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**ADMIN: Reason(s) Not Eligible**

# John Z. Duling Grant Application

**Please note: This application is available for viewing year-round, but may only be submitted July 1 - October 1.**

If you have any questions, please email dhettinger@treefund.org or call 630-369-8300 x204.

## Applicant

### Principal Investigator

| | |
|---|---|
| Prefix | Dr. |
| First name | Michael |
| Last name | Arnold |
| Status | Professor |
| Title | Professor of Landscape Horticulture and Assoc. Head for Undergraduate Programs |
| Organization | Texas A&M University |
| Mailing address | Dept. of Horticultural Sciences |
| Mailing address line 2 | 2133 TAMU |
| City | College Station |
| State/province | Texas |
| Zip/post code | 77843-2133 |
| Country | United States |

Email address ma-arnold@tamu.edu

Phone number 979-845-1499

Degrees

Doctor of Philosophy, North Carolina State University, August 1990.
Major: Horticultural Sciences
Master of Science, The Ohio State University, June 1987.
Major: Landscape Horticulture
Bachelor of Science in Agriculture, The Ohio State University, December 1984.
Major: Landscape Horticulture
Bachelor of Science in Business Administration, The Ohio State University, March 1983.
Major: Production and Operations Management.

Relevant citations authored

Garcia, L.M., M.A. Arnold, G.C. Denny, S.T. Carver, and A.R. King. 2015. Differential environments influence initial transplant establishment among tree species produced in five container sizes. Arboriculture and Urban Forestry (In press for Arboriculture and Urban Forestry).

Bryan, D.L., M.A. Arnold, A. Volder, W.T. Watson, L. Lombardini, J.J. Sloan, A. Alarcon, L.A. Valdez-Aguilar, A.D. Cartmill. 2011. Planting depth and soil amendments affect growth of Quercus virginiana Mill. Urban Forestry & Urban Greening 10(2):127-132.

Bryan, D.L., M.A. Arnold, A. Volder, W.T. Watson, L. Lombardini, J.J. Sloan, L.A. Valdez-Aquilar, and A.D. Cartmill. 2010. Effect of planting depth and selected cultural practices on landscape establishment of baldcypress and sycamore. Arboriculture & Urban Forestry 36(2):57-65.

Bryan, D.L., M.A. Arnold, A. Volder, W.T. Watson, L. Lombardini, J.J. Sloan, L.A. Valdez-Aguilar, and A.D. Cartmill. 2009. Planting depth during container production and landscape establishment affects growth of Ulmus parvifolia. HortScience 45(1):54-60.

Arnold, M.A. and G.V. McDonald. 2009. Groundcovers, organic and inorganic mulches, and masonry surfaces differentially affect establishment and root zone characteristics of urban trees. Arboriculture and Urban Forestry 35(5):232-240.

Arnold, M.A., G.V. McDonald, D.L. Bryan, G.C. Denny, W. T. Watson, and L. Lombardini. 2007. Below grade planting adversely affects survival and growth of tree species from five different families. Arboriculture & Urban Forestry 33(1):64-69.

Denny, G.C. and M.A. Arnold. 2014. Evaluation of drought tolerance of selected provenances of Taxodium. Journal for Arid Land Studies 24(1):223-230.

Arnold, M.A., D.L. Bryan, R. Cabrera, G.C. Denny, J.J. Griffin, J.K. Iles, A.R. King, G.W. Knox, L. Lombardini, G.V. McDonald, C.B. McKenney, D.T. Montague, G. Niu, H.B. Pemberton, A.L. Purnell,

L.J. Shoemake, D.K. Struve., and W.T. Watson. 2012. Provenance experiments with baldcypress, live oak, and sycamore illustrate the potential for selecting more sustainable urban trees. Arboriculture and Urban Forestry 38(5):205-213.

Arnold, M.A., G.V. McDonald, and D.L. Bryan. 2005. Planting depth and mulch thickness affect establishment of green ash and bougainvillea goldenraintree. J. Arboriculture 31(4):163-170.

Arnold, M.A. 2004. Challenges and Benefits of Transplanting Large Trees: An Introduction to the Workshop. HortTechnology 15(1):115-117.

Shoemake, L.J., M.A. Arnold, and F.T. Davies, Jr. 2004. Provenance impacts transplant establishment and adventitious root regeneration of sycamore. J. Amer. Soc. Hort. Sci. 129(3):360-367.

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| Has this investigator previously received funding from the TREE Fund? | Yes |
| If yes, was the funding for this project? | Yes |
| Previous TREE Fund awards | Does Size Really Matter With Container-Grown Trees? Hyland Johns Grant, Tree Research and Education Endowment Fund. M.A. Arnold (PI). Funded $24,790.<br><br>Does Propagation Method Impact Survival and Growth of Below Grade Planted Trees? Duling Grants Program, Tree Research and Education Fund. M.A. Arnold (PI). Funded $9,931.<br><br>Cutting Baldcypress Of At The Knees Duling Grants Program, Tree Research and Education Fund. M.A. Arnold (PI). Funded $9,982.<br><br>Assessing field level cold tolerance in improved genotypes of Taxodium distichum tolerant of alkaline soils and drought. Tree Research & Education Endowment Fund. M.A. Arnold (PI). $7,441.<br><br>Soil, irrigation, and production factors influencing establishment of container-grown trees at various planting depths. Tree Research & Education Endowment Fund. M.A. Arnold (PI). $7,500.<br><br>Interactions among planting depths and mulching applications on establishment of hypoxia tolerant and intolerant trees. M.A. Arnold (PI). Tree Research & Education Endowment Fund |

**Co-Principal Investigator (if applicable)**

Prefix

First name

Last name

| | |
|---|---|
| Status | |
| Title | |
| Organization | |
| Mailing address | |
| Mailing address line 2 | |
| City | |
| State/province | |
| Zip/post code | |
| Country | |
| Email address | |
| Phone number | |
| Degrees | |
| Relevant citations authored | |
| Has this investigator previously received funding from the TREE Fund? | |
| If yes, was the funding for this project? | |
| Previous TREE Fund awards | |

## Students/Interns (if applicable)

### Student/Intern 1

| | |
|---|---|
| Name | Ms. Lauren Garcia |
| Department or major | M.S. Horticulture: Former M.S. on the project, current Ph.D. student at Clemson Univ. |
| Status | Masters student |

### Student/Intern 2

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|---|---|
| Name | Mr. Joey Beasley |
| Department or major | B.S. Horticulture |
| Status | Undergraduate student |

### Student/Intern 3

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|---|---|
| Name | Ms. Kayln Mitchell |

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| Department or major | B.S. Horticulture |
| Status | Undergraduate student |

## Project

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| Project title | Long-Term Impact of Container Size on Tree Establishment |
| Research area | Root and soil management<br>Propagation, planting and establishment |
| Project summary | Many professionals have long contended that the greater transplant shock associated with planting larger trees and the rapid growth phase of smaller planting stock that is more akin to seedling growth responses can result in smaller stock establishing more quickly in the landscape. Our initial work on this project confirms this adage during initial establishment and even suggests that the smaller stock may eventually catch up with the larger size transplanted trees in the landscape. By growing our own clonal plants of three representative tree species and replicating planting of five different container sizes of each we have strong evidence for initial advantages of #3 to #7 container size trees in terms of physiological responses, initial growth, and added economic value, but lack the longer term data. For a nominal investment, this study can be extended to encompass five growing seasons after transplant which would represent much longer term value and growth responses. The final two years of field maintenance are what is being requested for this project. At completion it will represent 2 years of nursery responses and 5 years of growing season responses after transplanting to the field, an opportunity seldom encountered in controlled research settings. |
| Statement of problem | Consumers, municipal arborists, and landscape contractors constantly face the challenge of balancing the higher costs and immediate aesthetic impacts of larger planting stock with the lesser investment in smaller container stock while accepting the diminished immediate landscape impact of small transplanted trees. Earlier work suggested that we could obtain quicker establishment with the smaller container size stock, but much of this work had limitations associated with key areas: 1) insufficient numbers of container sizes were included to develop meaningful regression equations for growth or cost estimates across the test size range, 2) container size may have been confounded by nursery production conditions (stock came from different nurseries/regimes), and 3) genotypes of the different size stock were not often know resulting in a potential confounding of genotype with stock size. The stock used in the present work is of clonal origin (no genotype confounding), was grown sequentially in the various containers using the same production regime in the same nursery, and each species was produced in five sizes ranging from #1 to #45 containers. Initial short term results confirm some earlier industry adages, but long term responses can be garnered by extending the present work to five post-transplant growing seasons for limited investment of only landscape maintenance costs. |
| Significance of your proposed project as it relates to the | Beeson and Gilman (1992) demonstrated differences in tree transplant establishment rates among stock produced using different |

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| profession of arboriculture or urban forestry | production methods. Rapid establishment of trees is the most critical factor in their long-term success in the landscape. With trees being offered to the public in an ever increasing array of sizes, it is important to determine the times required for successful establishment of differing size stock and the trade-offs associated with initial size and establishment requirements. This work would permit the development of regression equations to estimate the time required for establishment of various size containers across the entire range encompassed by the tested container sizes. Preliminary data after two years indicates that smaller container sizes of vigorous taxa such as Vitex have nearly caught up to growth of transplanted larger size containers. Returns on investment after two years using replacement costs for the same size trees in the landscape suggest the largest returns from #3 and #7 containers, but longer term responses are uncertain. Data from this project could also be useful for estimating irrigation requirements for nursery owner, arborists, urban foresters, landscape contractors and agencies overseeing water management. Longer term this project will permit the development of curves to estimate the time needed to achieve a given size of tree in the landscape which would assist urban foresters, landscape designers, and the general public in developing cost / benefit trade-offs for installation of various size nursery stock. |
| Description of what is currently known about proposed project area | The trees of all three species have been grown using common methods in a single nursery to the size of 1, 3, 7, 25, and 45 gallon stock. These plants have been installed on 20 foot within row and 24 foot between row spacings in the initial establishment has been monitored by Ms. Lauren Garcia as a part of her Masters work. She was supported through 2015 on a combination of diversity fellowship, teaching assistantship, and summer funding from TREE Fund. With tight budgets over recent years our ability to hire student works, obtain supplies, and support summer assistantships internally has become very limited. All technical support staff have been eliminated or must be funded from external sources. Thus our goal is to carry this project forward to assess longer term outcomes in the landscape beyond the initial establishment period for which our current funding will support. We feel that there are important long term contributions to be made to our understanding of tree establishment by following these trees for a longer time in the field/landscape. Important information to assess environmental and economic implications that may accrue over the long term can be obtained for a relatively small input now that the initial production and establishment costs have been covered. Without a source of funds to support the longer term maintenance of these plots, this opportunity will be lost and it would require a much greater investment to recoup the same information in the future. A relatively modest investment now will yield excellent returns later by leveraging the resources presently available. A faculty member, Dr. Charles Hall, trained in Agricultural Economics is working with us to estimate the financial impacts of the container size on landscape values over time. Growth, physiological and economic measures are completed on the nursery and first two seasons after transplant. The third season is in progress, but funding runs out at the end of the year. The first year data comparing growth |

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| | on this site to an identical planting established in Starkville, MS was just accepted for publication in the journal Arboriculture and Urban Forestry. Papers on the initial physiological responses to transplant and one on the economic implications after two years in the field are in preparation for publication. Ms. Garcia has completed her thesis and any subsequent monitoring/maintenance will be done with student workers. |
| Summary of project goals | The goals of the project are to determine: 1) if smaller size planting stock catch up to larger size planting stock over the first five growing seasons after transplant and if not how substantial are the residual differences, 2) to determine the net values associated with the various planting stock by the end of the fifth growing season, 3) use the preceding data to develop regression curves to predict planting stock with optimum growth and net value. |
| Description of measurable outcomes expected | Mid-day (maximal water stress) and subsequent predawn (potential recovery) water potentials, along with photosynthetic gas exchange characteristics are being periodically monitored during the first two post-transplant growing seasons. Root growth was sampled at the end of the first growing season and again at the end of the second year to quantify root extension beyond the original planted rootball. Volumes of application are being recorded for each irrigation event to estimate water use during establishment for each container size / species combination. Growth measures, such as heights, canopy spreads, twig extension, and trunk diameters are also measured. Labor for pruning, water inputs, and growth measures will continue to be monitored to develop the growth response curves and economic value estimates indicated under the summary of project goals. |
| Project plan including design, hypotheses, methodology and analyses | The null hypothesis is that no changes in growth rates or relative values among the sizes of planting stock within a species will occur during post-transplant establishment in the landscape.<br>Three taxa of trees, Taxodium distichum clone TX8DD38 (a candidate baldcypress for release that is tolerant of drought, high pH soil, and soil salinity), Acer rubrum var. drummondii 'Maroon' (profuse red flowers and fruit, tolerant of higher pH soils), and Vitex agnus-castus (unnamed white flowering clone) have been grown from rooted cuttings to minimize genetic variation among treatments beginning in the late summer of 2010. Trees were sequentially propagated and upcanned using the same commercial substrate, fertilizer regimes, irrigation techniques, containers, and pruning techniques at a single container nursery to minimize variation in environmental and production system residuals during field/landscape establishment. By spring 2013, sufficient trees were produced of these clones to transplant six trees of each container size, 1, 3, 7, 24, and 45 gallon, and each species into a field site (College Station, TX). Trees were established on 20 ft within row and 24 ft between row spacings to minimize competition among trees and permit longer term studies. At the time of planting an additional sample of three trees of each species and container size were destructively harvested to calculate initial biomasses, root to shoot ratios, etc.<br>Initial water and photosynthetic gas exchange characteristics of the trees were determined in the nursery prior to planting and then monitored sequentially during the initial establishment period of the |

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| | trees (currently on-going at the College Station site). Irrigation is being supplied from minispray stakes beneath the canopy of each tree. Each combination of species and container size is controlled separately, resulting in 25 separate irrigation systems. Watering for trees of a given container size and species combination is determined by the monitoring of soil tensiometers, with -20 kPa determined empirically as a set-point to avoid water deficits in the trees. Volumes of application are being recorded for each irrigation event to estimate water use during establishment for each container size / species combination. Mid-day (maximal water stress) and subsequent predawn (potential recovery) water potentials, along with photosynthetic gas exchange characteristics are being periodically monitored during the first two post-transplant growing seasons. Growth measures, such as heights, canopy spreads, twig extension, and trunk diameters are also measured. Root growth was sampled at the end of the first growing season and again at the end of the second year to quantify root extension beyond the original planted root ball. Initial establishment is expected to culminate by the end of 2015, but this data will only answer the short-term establishment questions. We would like to continue this work in order to determine if over a longer time frame, will smaller plants catch up to larger transplanted trees? |
| Description of plan for disseminating the results of this project | Initial results on the immediate responses post-transplant have been presented at several industry/scientific venues by Ms. Lauren Garcia as a part of her Master work, including the ISA conference, the Southern Region of the American Society for Horticultural Sciences, and graduate student poster competitions at Texas A&M University. An initial paper from the first post-transplant year responses at the Texas and Mississippi sites is in press for Arboriculture and Urban Forestry. Later results will be presented at similar venues, two more manuscripts are in development and on detailing the longer term results will be developed if the project proceeds beyond the initial completion date this fall. |
| Project start date | 01/01/2016 |
| Project completion date | 05/01/2018 |
| Geographic range of project | USA & Canada |

## Budget

**Compensation/Stipend**

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| Proposed project budget | $20,800 |
| Requesting from TREE Fund | $5,200 |
| Funding from other sources | $15,600 |
| Value of in-kind support from other sources | $0 |

**Employee Benefits**

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| Proposed project budget | $2,102 |
| Requesting from TREE Fund | $526 |
| Funding from other sources | $1,576 |
| Value of in-kind support from other sources | $0 |

**Travel (> 50 miles)**

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| Proposed project budget | $3,066 |
| Requesting from TREE Fund | $800 |
| Funding from other sources | $2,216 |
| Value of in-kind support from other sources | $0 |

**Local Transportation (< 50 miles)**

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| Proposed project budget | $1,000 |
| Requesting from TREE Fund | $500 |
| Funding from other sources | $500 |
| Value of in-kind support from other sources | $0 |

**Equipment (vehicles, growth chambers, etc.)**

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| Proposed project budget | $0 |
| Requesting from TREE Fund | $0 |
| Funding from other sources | $0 |
| Value of in-kind support from other sources | $0 |

**Supplies (paper, ink, toner, etc.)**

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| Proposed project budget | $200 |
| Requesting from TREE Fund | $100 |
| Funding from other sources | $100 |
| Value of in-kind support from other sources | $0 |

**Contract Labor (contractor, speaker, etc.)**

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| Proposed project budget | $0 |
| Requesting from TREE Fund | $0 |
| Funding from other sources | $0 |
| Value of in-kind support from other sources | $0 |

**Other/Misc.**

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| Proposed project budget | $5,400 |
| Requesting from TREE Fund | $2,850 |
| Funding from other sources | $2,600 |
| Value of in-kind support from other sources | $15,796 |
| Description of other/misc. expenses | Consumables, fertilizer, data collection, and replacement parts for irrigation/machinery, conference registration fees, publication charges |

**Total**

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| Proposed project budget | 32568 |
| Requesting from TREE Fund | 9976 |
| Funding from other sources | 22592 |
| Value of in-kind support from other sources | 15796 |

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| Funds already received from other sources | $0 |
| Funds pending from other sources | $22,592 |
| Value of in-kind support already received from other sources | $0 |
| Value of in-kind support pending from other sources | $15,796 |

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| How did you hear about this grant? | TREE Fund website<br>Other |

Applications will be scored on the following scale:

- Applicant is qualified (0-10)
- Applicant has experience (0-5)
- Project has potential to result in transformative research ideas or approaches (0-5)
- Project directly meets one or all TREE Fund priorities (0-10)
- Project has clearly stated need (0-10)
- Project is clearly linked to arboriculture and/or urban forestry (0-5)
- Research has practical application (0-10)
- Project design is scientifically sound, methods are clear and analysis is appropriate (0-15)
- Project is likely to result in peer review publication (0-10)
- Objectives are achievable within proposed time frame (0-5)
- Objectives are achievable within proposed budget (0-5)
- Requested funds have potential to leverage future support from other funding sources (0-10)
- NOTE: proposals with documented cash or in-kind match will be awarded an additional 1-5 points

**Your application will not be available for editing after it has been submitted.**
**Please review your application for completion before submission.**