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Arboretum Development on the Campus of Southern Adventist University

Michael J. Baranda*, Benjamin Thornton¹

Abstract-Arboreta provide communities with opportunities to learn about and grow in appreciation of tree and shrub species. This increased appreciation can help foster conservation efforts of native species. Establishing a horticultural plan for an arboretum requires baseline data including the identification and number of all representative species. In this study, species richness and abundance of all trees on the main campus of Southern Adventist University (SAU) located in Collegedale, Tennessee was determined in order to develop a horticultural plan to increase the diversity of native species. Each tree was tagged with a specific number and diameter at breast height (DBH) was measured. High-precision global positioning system (GPS) was used to establish the location of each tree. This information was used to create a map with layers for each species. Species abundance and diversity were compared to the same for the arboreta at the University of Tennessee at Chattanooga (UTC), Vanderbilt University (VU), and East Tennessee State University (ETSU). We identified a total of 1,003 trees on our campus which included 76 species. Nineteen species were represented by only one individual each. *Tsuga canadensis* (Eastern hemlock) was the most abundant species with 142 trees. Of the 76 species, 50% (n = 38) were native to Tennessee as compared to 43% (n = 27) at UTC, 38% (n = 52) at VU, and 24% (n = 56) at ETSU. The horticultural plan is presented in this study.

Keywords: arboretum, diversity

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Introduction

According to Beech et al. (2017), the United States is home to 1,412 tree species found in unique landscapes and niches. Trees are beneficial in several different aspects. These diverse forests help the ecosystem by removing air pollution and providing homes for wildlife by creating unique niches. Forests also provide financial, physical, and mental benefits. Financially, trees provide positive return on investment in sustained timber harvests (McPherson et al. 2005). Physically, individuals who live in areas that are greener are much more likely to be physically active (Ellaway et al. 2005). Mentally, green spaces have been found to reduce human stress (Grahn and Stigsdotter, 2003). Trees are highly beneficial and highly diverse nationwide, some states more than others.

Tennessee (TN) has some of the most highly abundant forests anywhere in the United States with 100 species of native trees (Tennessee Invasive Plant Council, 2016 and the University of Tennessee Agricultural Extension Service, 1998). Trees native to their own state generally increase to the eastern side of the United States, thus TN is located in a prime location for an abundance of trees and tree diversity (Little, 1999; Jenkins et al., 2015). There are 91 arboreta certified under the Tennessee Urban Forestry Council (TUFC) and 31 certified by ArbNet. In areas where deforestation is a concern, arboreta provide opportunities for conservation.

Arboreta are areas set aside for the growing and effective display of woody plants (Wyman, 1960) and provide research and educational opportunities for the community. The following universities in eastern TN, cited in this study, maintain arboreta: East Tennessee State University, the University of Tennessee at Chattanooga, and Vanderbilt University. Arboreta

status is granted after meeting requirements according to a worldwide accreditation service, such as Arbnet, or by the state, such as the TUFC.

Arbnet has four different certification levels each with its own requirements. The first level of accreditation requires an arboretum plan, an arboretum organizational group, a minimum number of 25 species of trees or woody plants, arboretum staff or volunteers, and arboretum public dimension. The second level of accreditation includes satisfaction of all criteria for Level I along with a larger arboretum collection with a minimum number of 100 species; an arboretum collections policy; one or more arboretum employees; and enhanced educational and public programming. The third level of accreditation includes satisfaction of all criteria for Levels I and II along with a minimum number of 500 species; a dedicated curator, or curator-equivalent; sharing of plant collections data; an active agenda related to tree science, strategic planting, or conservation; and a substantial educational program. Level IV requires Levels I-III to be satisfied along with a scientific and/or conservation staff; institutional capacity, stability, and commitment; specific participation in collaborative scientific or conservation activities; and specific consideration of a conservation role (ArbNet).

Under TUFC, there are also four different levels each with certain requirements. The first level requires 30 different species of trees labeled and a map with tree locations with a TUFC logo is preferred, but optional. Level 2 requires 60 different species of trees labeled and a map or pamphlet with the TUFC logo showing the locations of trees must be available for self-guided tours. The third level requires 90 different species of trees labeled; a map or pamphlet from Level 2; and part-time staff or volunteers available for special tours. Lastly, Level 4 requires 120 different species of trees labeled; a map or pamphlet from previous Levels; full-time staff or volunteers; and a bi-annual newsletter to at least 120 persons (TUFC).

The number of tree species on the campus of Southern Adventist University (SAU; Collegedale, Tennessee) is unknown. In this study, trees on the campus proper were tagged with a unique number, identified to species, and located with a global positioning system (GPS). The data was used to establish an official arboretum on campus and develop a horticultural plan to increase the abundance and diversity of native trees.

Methods

All trees on the campus proper of SAU (Figure 1) were tagged with unique numbers and measured to identify diameter at breast height DBH. Each tree was identified to species and located using the Trimble Geo 7X (Sunnyvale, CA) and the coordinates differentially corrected with Trimble Pathfinder Office (Version 5.58). Trees were mapped in layers by species using plantsmap.com. Data collected in 2010 from the University of Tennessee at Chattanooga and Vanderbilt University were used to compare the number of trees and the representative species in their arboreta. Data collected in 2017 from East Tennessee State University of their arboreta was also used for comparison.

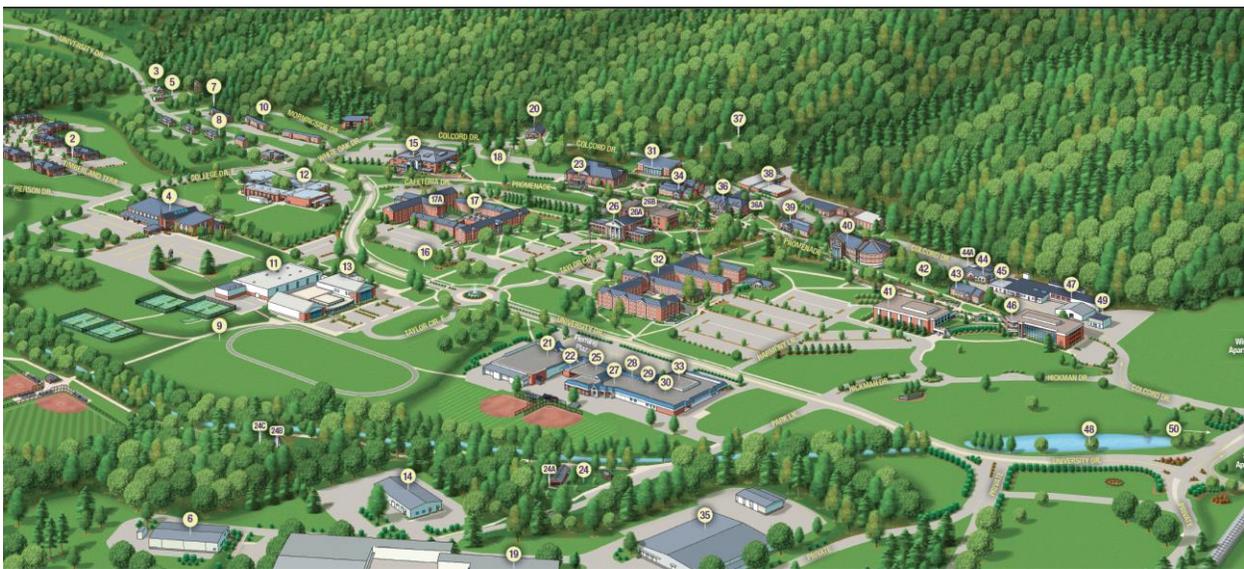


Figure 1. Campus proper of Southern Adventist University located in Collegedale, TN, USA.

Results

One-thousand and three trees were identified and tagged representing 76 different species (Table 1). Nineteen of the 76 species were represented by one individual each, and *Tsuga canadensis* (Eastern hemlock) was the most abundant species with 142 individuals. Of the 76 species, 55% (n=42) were native to Tennessee. The average DBH between all the trees was 26.8 cm with *Quercus phellos* (Willow oak) having the widest DBH of 136.4 cm. Shannon-Weiner Diversity index of the campus was calculated to be 3.66.

The most abundant species on the UTC campus was *Quercus phellos* (Willow oak) with 130 individuals, and seven species were represented by one individual each. The most abundant species on the campus of Vanderbilt University was *Acer saccharum* (Sugar maple) with 488 representatives and the least abundant was shared between 17 species, which were represented by only one individual each. The most abundant species was *Pinus strobus* (Eastern white pine) and the least abundant was shared between 109 species with one individual each on the campus of East Tennessee State University.

Table 1. Frequency of tree species in the arboreta of Southern Adventist University (SAU), the University of Tennessee at Chattanooga (UTC), Vanderbilt University (VU), and East Tennessee State University (ETSU). Native trees defined by the Institute of Agriculture at the University of Tennessee and the Tennessee Invasive Plant Council. Shaded rows are trees native to TN.

Species	University			
	SAU	UTC	VU	ETSU
<i>Abies balsamea</i> (Balsam fir)				1
<i>Abies concolor</i> (White fir)				2
<i>Abies fraseri</i> (Fraser fir)				1
<i>Abies sp.</i> (Fir species; unidentified)			2	
<i>Acer barbatum</i> (Florida maple)				1
<i>Acer buergerianum</i> (Trident maple)			15	3
<i>Acer campestre</i> (Hedge maple)			6	
<i>Acer davidii</i> (David maple)				2
<i>Acer ginnala</i> (Amur maple)	42			4
<i>Acer griseum</i> (Paperbark maple)			4	4

<i>Acer japonicum</i> (Full moon maple)				1
<i>Acer leucoderme</i> (Chalk maple)				1
<i>Acer negundo</i> (Boxelder)	8		2	4
<i>Acer miyabei</i> (Miyabe maple)				1
<i>Acer mono</i> (Painted maple)				2
<i>Acer nigrum</i> (Black maple)			3	
<i>Acer oliverianum</i> (Oliver maple)				1
<i>Acer palmatum</i> (Japanese maple)	13	28	20	20
<i>Acer pensylvanicum</i> (Striped maple)				1
<i>Acer platanoides</i> 'Crimson King' (Crimson King Norway maple)				14
<i>Acer platanoides</i> (Norway maple)		4	15	1
<i>Acer pseudosieboldianum</i> (Korean maple)				1
<i>Acer rubrum</i> (Red maple)	29	128	112	62
<i>Acer rufinerve</i> (Redvein maple)				1
<i>Acer saccharinum</i> (Silver maple)	6		43	11
<i>Acer saccharum</i> (Sugar maple)	46	27	488	142
<i>Acer trilforum</i> (Three flower maple)				2
<i>Acer x freemanii</i> (Freeman maple)			9	
<i>Acer sp.</i> (Maple species; unidentified)				1
<i>Acer spicatum</i> (Mountain maple)				
<i>Aesculus californica</i> (California buckeye)				1
<i>Aesculus chinensis</i> (Chinese buckeye)				1
<i>Aesculus flava</i> (Yellow buckeye)			3	4
<i>Aesculus glabra</i> (Ohio buckeye)			7	4
<i>Aesculus glabra var. arguta</i> (Texas Buckeye)				1
<i>Aesculus hippocastanum</i> (Horse Chestnut)			2	3
<i>Aesculus pavia</i> (Red buckeye)			4	1
<i>Aesculus sp.</i> (Buckeye/Horse chestnut species; unidentified)				3
<i>Aesculus sylvatica</i> (Painted buckeye)				2
<i>Aesculus turbinata</i> (Japanese horse chestnut)				1
<i>Aesculus x carnea</i> (Red horse chestnut)				3
<i>Aesculus x neglecta</i> 'Erythoblastos' (Yellow horse chestnut)				1
<i>Ailanthus altissima</i> (Tree-of-heaven)	10	18	12	
<i>Albizia julibrissin</i> (Mimosa)	6	3	2	
<i>Alnus serrulata</i> (Tag alder)				
<i>Amelanchier arborea</i> (Common serviceberry)			32	
<i>Amelanchier canadensis</i> (Shadblow serviceberry)			4	23
<i>Amelanchier laevis</i> (Allegheny serviceberry)			3	
<i>Amelanchier x grandiflora</i> (Apple serviceberry)			24	1
<i>Aralia spinosa</i> (Devil's walking stick)				
<i>Asimina triloba</i> (Pawpaw)			8	2
<i>Betula lenta</i> (Sweet birch)				1
<i>Betula nigra</i> (River birch)	8	41	93	14

<i>Betula pendula</i> (European white birch)				1
<i>Betula platyphylla</i> (Japanese white birch)			15	
<i>Betula populifolia</i> (Grey birch)			14	
<i>Betula x</i> (Birch; unidentified)				1
<i>Bumelia lycioides</i> (Buckthorn bumelia)				
<i>Carpinus betulus</i> (European hornbeam)		6	4	5
<i>Carpinus japonica</i> (Japanese hornbeam)				1
<i>Carpinus caroliniana</i> (American hornbeam)		5	12	3
<i>Carya cordiformis</i> (Bitternut hickory)			2	
<i>Carya glabra</i> (Pignut hickory)	10			3
<i>Carya illinoensis</i> (Pecan)		1	5	
<i>Carya pallida</i> (Sand hickory)	1			
<i>Carya ovalis</i> (Sweet pignut hickory)			1	
<i>Carya ovata</i> (Shagbark hickory)	17			
<i>Castanea mollissima</i> (Chinese chestnut)		1		3
<i>Castanea pumila</i> (Alleghany chinkapin)				
<i>Catalpa bignonioides</i> (Southern catalpa)			4	12
<i>Catalpa bungei</i> (Manchurian catalpa)				1
<i>Catalpa speciosa</i> (Northern catalpa)				
<i>Carya tomentosa</i> (Mockernut hickory)	11		2	
<i>Cedrela sinensis</i> (Chinese cedrela)				2
<i>Cedrus atlantica</i> (Atlas cedar)				1
<i>Cedrus deodara</i> (Deodar cedar)		2		1
<i>Celtis laevigata</i> (Southern hackberry)			136	
<i>Cedrus libani</i> (Cedar of Lebanon)				1
<i>Celtis occidentalis</i> (Common hackberry)	18	24	116	1
<i>Cercidiphyllum japonicum</i> (Katsura tree)				6
<i>Cercis canadensis</i> (Eastern redbud)	22	20	311	21
<i>Cercis chinensis</i> (Chinese redbud)				1
<i>Cercis yunnanensis</i> (Yunnan redbud)				1
<i>Chamaecyparis lawsoniana</i> (Lawson's cypress)				1
<i>Chamaecyparis nootkatensis</i> (Nootka falsecypress)				1
<i>Chamaecyparis obtusa</i> (Hinoki falsecypress)				10
<i>Chamaecyparis pisifera</i> 'Filifera Aurea' (Gold thread cypress)	2			9
<i>Chamaecyparis pisifera</i> (Sawara cypress)	7			
<i>Chamaecyparis thyoides</i> (White cypress)				4
<i>Chionanthus virginicus</i> (White fringe tree)	1	1	10	3
<i>Chionanthus retusus</i> (Chinese fringe tree)				2
<i>Cladrastis kentukea</i> (American yellowwood)	1	10	51	5
<i>Cleyera japonica</i> (Japanese cleyera)	1		330	
<i>Cornus alternifolia</i> (Pagoda dogwood)				1
<i>Cornus controversa</i> (Giant dogwood)				1
<i>Cornus drummondii</i> (Roughleaf dogwood)				
<i>Cornus florida</i> (Flowering dogwood)	39	36		82
<i>Cornus kousa</i> (Kousa dogwood)		4		24

<i>Cornus officinalis</i> (Japanese cornel dogwood)				1
<i>Cornus mas</i> (Cornelian cherry dogwood)				2
<i>Cotinus coggygria</i> (Common smoke tree)				1
<i>Cotibnus obovatus</i> (American smoke tree)				
<i>Cotinus sp.</i> (Cotinus species; unidentified)				1
<i>Crataegus sp.</i> (Hawthorn species; unidentified)		5		22
<i>Crataegus marshallii</i> (Parsley hawthorn)				
<i>Crataegus phaenopyrum</i> (Washington hawthorn)				
<i>Crataegus monogyna</i> (Singleseed hawthorn)				1
<i>Crataegus viridis</i> (Green hawthorn)		6		3
<i>Cryptomeria japonica</i> (Japanese cedar)				31
<i>Cunninghamia lanceolata</i> (China fir)				1
<i>Cupressus arizonica</i> (Arizona cypress)				7
<i>Cuprocyparis leylandii</i> (Leyland cypress)	15	40		3
<i>Diospyros sp.</i> (Perismmon species; unidentified)				1
<i>Diospyros virginiana</i> (American persimmon)				4
<i>Eucommia ulmoides</i> (Hardy rubber tree)				1
<i>Euonymus atropurpureus</i> (Eastern wahoo)				
<i>Euptelea pleiosperma</i> (Chinese euptelea)				2
<i>Fagus grandifolia</i> (American beech)		4		1
<i>Fagus orientalis</i> (Oriental beech)				1
<i>Fagus sylvatica</i> (European beech)				2
<i>Firmiana simplex</i> (Chinese parasol tree)				1
<i>Frangula alnus</i> (Glossy buckthorn)				1
<i>Fraxinus americana</i> (White Ash)	14		49	15
<i>Fraxinus ornus</i> (Flowering Ash)				1
<i>Fraxinus pennsylvanica</i> (Green ash)	24	10	143	23
<i>Fraxinus quadrangulata</i> (Blue ash)				1
<i>Fraxinus sp.</i> (Ash species; unidentified)				1
<i>Ginkgo biloba</i> (Ginkgo)		46		35
<i>Gleditsia triacanthos</i> (Sunburst honeylocust)	1		18	5
<i>Gleditsia triacanthos var. inermis</i> (Thornless honeylocust)		1		
<i>Gymnocladus dioicus</i> (Kentucky coffeetree)				2
<i>Halesia sp.</i> (Silverbell species)				1
<i>Halesia carolina</i> (Carolina silverbell)				1
<i>Hamamelis virginiana</i> (Common witch hazel)	1		10	
<i>Hamamelis japonica</i> (Japanese witch hazel)				2
<i>Hamamelis mollis</i> (Chinese witch hazel)				1
<i>Hamamelis vernalis</i> (Ozark Witch hazel)				1
<i>Hamamelis x intermedia</i> (Witchhazel)				10
<i>Hovenia dulchis</i> (Japanese Raisin tree)				1
<i>Idesia polycarpa</i> (Igiri tree)				3
<i>Ilex cornuta</i> (Chinese holly)	3		32	
<i>Ilex latifolia</i> (Lusterleaf holly)	6			
<i>Ilex opaca</i> (American holly)	23		134	17

<i>Ilex vomitoria</i> (Yaupon)	1			
<i>Ilex x attenuata</i> (Foster holly)	43		6	12
<i>Ilex x 'Nellie R Stevens'</i> (Nellie R Stevens holly)	7			30
<i>Ilex sp.</i> (<i>Ilex</i> species; unidentified)				8
<i>Juglans nigra</i> (Black walnut)	1		88	6
<i>Juniperus chinensis</i> (Chinese juniper)	2			
<i>Juniperus chinensis 'Torulosa'</i> (Hollywood Juniper)	3			
<i>Juniperus deppeana</i> (Alligator juniper)				1
<i>Juniperus scopulorum</i> (Rocky Mountain juniper)				1
<i>Juniperus virginiana</i> (Eastern red cedar)	22	27	16	3
<i>Koelreuteria bipinnata</i> (Chinese flame tree)				2
<i>Koelreuteria paniculata</i> (Golden raintree)		24		10
<i>Larix decidua</i> (European larch)				7
<i>Laurocerasus sp.</i> (Laurel species; unidentified)			2	
<i>Laurus nobilis</i> (Bay laurel)			33	
<i>Ligustrum sinense</i> (Chinese privet)		1		
<i>Liquidambar styraciflua</i> (Fruitless sweet gum)	43	8	34	8
<i>Liquidambar sp.</i> (Sweetgum species)				2
<i>Liriodendron chinense</i> (Chinese tulip tree)				1
<i>Liriodendron tulipifera</i> (Tulip tree)	15	6	259	17
<i>Lonicera japonica</i> (Japanese honeysuckle)			1	
<i>Maackia amurensis</i> (Maackia)				1
<i>Maclura pomifera</i> (Osage orange)			19	
<i>Magnolia acuminata</i> (Cucumber tree)			10	1
<i>Magnolia ashei</i> (Ashe's magnolia)				1
<i>Magnolia denudata</i> (Yulan magnolia)				1
<i>Magnolia liliiflora</i> (Lily magnolia)				1
<i>Magnolia macrophylla</i> (Bigleaf magnolia)				1
<i>Magnolia grandiflora</i> (Southern magnolia)	18	72	486	41
<i>Magnolia virginiana</i> (Sweetbay magnolia)	14	23	37	4
<i>Magnolia x soulangeana</i> (Saucer magnolia)		4	69	9
<i>Magnolia sp.</i> (<i>Magnolia</i> species; unidentified)			3	
<i>Magnolia stellata</i> (Star magnolia)			1	2
<i>Magnolia tripetala</i> (Umbrella magnolia)				1
<i>Malus floribunda</i> (Japanese flowering crabapple)				19
<i>Malus hopa</i> (Hopa crabapple)	1			
<i>Malus sp.</i> (Crabapple species; unidentified)			109	1
<i>Metasequoia glyptostroboides</i> (Dawn redwood)		3	17	3
<i>Morus alba</i> (White mulberry)			1	
<i>Morus papyrifera</i> (Paper mulberry)		3		
<i>Morus rubra</i> (Red mulberry)	11		16	1
<i>Nyssa aquatica</i> (Water tupelo)			1	
<i>Nyssa biflora</i> (Swamp tupelo)				1
<i>Nyssa ogeche</i> (Ogeechee tupelo)			3	
<i>Nyssa sinensis</i> (Chinese tupelo)				1
<i>Nyssa sylvatica</i> (Black gum)	7	2	10	2

<i>Ostrya virginiana</i> (American hop hornbeam)			1	1
<i>Oxydendrum arboreum</i> (Sourwood)	1		3	
<i>Parrotia persica</i> (Persian ironwood)			4	5
<i>Paulownia tomentosa</i> (Royal paulownia)			5	
<i>Phellodendron amurense</i> (Amur cork tree)				1
<i>Picea abies</i> (Norway spruce)	2	1	9	30
<i>Picea glauca</i> (White spruce)				5
<i>Picea pungens</i> (Colorado spruce)				10
<i>Pinus bungeana</i> (Lacebark pine)			2	1
<i>Pinus cembra</i> (Swiss stone pine)				1
<i>Pinus echinata</i> (Shortleaf pine)	17		19	1
<i>Pinus ellioti</i> (Slash pine)				3
<i>Pinus mugo</i> (Mugo pine)				1
<i>Pinus nigra</i> (Black pine)			12	5
<i>Pinus palustris</i> (Longleaf pine)				3
<i>Pinus resinosa</i> (Red pine)			4	
<i>Pinus rigida</i> (Pitch pine)				1
<i>Pinus strobus</i> (Eastern white pine)	3	7	139	154
<i>Pinus sylvestris</i> (Scots pine)				4
<i>Pinus taeda</i> (Loblolly pine)			5	1
<i>Pinus thunbergiana</i> (Japanese black pine)			90	
<i>Pinus virginiana</i> (Virginia pine)	11			
<i>Pinus wallichiana</i> (Himalayan white pine)				1
<i>Pistache chinensis</i> (Chinese pistache)			1	2
<i>Platanus x acerifolia</i> (London plane)			2	4
<i>Platanus hybrida</i> (London sycamore)			7	
<i>Platanus occidentalis</i> (American sycamore)	1	6	52	18
<i>Platanus orientalis</i> (Oriental plane tree)				1
<i>Platycarya strobilacea</i> (Platycarya)				1
<i>Platyphylla japonica</i> (Asian white birch)			5	
<i>Poliiothysis sinensis</i> (Chinese pearlbloom)				1
<i>Populus deltoids</i> (Eastern cottonwood)		2	3	
<i>Populus nigra</i> (Black poplar)			39	
<i>Populus tremuloides</i> (Quaking aspen)				1
<i>Prunus americana</i> (American plum)	2			
<i>Prunus angustifolia</i> (Chickasaw plum)				
<i>Prunus caroliniana</i> (Carolina cherry-laurel)		5	1	1
<i>Prunus cerasifera</i> (Cherry plum)			4	
<i>Prunus cerasus</i> (Sour cherry)	1			
<i>Prunus incisa</i> (Fuji cherry)				2
<i>Prunus laurocerasus</i> (Cherry laurel)			5	
<i>Prunus maackii</i> (Manchurian cherry)				1
<i>Prunus mume</i> (Japanese apricot)				2
<i>Prunus 'Okame'</i> (Tawan cherry)			4	
<i>Prunus persica</i> (Peach)				
<i>Prunus serotina</i> (Black cherry)	11	1	20	5

<i>Prunus serrulata</i> (Japanese flowering cherry)	6		58	16
<i>Prunus sp.</i> (Cherry species; unidentified)				1
<i>Prunus subhirtella</i> (Higan cherry)		5	6	
<i>Prunus yedoensis</i> (Yoshino cherry)	2	8	43	
<i>Prunus x incam</i> (Okame flowering cherry)			9	
<i>Pseudotsuga menziesii</i> (Douglas fir)				3
<i>Ptelea trifoliata</i> (Common hop tree)				3
<i>Pterocarya stenoptera</i> (Chinese wingnut)				1
<i>Pyrus calleryana</i> (Callery pear)	38	56	98	3
<i>Pyrus communis</i> (European pear)			1	
<i>Quercus acutissima</i> (Sawtooth oak)		12	7	3
<i>Quercus alba</i> (White oak)	41		54	13
<i>Quercus bicolor</i> (Swamp white oak)			23	6
<i>Quercus coccinea</i> (Scarlet oak)			1	1
<i>Quercus falcata</i> (Southern red oak)	18		1	1
<i>Quercus imbricaria</i> (Shingle oak)			25	
<i>Quercus lyrata</i> (Overcup oak)				3
<i>Quercus macrocarpa</i> (Bur oak)			34	4
<i>Quercus marilandica</i> (Blackjack oak)	1			
<i>Quercus michauxii</i> (Swamp chestnut oak)			1	
<i>Quercus montana</i> (Chestnut oak)				
<i>Quercus muehlenbergii</i> (Chinkapin oak)	1		4	1
<i>Quercus nigra</i> (Water oak)		5	13	
<i>Quercus nuttallii</i> (Nuttall oak)		2		3
<i>Quercus pagoda</i> (Cherrybark oak)				
<i>Quercus palustris</i> (Pin oak)	12		95	48
<i>Quercus phellos</i> (Willow oak)	32	130	132	10
<i>Quercus prinus</i> (Chestnut oak)			1	
<i>Quercus robur</i> (English oak)				1
<i>Quercus robur</i> 'Fastigiata' (Upright English Oak)		4		
<i>Quercus rubra</i> (Northern red oak)	34		25	22
<i>Quercus shumardii</i> (Shumard oak)		5	9	3
<i>Quercus sinuata</i> (Durand oak)	1			
<i>Quercus sp.</i> (Oak species; unidentified)				4
<i>Quercus stellata</i> (Post oak)	10			
<i>Quercus texana</i> (Texas red oak)				1
<i>Quercus variabilis</i> (Chinese cork oak)				1
<i>Quercus velutina</i> (Black oak)	9		1	5
<i>Rhamnus caroliniana</i> (Carolina buckthorn)	1			
<i>Rhus copallina</i> (Shining sumac)				
<i>Rhus glabra</i> (Smooth sumac)			2	
<i>Rhus typhina</i> (Staghorn sumac)			2	
<i>Robinia pseudoacacia</i> 'Purple Robe' (Black locust)		2	6	
<i>Robinia pseudoacacia</i> (Black locust)				9
<i>Salix alba</i> (White willow)				1
<i>Salix babylonica</i> (Weeping willow)	2	2		2

<i>Salix caroliniana</i> (Carolina willow)				
<i>Salix nigra</i> (Black willow)		2		
<i>Sapindus drummondii</i> (Western soapberry)				1
<i>Sassafras albidum</i> (Sassafras)			10	1
<i>Sinojackia xylocarpa</i> (Jack tree)				1
<i>Sophora (styphnolobium) japonica</i> (Japanese pagoda)	2	3	16	1
<i>Sorbus americana</i> (American mountain-ash)				1
<i>Stewartia pseudocameallia</i> (Japanese stewartia)			1	5
<i>Styrax amricanus</i> (American snowbell)				1
<i>Styrax japonicus</i> (Japanese snowbell)			4	6
<i>Styrax obassia</i> (Fragrant snowbell)				2
<i>Styrax sp.</i> (Snowebell species; unidentified)				1
<i>Symplocos tinctoria</i> (Common sweetleaf)				
<i>Syringa reticulata</i> (Chinese tree lilac)			7	1
<i>Taxodium ascendens</i> (Pond cypress)		3	1	1
<i>Taxodium distichum</i> (Bald cypress)	1	14	29	4
<i>Taxus sp.</i> (Yew species; unidentified)				1
<i>Thuja occidentalis</i> (Northern white cedar)	13			13
<i>Thujopsis dolobrata</i> (Hiba arborvitae)				1
<i>Thuja koraiensis</i> (Korean arborvitae)				3
<i>Thuja plicata</i> (Western redcedar)				6
<i>Tilia americana</i> (American basswood)			35	9
<i>Tilia cordata</i> (Littleleaf linden)		3	9	3
<i>Tilia platyphyllos</i> (Bigleaf linden)				1
<i>Tilia tomentosa</i> (Silver linden)				1
<i>Tsuga canadensis</i> (Eastern hemlock)	142	9	30	31
<i>Ulmus alata</i> (Winged elm)	1			
<i>Ulmus americana</i> (American elm)	1		63	6
<i>Ulmus carpinifolia</i> (Smoothleaf elm)				1
<i>Ulmus americana</i> 'Princeton' (Princeton elm)		3		
<i>Ulmus parvifolia</i> (Chinese elm)		52	3	8
<i>Ulmus procera</i> (English elm)			2	
<i>Ulmus pumila</i> (Siberian elm)			12	3
<i>Ulmus rubra</i> (Slippery elm)			21	
<i>Ulmus serotina</i> (September elm)			18	1
<i>Viburnum nudum</i> (Smooth witherod)			3	
<i>Viburnum prunifolium</i> (Blackhaw)			3	
<i>Viburnum rufidulum</i> (Rusty blackhaw)			1	
<i>Vitex agnus-castus</i> (Chastetree)				1
<i>X Cupressocyparis leylandii</i> (Leyland cypress)			4	
<i>Zelkova carpinifolia</i> (Caucasian zelkova)				1
<i>Zelkova serrata</i> (Japanese zelkova)	8	52	42	3

Discussion

The total number of all the species combined between the four campuses was 317 in which 23 of those species were all found in each campus. ETSU had the most number of species with 231 and UTC had the least number of species with 63. VU had the most number of individuals with 5,625 trees and SAU had the least number of individuals with 1,003 trees (Table 1 and 2). ETSU had the most number of single representatives while UTC had the least number of single representative species. The most diverse university was found to be ETSU with a value of 4.33 and the lowest was found to be UTC with a value of 3.36. ETSU, however, had 109 species with only one individual, thus it can be inferred that species distribution is not wide. UTC, inversely, had the least number of single representatives, thus being more evenly distributed than ETSU. VU had the second highest value and SAU had the third highest value.

Table 2. Shannon-Weiner index, number of trees, number of species, and percent of native tree species on the campuses of Southern Adventist University (SAU), the University of Chattanooga (UTC), Vanderbilt University (VU), and East Tennessee State University (ETSU).

University	Shannon-Weiner Index	Number of Trees	Number of Species	Percent of Native Tree Species
SAU	3.66	1,003	76	50% (n=38)
UTC	3.36	1,047	63	43% (n=27)
VU	3.80	5,625	137	38% (n=52)
ETSU	4.33	1,548	231	24% (n=56)

Horticultural Plan

Our results show that in the SAU arboretum, 58 native tree species are unrepresented, thus in order to meet our goals we need to plant additional native TN trees on our campus. Addition of native TN trees can foster the goal to educate the community on the diversity of trees native to TN.

SAU has eight native TN trees with only one representative each, thus three to five of each of these species should be planted in order to increase abundance, which is important to prolong the species on our campus in case of disease. These nine species of trees are *Carya pallida* (Sand hickory), *Chionanthus virginicus* (White fringetree), *Hamamelis virginiana* (Witch hazel), *Juglans nigra* (Black walnut), *Oxydendrum arboretum* (Sourwood), *Platanus occidentalis* (American sycamore), *Quercus muehlenbergii* (Chinkapin oak), *Rhamnus caroliniana* (Carolina buckthorn), and *Taxodium distichum* (Bald cypress). The addition of these tree species should be planted across the campus and not clumped together.

As previously stated, SAU has 58 unrepresented native TN tree species. These species vary in the growing conditions they require. According to the Tennessee Invasive Plants Council, 25 of the 58 native TN species unrepresented on our campus are recommended to be planted in the area that SAU is located in. (Table 3). Three to five individuals of each species should be planted to meet the goal of increasing the native TN tree diversity on our campus.

Table 3. Native TN species to be planted on the SAU campus that are currently unrepresented.

Species	Common Name
<i>Aesculus flava</i>	Yellow buckeye
<i>Amelanchier arborea</i>	Common serviceberry
<i>Aralia spinosa</i>	Devil's walking stick
<i>Asimina triloba</i>	Pawpaw
<i>Betula lenta</i>	Sweet birch
<i>Carpinus caroliniana</i>	American hornbeam
<i>Carya cordiformis</i>	Bitternut hickory
<i>Cornus alternifolia</i>	Pagoda dogwood
<i>Crataegus marshallii</i>	Parsley hawthorn
<i>Crataegus phaenopyrum</i>	Washington hawthorn
<i>Fagus grandiflora</i>	American beech
<i>Fraxinus quadrangulata</i>	Blue ash
<i>Halesia carolina</i>	Carolina silverbell
<i>Magnolia acuminata</i>	Cucumber tree
<i>Ostrya virginiana</i>	American hop hornbeam
<i>Quercus coccinea</i>	Scarlet oak
<i>Quercus prinus</i>	Chestnut oak

<i>Rhus typhina</i>	Staghorn sumac
<i>Salix nigra</i>	Black willow
<i>Sassafras albidum</i>	Sassafras
<i>Sorbus americana</i>	Mountain ash
<i>Tilia americana</i>	American basswood
<i>Viburnum prunifolium</i>	Blackhaw

Species with more than 35 individuals were considered to be highly abundant on our campus, thus due to our goal to increase the native TN tree diversity on campus, a thinning of these trees should be considered to provide more space to plant the new tree species. Non-native species include *Acer ginalla*, *Ilex x attenuata*, and *Pyrus calleryana*. Native species include *Acer saccharum*, *Cornus florida*, *Liquidambar styraciflua*, *Quercus alba*, and *Tsuga canadensis* (Table 1).

Tsuga canadensis (Eastern hemlock) was the most represented native TN tree with 142 individuals, over 10 percent of all trees on campus. However, several trees were found to be infected with Hemlock woolly adelgid, thus we will impede thinning of *Tsuga canadensis* until treatment of Hemlock woolly adelgid has been completed. We recommend using imidacloprid, a systematic neonicotinoid insecticide, and apply it to the soil near the base of the hemlock or directly to the tree trunk. Dosage will be based on the DBH of the hemlock utilizing an optimized dosage as found by Benton and Cowles (2016).

SAU has nine non-native tree species that are represented with only one individual. Since our goal is to increase the abundance and diversity of native trees, planting more individuals of these species is not currently recommended. Careful consideration should be given before planting more non-native trees.

In summary: In order to meet our goal of increasing the abundance and diversity of native trees, we should bolster the number of native tree species already present and begin planting

more native trees, which are appropriate for our growing conditions, that are not currently represented. Meeting these goals enhance community education of the different species of native trees and foster conservation of the same.

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