2009
GREAT SOUTHERN TREE CONFERENCE

RESEARCH REPORT

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IFAS

FNGLA

December 2 – December 4, 2009

UNIVERSITY OF FLORIDA
Environmental Horticulture Department
GAINESVILLE, FLORIDA 32611

Great Southern Tree Conference helps growers, landscapers, and arborists grow, plant, and manage trees more efficiently

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

SOLUTIONS

Our profession has changed dramatically during the past ten years. Growers and arborists developed pruning strategies for tree canopies in nursery and landscape settings. Although most growers won't admit to selling Florida Fancy trees, many growers actually do. If you doubt this, take a peak at the photos in the Grades and Standards document published 11 years ago by the Florida Department of Agriculture and Consumer Services (FDACS) and compare them with the trees planted across the state today.

UF-IFAS research has led to new tree production and maintenance practices that are the heart of this change. Florida Grades and Standards for Nursery Stock (developed and published by FDACS) has led to monitoring of tree quality. Growers, buyers, and researchers have become more informed about what makes trees strong. Today, Florida's nursery stock is among the best in the US. In fact our quality has improved so much that several other states have used FDACS Standards as a model to develop their own Standards. Any of us can drive through almost any community from Jacksonville south and see trees planted with fabulous trunk and canopy quality.

Now we focus on roots, and there is great news. You will be among the first to see and hear solutions which prevent formation of stem girdling roots. Through cooperation with our conference Partners and hard work by the Great Southern Tree Conference staff at the University of Florida – IFAS, we think we have discovered how to consistently produce quality roots systems in containers and in the field. These root systems comply with the current roots section of the Florida Grades and Standards for Nursery Stock.

Field nurseries in Florida discovered in the 1980s that root pruning hardens-off trees which allow trees to acclimate better to their ultimate landscape setting. Ironically, root pruning has been around for centuries; its time tested. Whether we tease roots of tiny liners apart when shifting to #3 containers, or slice the roots balls from top to bottom, or shave off the entire outer edge, our practices surely will be changing for the better as we learn together how to grow better trees. Please thank Chris Harchick, Maria del Pilar ("Pili") Paz, Christine Weise, and Jake Miesbauer for their hard work this year conducting studies, collecting data and writing this report.

Finally, I want to express my sincere appreciation to the Florida Nursery, Grower and Landscape Association, with the University of Florida – IFAS, and our industry partners who have allowed us to develop new research findings and deliver this information to each of you and many others throughout Florida.

Please thank our 2009 Great Southern Tree Conference Partners

Champion Level

Ellepot® USA
Flagler Wholesale Nursery
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Marshall Tree Farm
SMR Turf & Trees
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Southern Selections

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Great Southern Tree Conference: Live oak cultivar demonstration.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, FL

Objective: Demonstrate growth habits of clonal live oak cultivars produced from cuttings.

What we did: One 2.5-inch caliper tree of the cultivars Highrise®, Millenium™ or Cathedral Oak® were planted in the year 2000 in an open sunny location to evaluate growth form. The trees were irrigated and mulched for the first year only. The trees were fertilized 3 times in 2005, 2006 2007 and 2008 with 3.1 lbs of 16-4-18 per thousand square feet applied under the canopy. All trees were structurally pruned and canopy lifted in July 2006. In November 2006, two additional cultivars (Boardwalk™ and Parkside™) were planted as 4-inch caliper trees, mulched and irrigated regularly for one year. In December 2007, Sky Climber was planted as a 3-inch caliper tree, mulched and irrigated regularly for one year. All trees were fertilized twice in 2009 at a rate of 3.1 lbs of 16-4-18 per thousand square feet applied under the canopy. Caliper, height and spread were recorded in September 2009 for all trees.

What we found as of November 2009: The six live oak cultivars have different growth and canopy forms (Table 1 and photos on following page). All trees are taller than they are wide so far. Height to spread ratios are 1.03 for Millenium™, 1.48 for Highrise®, 1.20 for Cathedral Oak®, 1.58 for Boardwalk™, 1.50 for Parkside™ and 2.17 for Sky Climber.

Millenium™ has large foliage reminiscent of shade grown live oak. Branches are well spaced along the trunk and the tree is easy to prune into a strong structure. Highrise® has dark green foliage with upright branches. Subordinate competing stems to allow sunlight to reach lateral branches along the leader. Cathedral Oak® has a dense canopy with closely spaced branches when shipped from most nurseries. Subordinate lateral branches and thin crowded branches as you develop structure in the landscape. Boardwalk™ and Parkside™ have kept good central leaders, with well spaced branches that have somewhat of a horizontal growth. Parkside™ has more of a triangular shape when compared to Boardwalk™. Sky Climber was aptly name with it's branches growing very upright. All live oak cultivars are expected to require regular pruning in the landscape to develop good structure, just like the acorn-grown species.

Table 1. Growth and canopy forms of five live oak cultivars planted in 2000 as 2.5" caliper trees, 2006 as 4" caliper trees, and 2007 as 3" caliper trees.

Cultivar	Caliper (in)	Height (ft)	Spread (ft)
Planted 2000, 2.5" cal			
Highrise®	10.03	32.4	21.9
Millenium™	12.43	35.0	33.8
Cathedral Oak®	10.75	30.0	25.0
Planted 2006, 4" cal			
Boardwalk™	7.20	25.0	15.8
Parkside™	6.45	22.0	14.6
Planted 2007, 3"cal			
Sky Climber	4.63	23.0	10.6

‘First generation’ live oak cultivars 9 years after planting.

Cathedral Oak®

Highrise®

Millennium®

‘Second generation’ live oak cultivars 3 years after planting.

Boardwalk™

Parkside™

Sky Climber

Great Southern Tree Conference: Elm species and cultivar demonstration.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, FL

Objective: Develop a collection of native and introduced elm trees, including cultivars, to demonstrate suitability for street tree and landscape plantings.

What we did: In April 2007, eight of the nine elms were planted in an open sunny location to evaluate growth form and adaptability to north central Florida. The species and cultivars planted are listed in Table 1. *Ulmus parvifolia* 'Everclear' was planted in April 2008. All of the trees were about 3"caliper, except Cedar elm which was 2.5". Trees were mulched (no mulch was placed on root ball surface) at planting and irrigated for most of the year, except in the winter. The trees were fertilized with 1.76 lbs of 16-4-18 per tree under the canopy twice a year in 2008 and 2009. Caliper, height and spread were recorded in September 2009 for all trees.

What we found as of November 2009: The nine elms have different growth and canopy forms (Table 1, see photos below and on following page). All trees are much taller than they are wide. 'Everclear' and the American Elms are columnar in shape, while the rest are more spreading. All the trees look thinner at the demonstration site and in the photos because we photographed them in fall. It's important to note that the Cedar Elm was obtained sheered in the shape of a cone. The tree is now growing out of this shape. All elms require regular pruning to develop strong structure in the landscape.

Table 1. Growth and canopy forms of nine elms planted in 2007 and 2008.

Elm species/cultivar	Caliper (in)	Height (ft)	Spread (ft)
Ulmus parvifolia 'Bosque'	4.10	22.8	14.5
Ulmus parvifolia 'Allee™'	4.68	20.3	18.2
Ulmus parvifolia 'Burgundy'	4.54	19.1	11.6
Ulmus parvifolia 'Athena Classic'	4.40	18.7	11.1
Ulmus parvifolia 'Everclear'	3.55	23.0	5.2
Ulmus americana 'Creole Queen'	4.40	23.2	7.2
Ulmus americana 'Princeton'	5.40	23.2	8.6
Ulmus alata	5.55	21.4	17.8
Ulmus crassifolia	3.08	15.3	8.0

Chinese elm (*U. parvifolia*) cultivars

Bosque

Allee™

Burgundy

Chinese elm (*U. parvifolia*) cultivars

		**Your cultivar here**
Athena Classic	**Everclear**	

American elm (*U. americana*) cultivars

	
Creole Queen	**Princeton**

Winged (*U.* alata) and Cedar (*U. crassifolia*) elm

	
Winged Elm	**Cedar Elm**

Great Southern Tree Conference: Southern magnolia cultivar demonstration.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, FL

Objective: Demonstrate growth habits of southern magnolia cultivars in the landscape.

What we did: Eleven southern magnolia cultivars were planted in spring 2006 in an open sunny location to evaluate growth form. 'Little Gem' was planted several years prior. The cultivars planted are listed in Table 1. Trees were mulched at planting and are being irrigated once daily. The trees were fertilized 3 times in 2007 with 0.88 lbs, 3 times in 2008 with 1.76 lbs of 16-4-18 and twice in 2009 with 1.76 lbs of 16-4-18 per tree applied under the canopy. Caliper, height and spread were recorded in September 2009 for all trees.

What we found as of November 2009: The eleven southern magnolia cultivars have different growth and canopy forms (Table 1, see photos below and on following page). They also have different leaf shapes and amount of brown on the underside of leaves. All trees are taller than they are wide. Miss Chloe® had to be replaced because the first tree was infested with soft scale. To avoid contamination to the other cultivars, it was pulled out and burned.

Table 1. Growth and canopy forms of eleven southern magnolia cultivars planted in 2006.

Southern Magnolia Cultivars	Caliper (in)	Height (ft)	Spread (ft)
Claudia Wannamaker	5.30	22.0	9.1
Green Giant	4.68	14.9	9.8
Coco	4.48	18.5	10.6
Edith Bogue	4.04	15.5	9.2
Greenback™	4.68	19.0	8.1
Bracken's Brown Beauty™	4.25	16.8	9.1
Teddy Bear®	3.60	14.8	7.4
Alta®	3.50	13.7	6.2
Little Gem	6.05	21.9	11.6
D.D. Blanchard	3.88	18.3	8.6
Miss Chloe®	2.80	11.4	5.7

Southern magnolia cultivars 3 years after planting.

Claudia Wannamaker

Green Giant

Coco

Edith Bogue

Greenback™

Bracken's Brown Beauty™

Teddy Bear®

Alta®

Little Gem

D.D. Blanchard

Miss Chloe®

Your cultivar here

Great Southern Tree Conference: Holly species and cultivar demonstration.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, FL

Objective: Demonstrate growth habits of holly species and cultivars in the landscape.

What we did: Twelve species and cultivars of holly were planted in March 2008 in an open sunny location to evaluate growth form. The species and cultivars planted are listed in Table 1. *Ilex attenuata* 'Miss Priss' was planted in March 2009. The trees were mulched at planting and are being irrigated three times daily. The trees were fertilized in August 2008 with 0.88 lbs of 16-4-18 and twice in 2009 with 1.76 lbs of 16-4-18 per tree applied under the canopy. Caliper, height and spread were recorded in September 2009 for all trees.

What we found as of November 2009: The thirteen species and cultivars have different growth and canopy forms (Table 1, see photos below and on following pages). Most trees were sheered regularly in the nursery prior to arrival and are now growing out of that shape, reverting back to its natural habit. All trees are taller than they are wide. 'East Palatka', 'Aspire', and 'Eagleston' are columnar in shape. 'Mary Nell', 'Emily Brunner', 'Wirt L Winn' and 'Dark Green' were obtained sheered in a cone shape. It will be interesting to see how and in what time period the trees grow out of this shape, and what form they will take in the landscape with no maintenance of this shape.

Table 1. Growth and canopy forms of thirteen holly species and cultivars planted in 2008 and 2009

Holly species/cultivar	Caliper (in)	Height (ft)	Spread (ft)
Ilex opaca	2.32	11.1	5.7
Ilex cassine 'Tensaw'	2.41	10.7	7.0
Ilex X *attenuata* 'East Palatka'	3.92	14.9	10.4
Ilex X 'STBB' (Aspire)	4.57	13.3	4.5
Ilex X *attenuata* 'Eagleston'	3.93	16.2	11.1
Ilex vomitoria 'Pride of Houston'	Multi-Trunk	11.2	12.7
Ilex cornuta 'Fine Line'	Multi-Trunk	11.2	8.1
Ilex X 'Mary Nell'	5.45	12.0	5.8
Ilex X 'Emily Brunner'	Multi-Trunk	11.7	7.8
Ilex X 'Wirt L Winn'	Multi-Trunk	13.9	8.8
Ilex latifolia 'Dark Green'	Multi-Trunk	6.7	6.6
Ilex attenuata 'Fosteri'	2.73	3.7	3.8
Ilex cornuta 'Lib's Favorite'	Multi-Trunk	4.7	4.2
Ilex attenuata 'Miss Priss'	3.20	6.9	7.2

Holly species and cultivars 2 year after planting.

American Holly

Tensaw

East Palatka

Aspire

Eagleston

Pride of Houston

Fine Line

Mary Nell

Emily Brunner

Wirt L Winn

Dark Green

Fosteri (street tree grown)

Lib’s Favorite

Miss Priss

Your cultivar here

Great Southern Tree Conference: Evaluation of initial liner size and root pruning at planting of live oak into a field nursery.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009

Objective: Evaluate root pruning strategies when planting liners into a field nursery.

What we did and will do: In February 2007, 40 Cathedral Oak® live oaks were obtained in #3 Accelerators, all with an average 0.5" caliper. Twenty trees were shifted into #10 Accelerators and the other twenty were shifted into #15 Accelerators. Trees were root pruned when shifted from #3s 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. The top of the #3 root ball was washed for 10 seconds to expose root defects (kinks, descending, ascending, and circling roots). Defective roots were pruned at the point just before they were deflected by the #3 container wall. Essentially, the top inch or two of the root ball edge was shaved away. Trees shifted into the #10 containers were planted into the field nursery 8 months later in 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.

Before field planting, #10 and #15 root balls were either 1) sliced as described above, or 2) the outer inch of the sides and bottom shaved off (see photos next page) using a digging shovel. All 40 trees were planted into the same field with 12 ft between rows and 8 ft between trees and are being irrigated three times per day in the growing season. Trees were fertilized with 115g per tree of 16-4-8 in April 2008, 210g of 16-4-8 in July 2008 and 400g of 16-4-8 in September 2008, March 2009 and June 2009. Trees from #10 containers were staked in November 2007 and #15 trees at planting. Caliper and height were recorded in October 2009 for all trees. Root development will be measured at the end of 2009, and trees dug for the 2009 GSTC conference to show influence of root pruning strategies on root ball quality.

What we found as of November 2009: The type of root pruning (root ball shaving vs. slicing) when planting #10 and #15 containers into field soil had no effect on caliper or rate at which field trees grew. Sliced trees were a little taller that shaved trees, but this difference is not too significant (Table 1). This in encouraging because it means that the more aggressive (and we think more effective) root ball shaving does not slow growth compared to the more traditional root ball slicing technique. Although the #15 trees were larger (1.3" caliper) than the #10 trees (1" caliper) when planted into the field, #10 trees had slightly larger caliper and height when finished at 3" caliper trees (Table 2). Trees from #10 were planted into the field 3 months before #15 trees; which probably explains why these trees were larger at the end of the second growing season in the field.

Table 1. Caliper and height on field nursery-grown trees with #3 container root ball sides either sliced or shaved at planting.

Root pruning	Caliper (in)	% caliper increase	Height (ft)	% height increase
Slicing root ball sides	2.98	186	14.6 a[1]	79
Root ball shaving	2.94	184	13.9 b	72

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 20 trees per root pruning.

Table 2. Caliper and height on field nursery-grown trees planted from #10 or #15 containers.

Container Size	Caliper (in)	% caliper increase	Height (ft)	% height increase
#10	3.11 a[1]	193 a	14.9 a	78
#15	2.81 b	176 b	13.6 b	73

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 20 trees per container size.

Slipping the root ball out of the container shows that there are few roots visible on the outer surface.

A gentle washing of the outer surface shows that root defects are beginning to form just back from the periphery of the root ball.

A light washing of the outer surface of the root ball reveals that some roots are beginning to circle, dive, and kink. Some of these will grow to become large root defects at this position.

A blade is used to shave off the outer inch or so of the root ball before shifting to the larger container.

Shaving the root ball in this fashion should remove enough substrate so remaining roots are oriented straight out from the trunk.

Removed roots are not large in diameter, but there are many of them. If left unpruned, some of these will grow to become permanent circling or descending roots. Non-pruned root ball is shown on left; shaved root ball on right.

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 2 – December 4, 2009
Gainesville, Florida

Objective: Determine the best way to develop quality roots on field grown nursery stock.

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) planted directly into field soil; (2) shifted into #10 Accelerators; or (3) shifted into #15 Accelerators. Half of the trees 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 planting or shifting. The trees shifted into the #10 containers were planted into the field nursery October 2007, when the average trunk caliper averaged 1”. The #15 containers were 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 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 are being irrigated three times per day by drip emitters. Trees in the field are being root pruned in the following manner: 1) half were root pruned in the dormant season (Feb, Apr, Oct, Dec 08 and Feb and Apr 09) or 2) the other half were root pruned in the growing season (Apr, Jun, 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 16-4-8 and were staked in November 2007 for #3 and #10, and at planting for #15. Caliper and height were recorded in October 2009 for all trees. Trees will be dug for the 2009 GSTC conference.

What we found as of November 2009: Root ball slicing had no impact on tree caliper and height, although the growth has been quicker for sliced trees (Table 1). Trees pruned during the two different growing seasons are growing at similar rates (Table 2). Trees planted from #3 increased the most in height and those planted from #15 increased the most in caliper, but this did not have an impact on final tree caliper and height. Root pruning treatments and liner size at planting had no effect on tree caliper or height. Root slicing to compensate for root defects before field planting can be used without affecting final tree size. The season in which field root pruning takes place did not affect final tree size. We will all see the effect of root pruning timing on root ball quality at the outdoor portion of the field day.

Table 1. Caliper and height in October 2009 on field nursery-grown trees planted from #3 (Feb 07), #10 (Oct 07), or #15 (Jan 08) containers either sliced or not sliced at planting.

Root pruning at planting	Caliper (in)	% caliper increase	Height (ft)	% height increase
Not sliced	2.94	168 b[1]	14.1	78 b[1]
Sliced	2.94	183 a	14.2	90 a

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 60 trees per root pruning type averaged across initial container sizes and pruning season.

Table 2. Caliper and height on field nursery-grown trees planted from #3 (Feb 07), #10 (Oct 07) or #15 (Jan 08) containers and field root pruned in the dormant or growing season.

Root pruning season	Caliper (in)	% caliper increase	Height (ft)	% height increase
Dormant	2.95	173	14.3	82
Growing	2.92	175	14.0	83

Table 3. Caliper and height October 2009 on field nursery-grown trees planted from #3 (Feb 07), #10 (Oct 07) or #15 (Jan 08) containers.

Container Size (beginning caliper)	Caliper (in)	% caliper increase	Height (ft)	% height increase
#3 (0.5”)	2.97	175 ab[1]	14.4	105 a
#10 (1.0”)	2.90	179 a	13.9	69 b
#15 (1.3”)	2.95	162 b	14.0	61 b

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 40 trees per container size averaged across root pruning treatments.

Note: We will see the washed out root balls in the demonstration site.

Great Southern Tree Conference: Impact of live oak root ball slicing at planting on landscape stability.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, FL

Objective: Determine if severing circling roots at planting impacts survival, growth and landscape tree stability.

What we did: Sixty Cathedral Oak® live oaks were transplanted from #45 containers (~2.5" caliper) into the field on March 2005. Half of the trees were root pruned at planting (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), whereas the other half was planted without root slicing. Trees were fertilized with 100g of 16-4-8 per tree, applied to a 36" area around the stem in March, April and September 2005. In 2006, 400g of 16-4-8 were similarly applied to each tree in April, June and September. In April 2006, the trees were cleaned of small shoots from the ground up to the start of the canopy. Caliper, height and spread were measured in October 2007. Seven trees from each treatment were pulled over with a winch November 2007 and force required to pull the trunk to 5, 10, 15, 20 and 25 degrees recorded. Tree pulling stress was calculated based on force required to pull each tree, height from ground to pull point, and trunk diameter near ground. Root balls were later dug from the ground and data collected included number of roots growing into landscape soil over 5 mm in diameter, root diameter, largest root diameter, and root depth.

What we found out as of November 2009: Caliper and height in the first 30 months following planting were not affected by root slicing at planting (GSTC Report 2007). Slicing the root ball at planting had no impact on tree stability 2.5 years after planting (Table 1). Slicing had no effect on root ball characteristics (Table 2).

Table 1. Stress from pulls and final tree angle (degrees) after pulls of 5.5" caliper live oak planted from #45 containers 2.5 years earlier with and without root ball slicing at planting.

Treatment	Stress to 5 degs (lbs/sq in)	Stress to 10 degs (lbs/sq in)	Stress to 15 degs (lbs/sq in)	Max Stress (lbs/sq in)	Angle of tree after pulls
Root sliced	3974	5200	5711	6434	16.5
Not root sliced	4169	5617	6468	7238	17.6

Table 2. Root ball characteristics of 5.5" caliper live oak planted from #45 containers 2.5 years earlier with and without root slicing at planting.

Treatment	Number of roots growing into landscape soil	Average root diameter (mm)	Largest root diameter (mm)	Root depth (in)
Root sliced	55	6.7	14.6	5.8
Not root sliced	55	6.7	14.2	6.2

Conclusion: Slicing container root ball sides at planting, deep enough to sever circling roots appears to have no positive or negative impact on the tree.


Roots were cut on outside of ball.


Root ball was cut top to bottom in 5 locations with hand pruning.


Trees were installed and growth measured.


Force to pull trees to a 25 degree angle was measured on trees after root balls were either sliced or not at planting. Trees were installed March 2005 and pulled over in November 2007.


Root ball sat tilted after pulling trunk to 25 degree angle. The leeward side of the root ball sank (see right side of trunk) at the point where the original #15 container was; the windward side broke from the ground at the outer edge of the #45 container (see left side of photo).


There were circling roots on the edge of the container when trees were planted March 2005.


Same tree November 2007. The original root ball is clearly visible 2.5 years after planting into the landscape from #45 containers. There were plenty of roots growing into the landscape soil, but circling roots that were present at planting are still clearly visible 2.5 years after planting. Slicing the root ball at planting had no impact on circling roots or tree stability.

Great Southern Tree Conference: Live oak tree size and root deformations impact tree establishment and stability in the landscape.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, FL

Objectives: Determine impact of plant size and root form on tree establishment and stability.

What we did: Thirty Cathedral Oak® live oak from #45 containers, 30 from #15 containers, and 30 B&B were transplanted into the field at the end of March 2005. Following planting into the landscape, trees were fertilized with 100g of 16-4-8 per tree, applied to a 36" area around the stem in March, April and September 2005. In 2006, 400g of 16-4-8 were similarly applied to each tree in April, June and September. In April 2006, the #15 trees were limbed up 2 feet from the ground, whereas the #45 and B&B trees were cleaned of small shoots from the ground to the start of the canopy. In May 2006, defoliation following a very dry spring was evaluated due to considerable foliage discoloration and leaf drop. Tree caliper, spread and height were collected on November 2007 and compared to those at planting. To simulate wind loading, seven trees from each treatment were pulled over with a winch November 2007 and force required to tilt the trunk to 5, 10, 15, 20 and 25 degrees recorded. Stress placed on the tree was standardized based on force required to pull the tree to the set angles, height of pull point and tree diameter at the base of the tree. Root balls were dug from the ground and data collected included number of roots over 5 mm in diameter, root diameter and root depth.

What we found as of November 2009: During most dry periods in the first 432 days after planting (DAP), trees planted from #15 containers were the least stressed. Field grown transplanted trees were more stressed than all other planting treatments the first time irrigation was withheld 12 DAP, however 28 to 423 DAP were less stressed than trees planted from #45 containers either sliced or not at planting. Defoliation was greater for #45 container treatments than for #15 containers in severe post-planting drought (Table 1). Trunk diameter increase on #15 container grown and field grown trees was greater than for trees planted from #45 containers (Table 2). Field grown trees grew less in height and crown spread than others. Root system radius was similar for trees planted from #45 containers and field grown, and greater than for #15 trees planted from containers. Small trees appear to become drought resistant sooner after planting than larger trees.

Stress (force/unit trunk cross sectional area) required to tilt #15 and #45 container trees was similar (Table 3). Trees planted from #15 containers were as well secured to the landscape soil as trees planted from #45 containers. This probably indicates that both were equally resistant against a wind event 2.5 years after planting. Pulling stress required to tilt trunks to 10 degrees was greater for B&B trees than #15 or #45 container-grown trees (Table 1). This means that it would take a stronger wind event (by about 20%) to tilt the field-grown trees 2.5 years after planting than the container grown trees. The final resting tilt of the trunk after the pulls to 25 degree trunk angle was similar for #15 and B&B, and was less than for #45 trees.

Trees planted from a field nursery (B&B) had more than double the root number growing into the landscape than trees planted from either the #15 or #45 containers, and larger, shallower roots. In studies conducted by others (mostly in Europe) straight roots have been associated with greater stability in wind, and the field-grown trees used in this study had straighter roots (see photos next page). We will be learning much more about this in the next several years. We think we have developed a technique to develop straighter roots in containers by reducing root deflections, which will be discussed later in this report.

Conclusions: Small container grown live oak nursery stock appears to establish quicker and become self-sufficient sooner than larger nursery stock, and tree stability three years after planting appears to be greater for trees with straight roots in the root ball at planting. Part of the greater stability for field grown trees might be attributed to the soil that comprises the root ball; whereas' container substrate decomposes with time and likely provides less resistance to overturning moments caused by wind.

Table 1. Percentage of Cathedral Oak® live oak trees defoliating in a drought 14 months after planting April 2005 into field soil.

Size and caliper at planting	None	Some	Medium	Heavy	Average defoliation rating
	Defoliation severity[2] --- % of defoliated trees ---				
#15 (1")	93 a[1]	7 b	0 a	0 a	1.1 b
#45 (2.7")	0 c	64 a	21 a	14 a	2.5 a
Field grown (3")	43 b	36 ab	21 a	0 a	1.8 ab

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 30 trees per treatment
[2] Mean visual foliage drop by two assessors; none (1) = no defoliation; some (2) = up to about 1/3 of the foliage on the ground; medium (3) = between 1/3 and 2/3 of foliage on ground; heavy defoliation (4) = most foliage on the ground.

Table 2. Trunk caliper, tree height, and crown spread of Cathedral Oak® three growing seasons following planting.

Size and caliper at planting	Caliper after 3 growing seasons (in)	Caliper increase (in)	Height after 3 growing seasons (ft)	Height increase (ft)	Spread after 3 growing seasons (ft)	Spread increase (ft)
#15 (1")	3.35 c[1]	2.20 a	15.4 c	8.5 a	7.5 b	5.6 a
#45 (2.7")	4.45 b	1.85 b	17.7 b	5.6 b	11.5 a	5.6 a
Field grown (3")	5.20 a	2.05 a	18.4 a	3.3 c	12.1 a	4.6 b

[1]Means in a column with different letter are statistically different at P < 0.05. Based 30 trees per treatment

Table 3. Pulling stress required to tilt trees to a 10 deg angle 2.5 years after planting, tree tilt after pull, and root ball characteristics of live oak transplanted into the landscape from #15, #45 and field-grown (B&B) trees.

Size and caliper at planting	Stress to 10 deg (lbs/sqin)	Trunk tilt after pulling trunk to 25 degree angle	Number of roots	Average root diameter	Root depth (in)
#15 (1")	5901 b[1]	12.6 b	36 c	7.3 b	6.7 a
#45 (2.7")	5617 b	17.6 a	55 b	6.7 b	6.2 ab
Field grown(3")	6973 a	12.4 b	115 a	8.3 a	5.6 b

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 7 trees per treatment.

At planting: Trees from #45 containers had large roots deflected down or around at the position of the #15 container. This deflection point appeared to weaken attachment to the landscape soil.

At planting: Trees from the field nursery had more straight roots. This appeared to be responsible for the increased stability in the years following planting to the landscape.

3 growing seasons later: There were fewer roots growing into landscape soil 3 growing seasons after planting and they were smaller in diameter.

3 growing seasons later: There were more roots growing into landscape soil and they were larger in diameter than roots growing from #45 containers.

Great Southern Tree Conference: Planting depth did not affect live oak landscape stability

Chris Harchick, Maria Paz and Ed Gilman, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, Florida

Objective: Determine the impact of planting depth in the landscape on tree stability.

What we did: In June 2003, twelve trees were planted into each of the following treatments: top most root in the root ball 2" above grade, 0 to 1"below grade, 4" below grade, or 7" below grade. Hardwood mulch chips 3" deep were added over the root ball and around the tree in an 8 ft x 10 ft rectangular area and kept weed free with periodic Round-up™ application. Trees were fertilized 3 times in 2004 with 272g of 16-4-8 and 3 times in 2005 with 544g of 16-4-8. In 2006, trees were fertilized with 544g of 16-4-8 in March and July, and then with 800g of 16-4-8 in October. In 2007, trees were fertilized with 544g of 16-4-8 in March and 814g of 16-4-8 in July and October and at the same rate in April 2008. Twelve trees from each treatment were pulled over with a winch June 2008 and force required to pull the trunk to 5 degrees recorded. Stress on the trunk was calculated based on force required to pull the tree to set angles, height to the pull point, and tree diameter at the pull point. The root balls of all the trees were dug up with a 90 inch spade to characterize the root balls. Root measurements were collected just beyond the 90" root ball edge.

What we found as of November 2009: Growth across planting depths was very similar for 6 years after planting (2008 GSTC Report). Although trees planted at or above grade were slightly larger in diameter than those planted more deeply, stress required to tilt the trunk to several angles was similar for all planting depths (Table 1). Planting depth also had no effect on diameter of the ten largest roots to a depth of 4 ft (Table 2), which might explain why the pulling stress required to pull trees was similar for all planting depth treatments. However, trees planted deeper had deeper roots (Table 2). Trees planted deeper had roots that ascended toward soil surface at a steeper angle. Trees that were planted deeper had a deeper root flare and more roots growing over the flare (Table 3). Also, smaller roots matted more over the root flares of deeply planted trees. The size of the roots over the flare does was not affected by planting depth (Table 3). The difference in depths of the different root ball characteristics appears to not affect tree stability.

Conclusion: Planting depth had no impact on tree stability five years after planting. Trees planted deeply grew slightly slower than those planted shallower. Planting depth had an effect on depth of roots, but not diameter of roots growing into landscape soil.

Table 1. Trunk diameter at tree base and pulling stress to pull live oak planted at four different planting depths 5 years earlier.

Planting Depth into Landscape	Trunk diameter at base (in)	Stress to 1 deg (lbs/sq in)	Stress to 2 deg (lbs/sq in)	Stress to 5 deg (lbs/sq in)
2" above	7.6 ab[1]	1642	2374	3267
0 to 1" below	7.8 a	1535	2404	3598
4" below	6.9 b	1554	2612	3970
7" below	6.9 b	1595	2580	3723

[1] Means in a column with a different letter are statistically different at $P < 0.05$. Based on 12 trees per treatment.

Table 2. Characteristics of the largest diameter roots of root balls by planting depth

Planting Depth	Mean diameter of largest 10 roots on top 2 ft of ball (mm)	Mean depth of largest 10 roots growing from top 2 ft of ball (in)	Mean diameter of largest 10 roots growing from the 2-4ft depth of ball (mm)	Ascending angle of largest 5 ascending roots
2" above	34.7	10.2 bc[1]	23.6	14.6 c
0 to 1" below	37.1	8.1 c	24.1	21.8 bc
4" below	36.2	12.9 b	26.1	25.3 b
7" below	33.7	16.0 a	30.7	35.6 a

[1] Means in a column with a different letter are statistically different at $P < 0.05$. Based on 12 trees per treatment.

Table 3. Root ball characteristics as they relate to root flare by planting depth

Planting Depth	Root mat rating (1-10)[1]	Depth to root flare (in)	No. of roots > 2mm diameter over root flare	Average diameter of roots >2mm over flare (mm)
2" above	3.00 b[2]	1.8 a	3.3 b	19.1
0 to 1" below	2.75 b	0.4 a	5.5 ab	16.4
4" below	4.75 a	-2.6 b	6.2 a	15.6
7" below	5.75 a	-6.7 c	7.3 a	12.7

[1] 1 = No small roots matted over root flare; 10 = Dense mat of small roots over root flare.
[2] Means in a column with a different letter are statistically different at $P < 0.05$. Based on 12 trees per treatment.

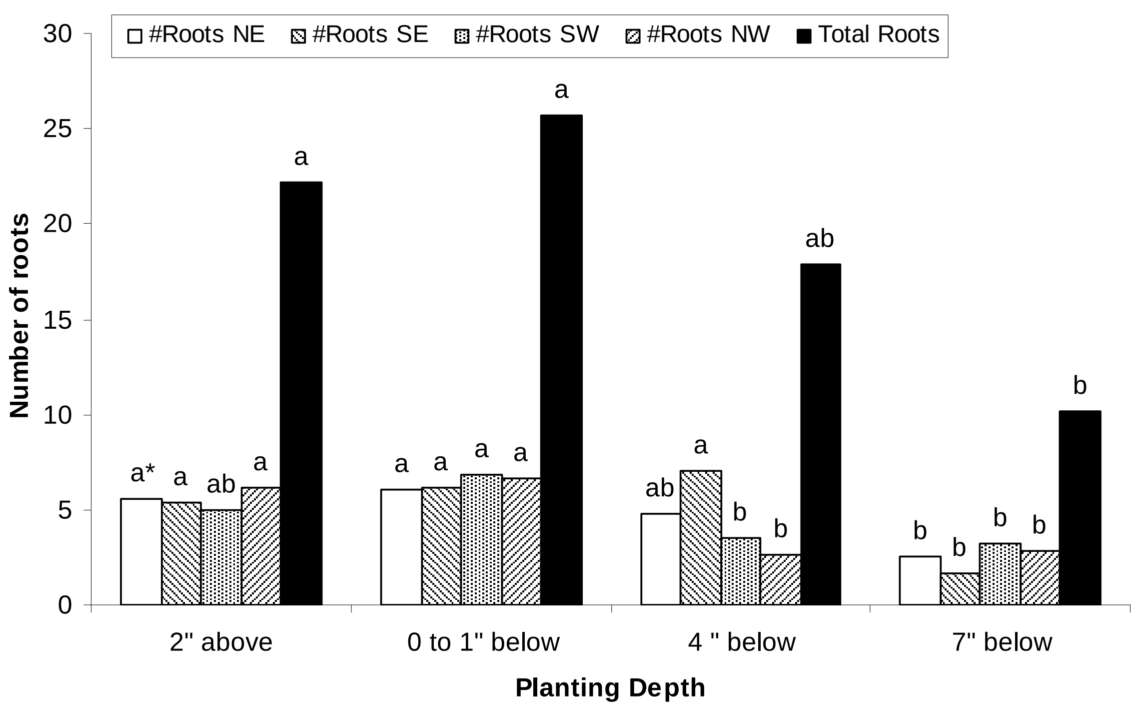

Figure 1. Number of roots > 5mm diameter growing into landscape soil from the top 12"of the root ball in each of four pie-shaped quadrants with apex at trunk. * Quadrant means with the same letter as statistically similar at $P > 0.05$ for each quadrant and root total between planting depths. Total root number means with similar letters are statistically similar.

Trees were pulled with an electric winch. A load cell recorded load required to tilt the trunk to a set angle.

Trees planted even with or slightly higher that the surrounding landscape soil had a distinctive flare at the base of the trunk.

Trees planted deeply had no flare at the base of the trunk. You will see the roots at the outdoor demonstration site.

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 2– December 4, 2009
Gainesville, Florida

Objective: Determine how planting depth in the root ball and planting depth in the landscape influence trees 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 2-3" 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 340g of 12-2-14, 400g of 16-4-8 in July 2008, and 800 g of 16-4-8 in July 2009. Caliper and height were measured in July 2009.

What we found as of November 2009: Trunk caliper and tree height four growing seasons after landscape planting were not affected by planting depth in the nursery (Table 1). Tree height 4 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. Trees that were root pruned by slicing the root ball prior to landscape planting were slightly shorter than trees that were not root pruned, but this difference was less than 6 inches. Although tree height was 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 4 growing seasons after landscape planting.

Nursery planting depth	Caliper (in)	Caliper growth in 4 growing seasons (in)	Height (ft)	Height growth in 4 growing seasons (ft)
Level in #3, #15, #45	4.22	1.39	15.38	2.22
2.5" below in #3 and #15, level in #45	4.24	1.35	15.04	2.29
4.5" below in #3 and #15, level in #45	4.18	1.30	14.97	2.43
2.5" below in #3, #15, #45	4.19	1.34	14.91	2.38

Table 2. Caliper and height of live oak produced at different nursery planting depths at each shift to larger container 4 growing seasons after landscape planting.

Landscape planting depth	Caliper (in)	Caliper growth in 3 years (in)	Height (ft)	Height growth in 3 years (in)
Level	4.25	1.39	15.62 a[1]	2.25
4" Below	4.16	1.30	14.80 b	2.20
8" Below	4.21	1.35	14.80 b	2.54

[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.

Root pruning	Caliper (in)	Caliper growth in 3 years (in)	Height (ft)	Height growth in 3 years (ft)
Yes	4.17	1.30	14.89 b[1]	2.21
No	4.24	1.39	15.26 a	2.45

[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 tree quality will continue to be collected to determine the effect of planting depth on landscape live oak growth. Roots will be excavated in several years and trees pulled over or blown with the wind machine 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.

Conclusion: Root pruning at planting had no impact on growth the first four growing seasons after planting. The following report compares this root pruning technique at planting with another root pruning technique. See report on the following page.

Great Southern Tree Conference: Highrise® live oak root system quality and stability following root pruning

Ed Gilman, Maria Paz, Chris Harchick and Christine Wiese, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, Florida

Objective: Compare stability and root form on trees subject to various root pruning methods at planting.

What we did: In March 2008, 48 Highrise® live oaks were planted to the field from #15 containers. Trees were produced in containers from rooted cutting liners with the following planting depth treatments: (1) 0.5" below grade into #3 container, level into #15 container; (2) 0.5" below grade into #3, 2.5" below grade into #15; (3) 2.5" below grade into #3, level into #15; or, (4) 2.5" below grade into #3 and #15. Trees from each of these four depths in the containers were root pruned in three different ways before planting to the field for a total of twelve treatment combinations. The three root pruning treatments were: (1) no root pruning; (2) root ball shaved by removing 1.5" of the edge and bottom of the root ball (see photos); (3) root slicing by cutting 3-4" deep into the side of the root ball in 6 equidistant places from the top of the root ball to the bottom (see photos). Planted trees were irrigated three times a day. Each tree was fertilized with 200g of 16-4-8 on May 2008 and 400g on August and September 2008, and March and June 2009. Caliper and heights were collected on September 2008. Half of the trees on each treatment were pulled in November 2008 and the other half in September 2009 to test tree stability. Pull force was transformed to moment, which is the bending force of the tree. After the pulls, root data collected included: number of roots greater than 2 mm in the top and bottom half of the root balls, diameter of each root, and number of circling roots.

What we found as of November 2009: Planting depth in the container had no impact on tree growth the first year following planting. Root pruning at planting had no effect on tree caliper or height the first year following landscape planting (Table 1). Tree stability one and two years after landscape planting was not affected by planting depth in nursery container. Root pruning at planting increased tree stability, but differently in the two years after planting (Figure 1). For trees that were pulled on November 2008 (one year after planting), bending moment (force x length) required to reach a given trunk tilt was higher for root balls that were shaved or sliced than trees not pruned at planting. For trees pulled on September 2009 (2 years after planting), bending moment to reach a given trunk tilt was greater for trees whose root balls were shaved at planting compared to those sliced at planting.

For trees pulled on one year after planting (November 2008), number of roots and root cross-sectional area in the top half of the root ball were affected by root pruning treatment (Table 2). Root balls that were either sliced or shaved had more roots than those that were not root pruned. For trees pulled two years after planting (September 2009), root cross-sectional area was greater for trees that were either shaved or sliced, when compared to trees that were not root pruned. Root pruning also reduced amount of circling roots. It appears that root pruning at planting is not detrimental to the tree and has the potential to produce more stable trees, with a greater number of straighter roots.

Table 1. Caliper and height of Highrise® live oak from four different planting depths in containers and three types of root pruning at planting into the landscape.

Container Depth	Root Pruning Type	Caliper (in)	Height (ft)
0.5” below in #3; level #15	No Pruning	1.84	9.0
	Sliced	1.90	8.4
	Shaved	1.94	9.2
0.5” below in #3; 2.5” below in #15	No Pruning	1.87	8.8
	Sliced	1.90	9.2
	Shaved	1.91	8.4
2.5” below in #3; level #15	No Pruning	1.99	9.1
	Sliced	1.96	8.7
	Shaved	1.77	8.7
2.5” below in #3 and #15	No Pruning	1.99	9.4
	Sliced	1.98	9.1
	Shaved	1.92	9.1

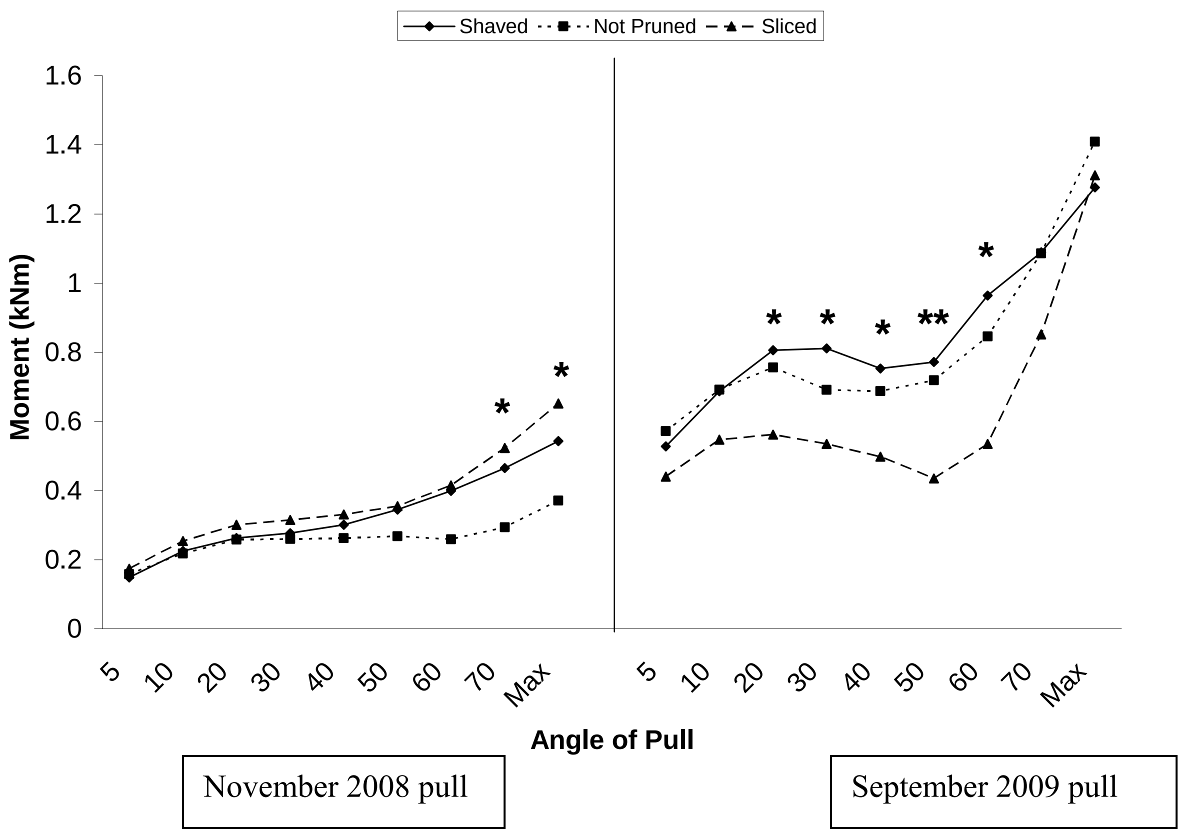

Figure 1. Moment (kNm) to pull trees to failure pulled at two different dates and under three types of root pruning (One star indicates $p<0.075$. Two stars indicates $p<0.05$).

Table 2. Effect of three types of root pruning on root ball characteristics and moment to 70 degrees of Highrise® live oaks pulled November 2008.

Root Pruning Type	Number of roots in top half of the root ball	Root cross-sectional area (mm^2) growing from top half of the root ball	Moment to 70 degs (kN*m)
No Pruning	6 b[1]	103.3 b	0.29 b
Sliced	12 a	192.7 ab	0.52 a
Shaved	12 a	268.4 a	0.46 a

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 8 trees per treatment.

Table 3. Effect of three types of root pruning on root ball characteristics and moment to 50 degrees of Highrise® live oaks pulled September 2009.

Root Pruning Type	Number of circling roots	Root cross-sectional area growing from root ball (mm^2)	Moment to 50 degs (kN*m)
No Pruning	11 a[1]	49.1 b	0.72 a
Sliced	5 b	73.1 a	0.44 b
Shaved	6 b	63.7 ab	0.77 a

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 8 trees per treatment.

Slicing made six radial cuts about 3 to 4 inches deep inside the root ball from top to bottom of the root ball.

Root ball shaving removed the entire outside inch of the root ball after planting by inserting the shovel blade tangent to the trunk as shown just inside of the periphery of the container root ball.

Great Southern Tree Conference: Impact of pruning dose on codominant stem growth of Highrise® live oak

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
Jason Grabosky, Dept of Ecology, Evolution and Natural Resources, Rutgers University
December 2 – December 4, 2009
Gainesville, Florida

Objective: Determine impact of amount of foliage removed from a codominant pruned stem on subsequent growth rate.

What we did: In May 2005, 48 5-inch caliper, 23 feet tall Highrise® live oaks were pruned to reduce the biomass of one codominant stem by one of four targeted pruning doses: 0% (control), 25%, 50%, or 75% foliage removed. On each tree, two similarly sized codominant stems growing from the same union were located, and the diameter at the base of each stem was measured. One of the stems (termed the codominant stem) was pruned according to the prescribed dose; the other stem was not pruned (termed the leader stem). To calculate the exact amount of biomass removed, the cross-sectional area of each pruning cut was measured and added together to give the total area of pruning cuts on that stem. Dose (as a percentage) was calculated as the total cross-sectional area of pruning cuts divided by the cross-sectional area of the pruned codominant stem just above the point where it joined the leader stem. One to four pruning cuts were made on each pruned stem to attain the targeted dose; some cuts were reduction cuts and some removal cuts. All trees were fertilized in a 12 ft x 16 ft plot with 2.4 lbs of 16-4-8 three times a year between 2003 and 2008. In May 2006, June 2007 and May 2008, the pruned and un-pruned stems of each tree were measured to determine stem diameter growth.

What we found as of November 2009: Pruned stems grew slower than stems that were not pruned in the first 3 years after administering the pruning (Figure 1). Increasing the pruning dose by removing more foliage and branches reduced growth in a more-or-less linear fashion. Pruned stems grew slower than stems that were not pruned (Figure 1). Furthermore, 3 years following pruning, the cross-sectional basal area of the non-pruned leader stem grew more for the target doses of 25% or 50% than trees pruned with the 75% dosage or non-pruned trees (Figure 2). Pruning at the 25% and 50% dose shifted (increased) growth to the leader compared to the leader on trees not pruned. Furthermore, pruning dose also had an effect on trunk diameter (Figure 3). Trees that received 25% pruning dose on the codominant grew more in trunk diameter (caliper) beginning in the first year following pruning than trees that were not pruned and trees that were pruned more severely (Figure 3).

Conclusion: Pruning reduced cross-sectional area growth on codominant stems compared to the leader stem that was not pruned, especially during the first 12 months following pruning. Increased pruning severity reduced cross-sectional area growth on the pruned stem in proportion to amount of foliage removed. In each of three years following pruning, cross-sectional area of the unpruned leader stem increased more on trees receiving targeted pruning severities of 25% or 50% than trees pruned with the 75% severity or trees not pruned. Shift in growth from the pruned to unpruned portion of the tree reduced diameter ratio between the two stems which should make the union stronger. Diameter ratio changed most for the 75% pruning severity. This supports the ANSI A300 pruning standard allowing more than 25% removal per stem, and provides guidelines for growers producing leaders when structurally pruning shade trees in a nursery, and for arborists pruning young trees in landscapes. It could also apply to younger outer portions of the crown of older trees where most structural pruning is conducted to resist storm damage.

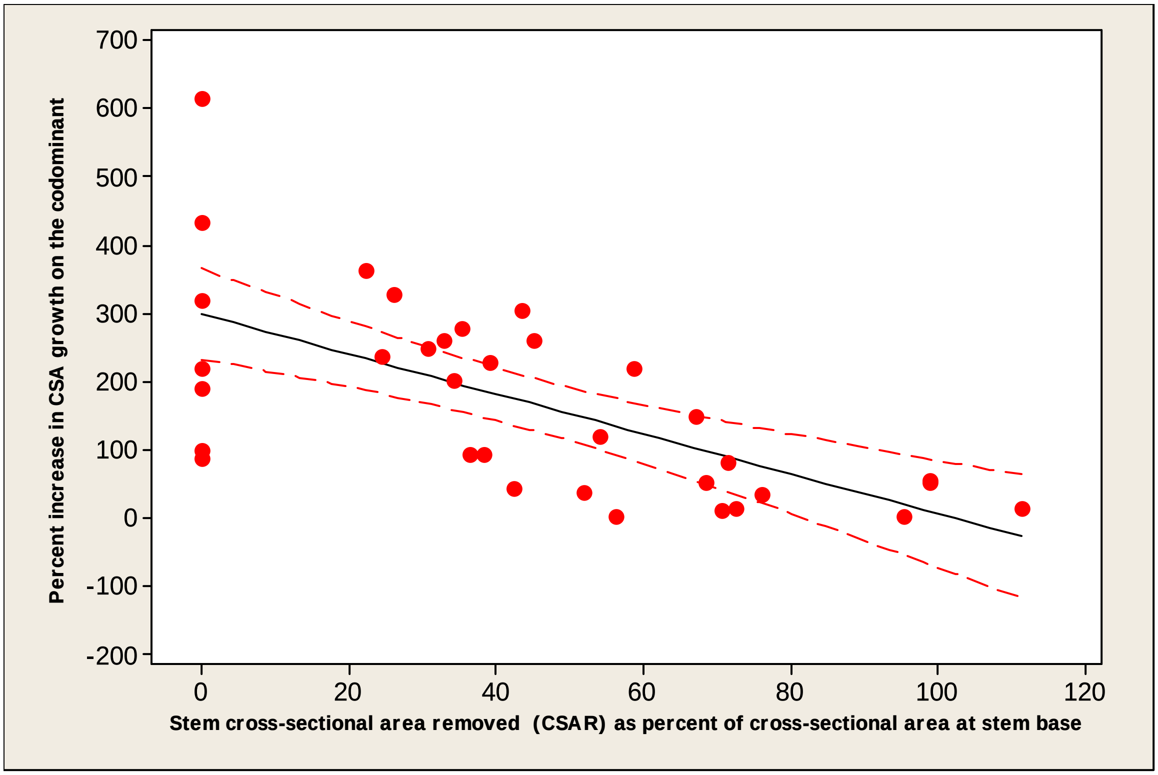

Figure 1. The percent increase in cross sectional area of the pruned codominant stem between May 2005 and May 2008 following removal of increasing amounts of stem cross-sectional area. Percent increase = 298.7 - 2.93 (CSAR), $r^2 = 0.43$, slope and intercept $P < 0.001$. The dotted lines represent a 95% confidence interval for the regression equation.

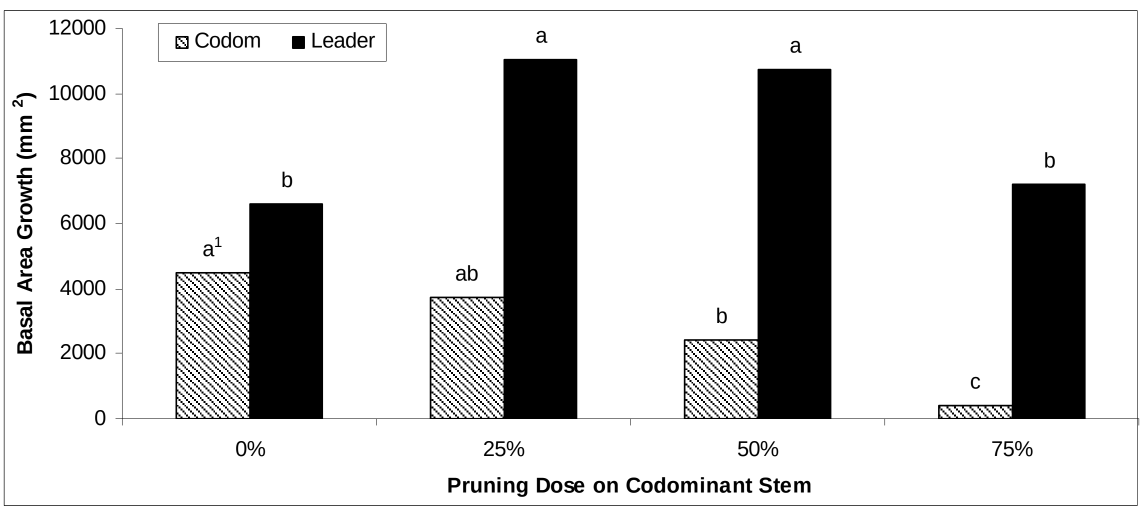

Figure 2. Basal area growth of pruned codominant stem and non-pruned leader stem following removal of target pruning dose. [1] Bars for leader or codominant stem with the same letter are not statistically different at $P < 0.05$. Codominant and leader stem are not compared.

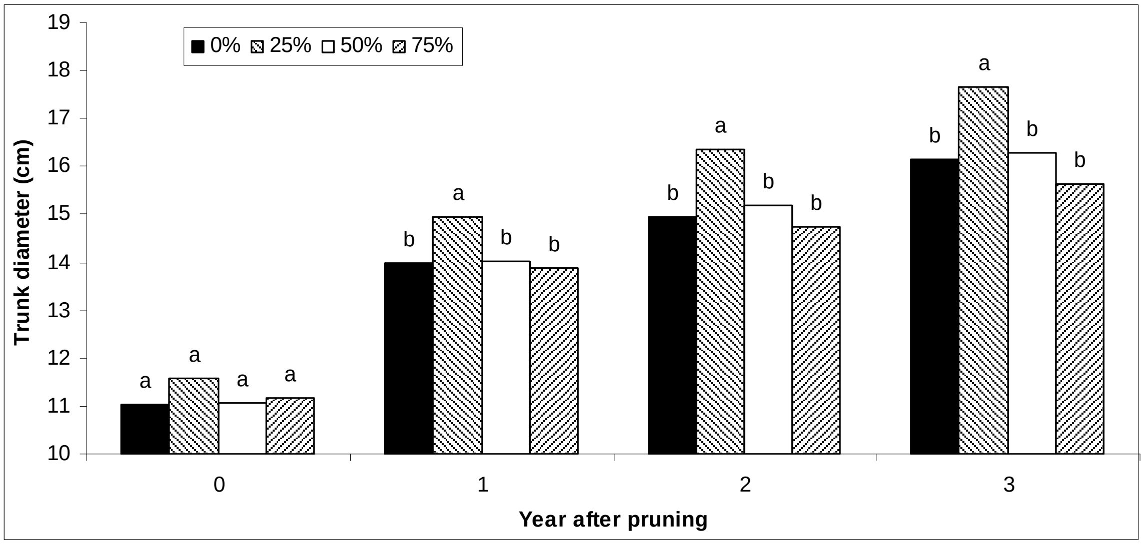

Figure 3. Trunk diameter 30 cm (12 in) from ground at pruning and in three subsequent years for four pruning severities (0, 25, 50 and 75%) from one codominant stem. Note: Within a year, bars with the same letter are not statistically different at P < 0.05.

Codominant stems were reduced by removing branches from the ends with reduction and removal cuts.

Pictured at left is the typical amount removed from a stem in the 75% dose treatment. Removed branches range from ½ to about 2 inches diameter.

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 2 – December 4, 2009
Gainesville, Florida

Objective: Determine impacts of container type and root ball shaving on root defects including kinks, formation of stem girdling roots and diving roots.

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, SmartPot®, RootBuilder®, RootMaker®, Fanntum™, Florida Cool Ring™, Airpot™ or Jackpot™, and were placed pot to pot. Substrate was 20: 60: 20 (New Florida peat: pine bark: sand, volume) for RootMaker®, RootBuilder®, Fanntum Pot, Florida Cool Ring™ and Jackpot™ , and 50: 40: 10 (New Florida peat: pine bark: sand) for Air-Pot™, Smart Pot® 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) since the largest size of RootMaker® is #5, and will be referred as the RootTrapper® from this point on. 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) will be destructively harvested to evaluate root defects. The rest of the trees (13 trees for each treatment combination) will be shifted into #45 containers of the same 8 container types. Roots will be pruned before shifting following the same protocol described above. In summer 2011, five trees of each treatment combination will be destructively harvested to evaluate root defects. The rest of the trees (8 trees for each treatment combination) will be planted into the landscape. In spring 2012, stress required to pull trees to a 10 degree angle will determine landscape tree stability. After 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 2009: Caliper on red maples growing in smooth-sided #3 containers was no different than for any other container type (Table 1). However, trees in RootMaker® pots produced larger caliper and height than trees in either Jackpot™ or Florida Cool Ring™, and trees in RootBuilder® and Smart Pot® grew more caliper than trees in Jackpot™. Jackpot™ had 15% less substrate than other containers which may have accounted for smaller caliper. Trees in Smart Pot® grew more in height than trees in Florida Cool Ring™. There were no other differences in caliper or height among container types. For #3 sized trees planted into landscape soil, there was no difference in caliper or heights for the different container types.

Only trees in smooth-sided containers had roots 100% around the top of containers (Table 2). As a result all 9 trees excavated from smooth-sided containers were graded a cull according to Florida Grades and Standards for Nursery Stock. Trees in smooth-side pots had lesser root ball quality rating than all other container types except RootMaker®, but trees in Jackpot™ and Airpot™ had a higher quality rating than those in smooth-sided and RootMaker® pots (Table 2). Diameter of the 5 largest roots emerging from the trunk was smaller in Jackpot™ than smooth-sided, RootMaker®, RootBuilder®, and Smart Pot® containers. RootMaker® had larger diameter peripheral roots than Fanntum pot, Jackpot™ and Smart Pot®. Jackpot™ had smaller diameter peripheral roots than smooth-sided and Smart Pot® (Table 2). A higher percentage of the largest 5 roots branched as they met the container wall in Smart Pot®, RootBuilder®, and Fanntum Pot compared to smooth-sided (Table 3). A larger percentage of the 5 largest roots circled as they met the container wall in the RootMaker® than in Air-Pot™, Florida Cool Ring™, and Jackpot™. A larger percentage of the 5 largest roots descended as they met the container wall in JackPot™, and Florida Cool Ring™ compared to RootBuilder®, RootMaker®, SmartPot® and Fanntum™ Pot. This project is ongoing and more data will be collected in the next four years to develop a better understanding of container types and root pruning on root form and stability following planting into the landscape.

Table 1. Caliper and height of 'Florida Flame' maples growing in eight different #3 and #15 container types, and field grown trees from #3 containers.

	#3 Containers		#15 Containers		#3s planted into landscape soil	
Container type	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	38.9	10.5
Cool Ring™	15.8 c	6.4 b	38.3 d	9.0 b	40.3	11.4
Fanntum™	17.4 ab	7.0 a	40.5 bc	9.3 ab	42.3	10.9
Jackpot™	14.6 d	6.5 b	37.8 d	8.7 b	38.3	10.6
RootBuilder®	17.7 a	7.2 a	40.1 c	9.0 b	40.6	10.5
RootMaker then RootTrapper®	17.7 a	7.1 a	41.2 bc	9.3 ab	39.3	10.4
SmartPot®	16.6 bc	6.9 a	43.1 a	9.2 ab	42.6	10.7
Smooth sided	17.4 ab	7.1 a	43.0 a	9.2 ab	38.3	9.9

[1]Means in a column with a different letter are statistically different at P < 0.05. Based on 48 trees per treatment for #3 and 36 trees per treatment for #15.

Table 2. Root ball characteristics of 'Florida Flame' maples finishing out in eight different #3 container types.

Container type	% root ball with circling roots	% trees graded as a cull[1]	Root ball quality rating[2] (1-5)	Diameter of 5 largest roots inside (mm)	Diameter of 5 largest roots on periphery (mm)
Airpot™	30 b[3]	33 ab	4.1 a	5.4 ab	3.7 abc
Cool Ring™	29 b	56 a	3.1 ab	6.0 ab	3.9 abc
Fanntum™	41 b	44 ab	3.2 ab	5.6 ab	3.5 bc
Jackpot™	30 b	22 ab	3.9 a	4.6 b	3.0 c
RootBuilder®	29 b	56 b	3.4 ab	6.3 a	3.9 abc
RootMaker®	47 b	56 a	2.5 bc	6.0 a	4.9 a
SmartPot®	51 b	67 a	3.0 ab	6.0 a	3.3 bc
Smooth sided	85 a	100 a	1.4 c	6.0 a	4.5 ab

[1] Based on Florida Grades and Standards for Nursery Stock.
[2]1 = poor quality root ball; 5 = excellent quality root ball.
[3]Means in a column with a different letter are statistically different at P < 0.05. Based on 9 trees per treatment.

Table 3. Form of the 5 largest diameter roots of red maple grown in eight different #3 container types.

	Percent of 5 largest roots reaching the container wall that:		
Container type	Branched	Circled	Descended
Airpot™	36.0 abcd[1]	21.2 b	37.6 abc
Cool Ring™	28.3 cd	23.3 b	38.4 ab
Fanntum™	39.3 abc	29.0 ab	27.7 bc
Jackpot™	27.3 cd	20.1 b	46.3 a
RootBuilder®	40.8 ab	26.9 ab	21.2 bc
RootMaker®	31.1 bcd	41.2 a	19.8 c
SmartPot®	44.4 a	25.5 ab	23.5 bc
Smooth sided	23.5 d	31.1 ab	37.3 abc

[1]Means in a column with a different letter are statistically different at $P < 0.05$. Based on 9 trees per treatment.


Air-Pot™


Florida Cool Ring™


Fanntum Pot™


SmartPot®


Jackpot™


RootBuilder®


RootMaker®


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 2 – December 4, 2009
Gainesville, Florida

Objective: Track growth, root characteristics, and stability of trees 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 irrigation the first 3 weeks followed by 7 gallons thereafter for #300, 5 gallons for #65 and #25, and 2.5 gallons for #3). 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, half of the irrigated trees and half of the non-irrigated trees for each size were mulched with a 3" layer of shredded hardwood, while the other half was kept bare with periodic applications of Roundup. Trees have not been fertilized since planting. Caliper and height measurements were collected for all trees in October 2009.

What we found as of November 2009: Mulch had a small growth enhancing effect on caliper and height three years after planting (Table 1). 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 1A). Height on the largest trees (planted from #300 containers) did not increase much the first three years after planting (Figure 1B). This allowed the smaller trees to somewhat catch up to these larger trees. The smaller trees grew more than the larger trees relative to where they began, with the #3 trees growing at the fastest rate (Table 2).

Irrigated trees grew more in caliper than non-irrigated trees, when comparing across all sizes. Irrigated trees had a caliper of 6.29-in, while non-irrigates trees had a caliper of 5.92-in. Irrigation interacted with tree size to affect height and caliper increase (Table 2). Irrigated trees from #3 containers had greater caliper only than those not irrigated from the same size. Irrigated trees from all the other sizes had similar height and caliper increases when compared to non-irrigated trees.

Table 1. Caliper (in) and height (ft) for mulched and non-mulched trees averaged over #3, #25, #65 and #300 container trees.

Mulch	Caliper (in)	Height (ft)
Yes	6.34 a[1]	26.1 a
No	5.86 b	24.8 b

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

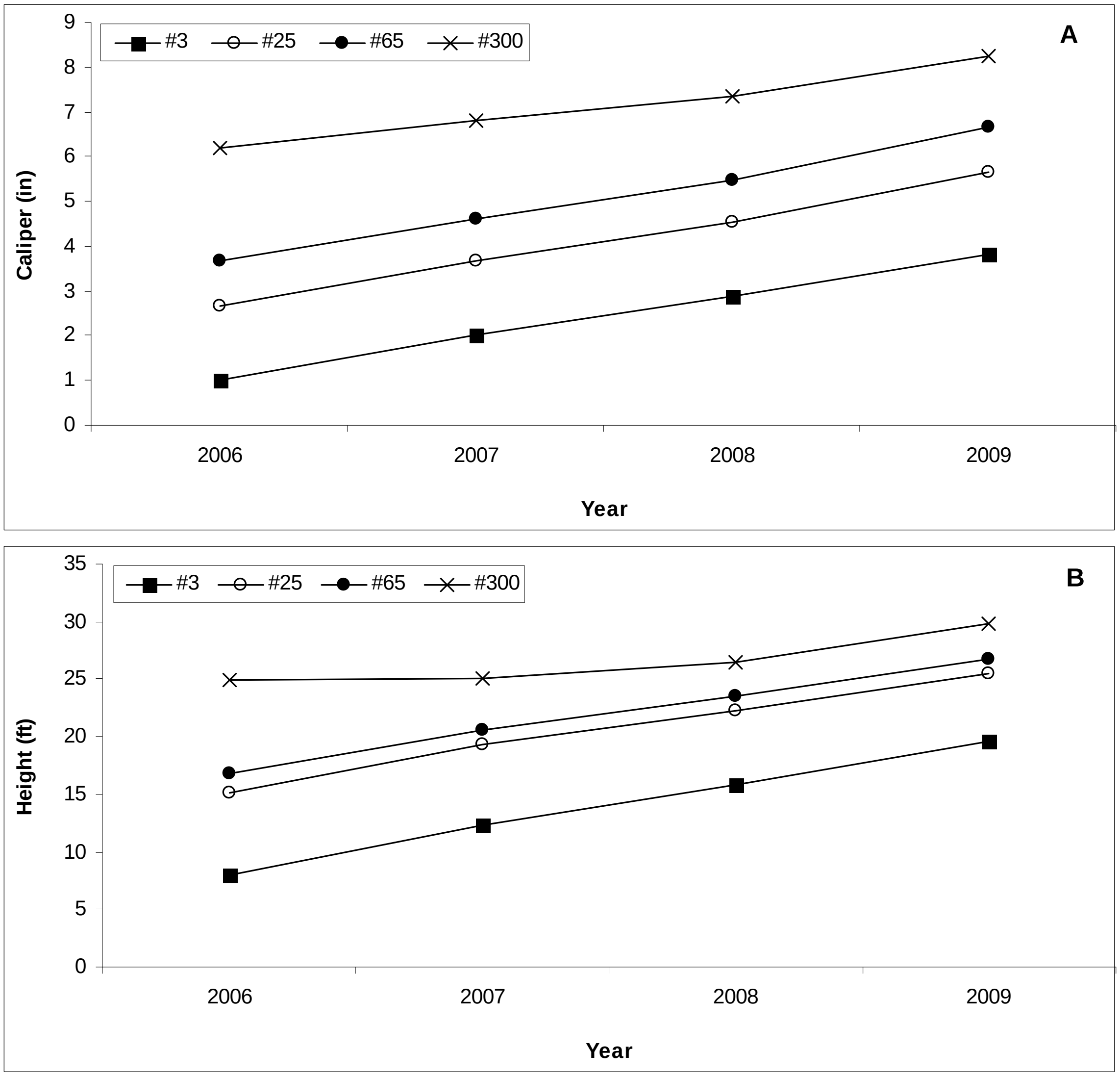

Figure 1. Caliper (A) and height (B) of 'Florida Flame' maples from September 2006 to October 2009 planted from #3, #25, #65 and #300 containers.

Table 2. Percent caliper and height increase between September 2006 and October 2009 after planting 'Florida Flame' maple into the field from #3, #25, #65 and #300 containers that were irrigated or not irrigated in the landscape.

Size at planting	Irrigation	Caliper increase (in)	Height increase (ft)
#3	Yes	3.2 a[1]	11.8 a
	No	2.4 bcd	11.4 a
#25	Yes	3.3 a	10.1 a
	No	2.7 abc	10.6 a
#65	Yes	3.1 ab	10.2 a
	No	2.9 ab	9.9 a
#300	Yes	2.0 d	4.9 b
	No	2.1 cd	4.8 b

[1]Means in a column with a different letter are statistically different at P<0.05. Based on 8 trees per treatment combination.

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 2 – December 4, 2009
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.

What we did: In April 2008, 40 #3 container-grown 'Florida Flame' maples and 40 Cathedral® 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 #15s 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 collected included: root ball quality ratings (where 1 = poor root ball quality and 5 = excellent root ball quality), main root diameter, number of roots growing into the #15 substrate greater than 2 mm diameter, and whether the tree was considered a cull based on Florida Grades and Standards for Nursery Stock. Caliper and heights of all trees were also collected in September 2008. 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 test tree stability in the landscape resulting from root pruning treatment with root balls intact. 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 watered three times a week and were fertilized with 200g of 16-4-8 on March and June 2009. Trees were pulled until the trunk base tilted 5 degrees to test stability on August 2009 for the maples and October 2009 for the live oaks. Moment was calculated as pulling force x distance between ground and pulling point..

What we found as of November 2009: 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 from 100% for non-root pruned trees to 40% for trees with shaved root balls (Table 1). Shaving maples before shifting into #15 containers also produced higher quality root balls and a greater number of lateral roots larger than 2 mm diameter growing into the #15 substrate (Table 1). These roots grew more-or-less straight out or at a slight angle away from the trunk. For live oaks, root ball shaving also improved root ball quality and increased number of roots growing out into the #15 substrate (Table 1).

Root pruning as trees were shifted from #3 into #15 containers had no effect on caliper, height, or bending moment required to tilt trunks to 5 degrees one year after landscape planting (Table 2). This project is ongoing and we will continue to pull trees to test tree stability for several years.

Conclusion: Shaved off root defects from the outer periphery of the root ball when trees were shifted from #3 to #15 containers in the nursery has not compromised growth or stability one year after planting into the landscape.

Table 1. Root ball characteristics of 'Florida Flame' maples and Cathedral® live oaks root pruned by shaving the outer inch of the root ball or not root pruned before shifting from #3 containers into #15 containers.

Species	Root Pruning	% Culls[1]	Root rating[2]	Main root diameter (mm)	Number of roots >2 mm[3]
Maples	No pruning	100	2.0 b[4]	15.3 a	26 b
	Shaving	40	4.3 a	11.5 b	47 a
Live Oaks	No pruning	50	2.7	12.9	37 b
	Shaving	30	3.1	13.3	47 a

[1] Based on Florida Grades and Standards for Nursery Stock.
[2] 1 = poor quality root ball 5 = excellent quality root ball.
[3] Number of roots growing out into the substrate in the #15 container.
[4] Means in a column with a different letter are statistically different at $P < 0.05$. Based on 10 trees per treatment.

Table 2. Caliper, height and trunk bending moment required to pull trees to 5 degree tilt one year after planting into the landscape of 'Florida Flame' maples and Cathedral® live oaks root pruned by shaving the outer inch of the root ball or not root pruned when shifted from #3 to #15 container.

Species	Root Pruning	Caliper[1] (in)	Height[1] (ft)	Moment (kNm)[1]
Maples	No pruning	2.38	13.0	0.37
	Root ball shaving	2.30	12.2	0.33
Live Oaks	No pruning	2.00	11.0	0.21
	Root ball shaving	1.92	11.0	0.22

[1] Based on 10 trees per species. There were no differences among treatments.

Shaving the root ball removes the outer edge and bottom of the root ball.

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 2 – December 4, 2009
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 were irrigated three times a week. Trees were fertilized with 400 grams of 16-4-8 on March and June of 2008. All trees were staked with the Terra Toggle root ball stabilization system in June 2008, which was removed in June 2009. Caliper and heights were collected on October 2009.

What we found as of November 2009: 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 (Table 1). There was no difference in heights between the 8 treatments almost two years after planting (Table 2). The average height for elms two growing seasons after landscape planting was 19.7 ft, and 21.8 ft for the maples. Some trees under went severe root removal, but it appears that it has not affected tree height in the landscape.

Elm trunk caliper two growing seasons after landscape planting was slightly affected by planting depth in the nursery container, with evenly planted trees having a greater caliper (3.8 in) than deep planted trees (3.6 in). Maple calipers were affected by the interaction of root removal and mulch over the root ball (Table 3). 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 2). This difference in caliper is small (less than half an inch), but it will be interesting to see how trees keep growing. This project is still ongoing and more time will be needed to determine the long term impact of the treatments.

Conclusion: Keeping mulch off the root ball had no detrimental effects on trees in the first 16 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.

Table 1. Time it took to remove root defects of even or deep planted in #45 on maples and elms.

Species	Planting Depth in #15	Air spade time (sec)	Root prune time (sec)	Total time (sec)
Elms	Level	70 b[1]	185 b	255 b
	2.5" deep	102 a	328 a	430 a
Maples	Level	98 b	380 b	478 b
	2.5" deep	153 a	756 a	909 a

[1]Means in a column within species with a different letter are statistically different at $P<0.05$. Based on 10 trees per treatment.

Table 2. Height of trees 16 months after planting that were root pruned or not root pruned before planting from #45 containers.

Species	Root pruning at planting	Height (ft)
Elms	Yes	19.8
	No	19.6
Maples	Yes	21.4
	No	22.2

Table 3. Effect of root defect removal prior to planting and placement of mulch over the root ball on caliper of maples16 months after planting.

Root defect removal at landscape planting	Mulch over root ball at planting	Caliper 16 months after planting(in)
Yes	Yes	4.20 ab[1]
	No	4.43 a
No	Yes	4.34 ab
	No	4.09 b

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

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.

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 (these trees are not shown here).

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 2 – December 4, 2009
Gainesville, Florida

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

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. All trees were irrigated three times a day. Maples and elms were staked in October 2007, and pruned to establish a leader in July 2008 and March 2009. Calipers and heights were collected on October 2007, 2008 and 2009.

What we found as of November 2009: For elms, caliper, height, and height increase were affected by time in different container sizes (Table 1). Overall, elms that spent less time in #3 had greater caliper, and elms that spent less time in #3 and #15 were shorter. For magnolias, caliper, height, caliper increase, and height increase were also affected by time in different container sizes (Table 1). Magnolias that spent less time in #3 containers had the greatest caliper, while those that spent less time in #3 and #15 were the tallest.

Maples responded differently. For maples, caliper, height, caliper increase, and height increase were affected by time in different container sizes (Table 1). Maples that spent less time in #3 and #15 containers had the smallest caliper and were the shortest. The main objective of this project is to study influence of time in each container size on root defects. This data was collected October 2009 but has not been analyzed. You will see the root systems at the demonstration site today.

Table 1. Caliper, height, % caliper increase, and % height increase from October 2007 to 2009 of elm, magnolia and maple grown for different times in #3, #15, and #45.

Treatment	Caliper (in)	% caliper increase	Height (ft)	% height increase
Elm				
4 mo #3; 8 mo #15; 20 mo #45	2.63 a[1]	214	12.9 b	110 b
7 mo #3; 10 mo #15; 15 mo #45	2.66 a	262	14.1 a	142 ab
9 mo #3; 12 mo #15; 11 mo #45	2.52 a	241	14.8 a	166 a
12 mo #3; 14 mo #15; 6 mo #45	2.36 b	247	13.9 ab	151 ab
Magnolia				
4 mo #3; 8 mo #15; 20 mo #45	2.42 a	215 bc	11.0 a	200 b
7 mo #3; 10 mo #15; 15 mo #45	2.44 a	263 a	10.3 b	246 a
9 mo #3; 12 mo #15; 11 mo #45	2.20 b	237 b	10.5 b	258 a
12 mo #3; 14 mo #15; 6 mo #45	2.02 b	195 c	10.2 b	231 ab
Maple				
4 mo #3; 8 mo #15; 20 mo #45	2.57 b	196 b	14.7 ab	181 b
7 mo #3; 10 mo #15; 15 mo #45	2.80 a	323 a	15.4 a	265 a
9 mo #3; 12 mo #15; 11 mo #45	2.74 a	334 a	14.6 b	259 a
12 mo #3; 14 mo #15; 6 mo #45	2.71 a	309 a	15.5 a	255 a

[1] Means in a column within species with a different letter are statistically different at $P<0.05$. Based on 20 trees per treatment for magnolia and maple, and 12 trees per treatment for elm.

Great Southern Tree Conference: Tropical tree production and root pruning.

Ed Gilman, Maria Paz and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, Florida

Objective: Determine if root pruning affects tropical tree production.

What we did: In May 2008, five species (Mahogany, Gumbo Limbo, Royal Poinciana, Lysiloma and pink Tabebuia) were shifted into #15. Ten trees of each species from smooth-sided #3 containers were shifted into #15. Before potting into #15, five trees were root pruned by shaving off the outer peripheral inch of the root ball sides with a sharp blade. The other five trees were potted with the root ball untouched. All trees were watered three times a day. Trees were pruned and staked in June 2008. Trees were fertilized with Graco slow release 19-5-11 with 200 g for the #15. The last week of October the trees had to be placed indoors to protect them from frost. Calipers and height were collected in October 2008. The root balls were harvested in November 2008 to characterize the root system.

What we found as of November 2009: Root pruning when shifting into #15 had no effect on tree caliper or height (2008 GSTC Report). Shaving the root ball of tropical trees eliminated culls, except for Gumbo Limbo (Table 1). All trees produced better root systems when the root ball was shaved; these root systems had straighter roots growing into the #15 media and almost no circling roots when compared to trees that were not root pruned (Table 1). For Mahogany, Royal Poinciana and Pink Tabebuia, root ball shaving produced a greater number of larger roots growing laterally into substrate in the #15 container (Table 1). It appears that root shaving tropical trees when shifting from #3 to #15dramatically improves root ball quality by reducing root ball defects without affecting tree growth in the nursery.

Table 1. Root characteristics of tropical trees root pruned or not when shifting into #15 containers.

Species	Root Pruning	% Cull[1]	Root rating (1-5)[2]	Number of roots >2mm[3]	# of primary roots with straight branching roots	# of roots circling at #3 container wall
Gumbo Limbo	None	20	2.8 b	15	1.2 b	3.2 a
	Shaved	0	4.4 a	34	3.4 a	0.2 b
Lysiloma	None	80 a[4]	1.8 b	17	1.4 b	2.2 a
	Shaved	0 b	4.2 a	18	3.8 a	0 b
Mahogany	None	80 a	1.2 b	17 b	0.6 b	2.6 a
	Shaved	0 b	4.6 a	33 b	3.6 a	0.4 b
Royal Poinciana	None	80 a	1.2 b	7 b	1.2 b	3.6 a
	Shaved	0 b	4.8 a	22 a	3.6 a	0.2 b
Pink Tabebuia	None	100 a	1.0 b	22 b	1.0 b	2.0 a
	Shaved	0 b	4.6 a	43 a	4.6 a	0 a

[1] Based on Florida Grades and Standards for Nursery Stock.
[2] 1 = poor quality root ball 5 = excellent quality root ball.
[3] Number of roots growing out into the substrate in the #15 container.
[4] Means in a column with a different letter are statistically different at $P < 0.05$. Based on 10 trees per treatment.

Tabebuia in a #15 not root pruned when shifted from a #3 showing several large diving and circling roots at the position of the #3 container.

Tabebuia in a #15 shaved when shifted from a #3 showing many straight roots and virtually no defects. Small roots circling the #15 container are easily removed when shifted to larger size.

Mahogany in #15 not root pruned when shifted from the #3. The roots that circled the #3 pot are clearly visible.

Mahogany in #15 shaved when shifted from a #3 showing many straight roots and virtually no defects. Root ball shaving works to reduce defects!

Great Southern Tree Conference: Interaction of fertilization and pruning in sabal palms.

Tim Broschat, Fort Lauderdale Research and Education Center (REC)
Ed Gilman, Maria Paz, and Chris Harchick, Environmental Horticulture, University of Florida
December 2 – December 4, 2009, Gainesville, FL

Objective: To demonstrate the interactive effects of fertilization and pruning on health and appearance of sabal palms.

What we did: Ten sabal palms spaced 20 feet apart with 24" deep plastic root barriers between trees received no fertilizer, ten received 0.12 lbs N/100 ft^2 from a 16-4-8 turf fertilizer every 3 months, and ten received the same amount of N from an 8-2-12-4Mg palm fertilizer every 3 months. Beginning March 2008, the 16-4-8 turf fertilizer was replaced with 16-0-8 due to availability. Fertilizer was spread over a circular 100 sq. ft. area. Half of the palms in each fertilizer treatment had only dead leaves removed once per year, while the other half had all but the 4 youngest leaves removed once per year. The trees were fertilized and pruned in March 2006, 2007, 2008, and 2009. Palms were fertilized again in July and November of each year. Total number of leaves, number of green leaves, and severity of potassium (K)-deficient leaves were recorded in March 2007, 2008 and 2009. A similar experiment was initiated at the Fort Lauderdale REC on January 2006 with data collected in October 2007, 2008, and 2009.

What we found as of November 2009: For both locations, fertilizer type had no effect on total number of leaves, number of green leaves, or potassium deficiency symptoms (Table 1 and 2). However, at Ft. Lauderdale, fertilization with either product slightly increased leaf blade length over that of unfertilized palms (Table 2). For both locations, severe pruning resulted in fewer living leaves one year later (Table 3 and 4). Since there were fewer leaves in severely pruned palms when compared to palms which had only dead leaves removed only, the proportion of leaves that were green was much greater for the severely pruned palms. Also, potassium deficiency scores were higher for severely pruned palms than for palms with only dead leaves removed (Table 3 and 4). These results have been consistent for the four years of results that have been analyzed for this experiment on both sites.

Conclusions: Severe pruning reduced number of leaves in the canopy to less than this number so that the potassium reserves were distributed among fewer leaves. This resulted in a smaller canopy and less visible potassium deficiency symptoms. This study is ongoing and more data will be collected annually.

Table 1. Effect of fertilizer type on number of total and green leaves, percent green leaves, and K deficiency score for sabal palms in Gainesville, March 2009.

Fertilizer	Total living leaves	Green leaves	% Green leaves	K deficiency score*
None	29	14	57.0	4.40
16-0-8	27	14	57.8	4.25
8-2-12+4	29	14	57.2	4.32

*0 = dead, 1 = severe K deficiency, 3 = moderate K deficiency, 5 = no deficiency symptoms.

Table 2. Effect of fertilizer type on number of total and green leaves, percent green leaves, and K deficiency score for sabal palms in Fort Lauderdale, March 2009.

Fertilizer	Total living leaves	Green leaves	% Green leaves	K deficiency score*	Leaf blade length (cm)
None	15	2	13.1	3.9	45.0 b[1]
16-4-8	17	4	22.0	4.0	49.5 a
8-2-12+4	17	4	22.9	4.1	47.5 a

[1] Means in a column with a different letter are statistically different at $P < 0.05$. Based on 5 trees per treatment.
*0 = dead, 1 = severe K deficiency, 3 = moderate K deficiency, 5 = no deficiency symptoms.

Table 3. Effect of leaf pruning on number of total and green leaves, percent green leaves, and K deficiency score for sabal palms in Gainesville March 2009.

Pruning	Total living leaves	Green leaves	% Green leaves	K deficiency score*
Dead only	39 a[1]	14	36.3 b	3.89 b
Severe	18 b	14	78.3 a	4.76 a

[1] Means in a column with a different letter are statistically different at $P<0.05$. Based on 5 trees per treatment.
*0 = dead, 1 = severe K deficiency, 3 = moderate K deficiency, 5 = no deficiency symptoms.

Table 4. Effect of leaf pruning on number of total and green leaves, percent green leaves, and K deficiency score for sabal palms in Fort Lauderdale, October 2008.

Pruning	Total living leaves	Green leaves	% Green leaves	K deficiency score*
Dead only	22 a[1]	5	22.9 b	3.96 b
Severe	12 b	8	64.5 a	4.89 a

[1] Means in a column with a different letter are statistically different at $P < 0.05$. Based on 5 trees per treatment.
*0 = dead, 1 = severe K deficiency, 3 = moderate K deficiency, 5 = no deficiency symptoms.

Potassium deficiency symptoms.

Sabal March after removing only dead leaves.

Same palm November.

Great Southern Tree Conference: Irrigation volume and frequency affect shrub establishment in Florida

Ed Gilman, Christine Wiese, and Maria Paz, Environmental Horticulture, University of Florida
December 2 – December 4, 2009
Gainesville, Florida

What we did: Three species, *Ilex cornuta* 'Burfordii Nana', *Pittosporum tobira* 'Variegata', and *Viburnum odorotissimum*, where planted from #3 containers in an open, sunny location in Citra, FL on May 2004 and November 2004 on 6 ft centers with tops of root balls even with the landscape soil, and immediately mulched with no mulch on top of the root balls. Two irrigation frequencies (every 2 or 4 days) and three irrigation volumes (3, 6, or 9 L per shrub per irrigation even) were evaluated. Five shrubs of each species were used for each treatment combination. Irrigation was discontinued 11 weeks after planting. Midday water potential (a measure of water stress) was measured two months after irrigation was discontinued. Shrubs were fertilized every 3 months, beginning 30 days after planting, at a standard rate of 1 lbs N/1000 sqft with 12-2-14 in a 3x3 ft area around each shrub. Shrub height and widths were measured at planting and 26, 34 and 52 weeks after planting. Root shrub radius was also collected 26, 34 and 52 weeks after planting and compared to shrub radius to root to shoot ratio. Shrubs were harvested 64 weeks after planting by cutting the trunk at ground level and collecting the entire above ground canopy. One quarter of the root system in the landscape soils was also harvested starting at the trunk and washing all the soil off. Shoot and root mass were dried and dry weight measured. Root to shoot biomass ratio was calculated by dividing the total calculated root system dry eight by canopy dry weight.

What we found: Irrigation frequency and volume had no effect on *Pittosporum* at any time for any measured root or shoot parameter (data not shown). Irrigation frequency and volume had no effect on *Ilex* and *Viburnum* canopy biomass, root biomass, root dry weight:canopy dry weight ratio, and stem water potential at any time after planting. Canopy growth was affected by irrigation treatment only for *Viburnum* plants installed in May 2004, and growth response to more frequent irrigation only occurred while plants were irrigated, with no lasting impact on growth once irrigation ceased (Figure 1). Root spread and root spread:canopy spread ratio for only one shrub, *Ilex*, were influenced by irrigation treatment (Figure 2). Applying excessive irrigation volume (in this case 9L) reduced root dry weight:shoot dry weight ratio for *Ilex* and could increase the time needed for plants to grow enough roots to survive without irrigation. We found only slight influences on shrub growth from the tested values of irrigation frequency and volume regardless of the time of year when data was collected. This indicates that these shrubs can be established with 3L irrigation applied every 4 days until roots reach the edge of the canopy under the mostly above normal rainfall conditions of this study. Applying more volume or more frequently did not increase survival or growth. Canopy growth and plant quality data combined with past research suggest that establishment of these shrub species may be more influenced by environmental conditions such as rainfall than by the irrigation frequency and volume used in this test (Figure 3).

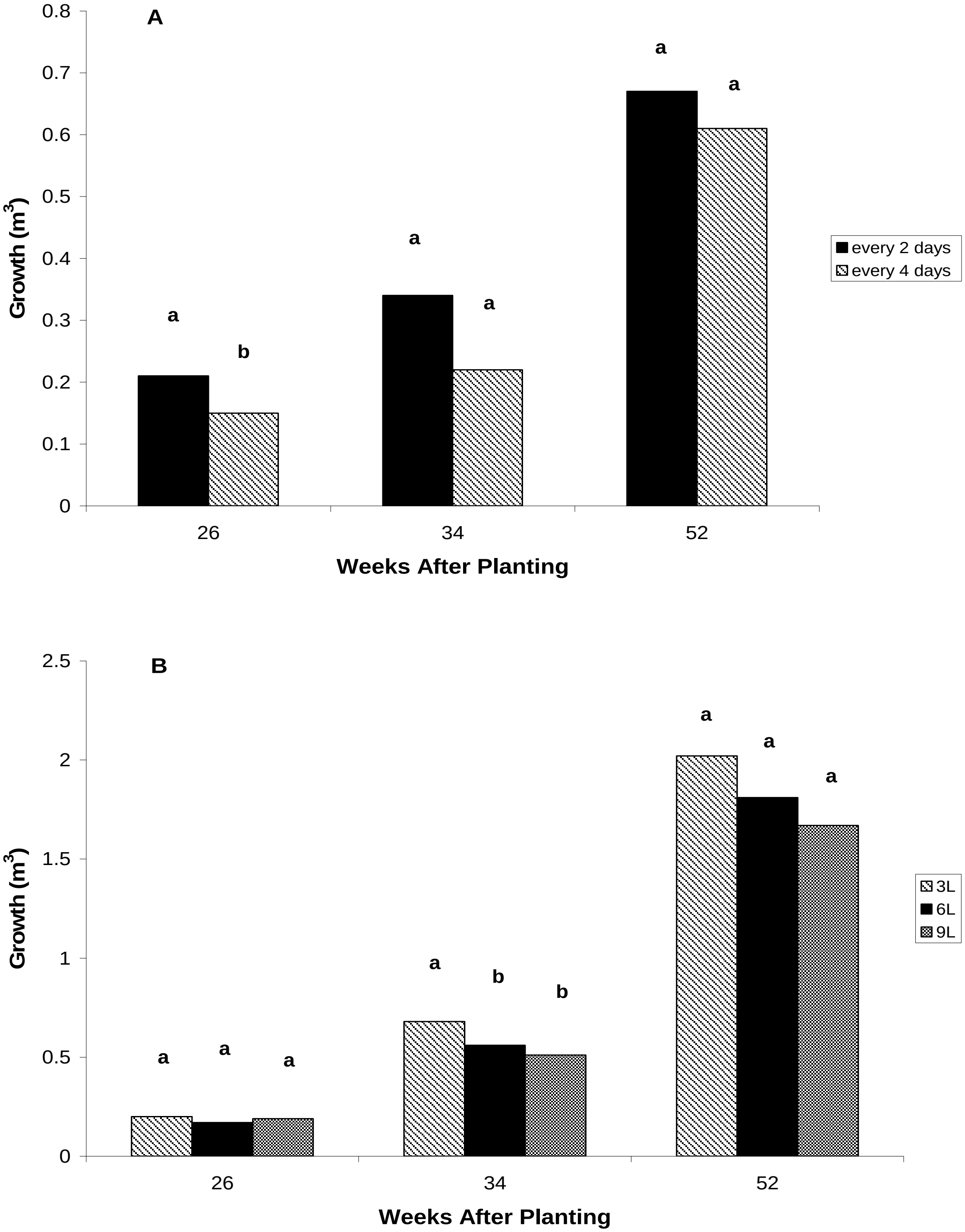

Figure 1. Effect of irrigation treatments on canopy growth of *Vibrunum*. Letters denote significant differences ($P < 0.05$) between irrigation frequencies (A) and volumes (B) at 26, 34, or 52 weeks after planting in May (A) or November (B).

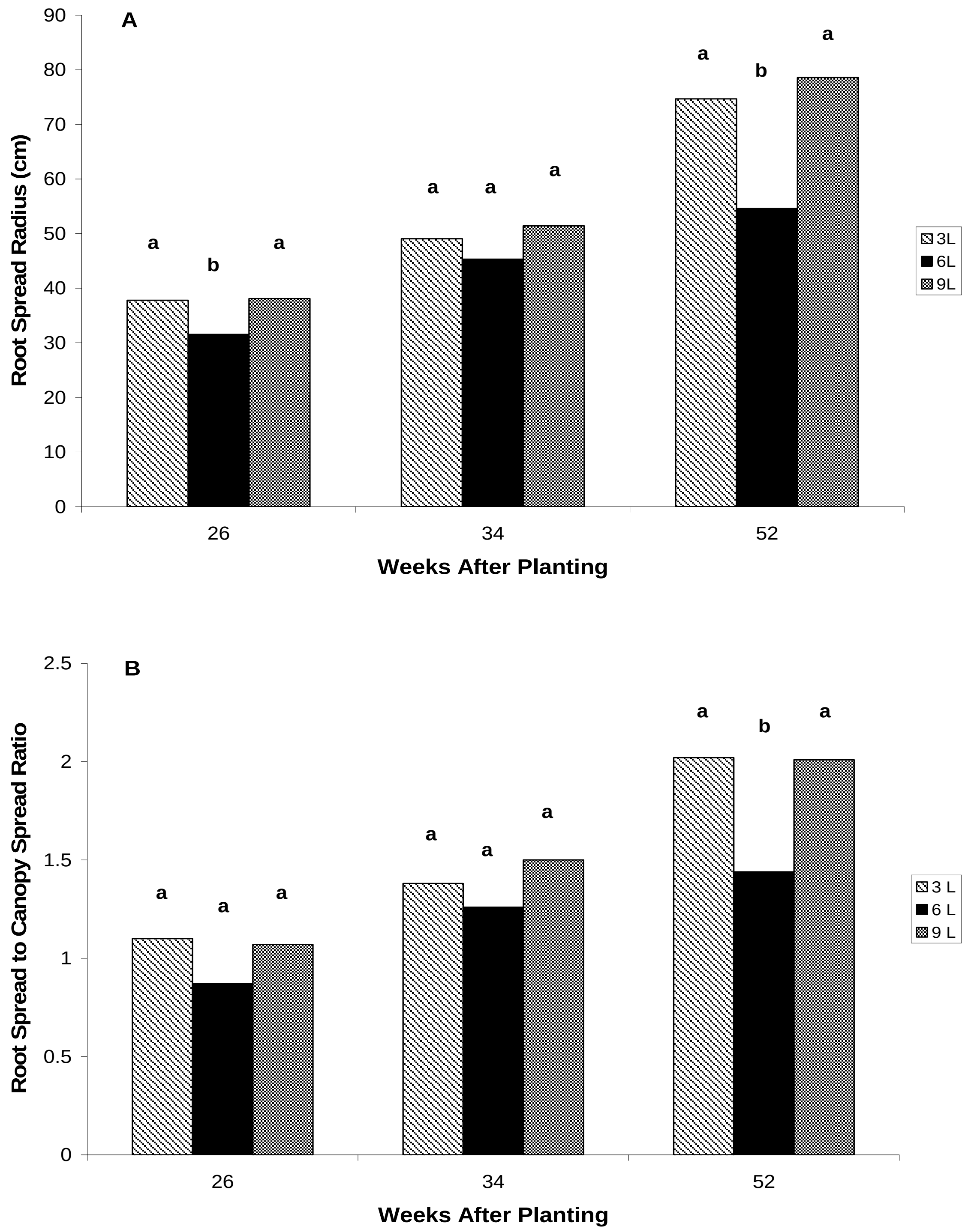

Figure 2. Effects of irrigation volume on root spread radius (A) and root spread to canopy spread ratio (B) of *Ilex* 26, 34, or 52 weeks after planting in May. Means for each week with the different letters are significantly different (P< 0.05).

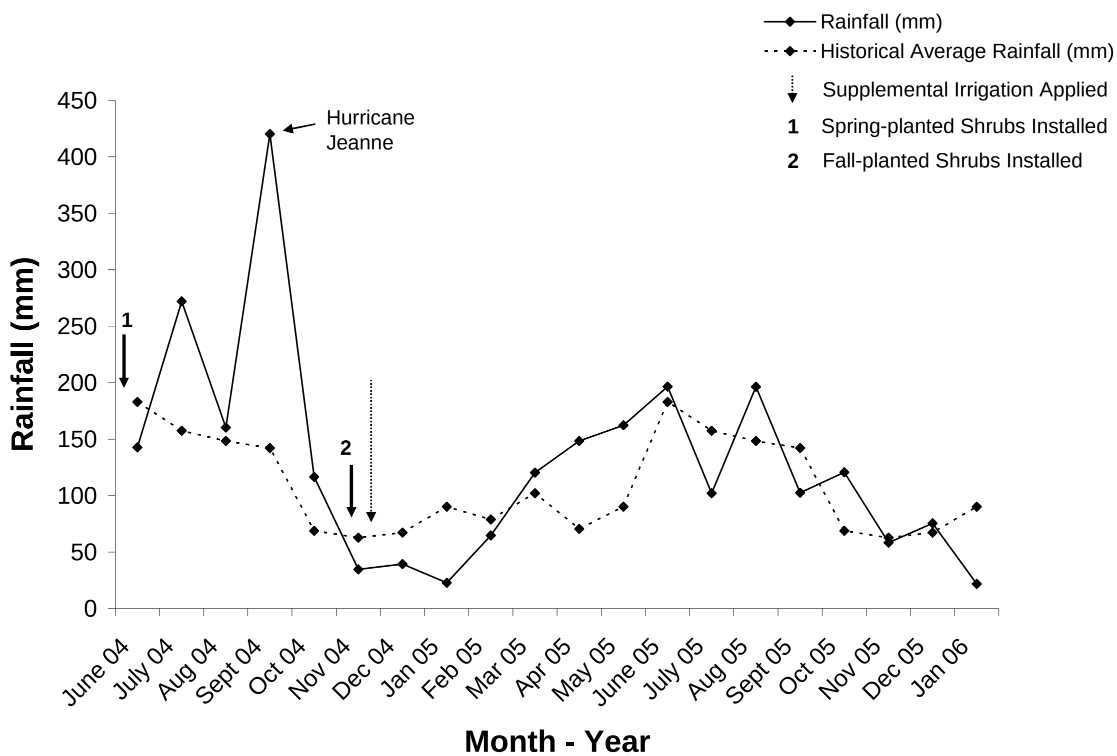

Figure 3. Actual monthly rainfall June 2004 through January 2006 and historical average monthly rainfall. Arrows (↓) indicate planting dates (May 27, 2004; November 16, 2004).

Roots of change for the better

Dr. Edward F. Gilman, Professor
University of Florida

Roots in nature

Perhaps one in a billion seeds becomes a mature tree. In the forest, rodents eat seeds, some are devoured by insects, some seeds rot, and some produce bad root systems. Roots on trees in nature result from seeds germinating on the forest floor. Root systems on mature trees have distinct characteristics that allow them to become large. They develop a spreading array of 6 to 12 large diameter roots growing more-or-less straight from the trunk (Fig 1).

We expect all trees we plant in a landscape to become large and produce benefits for everyone to enjoy. This makes it especially important that root systems have characteristics which allow them to grow to maturity. This process begins early in the first stage of propagation when the seed or rooted cutting forms its first roots.

Propagating liners

Most growers germinate seeds or stick cuttings directly in the field, in small containers, or in common trays of substrate. Trees in common trays must be carefully transplanted to a container of some type or planted into field soil. Root defects can form when a tap root is bent at planting. Bent tap roots are hard to correct and can negatively impact tree health and stability.

Trees propagated in containers have their challenges, but technology can help. Roots grow around the pot and down to the bottom naturally, or they are deflected there by container walls. This root form can result in tree instability and an abnormally deep root system not well suited for compacted soil in urban landscapes (Fig 2).

New propagation techniques including pots of thin paper, Oasis® cubes, and others show promise in producing quality root systems. Roots should be straight and may branch (Fig 3) but should not be directed down or around the container wall. These defects can become a permanent part of the root system and hamper proper growth, or could doom the tree to early death. Once roots begin circling or diving down the side of the pot they should be removed entirely when shifting to larger sizes (Fig 4) so retained root segments are oriented straight from the trunk. A look inside root balls we plant today shows that this is not happening with enough regularity.

Roots in container nursery

Root management continues in a container nursery that grows finished landscape trees. The goal is to produce a root system with straight roots from the trunk (Fig 5), not deflected down or around the pot. If this does not occur, shaving off root ball periphery at each shift to a larger container (Fig 6) appears to accomplish the same objective (Fig 7). Our research shows that if you manage irrigation carefully, caliper and height should not slow appreciably (1). Some nurseries in Florida and California are practicing a version of this and learning how to use it. In addition, root flare should be at or close to the surface. If the root flare is just a couple inches beneath substrate surface, roots deflected by the container wall can girdle the stem.

Roots in field nursery

Roots pruned several times in the nursery grow denser with smaller diameter roots and fewer large roots (Fig 8). This has been shown to increase digging survival and improve landscape performance (3). Nurseries that routinely move trees from one field to another during production automatically prune roots. Quality nurseries that produce certain trees without moving them implement root pruning in place.

Manage roots at planting

Treat root defects at planting including those wrapping or circling the trunk. Excavation and a pruning saw or clippers are needed to check for and treat defects at trunk. Roots matted against burlap on field grown trees should be removed at planting. A sharp digging spade can be used to remove all peripheral roots on container grown trees (Fig 9); slicing the root ball radially is less effective (2). If the root ball has no defects on the interior, this will help insure most circling and diving roots are removed from the root system. New roots will grow outward horizontal to soil surface to better stabilize trees.

Cited literature:

1. Gilman, E.F., C. Harchick, and M. Paz. 2010. Root ball shaving improves root systems on seven tree species in containers. J. Environ. Hort. (In review)
2. Gilman, E.F., C. Harchick, and M. Paz. 2009. Pruning roots affects tree quality in container-grown oaks. J. Environ. Hort. 27: 7-11.
3. Gilman, E.F. and P. Anderson. 2006. Root pruning and transplant success for Cathedral Oak® live oaks. J. Environ. Hort. 24: 13-17.

Fig 1. Roots of forest trees grow mostly straight.

Fig 2. Roots deflected down by liner container wall.

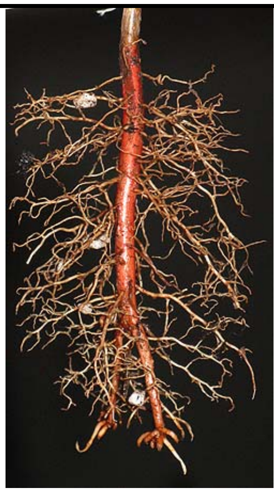

Fig 3. Quality liner root system with few deflected roots.

Fig 4. Eliminating defects by removing liner root ball periphery

Fig 5. Quality root ball grown in 3 gallon container without root pruning.

Fig 6. Shaving root ball periphery prior to shifting or planting into field.

Fig 7. Quality 15 gallon root ball resulting from shaving the 3 gallon prior to shifting.

Fig 8. Quality field-grown root ball resulting from multiple root prunings.

Fig 9. Removing root ball periphery immediately after planting 15 gallon container.