plan to have more information about his very serious issue in our next Newsletter.

February 18th, 2015: **Music in the Arboretum** – An expert and interesting performance by the Mélange Wind Quintet from the Frost School of Music was enjoyed on a rare cool evening in the Arboretum. It was not only good music, but also a music history lesson as the group shared quips about each performed piece.

March 4th, 2014: **Dr. Floria Mora-Kepfer Uy** – An entomologist who received her PhD from the University of Miami and who is now a Research Assistant Professor in the Biology Department at UM, Dr. Uy presented "**Symbiotic Relations Between Insects and Plants, and How to Attract Beneficial Insects to Your Garden.**" It was an insightful look at how nature has evolved complex interactions between species and how these interdependencies are vital to species survival.

March 18th, 2014: **Music in the Arboretum**— A fun and entertaining performance by the Big City Folk Band was enjoyed by a good turnout. Everyone was impressed with the energy and spirit of these young players. The command of their instruments was uniformly impressive, but the vocal harmonies between Nick Chouard and Katherine Evans were especially great.



We have some great programs and activities lined up for the remainder of the Spring Semester. Please plan to join us!

April 15, 2015 – Music in the Arboretum. Our final musical performance of this season will be by the Frost Horns, another very talented group from UM's Frost School of Music. The music will start at 6:00 PM, but it is likely that we will also be having an early Earth Day celebration starting before the music. More news to follow.

May 6, 2015 – Meeting and Presentation by Jennifer Possley MS - A Field Biologist with Fairchild Tropical Botanic Garden, Ms. Possley will present "The Secret Lives of Miami's Rare Native Ferns." Small, County preserves are home to 25 threatened and endangered fern species. Many of the wild populations have just a few dozen individuals, and chance event such as hurricanes, pest outbreaks, or even just moving a pile of fill can wipe out an entire population. Monitoring wild populations and building representative collections are paramount today. Ms. Possley will take us on a virtual tour to some of Miami's remaining fern grottoes and describe the work she and Fairchild are doing to preserve the remaining rare ferns. The evening will start in the Arboretum at 6:30 PM for a look at our new native fern collection that is being created with the help of Jennifer and Lenny Goldstein. We will then move inside for our meeting at 7:00 PM in Cox Science Center Room 166.

All Gifford Arboretum events are free and open to the public.

Arboretum Horticultural Notes:

We are pleased to announce our 2015 Gifford Arboretum Plant of the Year: *Exothea paniculata* (Inkwood), which was chosen based on its value to native fauna. A Florida native, Inkwood is particularly beneficial to many birds, including many migratory species, for shelter and food. It is a dense, medium-sized, evergreen tree that produces masses of small white, fragrant flowers that can add to the beauty of any landscape. Although individuals will at times produce a few flowers that are of the opposite sex or bi-sexual, the tree is generally dioecious so planting 2-3 is recommended to insure that you get the attractive fruit that are loved by so many birds. I believe you will enjoy this tree and the birds it attracts while you are also benefitting local fauna and the environment. Our poster is on the next page for your use and enjoyment.

Many of our older trees like *Butea monosperma* (Flame of the Forest; pictured at right), *Cochlospermum vitifolium* (Buttercup), and *Cassia bakeriana* (Pink Shower) have been in spectacular bloom lately. However, I am particularly happy to report that one of our recent additions, *Strongylodon macrobotrys* (Jade Vine), bloomed for the first time. Growing up one of the Arboretum's *Quercus virginiana* (Live Oak) trees, this species produces one of the world's showiest and most unusual flowers. As it continues to grow, we can look forward to an incredibly lovely sight in only a couple more years.



We have been continuing to add some very unusual and interesting new trees to the Arboretum, and we look forward to reporting about them in detail in our next issue.



2015 Plant of the Year – *Exothea paniculata* (Sapindaceae)
(Inkwood, Butterbough)

Available for distribution Spring 2015

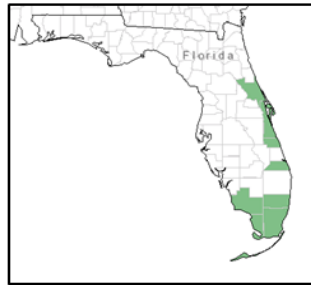


Figure 1: *E. paniculata* Flowers
Photo credit: Roger L. Hammer



Figure 2: Fruits of *E. paniculata*
Photo credit: Leon Levy Native
Plant Preserve

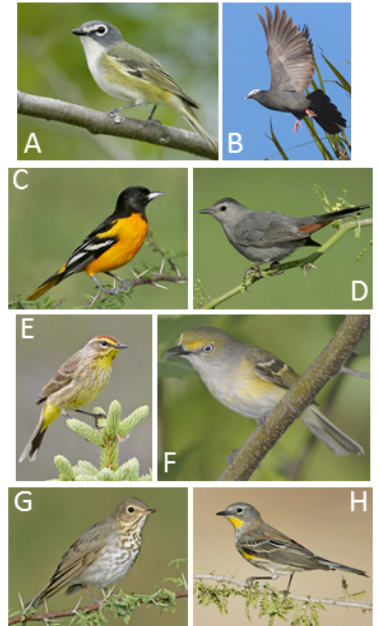
Description



Source of image: <http://plants.usda.gov>

Exothea paniculata is a handsome, dense tree that produces masses of small, white flowers with orange centers that are both attractive and fragrant (Figure 1). It is native to South Florida, the West Indies, and Mexico. It blooms winter through summer, with peak flowering in the spring. Inkwood provides food and cover to many native birds, with some eating the fruit and others eating the flowers. Butterflies also visit the tree for nectar. It is usually dioecious, with orange fruit turning purple when ripe (Figure 2). Its wood is hard and durable. The name “Inkwood” is derived from the use of its bark and berries to make homemade ink. The sap also darkens when dry.

Some Birds that
Use *E. paniculata*



- A. Blue Headed Vireo (B. Small)
- B. White-crowned Pigeon (P. Cannon)
- C. Baltimore Oriole (B. Small)
- D. Gray Catbird (B. Small)
- E. Palm Warbler (G. Bartley)
- F. White-eyed Vireo (G. Bailey)
- G. Swainson’s Thrush (B. Small)
- H. Yellow-rumped Warbler (B. Small)

Habit

- Medium tree, 25-35 feet high
- Bark – Light gray to reddish-brown, mottled and rough
- Leaves – Alternate, once-compound, with shiny, elliptic leaflets; evergreen
- Fruit – Berries that turn purple at maturity

Growth Requirements

- Watering: Moderately drought tolerant
- Light: Light shade to full sun
- Salt tolerance: Moderate, no saltwater flooding or direct saltwater spray
- Growth: Slow to moderate

Please Donate to the Gifford Arboretum

Mailing Address: John C. Gifford Arboretum, Rm. 231 Cox Science Center
University of Miami, 1301 Memorial Drive, Coral Gables, FL 33124-0421

Website: <http://www.bio.miami.edu/arboretum>

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Address: _____
City: _____ State: _____ Zip: _____
Phone: _____ Email: _____

- Please keep me informed of activities at the Gifford Arboretum.
- Please find enclosed my tax-deductible donation to the University of Miami-Gifford Arboretum. (Tax deduction excludes value of benefits)
- Please send me information about including the University of Miami in my estate plans.

Membership levels (annual)

- Student friends \$5
 Friends \$25
 Supporters \$100
 Donors \$1,000
 Benefactors \$5,000

Benefits

- newsletter and discounts
newsletter and discounts
all above plus t-shirt
all above plus special luncheon
all above plus display on plaque

T-shirt size (circle one): S, M, L, XL

Make your donation by check: Total amount enclosed \$ _____
(payable to *University of Miami- Gifford Arboretum*)
by credit card: Amount \$ _____
Type of Card (Master Card, Visa, AMEX, etc) _____

LEAVE A LEGACY FOR TOMORROW, TODAY

Through tax and estate planning techniques and incentives, planned gifts allow you to meet your personal financial objectives while ensuring the future of the Gifford Arboretum. Planned giving options include bequests, trusts, and charitable gift annuities.

PLAN YOUR GIFT

To learn more about planned giving opportunities that can benefit you and the Arboretum, contact Kyle Paige, JD '89, director of estate planning and giving, at kpaige@miami.edu or 305-284-1527.

Please make a gift to the Gifford and/or include Gifford Arboretum in your estate plans to help support the ongoing work of caring for the trees and to enable the Arboretum to remain a central feature of the UM campus for generations to come.

HELP US GROW

