2011
GREAT SOUTHERN TREE CONFERENCE

RESEARCH REPORT

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December 1 – December 2, 2011

UNIVERSITY OF FLORIDA
Environmental Horticulture Department
GAINESVILLE, FLORIDA 32611

Florida continues to set the standard for quality

Dr. Ed Gilman, Professor
Environmental Horticulture Department, University of Florida

2011

The University of Florida and the FNGLA, in cooperation with the corporate and association partners that have contributed more than $750,000 over the past 11 years, continue to bring you the Great Southern Tree Conference. Now in our second decade, this effort has led to many changes in our profession. Grades and Standards now sets the standard for nursery tree quality for the nation. We grow trees faster and more efficiently now more than ever. As a group, we are in the midst of a change in the way we deliver quality root systems to our customers.

Please accept this report as our latest effort to define quality and understand why it matters. We have conducted dozens of tests, demonstrations, and research projects that are summarized in our past reports. These can be found at http://hort.ifas.ufl.edu/woody/great-southern-tree.shtml. You will find that many projects are reported on for a number of consecutive years because they extend over several years. Some projects have been going for as long as 15 years.

Please thank Maria "Pili" Paz (staff biologist), Chris Harchick (farm manager), and Jake Miesbauer (Ph.D. candidate) for their continued dedication to the urban tree research and education efforts over the past years. Their assistance and devotion to executing high-quality research is exemplary.

Please thank our 2011 Great Southern Tree Conference Partners

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Great Southern Tree Conference: Effect of initial liner size and season of root pruning on live oak root systems in a field nursery

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, FL

Objective: Determine effects of live oak liner size and season of field root pruning on root system quality in field grown nursery stock after planting.

What we did and will do: In February 2007, 120 Cathedral Oak® live oaks averaging 0.5" caliper were obtained in #3 Accelerator containers. The treatments were: (1) 40 trees planted directly into field soil; (2) 40 trees shifted into #10 Accelerators; or (3) 40 trees shifted into #15 Accelerators. Half of the trees (20 for each liner size) were root pruned when planting to the field or shifting to the larger container size. Trees were root pruned by cutting 2" deep into the side of the root ball in 5 equidistant places from the top of the root ball to the bottom. Tops on root pruned trees were washed for 10 seconds to expose and remove circling and potentially girdling roots on the top 1 to 2". The other half of the trees per treatment was not root pruned at field planting or shifting. The trees shifted into the #10 containers were planted into the field nursery October 2007, when the trunk caliper averaged 1". The #15 containers were field planted when the trunks reached a caliper of about 1.3" in January 2008. Root balls that were sliced when shifted were again sliced at planting into field soil, while those not pruned when shifted were not pruned when planted to field soil.

All trees were planted in the same field with 12 ft between rows and 8 ft between trees and were irrigated three times per day during the growing season through drip emitters. Trees in the field were root pruned in the following manner: 1) half were root pruned in the dormant season (Feb, Apr, Oct, Dec 08 and Feb, Apr 09); or 2) the other half were root pruned in the growing season (Apr, June, Aug, Oct 08 and Apr, June 09). At each root pruning, two 1/8 circumference sections opposite one another were cut with a sharp 12" long digging shovel starting 8" from trunk; each subsequent root pruning was about 1" farther from the trunk and rotated another 1/8 around circumference. Trees were fertilized three times a year with 115 g of 16-4-8 and were staked in November 2007 for #3 and #10, and at planting for #15. The experimental design was 3 liner sizes x 2 root pruning at shifting and field planting x 2 field root pruning seasons x 10 replicates = 120 trees.

Half of the trees for each treatment combination (5 trees in each of 12 treatment combinations = 60 trees) were dug with a 36 inch tree spade November 2009. Trees were lifted and placed back in the ground in the same hole. Trees were then rocked back and forth by one person three times in the north-south direction, then three times in the east-west direction to determine firmness. Root development was measured on these 60 trees December 2009 to show influence of root pruning strategies on root ball quality. Root data results can be found in the 2010 GSTC Report.

The other half of the trees left in the field (5 trees in each of 12 treatment combinations = 60 trees) were all moved in March 2010 with a 36 inch diameter tree spade without wire basket or burlap. Caliper and tree height was recorded. Once moved, trees were watered in by hand. Trees are now being irrigated every other day with periodic dry days to measure stress caused by water deficit. Water stress was measured April 18, April 28 and May 5, 2011. In September 2010 all trees were fertilized with 300 g of 20-0-8, and with 400 g of 20-0-8 on March and June 2011. Caliper and heights were recorded on September 2011. Trees were pulled until the trunk base tilted 5 degrees to test stability on March 2011. Moment was calculated as pulling force x distance between ground and pulling point. Trees were held for a minute at 5 degrees tilt, and distance from the trunk to dip point on leeward side measured (hinge point). When pull was released, final angle at the trunk base was recorded.

What we found as of November 2011: Root ball slicing at planting or season of root pruning in the field nursery had no impact on tree caliper or tree height in the nursery or in the 18 months following landscape planting. There was also no impact of planting season or season of rot pruning during production on tree stability 18 months after planting (data not shown). Water stress after landscape planting was not affected by either initial nursery liner container size or season of root pruning during production. Trees planted from #3 and #15 containers were tallest 18 months after transplanting, but all trees grew in height at a comparable rate (Table 1), indicating very small differences among treatments. Trees planted from #10 containers are growing the slowest in caliper, while those from #15 and #3 containers are growing at a comparable rate (Table 1). Trees planted from #3 containers as liners into the field nursery were the most stable 18 months after planting to the landscape (i.e. they required a larger moment to pull them to 5 degrees trunk tilt) (Table 2). All trees returned to a similar position (rest angle) after testing for stability (Table 2).

Table 1. Caliper and height 18 months after transplanting (September 2011) field nursery-grown live oaks initially planted from #3 (Feb 07), #10 (Oct 07) or #15 (Jan 08) containers.

Liner container size (beginning caliper)	Caliper 18 months after landscape planting(in)	Caliper increase 18 months after transplanting from field nursery (in)	Height (ft)	Height increase 18 months after transplanting from field nursery (ft)
#3 (0.5”)	4.11	1.00 ab	17.6 a[1]	2.5
#10 (1.0”)	3.92	0.93 b	16.6 b	2.3
#15 (1.3”)	4.13	1.03 a	17.4 a	2.6

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 20 trees per container size averaged across root pruning at planting and field root pruning season.

Table 2. Pulling moment to 5 degrees, hinge point and angle of field nursery-grown live oaks initially planted from #3 (Feb 07), #10 (Oct 07) or #15 (Jan 08) containers.

Container Size (beginning caliper)	Pulling moment to 5 degrees (kNm)	Hinge point[2] (in)	Rest angle (degrees)
#3 (0.5”)	3.3 a[1]	3.8 b	1.1
#10 (1.0”)	2.4 b	4.8 a	1.2
#15 (1.3”)	2.9 ab	5.1 a	1.3

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 20 trees per container size averaged across root pruning at planting and field root pruning season.

[2] Hinge point is distance from trunk to dip in the soil on the pulling side of the tree.

Great Southern Tree Conference: Effect of planting depth in containers and in the landscape on growth after field planting Cathedral Oak® live oak.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1– December 2, 2011
Gainesville, FL

Objective: Determine how planting depth in the root ball and planting depth in the landscape influence Cathedral Oak® live oak following landscape planting.

What we did: In July 2006, 144 Cathedral Oak® live oaks about 2.7" caliper were planted to a Bahia grass field in Citra, FL (20 miles south of Gainesville) from #45 containers. Twenty-four trees were planted on 50-foot centers and the remaining 120 trees were planted on 25-foot centers. Portions of the site were poorly drained. Trees were produced in containers from rooted cutting liners with the following planting depth treatments: (1) top-most root at soil level into #3, #15 and #45; (2) 2.5" below grade in #3 and #15, level into #45; (3) 4.5" below grade into #3 and #15, level into #45; or, (4) 2.5" below grade in #3, #15 and #45. Trees from each of these four depths in the containers were planted into the landscape at three different depths for a total of twelve treatment combinations. Landscape planting depths were: (1) 0", media surface level with landscape soil; (2) 4" below grade; (3) 8" below grade. Half of the trees were root pruned at planting (trees were root pruned by cutting 4-5" deep into the side of the root ball in 5 equidistant places from the top of the root ball to the bottom using a sharp balling spade), whereas the other half was planted without root pruning. Following transplanting, all trees were mulched and irrigated with 34 gallons/day for approximately 2 ½ weeks. At the end of July 2006, irrigation was reduced to 7.5 gallons/day for two weeks. In mid-August 2006, irrigation was once more reduced to 7.5 gal every other day for 3 weeks and reduced further to 7.5 gal every three days for two weeks. Trees are now irrigated when they show signs of stress, which is usually in the spring. Trees were fertilized April 2007 with 340 g of 12-2-14, 400 g of 16-4-8 in July 2008, and 800 g of 16-4-8 in July 2009. Caliper and height were measured in September 2011.

What we found as of November 2011: Trunk caliper and tree height five years after landscape planting were not affected by planting depth in the nursery container (Table 1). Tree height 5 years after planting appeared to be affected by landscape planting depth and root pruning at planting (Table 2 and 3). Trees that were planted into the landscape deeper were slightly shorter than those planted even with landscape soil probably because they were shorter at planting due to the deeper planting. Trees that were root pruned by slicing the root ball when planted into the landscape were slightly shorter than trees that were not root pruned. Although tree height was slightly affected by landscape planting depth and root pruning, the relative growth of all trees has been similar for all treatments.

Table 1. Caliper, height and growth of live oak, produced at different nursery planting depths at each shift to larger container, 5 years after landscape planting.

Nursery planting depth	Caliper (in)	Caliper growth in 5 years (in)	Height (ft)	Height growth in 5 years (ft)
Level in #3, #15, #45	6.21[1]	3.38	19.6	6.5
2.5" deep in #3 and #15, level in #45	6.04	3.16	19.0	6.3
4.5" deep in #3 and #15, level in #45	6.15	3.28	19.0	6.5
2.5" deep in #3, #15, #45	6.01	3.16	19.1	6.6

[1]Means averaged across landscape planting depths and root pruning treatments.

Table 2. Caliper and height of live oak produced at different nursery planting depths 5 years after landscape planting at three different landscape planting depths.

Landscape planting depth	Caliper (in)	Caliper growth in 5 years (in)	Height (ft)	Height growth in 5 years (in)
Level (at grade)	6.28	3.42	19.8 a[1]	6.4
4" Below landscape surface	5.93	3.07	18.8 b	6.2
8" Below landscape surface	6.10	3.24	19.0 b	6.7

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 48 trees per treatment, averaged over nursery planting depth and root pruning treatment.

Table 3. Caliper and height of live oak that were root pruned or not root pruned at planting five years ago.

Root pruning	Caliper (in)	Caliper growth in 5 years (in)	Height (ft)	Height growth in 5 years (ft)
Yes	6.00	3.13	18.8 b[1]	6.1
No	6.20	3.35	19.6 a	6.7

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 72 trees per treatment, averaged over nursery and landscape planting depth.

What's next: Caliper, heights and root system quality will continue to be collected to determine the effect of planting depth on landscape live oak growth. In the coming year, trees will be pulled over and roots will be excavated to measure root structure, tree health and tree stability.

Here is a correctly planted tree with substrate surface slightly above surrounding soil. Root pruning (white lines) at planting cut several inches inside the root ball all the way to the bottom of the root ball. This root pruning does not correct any defects further inside the root ball.

Great Southern Tree Conference: Effect of container type and root pruning on root quality of ‘Florida Flame’ maple.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, FL

Objective: Determine impacts of container type and root ball shaving on root form on ‘Florida Flame’ maple.

What we did and will do: In April 2008, 384 ‘Florida Flame’ maple trees from liner containers were potted into eight different #3 container types with the top-most root planted right at soil level. The container types are smooth sided (Nursery Supplies, Inc., Chambersburg, PA), SmartPot® (Root Control, Inc., Oklahoma City, OK), RootBuilder® and RootMaker® (Rootmaker® Products Company, LLC, Huntsville, AL), Fanntum™ (Fanntum Products, Inc., Statesville, NC), Florida Cool Ring™ (The Florida Cool Ring Company, Lakeland, FL), Airpot™ (Caledonian Tree Company, Ltd., Scotland) or Jackpot™ (Legacy Nursery Products, LLC, Palm City, FL), and were placed pot to pot. Substrate was 20: 60: 20 (New Florida peat: pine bark: sand, by volume) for RootMaker®, RootBuilder®, Fanntum™, Florida Cool Ring™ and Jackpot™ , and 50: 40: 10 (New Florida peat: pine bark: sand, by volume) for Airpot™, SmartPot® and smooth sided. Volume of substrate in each container was similar except the Jackpot™, which was about 15% smaller in volume than others. Trees were irrigated 3 times daily and were staked in May 2008. Calipers and heights were collected in September 2008. Root balls on 9 trees of each container were excavated November 2008 and root balls evaluated. In February 2009, 288 trees total of the #3 container types were shifted to the same type of #15 containers with the same substrate. The RootMaker® was replaced by RootTrapper® (a type of fabric container from the same manufacturer) since the largest size RootMaker® is #5, and will be referred as the RootTrapper® in this report. Before shifting into #15 containers, root balls on half of the trees of each container type were pruned in one of two ways: a) no root pruning, or b) shaving off the outer root ball, which removes the peripheral and bottom one inch of the root ball. The remaining 24 trees (3 for each container type) were planted directly into the ground, with the root ball intact and planted even with the soil.

In November 2009, five trees of the #15 of each treatment combination (container type and root pruning – 80 trees total) were destructively harvested to evaluate root morphology. In February 2010, 10 trees for each treatment combination were shifted to the same type #45 containers with the same substrate. Roots were pruned before shifting following the same protocol described above. The remaining 48 trees (3 for each treatment combination) were planted directly into the ground, with the root ball intact and planted even with the soil in a randomized complete block design.

In May 2011, five trees of the #45 of each treatment combination were destructively harvested to evaluate root morphology. The rest of the trees (5 trees for each container type and root pruning combination) were planted into the landscape with the root ball intact and planted even with the soil in a randomized complete block design. In May 2011, trees planted from #3 containers into the landscape were pulled until the trunk base tilted 5 degrees to test stability. Moment was calculated as pulling force x distance between ground and pulling point. Trees were held for a minute at 5 degrees tilt, and distance from the trunk to dip point on leeward side was measured (the point of the maximum dip was called the hinge point). When pull was released, final angle at the trunk base was recorded as rest angle. These trees were compared with trees that were planted from propagation liners directly into the landscape on April 21, 2008, with no root manipulation. Trees planted from #15 and #45 containers will also be pulled 26 months after planting to test stability, along with the #3 and liner trees. After the last pulling, trees will be dug to characterize root systems; root form will be related to stability characteristics. This will help develop a better understanding of what root form makes trees stable.

What we have found as of November 2011: Caliper of red maples growing in smooth sided #45 containers were greater than for any other container type, except SmartPot® and Airpot™; however differences were small (Table 1). While those in Jackpot™ had the smallest tree caliper (Table 1), they also had 15% less substrate than other containers. Height of trees finished in #45 containers was not affected by container type (Table 1). Root pruning prior to shifting to the next container size had no effect on caliper or height of trees in the nursery (data not shown). This has typically been the case in our previous root pruning studies; trees may have been stunted had we not kept pace with irrigation needs. For #15 sized trees planted into landscape soil in November 2009 there was no difference in caliper or heights for the different container types 2 years after planting (Table 2). Trees planted from #3 Airpot™ in November 2008 were the shortest, but there was no effect of container type on caliper from container types 3 years after planting (Table 2). Caliper and height of trees planted from #45 containers in May 2011 were similar for each of the 8 container types 6 months later in November 2011 (Table 2).

Fanntum™ produced the largest root diameter and root length at the edge of #45 (Table 3). Container type had no effect on percent trunk circled by roots at any container (data not shown). There were other differences in root systems of maples in the various container types (Table 3). Root ball shaving prior to shifting #3 containers into #15, and #15 to #45 dramatically improved root system quality by reducing the percentage of trees considered culls from 95 to 42% at the #3, and from 50 to 2% at the #15 (Table 4). Shaving also reduced the percentage of trunk circled by roots at all container sizes, and reduced the percentage of trees with roots growing over the flare (Table 4). Root ball shaving also increased the diameter of the five largest roots at the edge of the #45 on the north and south side of the ball, while decreasing the diameter of the 5 largest roots on the edge of the #3 (Table 4). This means that shaving forced more woody roots to the edge of the #45 in a more natural position instead of maintaining a deflected, deformed root structure inside the original #3 container volume. Put another way, shaving eliminated the “imprint” of the root system caused by growing in a smaller (#3) container. For all container types (except RootTrapper®), root ball shaving also increased the amount of radial roots > 2mm in the #45 container. Root ball shaving appears to improve tree quality while not affecting growth in the nursery or in the landscape after planting.

Tree stability 2 years after planting #3 containers into the landscape was not affected by container type (Table 5). Trees field-grown from liners in propagation containers had a dip point (distance from the trunk to the lowest point where root plate sunk on the pull-side of the tree) further from the trunk when compared to trees planted from #3 containers (Table 5).

Conclusion: Shaving the roots ball periphery when shifting a container-grown tree to the next larger size, and when planting into a field nursery or landscape, appears to have a greater impact on root system quality than container type.

Table 1. Caliper and height of a finished crop of 'Florida Flame' maples grown in eight different container types.

Container type	Finished #3 Containers		Finished #15 Containers		Finished #45 Containers	
	Caliper (mm)	Height (ft)	Caliper (mm)	Height (ft)	Caliper (mm)	Height (ft)
Airpot™	16.7 abc[1]	7.1 a	41.8 ab	9.5 a	69.5 ab	17.5
Cool Ring™	15.8 c	6.4 b	38.3 d	9.0 b	67.3 dc	17.6
Fanntum™	17.4 ab	7.0 a	40.5 bc	9.3 ab	67.6 bcd	17.8
Jackpot™	14.6 d	6.5 b	37.8 d	8.7 b	65.9 d	17.4
RootBuilder®	17.7 a	7.2 a	40.1 c	9.0 b	66.5 d	17.8
RootTrapper®	17.7 a	7.1 a	41.2 bc	9.3 ab	68.7 bc	17.9
SmartPot®	16.6 bc	6.9 a	43.1 a	9.2 ab	69.3 abc	17.8
Smooth sided	17.4 ab	7.1 a	43.0 a	9.2 ab	71.3 a	17.9

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 48 trees per treatment for #3, 36 trees per treatment for #15, and 20 trees per treatment for #45 averaged across root pruning treatment.

Table 2. Caliper and height in Nov. 2010 of 'Florida Flame' maples planted to the landscape from #3 (Nov 2008), from #15 (Nov 2009) and from #45 (May 2011) containers.

Container type	#3 planted into landscape soil		#15 planted into landscape soil		#45 planted into landscape soil	
	Caliper (mm)	Height (ft)	Caliper (mm)	Height (ft)	Caliper (mm)	Height (ft)
Airpot™	76.0	17.5 b[1]	75.8	19.2	84.5 ab	18.4
Cool Ring™	91.4	21.1 a	75.7	19.7	83.7 abc	18.8
Fanntum™	89.5	21.4 a	78.4	19.7	83.5 abc	19.2
Jackpot™	81.1	19.5 ab	77.0	19.4	81.2 cd	18.6
RootBuilder®	82.9	20.7 a	75.5	18.8	79.9 d	18.9
RootTrapper®	87.2	20.4 a	78.7	20.4	81.8 bcd	19.1
SmartPot®	88.1	20.0 a	79.1	20.0	83.4 abc	18.7
Smooth sided	82.1	20.9 a	76.5	19.3	85.8 a	19.2

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 3 trees per container type for #3, 6 trees per container type for #15, and 10 trees per container type for #45 averaged across root pruning treatment.

Table 3. Effect of container type on root ball characteristics of 'Florida Flame' maples finishing out in eight different #45 container types.

Container type	Diameter of 5 largest roots at edge on north side of #45 (mm)	Length of 5 largest roots at edge on north side of #45 (in)	Diameter of 5 largest roots at edge on south side of #45 (mm)
Airpot™	6.03 c[1]	2.87 bc	4.67 b
Cool Ring™	7.83 ab	5.62 a	5.77 ab
Fanntum™	8.19 a	5.78 a	7.03 a
Jackpot™	5.69 c	3.38 bc	5.44 ab
RootBuilder®	6.27 bc	2.36 c	5.62 ab
RootTrapper®	6.85 abc	3.77 b	5.70 ab
SmartPot®	6.35 bc	3.62 bc	6.98 a
Smooth sided	6.42 bc	6.16 a	4.48 b

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 10 trees per container type averaged across root pruning treatment. Root circling appeared more prominent on the north side of most containers regardless of type.

Table 3. Continued

Container type	Length of 5 largest roots at edge on south side of #45 (in)	Diameter 5 largest roots inside[1] #15 (mm)	% 5 largest root on inside[1] #15 that: Descend	Circle
Airpot™	2.92 cd[2]	6.69 bc	20 b	66 abc
Cool Ring™	4.15 bc	10.98 a	54 a	42 cd
Fanntum™	5.44 a	10.73 a	44 a	46 bcd
Jackpot™	3.14 cd	9.52 ab	22 b	55 abc
RootBuilder®	2.78 d	5.65 c	15 b	67 abc
RootTrapper®	4.06 bcd	7.23 bc	24 b	68 ab
SmartPot®	3.10 cd	10.77 a	60 a	30 d
Smooth sided	4.60 ab	6.26 c	15 b	76 a

[1]Measured inside #15 wall, before descending, circling, kinked, or ascending.
[2]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 10 trees per container type averaged across root pruning treatment.

Table 4. Effect of root pruning #3 and #15 root balls when shifting to #15 and #45, respectively, on root ball characteristics of 'Florida Flame' maples averaged over eight different #45 container types.

Root pruning	% trees graded as a cull at #3[1]	% trees graded as a cull at #15[1]	% trunk with circling roots at #3	% trunk with circling roots at #15	% trunk with circling roots at #45
None	95 a[2]	50 a	82 a	48 a	10 b
Shaved	42 b	2 b	41 b	8 b	12 a

[1]Based on Florida Grades and Standards for Nursery Stock.
[2]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 40 trees per treatment averaged across 8 container types.

Table 4. Continued.

Root pruning	Diameter of 5 largest roots at edge on north side of #45 (mm)	Diameter of 5 largest roots at edge on south side of #45 (mm)	Diameter 5 largest roots edge[1] of #15 top 3" of root ball (mm)
None	5.27 b[2]	4.75 b	4.35 b[1]
Shaved	8.14 a	6.67 a	6.00 a

[1]Measured after pruning #45 roots back to #15
[2]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 40 trees per treatment averaged across 8 container types.

Table 4. Continued.

Root pruning	Diameter 5 largest roots inside[1] #15 (mm)	% trees with roots >5mm over flare inside #45
None	10.69 a	90 a
Shaved	6.27 b	38 b

[1]Measured inside #15 wall, before descending, circling, kink or ascending.
[2]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 40 trees per treatment averaged across 8 container types. (Smaller root diameter at the edge of the #15 than at the edge of the #45 container might be because only roots in the top 3" at the #15 position were measured whereas rot along the entire profile were measured in the #45).

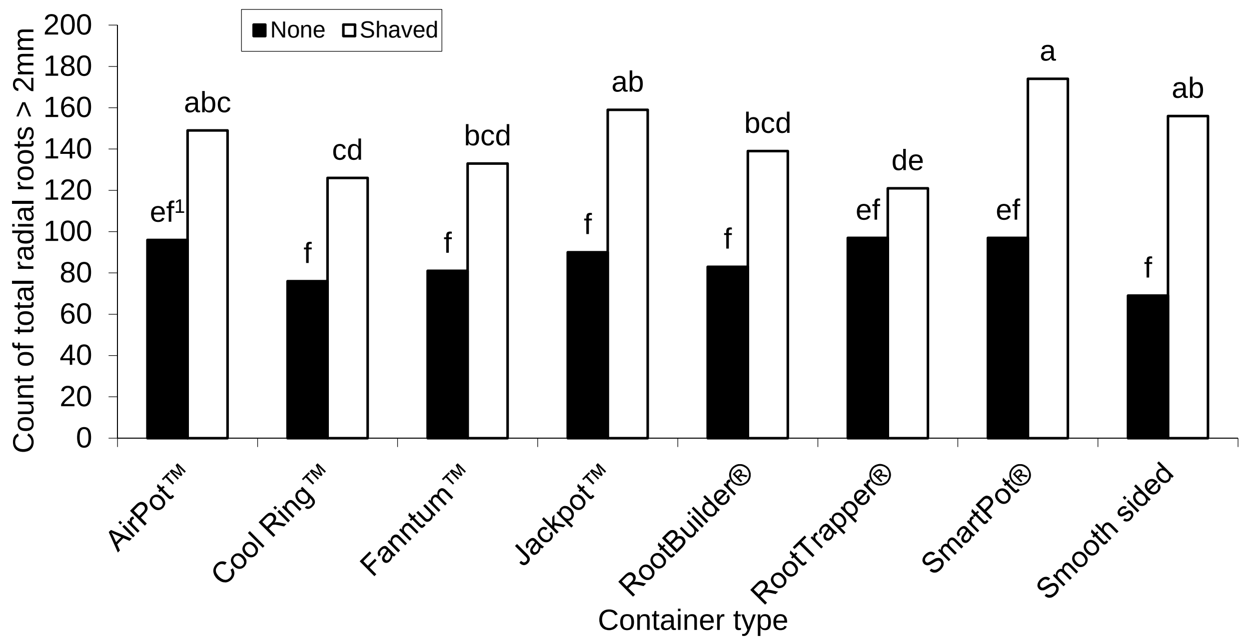


Figure 1. Count of radial roots (roots growing straight away from trunk) > 2mm diameter on trees where root balls were shaved or not in 8 different container types. [1]Bars with a different letter are statistically different at P < 0.05. Based on 5 trees per treatment.

Table 5. Pulling moment to 5 degrees, hinge point, and rest angle of red maple grown in eight different #3 container types prior to planted into the landscape for 26 months, and of liners planted directly into field soil 4 years earlier.

Treatment	Pulling moment to 5 degrees (kNm)	Hinge point[1] (in)	Rest angle (degrees)
Field-grown liners	0.88	7.0 a[2]	1.1
Airpot™	1.05	4.5 b	1.0
Cool Ring™	1.44	4.0 b	0.9
Fanntum™	1.42	4.4 b	1.0
Jackpot™	1.06	4.4 b	0.9
RootBuilder®	1.09	4.8 b	1.2
RootTrapper®	1.27	3.8 b	1.1
SmartPot®	1.25	4.3 b	0.9
Smooth sided	1.21	4.7 b	0.7

[1] Hinge point is distance from trunk to dip in the soil on the pulling side of the tree.
[2] Means in a column with a different letter are statistically different at P < 0.05. Based on 3 trees per container type and 10 trees for field-grown liners.

AirPot™

Florida Cool Ring™

Fanntum™

SmartPot®

Jackpot™

RootBuilder®

RootTrapper®

Smooth sided

One #3 finished red maple root system from each of the 8 container types in the test.

Great Southern Tree Conference: Effect of tree size, mulch and irrigation on 'Florida Flame' maple landscape performance.

Ed Gilman, Maria Paz, Chris Harchick, and Richard Beeson, Environmental Horticulture, and Central Florida REC, University of Florida
December 1 – December 2, 2011
Gainesville, Florida

Objective: Track growth, root characteristics, and stability of 'Florida Flame' maple planted in the landscape from various container sizes under two different irrigation and mulch treatments.

What we did: In February and March 2006, 16 red maples were planted into the landscape from #3, #25, #65 or #300 containers, for a total of 64 trees. Trees were irrigated daily from planting to the beginning of May 2006 (15 gallons per irrigation the first 3 weeks followed by 7 gallons thereafter for #300, 5 gallons for #65 and #25, and 2.5 gallons for #3). All irrigation was applied to the root ball only. This was followed with approximately 2 weeks of no irrigation. Irrigation resumed to every other day at the end of May 2006 with #300 receiving 18 gallons, #65 receiving 9 gallons, #25 receiving 6 gallons and #3 receiving 3 gallons of water each irrigation day. The weather remained dry so an exception to this schedule was made during 3 weeks in June, when irrigation was administered every day. Water was turned off in March 2007. In May 2007, half the trees (8) for each size were irrigated Monday, Wednesday and Friday. The other half of the trees (8) for each size were not irrigated ever again in the study. Also in May 2007 (one year after planting), half of the irrigated trees and half of the non-irrigated trees for each size were mulched up to the trunk with a 3" layer of shredded hardwood, while the other half was kept bare with periodic applications of Roundup. Roundup was also used to keep mulched plots clean of weeds. Trees have not been fertilized since planting. Caliper measurements were collected for all trees in September 2011.

What we found as of November 2011: Mulch and irrigation had a small growth enhancing effect on caliper five years after planting (Table 1 and 2). Trees appeared to grow in trunk caliper at the same rate regardless of initial tree size, with the larger tree sizes retaining greater calipers (Figure 1).

Table 1. Caliper (in) and caliper growth in five years (in) for mulched and non-mulched trees averaged over #3, #25, #65 and #300 container trees.

Mulch	Caliper (in)	Caliper growth in 5 years (in)
Yes	7.43 a[1]	4.02 a
No	6.84 b	3.49 b

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 32 trees per treatment.

Table 2. Caliper (in) and caliper growth in five years (in) for irrigated and non-irrigated trees averaged over #3, #25, #65 and #300 container trees.

Irrigation	Caliper (in)	Caliper growth in 5 years (in)
Yes	7.30 a[1]	3.89
No	6.98 b	3.62

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 32 trees per treatment.

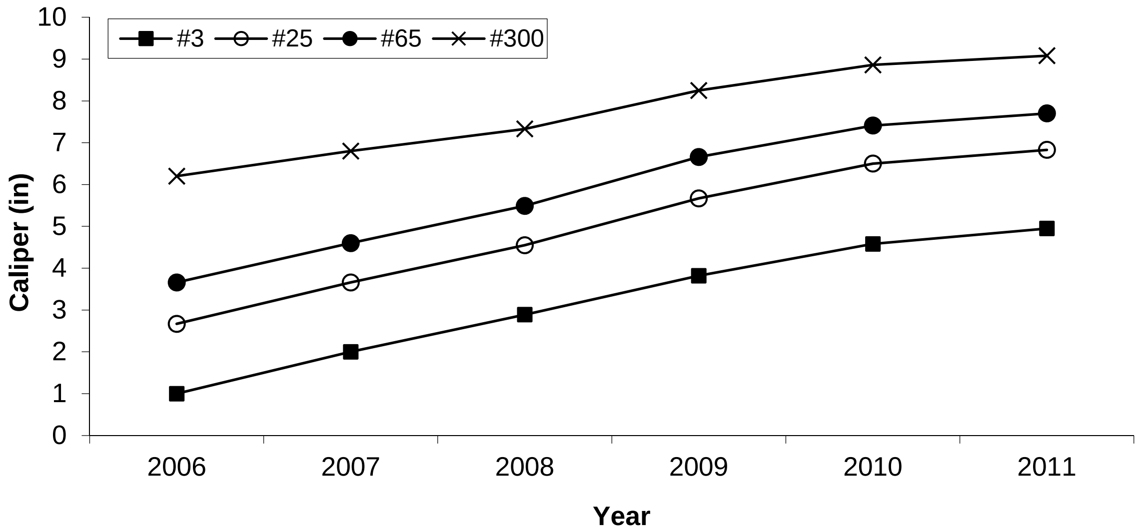


Figure 1. Caliper (in) of ‘Florida Flame’ maples from September 2006 to September 2010 planted from #3, #25, #65 and #300 containers.

Conclusions: Trees planted from small containers are growing at the same rate as trees planted from 300 gallon containers. Mulch placed on and around the root ball one year after planting slightly increased growth in the subsequent 4 years. Irrigation applied to the root ball surface for five years after planting slightly improved growth compared to no irrigation. A quick look (data to be presented next year) at the force (stress) required to pull the trunks to various angles simulating a wind event appears to show that trees planted from smaller containers are better secured to the landscape soil than those planted from larger containers.

Great Southern Tree Conference: Impact of root pruning techniques on root system quality of red maple and live oak in containers and landscape stability.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, Florida

Objective: Demonstrate the effects of removing all roots on the outer one inch of #3 container root balls on top and root growth of red maple and live oak.

What we did: In April 2008, 40 #3 container-grown 'Florida Flame' maples and 40 Cathedral Oak® live oaks were potted into #15 containers. Twenty trees of each species were root pruned by shaving about one inch from the outer root ball and bottom from #3 Airpots before shifting into #15 smooth sided pots. The other twenty trees were potted without disturbing the root balls. Trees were irrigated three times daily and pruned and staked in June 2008. In September 2008, ten maples of each treatment were destructively harvested to dissect the root balls. Root ball data was collected and results included in the 2009 GSTC Report. Twenty trees of each species (10 per treatment) were planted in the field in November 2008 for the maples and January 2009 for the live oaks, to compare tree stability in the landscape resulting from root pruning treatment against no root pruning. When the trees were in containers, north was marked on all trees and the mark was placed either north or south when field planting, to test whether heat from direct sun exposure on the south side of container affects root distribution and tree stability after landscape planting. Trees are being watered three times a week and were fertilized with 200 g of 16-4-8 on March and June 2009, and 400 g of 20-0-8 on March and May 2010, and March and June 2011. Trees were pulled until the trunk base tilted 5 degrees to test stability on August 2009, 2010 and 2011 for the maples, and October 2009, 2010 and 2011 for the live oaks. Moment was calculated as pulling force x distance between ground and pulling point. Tree caliper and height were collected September 2011.

What we found as of November 2011: Tree caliper and heights in #15 containers were not affected by root pruning for either species (2008 GSTC Report). For maples, shaving root balls reduced culls, produced higher quality root balls and a greater number of lateral roots. For live oaks, root ball shaving also improved root ball quality and increased number of roots growing out into the #15 substrate (2009 GSTC Report). Root pruning as trees were shifted from #3 into #15 containers had no effect on caliper and height three years after landscape planting (Table 1). Bending moment required to tilt trunks to 5 degrees one, two and three years after landscape planting was not affected by root pruning (Table 2). Orientation at planting (i.e., the side of the tree facing north planted to the north vs. planting the north side facing south) in the landscape has had no effect on parameters measured (data not shown).

Conclusion: Shaving off root defects from the outer periphery of the root ball when trees were shifted from #3 to #15 containers in the nursery removed root defects without compromising growth or stability three years after planting into the landscape.

Table 1. Caliper and height three years after landscape field planting of 'Florida Flame' maples and Cathedral Oak® live oaks root pruned by shaving the outer inch of the root ball or not root pruning when shifted from #3 to #15 container. #15 containers were planted into landscape without root pruning.

Species	Root Pruning	Caliper[1] (in)	Height[1] (ft)
Maples	No pruning	3.88	18.9
	Root ball shaving	3.78	18.5
Live Oaks	No pruning	3.95	18.2
	Root ball shaving	3.94	18.1

[1] Based on 10 trees per species x root pruning combination (40 trees total). There were no differences among treatments.

Table 2. Trunk bending moment required to pull trees to 5 degree tilt, one, two and three years after planting into the landscape of 'Florida Flame' maples and Cathedral Oak® live oaks root pruned by shaving the outer inch of the root ball or not root pruning when shifted from #3 to #15 container. #15 containers were planted into landscape without root pruning.

Species	Root Pruning	Pulling moment one year after planting[1] (kNm)	Pulling moment two years after planting[1] (kNm)	Pulling moment three years after planting[1] (kNm)
Maples	No pruning	0.37	1.71	2.89
	Root ball shaving	0.33	1.62	2.87
Live Oaks	No pruning	0.21	1.31	3.41
	Root ball shaving	0.22	1.62	3.94

[1] Based on 10 trees per species x root pruning combination (40 trees total). There were no differences among treatments.

Shaving the root ball removes the outer edge and bottom of the root ball as root balls from the #3 containers were shifted into #15 containers.

Shaved root balls are smaller after pruning (right) than before (left).

Great Southern Tree Conference: Root defect removal and mulch effects on landscape performance of elm and maple.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, Florida

Objective: Determine how planting depth in containers, root defect removal when planting, and mulch over root balls affects landscape performance of recently planted elms and maples.

What we did: In February 2008, 40 elms and 40 maples were planted in the landscape from #45 smooth-sided containers raised from cuttings. Cuttings were potted into #3 Airpots either with the top-most root even with the surface or 2.5" deep; then they were shifted to #15 Airpots even with the surface or another 2.5" deep; then they were shifted into smooth-sided #45 containers even with the substrate surface. Before planting into the landscape, ten trees of each planting depth and species (40 trees total) were air spaded to expose the root flare. Roots growing over the root flare were removed to the edge of the root ball. Time required to air spade and remove root defects was recorded for each tree. The other twenty trees of each species were left untouched. Trees were planted into the landscape with the top of the root ball an inch or two above surrounding landscape soil. Mulch 4" deep was applied around the root ball but not over the root ball on half the trees; the other half of the trees were mulched up to the trunk. There are a total of 8 treatments (2 planting depths in containers x 2 root removal treatments x 2 mulch treatments) combinations for each species, with 5 replicate trees for each treatment. All trees are being irrigated three times a week. Trees were fertilized with 400 g of 16-4-8 on March and June of 2008 and 2009, and with 400 g of 20-0-8 on March and May 2010, and March 2011. All trees were staked with the Terra Toggle root ball stabilization system in June 2008, which was removed in June 2009. Trees were pulled until the trunk base tilted 5 degrees to test stability on March 2011. Moment was calculated as pulling force x distance between ground and pulling point. Trees were held for a minute at 5 degrees tilt, and distance from the trunk to dip point on leeward side measured (hinge point). When pull was released, final angle at the trunk base was recorded.
Tree caliper was collected September 2011.

What we found as of November 2011: Trees of both species that were planted deeply in the container took much longer to remove substrate and root defects at planting than trees planted at the appropriate depth in containers (2010 GSTC Report). Elm trunk caliper three growing seasons after landscape planting was not affected by planting depth in the nursery container, root removal treatments or mulch treatment (data not shown). Maple caliper was affected by the interaction of root removal and mulch over the root ball (Table 1). For trees with no mulch placed over the root ball, trees that had root defects removed prior to planting have larger calipers than trees without root pruning at planting (Table 1). This difference in caliper is small (less than half an inch), but it will be interesting to see how trees keep growing. Thus far, the different treatments haven't had an effect of tree stability. Tree bending moment, hinge point, and rest angle were affected by the treatments for elms or maples (data not shown). Trees will be pulled again March 2012 to continue evaluating tree landscape stability.

Conclusion: Keeping mulch off the root ball surface had no detrimental effects on trees in the first 43 months after planting. Mulch placed over the root ball did not improve growth or health on elm or maple trees. Planting trees deeply in the root ball in the nursery makes it very difficult to plant trees correctly into the landscape due to the enormous amount of roots growing over the flare. These must be removed at planting.

Table 1. Effect of root defect removal prior to planting and placement of mulch over the root ball or not on caliper of maples 43 months after planting.

Root defect removal at landscape planting	Mulch over root ball at planting	Caliper 43 months after planting(in)	Caliper growth 43 months after planting (in)
Yes	Yes	5.44	3.38 ab[1]
	No	5.67	3.49 a
No	Yes	5.45	3.42 a
	No	5.11	3.12 b

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 10 trees per treatment combination (40 trees total).

Substrate removed from top of root ball exposed roots so root defects could be removed. Roots that were kinked, circled, diving or crossing roots were removed to the first major roots shown above. This required 12 minutes per tree.

Roots were cut and removed if they circled over the major flare roots. Note the two visible cuts above. Another set of trees was planted without removing root defects (those trees are not pictured here).

Great Southern Tree Conference: Container planting depth, root shaving and landscape planting depth effect on Miss Chloe® magnolia landscape performance

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, Florida

Objective: Determine how planting depth in containers, root ball shaving when planting, and landscape planting depth affects landscape performance of recently planted Miss Chloe® magnolia.

What we did: In September 2008, 48 Miss Chloe® magnolias were planted in the landscape from #45 smooth-sided containers raised from cuttings. Cuttings were potted into #3 Airpots either with the top-most root even with the surface or 2.5” deep; then they were shifted to #15 Airpots even with the surface or another 2.5” deep; then they were shifted into smooth-sided #45 containers even with the substrate surface. When planted into the landscape, half of the trees were either planted 2 inches above the soil surface, or 4 inches below the soil surface. After the trees were set in the ground, half of each of the treatment combinations was either planted with no root shaving, or the root balls were shaved before completely filling the landscape planting hole. Root balls were shaved by edge pruning to remove approximately 2 inches of the outer edge of the entire root ball. There are a total of 16 treatments (4 planting depths in containers x 2 landscape planting depths x 2 root shaving treatments) combinations, with 3 replicate trees for each treatment. Trees were mulched immediately after planting with mulch to the trunk. Trees that were planted high were mulched with 2 inches of mulch on the root ball and 4 inches outside the ball, while those planted deep, had 4 inches of mulch over ball and outside the ball. All trees are being irrigated once a day. Trees were fertilized with 400 g of 16-4-8 on November 2008, and March and June of 2009, and with 400 g of 20-0-8 on March and May 2010, and March and June 2011. Radius of the root system was measured by gentle excavation on May and November 2009 and compared to tree canopy radius to determine root to shoot ratio. Caliper and height were collected September 2011.

What we found as of November 2011: Planting depth into the nursery container had no impact on any measurements (data not shown). Only landscape planting depth had an effect on root system radius and root to shoot ratio of magnolias (Table 1). Eight months after planting, roots of magnolias that were planted high in the landscape extended farther into the landscape than those planted deeply, thus the root to shoot ratio was higher. But 14 months after planting, the difference was no longer significant (Table 1). About one year after landscape planting, magnolia roots had extended past the tree canopy (root to shoot ratio November 2009).

Landscape planting depth had a negligibly effect on trunk growth and height growth in the three years after planting (Table 2). Root ball shaving that removed roots from the periphery of the root ball at planting statistically decreased the growth in trunk caliper (0.04 inches annually) and height (2.5 inches annually) of the trees, but the difference is probably a little practical importance (Table 3). Trees will be pulled in the future to determine the effect of planting depth and root ball shaving on magnolia tree stability in the landscape, and root systems will be mapped to evaluate the impact of planting depth and shaving on root morphology.

Conclusion: Root ball shaving to reduce root defects when planting #45 containers into the landscape did not impact root system expansion into landscape soil, but it slightly reduced top growth of Magnolia the first 3 years after planting. Planting deeply into the landscape appears to slow establishment rate slightly in the first few months after planting in this well-drained soil, but then trees grew similarly regardless of landscape planting depth. Planting depth into nursery containers had no impact on growth after planting into the landscape. Results may have been different in a soil than drains poorly, or for a different species of tree.

Table 1. Effect of landscape planting depth on root radius and root to shoot ratio of Miss Chloe® magnolias in May and November 2009.

Landscape planting depth	Root radius May 09 (in)	Root:Shoot ratio[1] May 09	Root radius Nov 09 (in)	Root:Shoot ratio[1] Nov 09
2 inches high	30.1 a[2]	0.71 a	48.6	1.09
4 inches deep	23.3 b	0.56 b	45.1	1.03

[1]Root:shoot ratio of 1 means the longest root has reached the dripline.
[2]Means in a column with a different letter are statistically different at P < 0.05. Based on 24 trees per treatment averaged across root pruning at planting and planting depth in containers.

Table 2. Effect of landscape planting depth on caliper and height of Miss Chloe® magnolias three years after planting

Landscape planting depth	Caliper (in)	Caliper growth in 3 years (in)	Height (ft)	Height growth in 3 years (ft)
2 inches high	4.59 a[1]	1.73	18.0	6.4
4 inches deep	4.27 b	1.66	17.8	7.2

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 24 trees per treatment averaged across root pruning at planting and planting depth in containers.

Table 3. Effect of root shaving treatment on caliper and height of Miss Chloe® magnolias three years after planting

Root shaving	Caliper (in)	Caliper growth in 3 years (in)	Height (ft)	Height growth in 3 years(ft)
Yes	4.39	1.63 b[1]	17.6	6.6 b
No	4.47	1.76 a	18.2	7.4 a

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 24 trees per treatment averaged across root pruning at planting and planting depth in containers.

Shaving the root ball at planting reduced root defects without any negative impacts on survival, health, or growth the first two years after landscape planting.

Great Southern Tree Conference: Impact of length in nursery containers on Miss Chloe® magnolia, 'Florida Flame' maple and Allée® elm quality.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, Florida

Objective: Demonstrate the impact of the time magnolias, maples and elms are left in #3 and #15 containers in the nursery on subsequent root quality on finished trees in #45 containers and field performance.

What we did and will do: In February 2007, eighty liners of each species (Miss Chloe® magnolia, 'Florida Flame' maple and Allée® elm) were potted into #3 black nursery containers. Thirty two (32) elms died from freezing damage and subsequent water stress. Twenty magnolia and maples, and twelve elms were: (1) potted June 2007 into #15 after 4 months in #3, and then potted Feb 2008 into #45 after 8 months in #15; or (2) potted Sept 2007 into #15 after 7 months in #3, and then potted July 2008 into #45 after 10 months in #15; or (3) potted Nov 2007 into #15 after 9 months in #3, and then potted Nov 2008 into #45s after 12 months in #15; or (4) potted Feb 2008 into #15 after 12 months in #3, and then potted April 2009 into #45 after 6 months in #15. Trees were finished in #45 containers in October 2009, when 5 trees of each treatment were harvested and root balls dissected for data collection. Root balls were not pruned when shifted to a larger container and were planted even with the substrate in the larger container.

In May 2010, the remaining trees were planted in the landscape. Twenty elms were planted into the landscape with root balls undisturbed and planted even with the landscape soil. For the magnolias and maples, the root balls of half of the trees for each species were either: 1) left intact; or 2) after placing in the planting hole, the balls were shaved with a balling shovel to remove approximately 2 inches of the outer periphery of the entire root ball. All trees were planted even with the landscape soil. All trees are being irrigated every other day (three times a day on these days). Trees were fertilized with 800 g of 20-0-8 in June 2010, and 400 g of 20-0-8 in March and June 2011. Caliper and height for all trees were collected September 2011. Water stress was measured March 25 and April 26, 2011. Trees were pulled until the trunk base tilted 5 degrees to test stability in November 2010. Moment was calculated as pulling force x distance between ground and pulling point. Trees were held for a minute at 5 degrees tilt, and distance from the trunk to dip point on leeward side measured (hinge point). When pull was released, final angle at the trunk base was recorded.

What we found as of November 2011: Caliper and height growth on elms and magnolias planted into the landscape was not affected by time spent in either size nursery container (Table 1). However, maples that spent less time in #3 and #15 and more time in #45 had smaller calipers when compared to those that spent similar times in these sizes, but all are increasing in caliper at a comparable rate (Table 1). Maple height growth 16 months after landscape planting was least for trees that spend the most time in #3 and the least time in #45 containers (Table 1). Caliper and height growth on maples and elms was not affected by root pruning at landscape planting (data not shown). Caliper of root pruned magnolia trees was smaller 16 months after planting; however, caliper growth rate after planting was not impacted indicating a negligible impact from root pruning (Table 2). Magnolia height was not affected by root pruning at the time of landscape planting (Table 2).

The length of time magnolia and elms spent in the various container sizes did not impact stability (anchorage), hinge point, or rest angle immediately following pulling the trunk to 5 degrees. Maples that spent the least time in the #3 and #15 and the most time in the #45 containers required less moment to pull them to 5 degrees tilt when compared to the other retention times, and also has a greater resting angle after pulling to 5 degrees trunk tilt (Table 3). This indicates that maples that spent more time in #45 were less stable in the landscape than those that spent less time in #45. This project is ongoing, and trees will be pulled again to evaluate landscape stability or anchorage. It should be interesting to see how stability is affected as trees become more established in the landscape.

Conclusions: Pruning roots at planting to remove defects had little impact on water stress, growth, or lateral stability in the first 16 months after planting into the landscape for all three tree species tested. Maples retained in #45 size containers for the longest time period were less stable 16 months after planting into the landscape than maples retained for a shorter time period in #45 containers. However, stability for the other two species tested was not impacted by retention time in the various container sizes.

Table 1. Caliper and height of elms, maples and magnolias grown for different time periods in #3, #15, and #45 containers, 16 months after planting into landscape field soil (May 2010).

Treatment (retention time in containers)	Caliper (in)	Caliper growth in 16 months (in)	Height (ft)	Height growth in 16 months (ft)
Elms				
4 mo #3; 8 mo #15; 20 mo #45	3.66	0.61	18.5	3.3
7 mo #3; 10 mo #15; 15 mo #45	3.60	0.51	17.8	3.4
9 mo #3; 12 mo #15; 11 mo #45	3.51	0.55	19.1	3.1
12 mo #3; 14 mo #15; 6 mo #45	3.56	0.65	19.3	3.9
Maples				
4 mo #3; 8 mo #15; 20 mo #45	3.71 b[1]	0.60	18.7	2.3 ab
7 mo #3; 10 mo #15; 15 mo #45	4.24 a	0.73	19.3	2.5 ab
9 mo #3; 12 mo #15; 11 mo #45	4.16 a	0.77	19.4	3.5 a
12 mo #3; 14 mo #15; 6 mo #45	3.99 ab	0.62	18.4	1.9 b
Magnolias				
4 mo #3; 8 mo #15; 20 mo #45	3.41	0.53	15.2	2.6
7 mo #3; 10 mo #15; 15 mo #45	3.38	0.56	15.0	2.8
9 mo #3; 12 mo #15; 11 mo #45	3.30	0.49	14.5	2.2
12 mo #3; 14 mo #15; 6 mo #45	3.59	0.71	14.6	2.6

[1]Means in a column within species with a different letter are statistically different at $P < 0.05$. Based on 10 trees per treatment for magnolia and maple averaged across root pruning, and 5 trees per treatment for elm.

Table 2. Caliper and height 16 months after planting into landscape field soils (May 2010) of magnolias that were root pruned at planting or not.

Root pruning	Caliper (in)	Caliper growth in 16 months (in)	Height (ft)	Height growth in 16 months (ft)
Yes	3.29 b[1]	0.53	14.6	2.4
No	3.55 a	0.62	15.1	2.7

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 20 trees per treatment averaged across time in pot.

Table 3. Pulling moment to 5 degrees, hinge point and rest angle of maples (elm and magnolia were not affected) grown for different time periods in #3, #15, and #45 containers pulled to 5 degrees 18 months after planting into the landscape.

Treatment	Pulling moment to 5 degrees (kNm)	Hinge point[1] (in)	Rest angle (degrees)
4 mo #3; 8 mo #15; 20 mo #45	1.18 b[2]	7.3	1.11 a
7 mo #3; 10 mo #15; 15 mo #45	1.77 a	7.7	0.86 b
9 mo #3; 12 mo #15; 11 mo #45	1.67 a	7.5	0.91 b
12 mo #3; 14 mo #15; 6 mo #45	1.54 a	8.2	0.98 ab

[1] Hinge point is distance from trunk to dip in the soil on the pulling side of the tree.
[2] Means in a column within species with a different letter are statistically different at $P < 0.05$. Based on 10 trees per treatment averaged across root pruning.

Great Southern Tree Conference: Propagation tray type and time in tray affects root development of red maple

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, Florida

Objective: Determine impact of propagation tray type and time in tray on root development of red maple.

What we did and will do: In August 2008, red maple cuttings were stuck in six different propagation tray types: smooth, Elle pot to pot, Elle spaced, Elle in a smooth liner tray, Accelerator, or RootMaker®. Cuttings were held at the greenhouse for either 2 (Oct 2008) or 6 (Feb 2009) months. After each of these time periods, ten liners of each propagation tray treatment were destructively harvested and root balls (roots > 2 mm diameter) characterized. Another 140 liners for each tray type were potted into smooth sided #3 containers. Root balls shifted to #3s October 2008 were left intact; whereas those shifted February 2009, half of the root balls were left intact and the other half were shaved with a sharp scissor. Five trees of each treatment were destructively harvested to characterize root balls after 10 months of growing in the #3 containers. At the same time, thirty trees of each treatment were planted into field soil and thirty were planted into #15 smooth sided containers. Half of the trees planted in field soil were left untouched and for the other half, the root balls were shaved at planting. Field and container trees are being irrigated every day and were fertilized with 65 g of 20-08 on April 2010 and with 100 g of 20-0-8 on June 2010.

What we have found as of November 2011: Cuttings propagated in Elle Spaced and Elle in smooth had the greatest number of roots in the top half of the root ball, while Accelerators had the greatest number of roots in the bottom half of the root ball and the least in the top half (Table 1). Smooth sided propagation trays produced the largest root diameters in cuttings, which was only comparable to the number produced in Accelerator and RootMaker® (Table 1). All other propagation tray types had smaller average root diameters. Smooth sided propagation trays also had the greatest number of roots deflected down, and Ellepot-to-pot had the least. Ellepot-to-pot and Ellepot spaced had the least amount of circling roots (Table 1). Holding cuttings in propagation trays longer increased root diameter and roots deflected by the edge of the trays (Table 2).

Red maples propagated in smooth sided trays and in Elle in smooth tray had the most visible liner imprint when harvested from #3 containers (Table 3). These two propagation tray types also increased the number of roots deflected by liner sides and increased root depth after growing in #3 for 10 months (Table 3). Ellepot to pot and Ellepot spaced trays produced straighter roots in #3 containers (Table 3). Holding cuttings in propagation trays longer before shifting to #3 containers increased root diameter and length, and produced more straight root length in the #3 containers possibly due to an increase in new roots generated close to the top of the propagation tray root ball (Table 4). Root pruning prior to potting up into #3 containers improved tree quality and produced straighter roots in the finished #3 containers (Table 5). Other studies showed that trees with straighter roots are more stable after planting into the landscape. Tree calipers and heights on finished #3 trees were not affected by propagation tray type or root pruning prior to potting up into #15 (data not shown).

Tray type had an effect on height of trees growing in #15 containers (Table 6), but had no effect on caliper. Tree that grew in the Elle in smooth tray were the shortest trees and are growing in height the slowest (Table 6). Tray type had no effect on caliper or height of field-grown trees (data not shown). Time in propagation tray had an effect on caliper and height of both field and container-grown red maples (Table 7). Trees that spent only 2 months in trays were the tallest and largest in caliper (Table 7).

Pruning prior to either field or container planting had an effect on growth for both field and #15 container-grown trees (Table 8). In the case of field-grown trees, only caliper growth was affected, with shaved trees increasing in caliper more so that none-shaved trees (Table 8). The opposite occurred in #15 container-grown trees; trees that were not shaved grew taller than those that were shaved (Table 8).

Conclusions: Elle in an open tray either spaced apart or pot-to-pot produced root balls with the least amount of deflected roots without root pruning. Shaving liners from any tray type resulted in high-quality root systems without impacting growth rates.

Table 1. Propagation tray type effect on red maple root counts and diameter.

Tray type	# of roots top half of root ball	#of roots bottom half of root ball	Diameter of largest roots (mm)	# roots deflected around edge (circling roots)	# of roots deflected down
Smooth	10.9 bc[1]	14.7 c	1.9 a	4.6 ab	20.9 a
Elle pot to pot	9.2 c	14.5 c	1.5 b	0.05 c	0.5 d
Elle spaced	14.1 a	17.2 b	1.6 b	0.4 c	1.1 d
Elle in smooth	14.1 a	15.7 bc	1.5 b	6.8 a	13.1 c
Accelerator	10.2 c	21.0 a	1.8 ab	2.1 bc	17.0 b
RootMaker®	11.5 b	15.6 bc	1.7 ab	7.3 a	11.4 c

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 20 trees per treatment averaged across time in propagation tray.

Table 2. Time in propagation tray effect on roots of red maple cuttings harvested from propagation trays.

Time in propagation tray	Diameter of largest roots (mm)	# roots deflected around edge
2 months	1.43 b[1]	2.0 b
6 months	1.87 a	5.3 a

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 60 trees per treatment averaged across propagation trays.

Table 3. Effect of propagation tray type on root characteristics of red maples 10 months after shifting to #3 containers.

Tray type	Original liner visible (1-5)[1]	# roots deflected by liner sides > 2mm	Depth of roots 2.5 cm inside #3 wall (mm)	Diameter of roots 2.5 cm inside #3 container wall (mm)	Angle from horizontal of 5 largest roots
Smooth	4.9 a[2]	10.8 a	98.3 a	2.5 a	79.0 a
Elle pot to pot	1.6 c	2.3 d	75.1 bc	2.4 a	47.7 b
Elle spaced	2.9 b	4.5 c	71.3 c	1.9 b	45.5 b
Elle in smooth	4.6 a	11.1 a	92.6 a	2.2 ab	73.8 a
Accelerator	3.6 ab	7.3 b	89.9 ab	2.2 ab	67.1 a
RootMaker®	3.8 ab	8.1 b	85.8 abc	2.4 a	66.6 a

[1]1= Not visible; 5=Very visible.
[2]Means in a column with a different letter are statistically different at P < 0.05. Based on 62 trees per treatment.

Table 4. Red maple root characteristics in #3 containers from propagating cuttings held 2 or 6 months in six different propagation tray types

Time in propagation tray	Diameter of 5 largest roots at trunk (mm)	Angle from horizontal of 5 largest roots	Average length of straight roots (mm)
2 months	5.4 b[1]	67.5 a	70.0 b
6 months	7.1 a	57.8 b	93.7 a

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 30 trees per treatment averaged across tray types.

Table 5. Red maple root characteristics on trees in #3 containers when liners were either pruned or not before shifting into #3 containers ten months earlier.

Pruning	% trunk circled by roots > 2mm	% Culls	Original liner visible (1-5) [1]	# roots deflected by liner sides > 2mm	Angle from horizontal of 5 largest roots
Yes	1.2 b[2]	0 b	1.4 b	1.9 b	42.1 b
No	21.5 a	23 a	3.7 a	7.3 a	57.8 a

[1]1= Not visible; 5=Very visible.
[2]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 60 trees per treatment averaged across tray types.

Table 6. Caliper and height of #15 container-grown red maple shifted from six different propagation tray types, with no root pruning prior to planting into #3.

Tray type	Caliper (in)	Caliper increase in one year (in)	Height (ft)	Height increase in one year (ft)
Smooth	1.79	0.60	14.2 a[1]	5.7 a
Elle pot to pot	1.74	0.59	14.3 a	5.8 a
Elle spaced	1.78	0.60	14.0 a	5.5 a
Elle in smooth	1.83	0.62	13.1 b	4.7 b
Accelerator	1.78	0.60	14.7 a	5.9 a
RootMaker®	1.82	0.60	14.2 a	5.7 a

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 30 trees per treatment averaged across time in tray and root pruning as trees were shifted into #15.

Table 7. Caliper and height of field and #15 container-grown red maple held 2 or 6 months prior to shifting to #3 containers, then held in #3s 10 months prior to planting into either the field or into #15 containers.

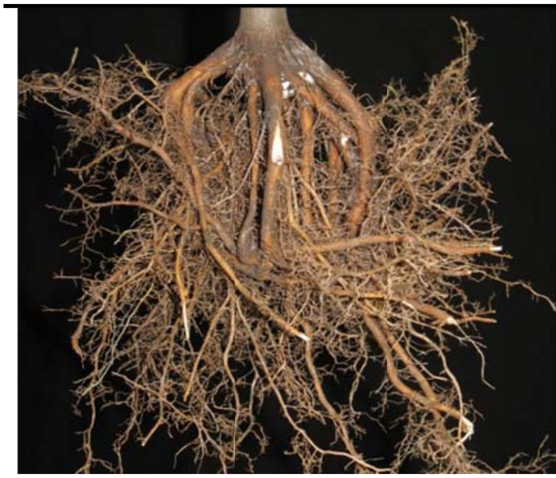
Time in propagation tray	Caliper (in)	Caliper increase in one year (in)	Height (ft)	Height increase in one year (ft)
		Field-grown		
2 months	1.88 a[1]	0.62	12.4 a	4.2 a
6 months	1.55 b	0.61	10.7 b	3.7 b
		#15 container-grown		
2 months	1.84 a	0.64 a	14.4 a	5.7
6 months	1.73 b	0.56 b	13.7 b	5.4

[1]Means in a column within each group with a different letter are statistically different at $P < 0.05$. Based on 60 trees per treatment averaged across tray types for field-grown trees, and 70 for container-grown trees.

Table 8. Caliper and height of field and #15 container-grown red maple held for 6 months in six different propagation tray types and shaved or not before planting into #3 and #15 containers.

Pruning prior to planting	Caliper (in)	Caliper increase in one year (in)	Height (ft)	Height increase in one year (ft)
		Field-grown		
None	1.52	0.59 b[1]	10.6	3.6
Shaved	1.58	0.65 a	10.7	3.8
		Container-grown		
None	1.78 a	0.59 a	14.0 a	5.6
Shaved	1.67 b	0.55 b	13.4 b	5.4

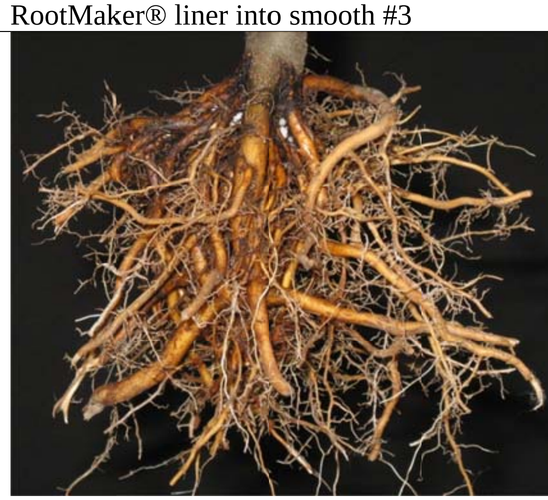
[1]Means in a column within each group with a different letter are statistically different at P < 0.05. Based on 60 trees per treatment averaged across tray types for field-grown trees, and 70 for container-grown trees.



Smooth liner into smooth #3

RootMaker® liner into smooth #3

Elle pot to pot liner into smooth #3



Accelerator liner into smooth #3

Great Southern Tree Conference: Imposed tree form impacts red maple (*Acer rubrum* L. 'Florida Flame') natural frequency and damping

Jason W. Miesbauer and Ed Gilman, Environmental Horticulture, University of Florida
December 1 – 2, 2011
Gainesville, Florida

Objective: Determine how trees of different growth habits react to simulated storm loading events.

What we did: A pull-and-release test was designed to measure the impact of tree architecture on how trees react to dynamic forces such as wind. Sixteen red maple (*Acer rubrum* 'Florida Flame') trees with an approximate caliper of 3 inches were planted from 45 gallon plastic containers at an approximate spacing of 20 ft in April 2008 and irrigated regularly. In July 2009, 8 trees were structurally pruned with 15 to 20 reduction cuts between 0.5-1.5 inches diameter to reduce occurrence of upright branches. As a result, trees developed a dominant main trunk and main branches were primarily horizontally oriented (excurrent) (Figure 1a). The other 8 trees were pruned primarily with removal cuts of lateral branches that were more or less horizontal oriented to encourage growth of many upright stems that originate low in the canopy and compete for dominance (decurrent), as is so common in most landscapes (Figure 1b).

The first pull-and-release test was performed summer 2010. Two strain gauges were attached to the tree trunks at an approximate height of 39 inches. One strain gauge was positioned in line with pull direction and the other was oriented 90 degrees to pull direction. Two devices that measure displacement (string pots) were secured to 4 x 4 inch posts, one of which was oriented in line with pull direction, and the other at 90 degrees from pull direction. A cable tie was attached to the trunk of tree near the base of the canopy. String pot cables were connected to the cable tie with a snap connector. A quick release mechanism was attached to the tree immediately below the lowest branch of the canopy. The release mechanism was attached to a 0.5-in diameter, low-stretch rope. The rope was passed through a pulley, which was attached to a tractor bucket with a carabineer. Static weights, with a total mass of 220 lbs were attached to the rope. The tractor was positioned so the bucket was approximately 50 ft from the tree at a compass reading of 45 degrees from north. The tractor bucket was raised until the weights were lifted approximately 1 ft off the ground, causing the tree to deflect under tension. The release mechanism was triggered, allowing the tree to sway at its natural frequency until it came to rest. The process was repeated with the pull point at ¼ of the canopy height and again with the pull point at ½ canopy height. The tractor was repositioned to a compass reading of 315 degrees from north, which was orthogonal (90 degrees) to the first position. Pull and release tests were repeated as above. Tests were conducted in orthogonal directions to test for differences in crown geometry and architecture.

Immediately after pulling in summer 2010, trees were then pruned in a manner consistent with the first pruning that occurred in July 2009. Excurrent trees were structurally pruned, where branches that were growing upright were pruned back to lateral branches that had a more horizontal orientation. For decurrent trees, branches that were growing with a horizontal orientation were pruned back to lateral branches with an upright orientation (Figure 1). Pull-and-release tests were repeated as above. There were a total of 12 pull-and-release tests per tree.

A second round of pull-and-release tests were conducted in winter 2011, when trees were in a leafless condition. Tests were tested as above with one exception. Trees were not pruned and retested in the winter. Therefore, a total of 6 pull-and-release tests were performed per tree in winter. The third round of pull-and-release tests were conducted in summer 2011. Tests were performed as described for the summer 2010 tests.

A fourth round of tests is scheduled to be performed in winter 2012. When completed, we will have data for trees in the 'in-leaf' and 'leafless' condition over a 2-year period. This will allow us to determine how tree form impacts tree motion when different types of pruning are applied.

What we found as of November 2011: We have completed 3 of the 4 scheduled pull-and-release tests. The final test will be performed winter 2012. Upon completion of the final test, data will be analyzed to determine if tree form, based on pruning treatments, impacts damping characteristics over a period of 2 ½ years. Data analysis of tree damping characteristics for the first 3 rounds of pull-and-release tests is ongoing (Figure 2). If we find that trees pruned to reduce occurrence of upright branches have different damping attributes than trees pruned in other manners, this could provide a beginning to an entirely new area of discovery in tree biomechanics. Furthermore, this information can be used to train arborists how to prune trees to reduce likelihood and severity of trees being damaged during storms.

Figure 1. a) Tree pruned to have a dominant central leader with horizontal lateral branches (excurrent), or **b)** to have many large, upright branches competing for dominance in the canopy (decurrent), typical of many trees in the urban landscape.

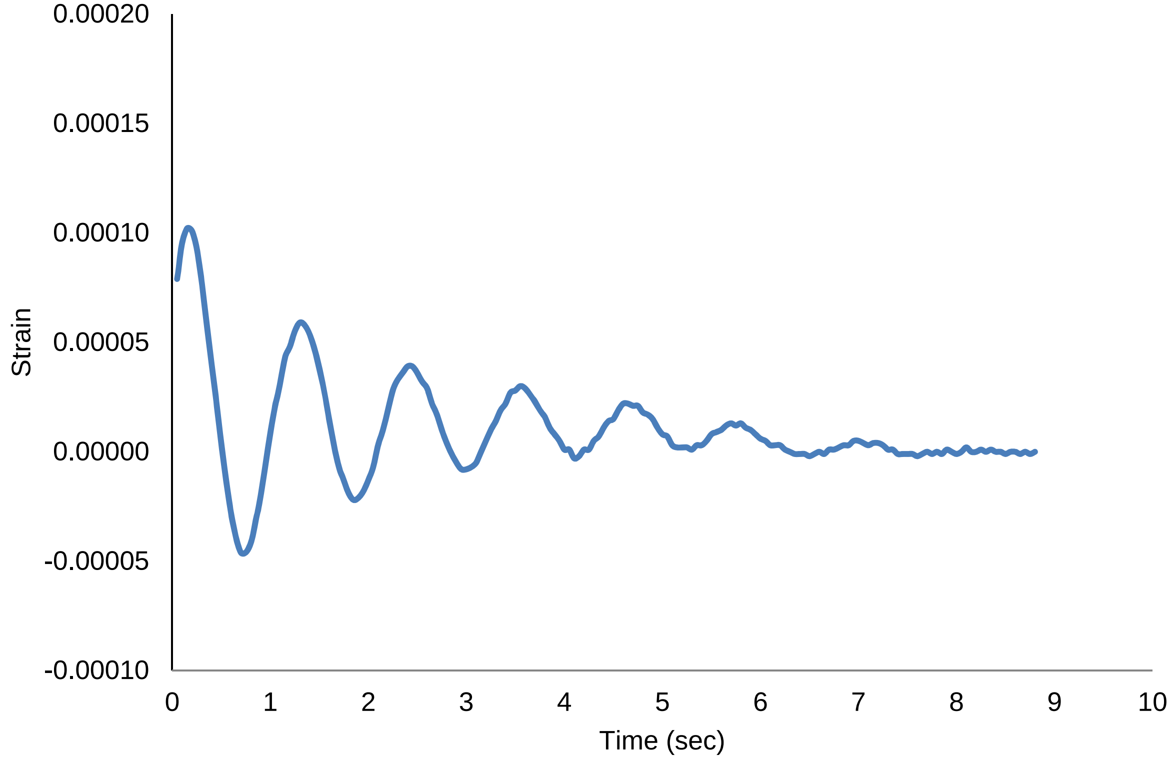


Figure 2. Amount of strain on the trunk decreased due to damping properties of the tree. The plot of strain is typical in shape for most trees. Pruning in certain manners may enhance damping resulting in less damage in wind storms.

Great Southern Tree Conference: Decay and root regeneration of large severed live oak roots.

Ed Gilman, Chris Harchick and Maria Paz, Environmental Horticulture, University of Florida
December 1 – December 2, 2011
Gainesville, Florida

Objective: Determine the impact of cut root diameter on new root generation potential and decay of established trees.

What we did: Roots from 1 to 6 inches in diameter were severed October 2006 on live oaks with trunks averaging 30” dbh. In January and February 2011, all 100 cut roots on the ten trees were excavated and harvested to measure root regeneration and root decay on cut roots. At time of harvest, the diameter of the original cut root was measured, as well as location(s) and size of callus and wound wood. The number of new roots from cuts was counted and diameter measured. The original cut roots were then split, through the anatomical center along the rays, to measure extent and area of decay. The relationship between the cut diameter and root regeneration and decay was determined.

What we have found as of November 2011: Number and diameter of new roots generated from the root pruning cut was not affected by the diameter of the cut root, but cross sectional area of new roots was affected (Table 1). The diameter of the cut root had an effect on total cross sectional area of new roots, callus and wound wood formed, as well as the area of decay inside the root (Table 1 and Figure 1, 2 and 3). The larger the diameter of the cut root, the greater the total cross sectional area of new roots, callus, woundwood and area of decay, which is expressed by a significant positive Pearson’s correlation as well as a positive regression coefficient (Table 1 and Figure 1, 2 and 3).

Table 1. Effect of diameter of severed root on new root generation and root decay**.**

Attribute	**Pearson correlation coefficient**[1]	**P-Value**
Number of new roots from cut	0.17885	0.1221
Diameter of new roots from cut	0.13168	0.2568
Total cross sectional area new roots	0.30536	0.0077
Average callus size per root	0.41592	0.0002
Total callus size per root	0.41592	0.0002
Average wound wood size per root	0.46588	<0.0001
Total wound wood size per root	0.46588	<0.0001
Total callus and wound wood size per root	0.72234	<0.0001
Area of decay inside root	0.80312	<0.0001

[1]A higher number means a greater relationship, with the highest possible number being 1.

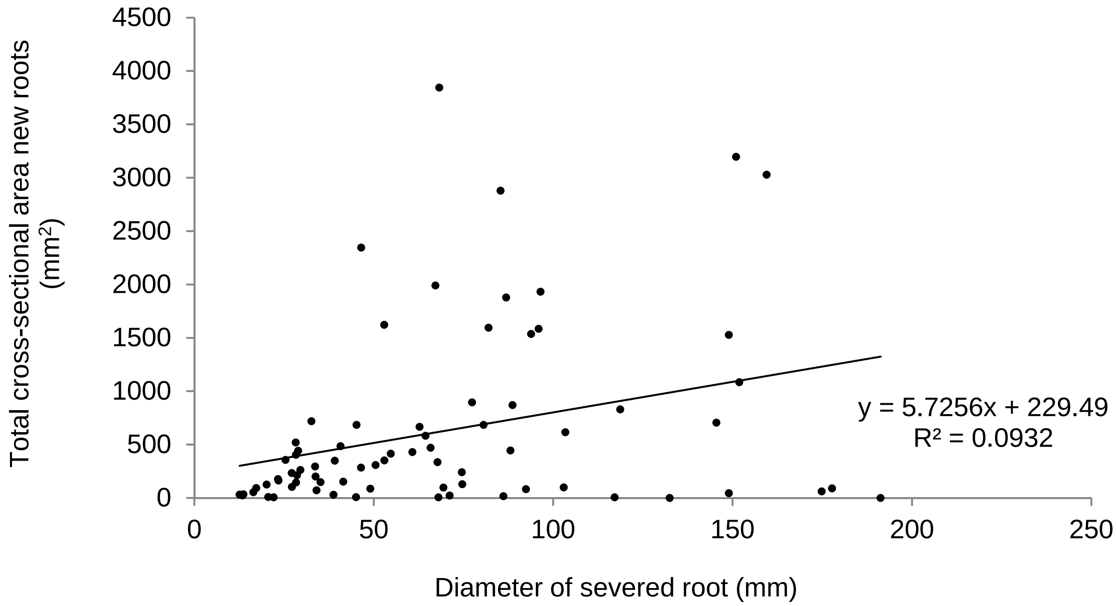


Figure 1. Relationship of diameter of severed root to total cross-sectional area of new roots (P=0.0077)

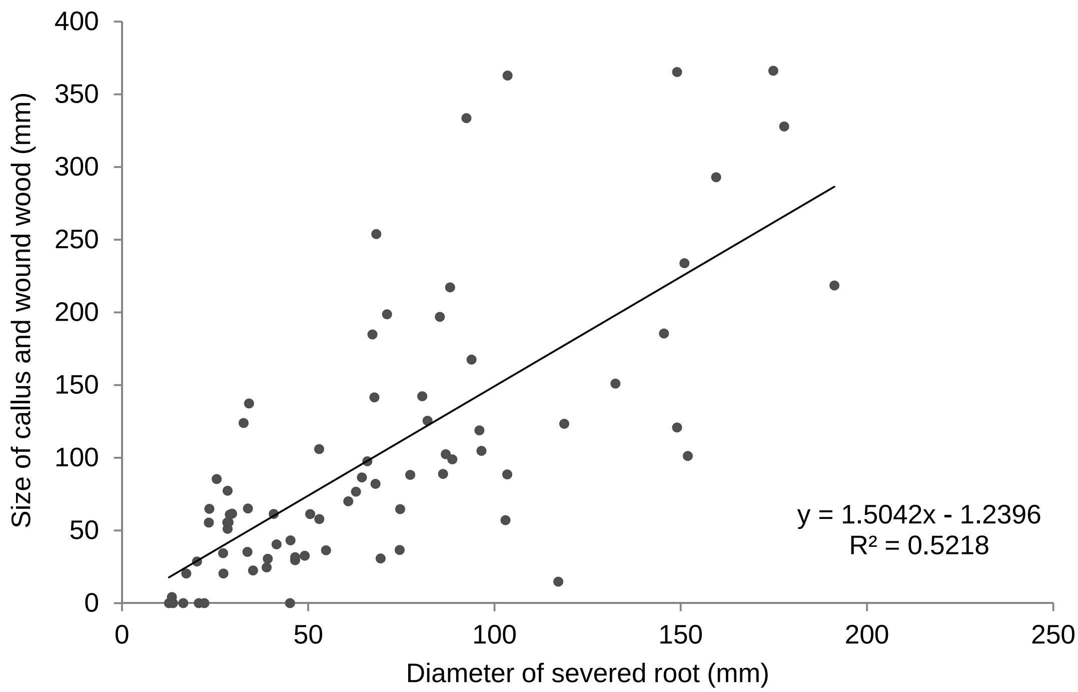


Figure 2. Relationship of diameter of severed root to size of callus and wound wood produced (P < 0.0001)

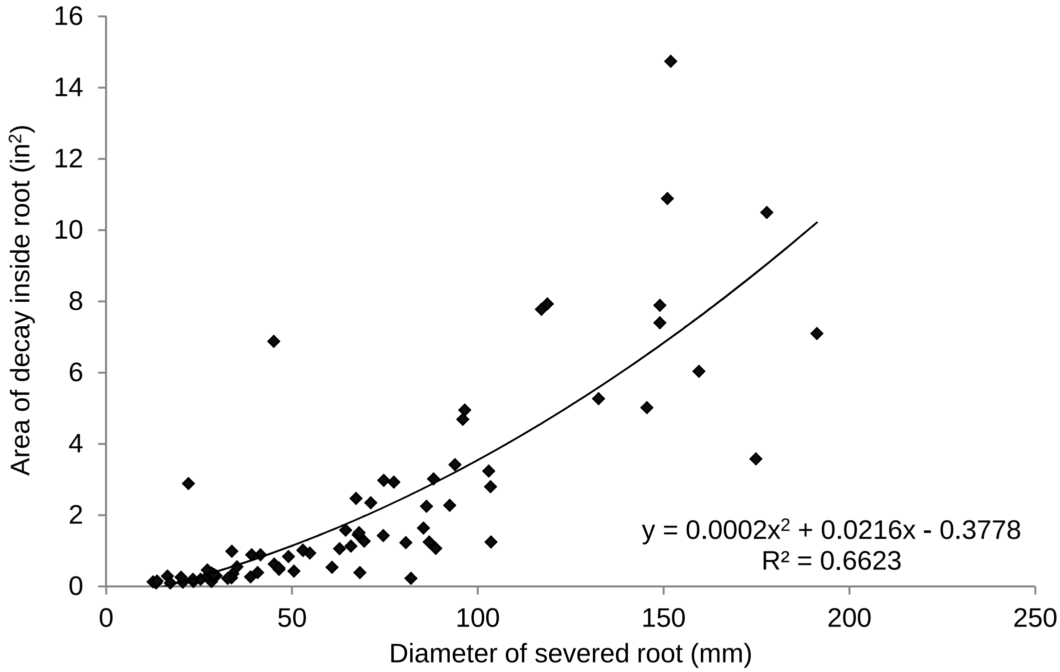


Figure 3. Relationship of diameter of severed root to size of callus and area of decay produced inside root ($P < 0.0001$).

Great Southern Tree Conference: Urban tree survival and performance

Ed Gilman, Chris Harchick, Maria Paz, Environmental Horticulture, University of Florida, and
Charlie Marcus, Florida Forest Service, Tallahassee, FL
December 1 – December 2, 2011
Gainesville, Florida

Objective: Evaluate the survival of installed urban trees and identify conditions that contributed to enhanced or reduced survival.

Acknowledgement: Thanks for the Florida Forest Service for funding this study

What we did: Records for Florida Forest Service urban forestry tree planting grants were collected for site visits and tree measurements. These records include information on planting date, size of trees planted, number of trees planted, and quality of trees planted. Only projects that included trees planted at least one year prior and with a map with the location of trees were selected. Project selected were visited from July to August 2010. Data was collected for twenty six projects located in 17 counties and 24 cities or towns in Florida (Table 1). Species measured were live oak, baldcypress and southern magnolia. Data collected included: number of trees alive, tree caliper, soil compaction, tree quality, site type and whether there was an installed irrigation system. Survival rate was reported as living trees at the time of the survey ÷ number of trees originally planted × 100. Trees with at least some foliage were considered living. To evaluate soil compaction, mulch was removed from a small soil section twelve inches beyond the periphery of the original root ball in the north and south directions. The highest reading on a soil penetrometer (soil compaction tester, model 15585as1, DICKEY-john® Corp, Auburn, IL) with the 0.75 inch diameter tip as it was inserted six inches below soil surface was recorded around each tree. A total of 1197 live oaks, 240 baldcypress and 154 southern magnolia were measured.

What we have found as of November 2011: Live oaks planted in sites with installed irrigation grew the most trunk caliper, had less dieback, and a better tree condition than sites with no irrigation. However, installed irrigation had no effect on survival rate when compared to those with no irrigation system installed (Table 2). For baldcypress, an installed irrigation system increased projected survival rate in 10 years and reduced shoot dieback, but had no effect on current survival rate, growth or tree condition (Table 2). Southern magnolia saw the most improvement with an installed irrigation system, with increased survival rates, higher growth rates, improved tree condition, and decreased dieback (Table 2).

The highest soil compaction was recorded for highway medians, followed by parking lot, and the lowest compaction was recorded for street, open lawn and the park sites (Table 3). Live oaks planted in the more compacted highway median grew the least in caliper; whereas, trees grew best in open lawn, park and parking lots (Table 3). The same was observed for southern magnolias in this study, which had the least growth in the most restricted site (Table 3). Baldcypress growth was not impacted by site type (Table 3). Site type had no effect on survival rate of like oak, but it did affect survival rate in baldcypress and southern magnolia (Table 3). Highway median, the most compacted site type, had the lowest survival rates for baldcypress. This low survival rate was probably in response, not only to soil compaction, but also the quality of the soil in this site type. Although we did not collect data on soil quality other than compaction, soils of highway medians contained pieces of concrete and typical urban soil debris from road construction. No magnolias were found in highway medians from the sites visited. The lowest survival rates for magnolia were for open lawn and street trees (Table 3).

Table 1. List of site locations by county and region of Florida where data was collected.

Florida Region	County	City or Town
North (temperate zone)	Clay	Penney Farms
	Marion	Ocala
	Putnam	Palatka, Crescent City
	St Johns	St Augustine
	Volusia	New Smyrna, DeLand
Central (transition zone)	Brevard	Viera, Palm Bay, Rockledge
	Hillsborough	Tampa
	Indian River	Vero Beach
	Lake	Mount Dora
	Orange	Orlando
	Pinellas	Oldsmar
	Polk	Lakeland
	Seminole	Sanford, Winter Springs
South (subtropical zone)	Charlotte	Port Charlotte
	DeSoto	Arcadia, Fort Ogden
	Highlands	Sebring, Lake Placid
	St Lucie	Fort Pierce

Table 2. Live oak, baldcypress and southern magnolia survival rate, annual caliper growth, tree condition, and crown dieback by presence or absence of irrigation system at tree planting site.

Irrigation system	Survival rate (%)	Projected survival rate in 10 years[1] (%)	Annual caliper growth (in)	Tree condition[2] (1-4)	Crown dieback (%)
			Live Oak		
Yes	98	96	0.86 a[3]	3.4 a	6.9 a
No	96	93	0.62 b	3.2 b	11.0 b
			Baldcypress		
Yes	91	91 a	0.93	3.2	9.2 b
No	87	81 b	0.96	2.9	16.3 a
			Southern Magnolia		
Yes	98 a	96 a	0.50 a	3.5 a	6.8 b
No	71 b	47 b	0 b	2.4 b	23.5 a

[1]Estimation of survival based on current tree condition and health.
[2]Tree condition 1= Poor, 2= Fair, 3= Good, 4= Excellent.
[3]Means followed by different letters are significantly different at $P < 0.05$ within a column and species. Based on 1197 live oak (482 irrigated, 715 non-irrigated), 240 baldcypress (80 irrigated, 160 non-irrigated) and 154 southern magnolia (86 irrigated, 68 non-irrigated).

Table 8. Live oak, baldcypress and southern magnolia survival rate, annual caliper growth, tree condition, crown dieback, tree firmness, and leaning by tree planting site types

Site Type	Soil compaction[1] (psi)	Survival rate (%)	Projected survival rate in 10 years (%)	Annual caliper growth (in)	Tree condition[2] (1-4)	Crown dieback (%)	Tree firmness rating[3] (1-5)	% trees leaning
				Live Oak				
Open lawn	186 c[4]	96	93	0.75 a	3.2	9.9 b	4.6	13 b
Highway median	265 a	97	95	0.55 b	3.6	6.1 d	4.7	22 a
Park	200 c	99	97	0.76 a	3.3	8.0 c	4.7	14 ab
Parking lot	226 b	95	95	0.81 a	3.6	4.4 e	4.9	22 a
Street	183 c	96	92	0.57 b	3.1	12.4 a	4.4	9 b
				Baldcypress				
Open lawn	186 c	92 a	86 ab	0.94	3.0	15.2 c	4.5	3 b
Highway median	265 a	40 c	40 c	0.80	1.5	65.0 a	4.5	50 a
Park	200 c	96 a	92 a	0.48	2.6	18.9 b	4.5	0 b
Parking lot	226 b	90 ab	90 ab	1.13	3.9	0 d	5.0	0 b
Street	183 c	75 b	75 b	1.23	3.6	1.1 d	5.0	9 ab
				Southern Magnolia				
Open lawn	186 b	76 b	55 c	0.29 b	2.7 b	21.8 a	3.8 b	9 a
Park	200 b	100 a	100 a	0.57 a	3.7 a	1.4 d	4.7 a	0 b
Parking lot	226 a	94 a	89 ab	0.52 a	3.4 ab	9.0 c	4.8 a	0 b
Street	183 b	83 ab	79 b	0 c	2.8 b	12.2 b	5.0 a	3 ab

[1]Soil compaction was compared for site type only.
[2]Tree condition 1= Poor, 2= Fair, 3= Ok, 4= Excellent.
[3]Firmness rating 1= Very loose; 5= Very firm in the soil as trunk was rocked back-and-forth.
[4]Means followed by different letters are significantly different at $P < 0.05$ within a column and species. Based on 1197 live oak (798 open lawn, 109 highway median, 96 park, 67 parking lot, 127 street), 240 baldcypress (193 open lawn, 2 highway median, 14 park, 9 parking lot, 22 street) and 154 southern magnolia (69 open lawn, 29 park, 20 parking lot, 36 street).