

SUMTER COUNTY COMPOST FOR FOREST CROPS

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by

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Abstract

This multiyear project addresses the need for environmentally sound, economically feasible, practical, and applicable solutions for recycling and utilizing organics by research on and demonstration of fast-growing forest tree responses to Sumter County Compost (C), development of guidelines for C use on these short rotation forest crops, estimation of associated economic and environmental benefits, and dissemination of this information to clientele. Our research and demonstration study planted at FORCE in September 2002 was doubled in size by planting over 2,000 trees in four cultural treatments in the first quarter of 2004. This FORCE study also was visited and utilized by Alachua County School science teachers and students participating in a NSF-funded summer science programs in 2004 and 2005. To further extend the evaluation of C on forest crops, a study was installed at the UF/IFAS Southwest Florida Research and Education Center (SWFREC) at Immokalee in July 2004 and partially replanted in July 2005. A study planted in January 2004 on a sandhills site near Brooksville, FL, to assess cultural options including C for cypress (**TD**, *Taxodium distichum*), a 2000 study assessing **TD** response to C, and a 2003 study evaluating C influences on tree-fern mixes for phytoremediation also contribute to the project. Based on data through 2006, while C alone helps growth and survival of **TD**, cottonwood (**PD**, *Populus deltoides*), *Eucalyptus grandis* (**EG**), and *E. amplifolia* (**EA**), C plus irrigation produces the fastest growth and highest survival, and the most productive genotypes within these species could increase yields considerably. The project was the subject of a poster, presentation, and tour at AGRIunity 2006 held at the Sumter County Fairgrounds in December 2006.

Introduction

C considerably enhanced the productivity of forest tree crops increasingly in demand in Florida, namely **TD** and fast growing hardwoods, such as **PD**, **EG**, and **EA** that consume high amounts of water and nutrients. C increased **TD** growth in three studies, including Study 86 (Table 1) where C raised pH and greatly enriched the nutrient poor spodosol. Composted and bedded trees were statistically taller and had two and 10 times more biomass, respectively, than bedded-only and unbedded trees. Leaf and twig nitrogen concentrations were also higher in composted trees, which also had more foliage and dense fine roots surrounding clumps of organic matter in the rhizosphere, suggesting potential for rapid future growth. Across the studies, survival was noticeably greater with C, ranging from 8 to 18% higher than non-C treatments. C amendments also significantly increased the growth of **EA** in adjacent studies.

In response to effluent (E), E+C (EC), E+mulch (EM) and E+C+mulch (ECM) on sandhills west of Orlando (Study 72 in Table 1), **EG** more than doubled the biomass of **PD** after two years. EM increased yields by 131%, EC by 76%, and ECM by 158% compared to E. The trees removed up to 534 kg N ha⁻¹ and 198 kg P ha⁻¹. **EG**'s superior productivity has obvious value for phytoremediation and for potential commercialization in rotations as short as two years for mulchwood and energywood. **EG** plantations can increase water loading and reduce N and P leaching by up to 75% when water only is applied and 85% when mulch is added for weed control.

Our multi-year research project extends these preliminary findings to additional practical field applications of the “wet” form of C in forestry, identify market potentials, and disseminate information concerning practical applications and field implementations to appropriate public and private audiences. Thus, the project will meet the need for environmentally sound, economically feasible, practical, and applicable solutions for recycling and utilizing organics, development of guidelines for C use on forest crops, and estimation of economic and environmental benefits.

Table 1. Field studies contributing to assessments of **PD**, **EG**, **EA**, and **TD** receiving C.

Study	Location	Estab. Date	Species	Description
72	Orlando, FL	4/98	PD, EA, EG	1,076 trees from 3 clones, 6 and 6 progenies + C, mulch, and/or sewage effluent
74	Old Town, FL	6/98	EA, EG	80,000 trees from 50 and 15 progenies
79	Cross City, FL	1/99	TD	660 trees from 20 accessions + C
80	Old Town, FL	4/98	EA	1,500 trees from 59 progenies + C, etc., with I
81	Quincy, FL	7/99	PD, EA	4,850 trees from 1,100 clones and 50 progenies
82	St. Augustine	8/00	PD, EA	630 trees from 15 clones and 15 progenies + Toluene
84	Green Cove Springs, FL	12/00	PE	2,055 trees + 9 cultures on mined and unmined sites
86	Waldo, FL	2-3/00	TD	1,800 trees from 14 accessions + 6 cultures
90	Lakeland, FL	4-6/01	PD, EA, EG	200,000 trees from 6 clones, 6 and 6 progenies + 5 cultures
91	Palmdale, FL	8/01	EA, EG	980 trees from 4 progenies, 18 clones, 4 clones, and 10 hybrids
92	Ft. Meade, FL	3/02	PE, TD	2,600 trees from 36 pure and hybrid progenies, 3 clones and 6 accessions + 3 cultures
94	Lakeland, FL	12/01	PE, TD	1,700 trees from 33 pure and hybrid progenies, 9 clones and 26 accessions
102; 102A	Sumterville, FL	09/02; 01-04/04	PD, EA, EG; PD, TD, EA, EG	2,100 trees from 11 clones, 9 and 9 progenies + control, C, irrigation, C+irrigation; >3,500 trees from 50 clones, 29, 10, and 16 progenies + control, C, irrigation, fertilization+irrigation, C+irrigation;
105	Archer, FL	4, 8/03	PD, EA, EG	770 trees from 44 clones, 8 and 30 progenies + 2 cultures + As
106	Brooksville, FL	01/04	TD	2,432 trees from 78 progenies in control, C, and fertilization treatments
107	Immokalee, FL	07/04; 08/05	PD, TD, EA, EG	1,120 trees from 16 clones, 5, 4, and 12 progenies + control and C;
117	Wimauma, FL	03-09/06	PE, EA, EG, LI, MG, MC, SR, IC	8,421 plants from 30 clones, 5 and 7 progenies, 4 and 4 varieties, and single sources, respectively - low, medium, and high C and F applications with and without I
	Ft. Meade, FL	12/06-1/07	TD	100 trees from one source in control, and 3 C mixes

	Citra, FL	03/13/07	PT, EA, PE, JV	1,364 plants from 1 clone, 5 progenies, and single sources, respectively - C application with I
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Methodology

The genetics x silviculture Study 102, initiated in September 2002 at the FORCE 40 acre demonstration farm, was expanded to be the primary demonstration in our project. Study 102 has three species (**PD**, **EG**, and **EA**) and four cultural (irrigation, C, and/or fertilization combinations) treatments (irrigation (I), C, I+C, and a control coded subsequently as 100, 010, 110, and 000, respectively) in a split-plot, randomized complete block design (Rows 1-14 in Appendix Figure 1). The site was prepared by herbiciding the grass in 4' wide strips, which were rotovated two weeks later. The cultural treatments that included "wet" C were implemented by strip applying 2" of C that was then rotovated to an 8" depth. Irrigation was added to Rows 1-7 by stretching driplines that emit water as needed to maintain field capacity. Trees in Rows 1-6 and 9-14 are spaced 3' apart in rows that are 10' apart. To represent a "corn row" configuration that may maximize production by harvests at 1-2 year intervals with combine-like machines, trees in Rows 7 and 8 were planted in pairs 2.5' apart. The three species occur in whole plots that have an interior measurement row of nine to 11 genotypes: 11 **PD** Clones, 9 **EG** Progenies, and 9 **EA** Progenies (Table 2). From December 2003 to April 2004, the study at FORCE was doubled in size (Rows 15-28 in Appendix Figure 1) to extend the evaluation of C on **PD**, **EG**, and **EA** and to include **TD** in the evaluation. In Study 102A, four cultural treatments (I, I+C, I+Fertilizer (F), and a control subsequently coded as 100, 110, 101, and 000, respectively) were incompletely replicated in a split-block design following procedures used in 2002 except that 8" of C was rotovated to an 8" depth. The fertilizer application of 8 ounces of Osmocote 15-9-12/tree supplied nutrients similar to the C. The 575 trees from 19 **TD** seed orchard progenies in Rows 21, 25, and 26 as 3-tree row plots also estimate genetic variation that can be used to increase **TD** productivity. All 1,486 unrooted cuttings of 50 **PD** clones (Table 2) were planted in a double row (paired trees 2.5' apart) configuration in Rows 15-20, 22-24, and 27-28. Representative rows of the FORCE studies were measured for tree height, DBH, and survival on June 22, 2004, and June 21, 2005, and all trees in Rows 1-28 were remeasured for tree height and/or DBH, vigor, and survival in October 2005. On May 25-26, 2006, 8" of C was broadcast between tree rows in the compost treatments in Rep 1 of Study 102 and Reps 1 and 2 of Study 102A (Figure 1); a nutritionally equivalent amount of Osmocote 15-9-12 (8 ounces/tree) was applied to the corresponding fertilizer treatment in Study 102A on May 30. On February 17, 2007, breast height 5mm increment cores were taken from 50 ramets of 26 **PD** clones in Study 102A to evaluate basic wood properties.



Figure 1. May 2006 C applications to Study 102 (left) and Study 102A (right).

Some 290 tons of C were applied in late January 2004 in the 3.4-acre **TD** Study 106 near Brooksville, FL, on a sandhills site on the Withlacoochee State Forest (WSF) in collaboration with the Florida Division of Forestry (Figure 2). No, C (8" deep rotovated into 4' wide strips), and F (8 ounces of Osmocote 15-9-12/tree) amendments were applied in split-blocks of 30 replications of a randomized complete block design, with 78 **TD** progenies (19 common to Study 102A) planted systematically in single tree subplots at a 20' x 3' spacing on January 30-31, 2004. Tree height and survival were measured in June 2004, and survival was reassessed

in October 2004.

Table 2. **PD** clones and **EA** and **EG** progenies in four field studies. (, # = # of 2/17/07 wood samples)

Clone	Study				Clone\ Progeny	Study			
	102	102A	107	117		102	102A	107	117
PD					PD				
3-1		X,2			111733		X		
9-5		X,3			112127		X		
50B-3		X	X		112740		X,1		
72C-1		X,2			Ken8	X	X,4		
72C-2		X			S7C1	X	X,4		
72C-7		X,2	X		S13C20	X	X,2	X	
73-2		X,1			EA				
74F-1		X,1			4899			X	
76-1		X			4925				X
77-4		X			5021			X	
79-4		X,2			5025	X	X		
80-2		X			5033	X	X		
80-3		X,1			5035	X	X	X	
81B-5		X			5050	X	X	X	
83-2		X,1			5061				X
84A-6		X	X		5068	X	X		
90-3		X,1	X		5091	X	X		
90-7		X,1			5093				X
91B-4		X	X		5107	X	X		
92-4		X			5108	X	X	X	
93-1		X			5116				X
93-6		X			5117				X
93-7		X,2			WC14		X		
94-1		X,2			EG				
94-3		X,1			1016			X	
94-4		X,7			2310			X	
95A-6		X,1			2814	X	X	X	
100-3		X			3019	X	X		
105-1		X,1	X		3198	X	X		
109-7		X,1			3204			X	
115-1		X			3309	X	X	X	
119-6		X,2			3329				X
120-4		X			3431			X	
133-3		X			3467			X	
134-1		X	X		3469			X	
142-5		X			3604				X
147-1		X,1			3680	X	X		
151A-1		X,2			3773				X
154A-1		X			3816			X	
158A-4		X			3879	X	X		
189-4		X,2			3951	X	X	X	
ST-66	X				3971			X	
ST-71		X			4047			X	
ST-72	X				4064			X	
ST-124	X				4199			X	
ST-148	X				4204	X	X	X	
ST-163	X				4272			X	
ST-240	X				4328			X	
ST-259	X				4330				X
ST-261	X				4340	X	X		X
110531		X			4366				X
110807		X			4366				X

Study 105 (Table 1) at Archer, FL, evaluates C's importance in the phytoremediation of arsenic. Along with **PD**, **EG**, and **EA**, the study has Chinese brake fern, an arsenic hyperaccumulator, in pure and mixed plots with and without C as part of an intensive investigation to identify critical factors in cleaning up arsenic contaminated soil and groundwater throughout Florida. Study 105 was measured for tree height, DBH, and survival on June 23, 2004, June 22, 2005, and December 15, 2005, and several trees damaged by hurricanes in August-September, 2004, were harvested for biomass and arsenic analyses.

Study 107 (Table 1) was established at the Southwest Florida Research and Education Center (SWFREC) near Immokalee, FL, on July 6-8, 2004, to evaluate the opportunities for growing **TD**, **PD**, **EG**, and **EA** with and without C in the vegetable producing sand lands of southwestern Florida. **TD** was represented by five progenies (97, 104, 168, 251, 334), **PD** by eight clones (Table 2), **EA** by four progenies (Table 2), and **EG** by 16 progenies (Table 2). Due to droughty conditions at and following the planting which resulted in survivals ranging from very high (**TD**), high (**PD**), moderate (**EA**), to low (**EG**), dead trees were replanted on August 12 with the same or best available genotypes of **EG**, **EA**, **TD**, and **PD**. C as a site amendment there has already been shown to increase organic matter, fertility, and water retention, and composted trees are expected to reduce leaching of nutrients when planted as a riparian buffer or other component of agroforestry systems. Tree height and survival were measured on December 3, 2004. Slash pine genotypes were added to the study on May 12, 2005. Due to continued low survival of **EG**, these plots were redisked and replanted on July 15, 2005, with eight progenies of **EG** (1016, 3309, 3469, 3816, 3951, 3971, 4047, 4064) and two of **EA** (4899, 5108). At the last measurement in November 2006, foliage samples were collected from **PE**, **PD**, and **EA** in plots with and without C in three reps to determine compost related nutrient differences (Table 3).

Table 3. Number of foliage samples taken by **PE**, **PD**, and **EA** genotypes in Study 107 in November 2006.

Species	Without Compost	With Compost
PE Clone 8312	3	3
PD Clone 91B-4	3	3
EA Progeny 5050	3	3

Study 117 at the UF/GCREC assesses the effects of 1) eight species - crape myrtle (*Lagerstroemia indica*, **LI**), wax myrtle (*Myrica cerifera*, **MC**), dahoon holly (*Ilex cassine*, **IC**), saw palmetto (*Serenoa repens*, **SR**), southern magnolia (*Magnolia grandiflora*, **MG**), **PE**, **EG**, and **EA**, 2) two within row spacings - 3' or 6', 3) row configurations - 3, 5, or 8 staggered rows, 4) several cultures including low, intermediate, and high C and F applications at establishment with and without I, and 5) various management practices (Table 1) on windbreak development. Species, spacing, configuration, and culture combinations were allocated to 100' long segments of the 7,400' of windbreaks established in 2006; each combination was replicated two to five times. All segments were disked and/or rotovated before planting or C application. C supplied by Sarasota County Utilities was applied at rates of 67, 153, 209, and 468 tons/acre and rotovated in to a depth of 8". Fertilization involved applying Osmocote 15-9-9 with micros at the rates of 4 or 8 ounces per plant split between two holes on opposite sides of the plant. I was supplied by driplines. Establishment required several months, and species representation ranged from single native sources (**MC**, **SR**, **IC**) to commercial varieties (**LI**, **MG**) to clones or progenies (**PE**, **EA**, **EG**) (Table 2) as subplots within species. Post-planting weed control was practiced periodically using manual and/or chemical techniques. All plants were measured for height after establishment and for height and/or survival on November 5, 2006.

The study near Ft. Meade will assess the effect of soil mixing rate for Sumter County C on **TD** root development in the clay settling areas (CSA) common to phosphate mined lands (Table 1). Five soil mixes (0, 25, 50, 75, or 100% Sumter County C with the heavy CSA clay) in 1' wide by 1' deep holes, arranged in two repetitions of a Latin Square design at 10x10' spacing, were planted with 1-year-old bareroot seedlings of one **TD** source in March 2007. A similar greenhouse study involving one repetition of the same five soil mixes in 2 gallon pots planted with rooted cuttings of the **TD** hybrid 'Nanjing Beauty' was initiated on March 27, 2007. In June 2007, these five soil mixes were repeated in 1' wide by 1' deep holes within row plots of five **TD** progenies in Study 86 (Table 1).

The study at the UF/IFAS Plant Science and Education Unit at Citra assesses the effects of four species - **PE**, *P. taeda* (**PT**), **EA**, and *Juniperus virginiana* (**JV**) – at 3' within row spacing within two row configurations (2 or 3 rows 8' apart), and high C application at establishment with I on windbreak development (Table 1). Species and configuration combinations were allocated to various segments of the 1,600' of windbreaks established in March 2007 around a 450'x280' citrus block. Sumter County C was applied at a rate of ~200 tons/acre and rotovated in to a depth of 8". I was supplied by above ground emitters. Species representations were single native sources (**PE**, **JV**), five progenies (**EA**), and a commercial clone (**PT**) (Table 2) arranged as subplots within species blocks. Post-planting weed control was practiced periodically using manual and/or chemical techniques. All plants were measured on March 13, 2007, for initial height.

Other established studies (Table 1) provide supplemental comparisons for using C. Studies 72, 74, 79, 80, and 86 include C and no C treatments, with Study 86 having received C in 2003. Studies 81, 82, 84, 90, 91, 92, and 94 benchmark **PD**, **EG**, **EA**, **TD**, and slash pine (**PE**) productivity on a range of sites for contrast with growth rates observed with C. The C portion of Study 86 was measured for tree height, DBH, and survival on June 28, 2004, June 27, 2005, December 13, 2005, and March 8, 2007.

Results and Discussion

As summarized in Tables 4 and 5, species and cultural treatments are having significant impacts on growth of **EA**, **EG**, **PD**, and **TD** in Studies 102, 102A, 106, and 107. In October 2005, the most encouraging species and cultural treatment combinations include **EA**, **EG**, and **PD** receiving C or F along with I (Figure 2). Through 8 months, **PD** was the most vigorous species when C is combined with I, and **EA** and **EG** were taller after 8 months of I following F equivalent to 0.075, 0.045, and 0.06 pounds of N, P, and K, respectively, per tree (1089, 653, and 871 pounds of N, P, and K, respectively, per acre). However, 18 months after C application, tree vigor for I+C may be declining compared to I+F (Table 5). In July 2006 in Study 102A, the I only treatment was noticeably inferior for all species, while the I+F and I+C treatments resulted good tree growth (Figure 3).

The importance of I during establishment years with periodic droughts was clearly evident. In Study 106, **TD** initiated growth earlier in the C culture than in the F or Control cultures, but after the April-May drought virtually all trees were dead, as compared to 75% or better survival in the irrigated cultures in Study 102A (Table 4). Initial survival of **EA**, **EG**, and **PD** in Study 107 suffered because of dry conditions at and after planting, whereas these species had 70% and higher survival with I in Study 102A. I with C in Studies 102 and 102A also considerably increased tree growth and vigor compared to C with no I in Studies 102 and 107 (Tables 4 and 5).

Genetic and cultural factors continue to influence SRWC growth in Studies 102, 102A, and 107 through December 2006. As earlier, **EA** and **EG** receiving C or I+C in Study 102 or **EA** and **EG** with I+F and **PD** with I+C in Study 102A are still the most productive species and cultural treatment combinations. Another year of measurement will detect if peak productivity was reached in Study 102 in 2006 at age 5 years, and potentially in 102A at age 3 years, for the genetics-culture combinations with maximum growth. High C amounts are beneficial, with the 8" applied in Study 102A perhaps being ideal prior to establishment as opposed to the inadequate but still enhancing 2" used in Study 102. Early planting is better than late planting to insure adequate survival, particularly of the freeze susceptible **EG**. The same **PD** clones and **EA** and **EG** progenies noted earlier continue to excel (Table 6). The May 2006 reapplication of 8" of C between tree rows (Figure 1) and equivalent amounts of Osmocote in portions of Studies 102 and 102A have visually enhanced tree growth and vigor.

Within species variation is important to maximizing response to C amendments. In comparison to the species averages given in Tables 4 and 5, the spread of genotype means around these averages was often large (Table 6). For example, the best **EA** and **EG** progenies and **PD** clones were as much as 50% larger than their species averages in December 2005. **PD** clones 112740, 95A-6, and 80-3, **EA** progenies 4899, 5035, and 5050, and **EG** progenies 1016, 2814, and 3431 appear to be the most productive genotypes. In the case of **EG**, freeze resilient progenies had much better survival in Study 102. A limited availability of propagules constrains wide-scale use of the most productive genotypes.

Table 4. Height (H, in m), DBH (D, in cm), vigor (V), and/or survival (S, in %) trait summaries by species and culture (000=Control, 010=C only, 100=I only, 110=I+C, 101=I+F) at ages 27, 8, or 5 months (27, 08, 05), respectively, in Studies 102, 102A, 106, and 107.

Trait	Culture	Species				
		EA	EG	PD	TD	All
Study 102: FORCE Rows 1-14						
Number of Genotypes		9	9	11	-	
H27	000	2.0b*	1.8a	1.4c	-	1.7B
	010	5.3a	7.3a	2.5b	-	4.2A
	100	2.3b	2.5a	1.2c	-	2.0B
	110	4.8a	3.7a	3.5a	-	4.0A
	All	3.6A	3.5A	2.2B	-	3.0
D27	000	1.5a	1.7a	0.6b	-	1.1C
	010	4.8a	7.8a	1.2ab	-	3.4A
	100	3.6a	2.5a	0.2b	-	2.5B
	110	4.3a	3.7a	2.3b	-	3.4A
	All	3.7A	3.7A	1.4B	-	2.9
S27	000	75.0a	12.5c	75.0a	-	54.2B
	010	75.0a	12.5c	68.8a	-	52.1B
	100	100.0a	50.0b	87.5a	-	79.2A
	110	100.0a	93.8a	87.5a	-	93.8A
	All	87.5A	42.2B	79.7A	-	69.8
Study 102A: FORCE Rows 15-28						
Number of Genotypes		10	16	50	29	
H08	100	0.64b	0.86b	1.26b	0.70c	0.91C
	110	1.86a	1.89a	3.06a	1.40a	2.23A
	101	1.87a	2.08a	1.82b	1.05b	1.83B
	All	1.48AB	1.66AB	2.12A	1.10B	1.71
V08	100	3.6b	2.7b	2.2b	1.6b	2.7C
	110	2.0a	1.3a	1.2a	0.3a	1.3A
	101	1.9a	1.3a	1.6a	0.7a	1.5B
	All	2.5C	1.7B	1.6B	0.8A	1.8
S08	100	92.0a	79.7a	71.8a	75.7a	79.2A
	110	80.8b	71.7a	71.4a	89.0a	76.0A
	101	85.0ab	83.8a	69.4a	79.2a	77.7A
	All	85.5A	78.2AB	70.8B	82.2AB	77.5
Study 107: SWFREC						
Number of Genotypes		4	12	8	5	
H05	000	0.6b	0.6a	0.8b	1.1a	0.7B
	010	0.8a	0.7a	1.2a	1.0a	0.8A
	All	0.7A	0.7A	1.0A	1.1A	0.7
S05	000	100.0a	91.1a	81.8a	100.0a	92.9A
	010	95.2b	74.1a	84.4a	87.5a	80.6B
	All	97.6A	82.6A	83.1A	93.8A	86.8
Study 106: WSF						
S05	000	-	-	-	0.0	-
	001	-	-	-	0.0	-
	010	-	-	-	0.0	-

*Lower case letters in a trait indicate significant differences among cultures within a species; Uppercase letters in a trait indicate differences among cultures across species or among species across cultures

Table 5. Height (H, in m), DBH (D, in cm), and/or survival (S, in %) trait summaries by species and culture (000=Control, 010=C only, 100=I only, 110=I+C, 101=I+F) at ages 41 or 18 months (41, 18), respectively, in Studies 102 and 102A.

Trait	Culture	Species				
		EA	EG	PD	TD	All
Study 102: FORCE Rows 1-14						
Number of Genotypes		9	9	11	-	
H41	000	3.0b*	2.8a	1.8c	-	2.5C
	010	8.8a	14.2a	4.2b	-	7.2A
	100	3.6b	3.7a	1.9c	-	3.0C
	110	5.8a	5.3a	4.2a	-	5.1B
	All	5.2A	5.3A	3.0B	-	4.4
D41	000	3.1a	2.8a	0.7b	-	2.7D
	010	4.0a	5.8a	3.0a	-	4.7B
	100	4.1a	4.0a	1.5b	-	3.6C
	110	6.0a	5.9a	3.0a	-	5.4A
	All	4.7A	4.8A	2.3B	-	4.3
S41	000	86.7a	35.0c	10.5a	-	31.6B
	010	84.4a	30.7c	25.8a	-	47.0AB
	100	94.5a	50.4b	16.4a	-	39.9B
	110	97.7a	62.5a	36.7a	-	65.6A
	All	90.8A	44.8B	18.2C	-	43.7
Study 102A: FORCE Rows 15-28						
Number of Genotypes		10	16	50	29	
H18	100	0.92b	1.62b	1.73b	-	1.41B
	110	3.75a	4.79a	4.05a	0.74a	4.14A
	101	5.45a	6.88a	3.25b	0.52b	5.19A
	All	3.35A	4.56A	3.00A	1.34B	3.59
D18	100	0.57b	0.85b	0.80b	-	0.78C
	110	3.80a	4.50a	3.47a	-	3.69A
	101	3.88a	4.60a	1.83a	-	3.28B
	All	3.59C	4.06B	2.38B	-	3.10
S18	100	84.5a	63.5a	71.5a	20.0b	63.5A
	110	80.0b	69.2a	71.7a	54.2a	70.5A
	101	77.3ab	72.8a	69.8a	38.1c	67.7A
	All	80.3A	68.9AB	71.0B	37.4C	67.5

*Lower case letters in a trait indicate significant differences among cultures within a species; Uppercase letters in a trait indicate differences among cultures across species or among species across cultures

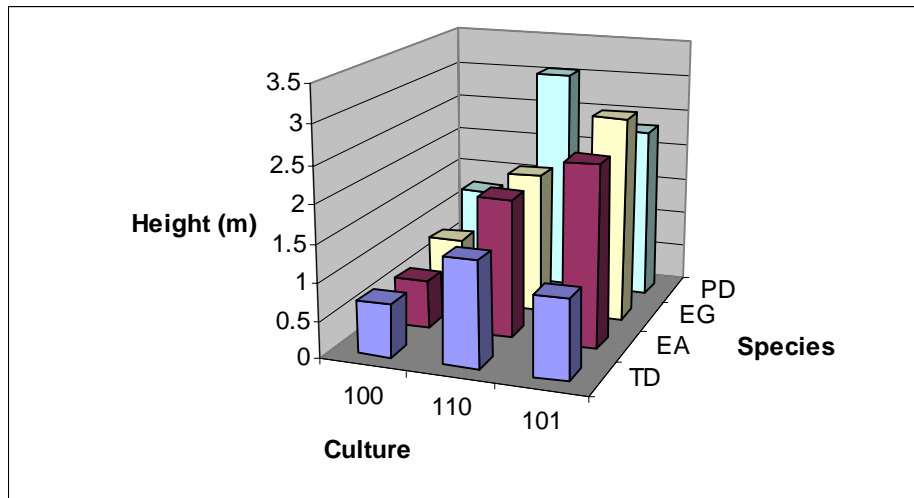


Figure 2. 18-month tree height by species and culture (100=I only, 110=I+C, 101=I+F) in Study 102A. Age 8

Table 6. Number, mean, range, and best of *PD*, *EA*, and *EG* genotypes for 18-month height, survival, and BAH in Study 102A.

Species	No.	Mean	Range	Best Genotypes
<i>PD</i>	50	3.0m ^B	1.8 – 4.0m	112740
		71.0% ²	0 – 100%*	95A-6
		1.6m /ha ^C	0 - 5.6m /ha*	80-3
<i>EA</i>	10	3.4m ^B	2.9 – 3.7m	4899
		80.0% ²	48 – 90% ²	5035
		2.9m /ha ^B	1.9 - 3.9m /ha	5050
<i>EG</i>	16	4.6m ^A	3.1 – 6.1m	1016
		69.0% ²	50 – 78% ²	2814
		4.0m /ha ^A	1.8 - 5.6m /ha	3431

* following a range indicates significant differences among genotypes within a species;
 Different uppercase letters following a trait mean indicate differences among species across cultures

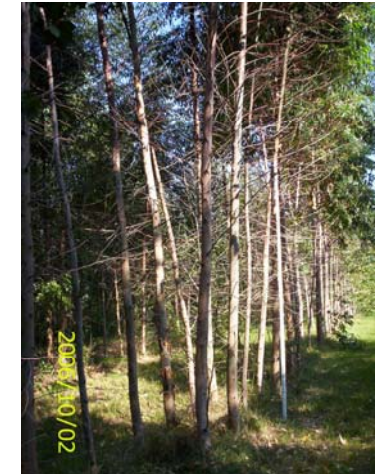
PD



EA



EG



I

I+F

I+C

Figure 3. October 2006 comparisons of cultures I only (left), I+F (middle), and I+C (right) in Study 102A by species: **PD** (top), **EA** (middle), **EG** (bottom).

The increment cores taken in Study 102A in February 2007 will provide basic wood properties for **PD** grown with C (Table 7). The range among 26 clones for specific gravity and other properties will suggest **PD** potential for various composite products and bioenergy applications.

Table 7. **PD** wood properties to be determined by clone.

Clone	Property			
	Specific Gravity	Moisture Content	Lignin Content	Microfibril Angle
PD				
3-1				
9-5				
72C-1				
72C-7				
73-2				
74F-1				
79-4				
80-3				
83-2				
90-3				
90-7				
93-7				
94-1				
94-3				
94-4				
95A-6				
105-1				
109-7				
119-6				
147-1				
151A-1				
189-4				
112740				
Ken8				
S7C1				
S13C20				
109-7				

The opportunities and challenges for growing **TD**, **PE**, **PD**, **EG**, and **EA** with and without C on sand lands in southwestern Florida were evident in Study 107. C amendments increased soil OM, pH and Mehlich 1-extractable P, K, Ca, and Mg concentrations (Rockwood et al 2006, Ozores-Hampton et al., 2004). Still, initial survival in Study 107 ranged from very high (**TD**), high (**PD**), moderate (**EA**), to low (**EG**) because of dry conditions at and after planting in July 2004, whereas these species had 70% and higher survival with I in Study 102A. I+C in Studies 102 and 102A also considerably increased tree growth and vigor compared to C alone in Studies 102 and 107 (Figure 4). Survival and growth after replanting in August showed a modest C advantage for **EA** and **TD** height but slight survival decrease for **EA** survival in December 2004. The addition of I to Study 107 in 2005 increased survival of the replanted **EA** and **EG**, but none of the replanted trees grew appreciably, and the trees initially planted grew little even with C. By November 2006, **EA**, **EG**, and **PD** displayed a positive response to C, as their tree heights with C were typically doubled those without (Figure 4). **TD**'s poor response to C may be attributable to heavy competition from **PD**.

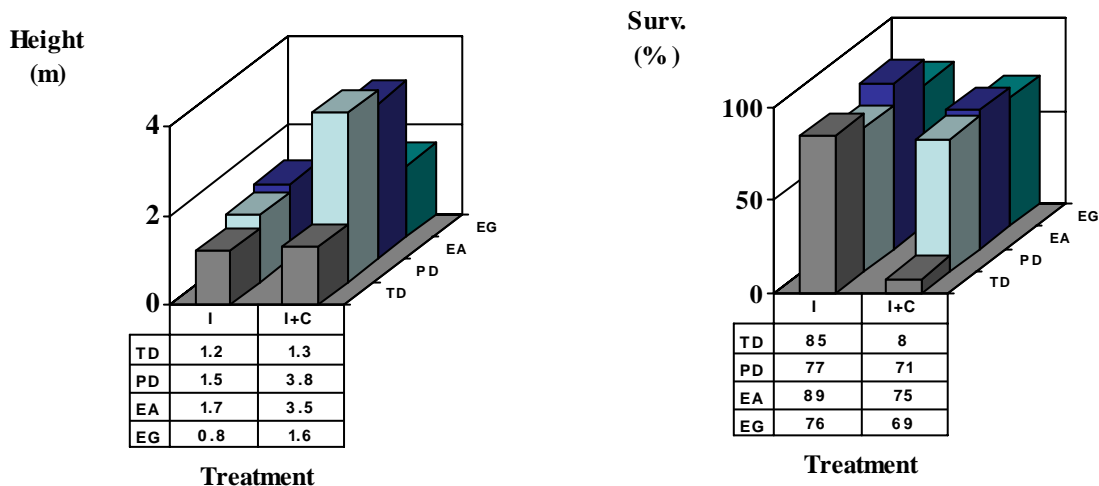


Figure 4. Tree height and survival for four species and two cultures (I, I+C) in Study 107 in November 2006.

As with tree growth, C typically increased foliage nutrients in the November 2006 samples (Table 8). Just as C amendments increased soil OM, pH, P, K, Ca, and Mg concentrations (Rockwood et al 2006, Ozores-Hampton et al., 2004), C increased foliar N and K in each species. **PD** tended to have higher foliar N, Ca, Mg, Fe, Zn, and B than **PE** and **EA**. C appeared to bind Mn, especially in **EA**.

Table 8. Foliage N, P, K, Ca, and Mg in % and Fe, Mn, Zn, Cu, and B in ppm by treatment-species, species, and overall for **PE**, **PD**, and **EA** in Study 107 in November 2006.

Trt	Sp	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
C	<i>PD</i>	2.18	0.30	0.50	2.64	0.74	101.4	20.97	337.8	9.99	133.3
N	<i>PD</i>	1.73	0.23	0.40	1.73	0.55	161.6	19.81	107.1	8.00	65.65
	<i>PD</i>	1.95	0.26	0.45	2.19	0.64	131.5	20.39	222.4	9.00	99.49
C	<i>PE</i>	1.36	0.17	0.43	0.35	0.10	19.30	29.58	61.67	4.65	10.87
N	<i>PE</i>	0.88	0.17	0.22	0.37	0.10	21.42	63.43	43.75	3.22	11.84
	<i>PE</i>	1.12	0.17	0.33	0.36	0.10	20.36	46.51	52.71	3.94	11.36
C	<i>EA</i>	1.41	0.57	0.51	3.32	0.30	30.93	69.87	64.95	10.64	60.00
N	<i>EA</i>	1.27	0.66	0.45	2.30	0.42	36.22	425.8	72.33	13.26	54.35
	<i>EA</i>	1.34	0.62	0.48	2.81	0.36	33.58	247.8	68.64	11.95	57.18
	Ave							104.9	114.6		
	.	1.47	0.35	0.42	1.79	0.37	61.83	1	1	8.29	56.01

Study 117 at the UF/GCREC is determining the best species/species mixes, designs, and establishment and management techniques for windbreaks. To date, of the eight species, **LI** has grown most and is most tolerant of varying cultures (Table 9). **MC**, **IC**, and **MG** have grown modestly. **PE** response to treatment factors has been limited by accidental herbiciding, and **SR** has grown very little but has survived well. **EG** and **EA**, primarily planted in September, have yet to differentially respond to treatments. Within **LI** and **MG**, variation among commercial varieties is already evident.

Table 9. Height (H, in m) and/or survival (S, in %) summaries for eight species and four cultures (I, I+C low, I+C medium, I+F) in Study 117 in November 2006.

Trait	Culture	Species							
		EA	EG	PE	MG	LI	MC	IC	SR
Number of Genotypes		5	7	49	4	4	1	1	1
H	I	0.3	0.3	0.9	0.3	-	0.6	0.6	na
	I+Cl	0.2	0.2	1.0	0.4	1.1	0.8	-	na
	I+Cm	0.3	0.3	1.0	0.5	1.1	0.8	-	na
	I+F	0.2	0.2	1.0	0.3	1.1	0.6	-	na
S	I	27	30	29	73	-	58	76	na
	I+Cl	93	89	83	91	100	90	-	na
	I+Cm	80	18	85	82	100	82	-	na
	I+F	79	77	86	81	97	58	-	na

Cultures including three C levels and F applications at establishment have not yet influenced plant growth, primarily because of weed competition. Irrigation alone is insufficient for early survival on these nutrient poor sandy soils.

Three studies assess the effect of Sumter County C mixing rate with heavy clay soil on **TD** root development. Five soil mixes (0, 25, 50, 75, or 100% Sumter County C with the heavy CSA clay) in 1' wide by 1' deep holes, arranged in two repetitions of a Latin Square design at 10x10' spacing, on a CSA near Ft. Meade were planted with 1-year-old bareroot seedlings of one **TD** source in March 2007. A similar greenhouse study involving one repetition of the same five soil mixes in 2 gallon pots planted with rooted cuttings of the **TD** hybrid 'Nanjing Beauty' was initiated on March 27, 2007. In June 2007, these five soil mixes were repeated in 1' wide by 1' deep holes within row plots of five progenies in Study 86 (Table 1).

Table 10. Height (H, in m), survival (S, in %), and/or root biomass (R) for **TD** planted in a field study near Ft. Meade study, a greenhouse study, and in Study SR-86.

% C	Ft, Meade			Greenhouse			SR-86
Trait	H	S	R	H	S	R	R
0	1.2	100	na	0.2	100	na	na
25	1.2	100	na	0.2	100	na	na
50	1.2	100	na	0.2	100	na	na
75	1.2	100	na	0.2	100	na	na
100	1.2	100	na	0.2	100	na	na

The windbreak study at Citra assesses the effects of a high C application at establishment with I on **PE**, **PT**, **EA**, and **JV** planted at 8x3' spacing in 2- or 3-row configurations (Table 11). The potted **PE** and **JV** trees were larger initially than the bareroot **PT** and containerized **EA**, but some **PE** and **JV** died soon after planting.

Table 11. Height (H, in m) and survival (S, in %) on March 13, 2007, of four species in I+C culture in a windbreak study with two row configurations at Citra.

Trait	Culture	Configuration	EA	PE	PT	JV
Number of Genotypes			5	1	1	1
H	I+C	2 rows		1.2		0.6
S	I+C	2 rows		92		98
H	I+C	3 rows	0.4	1.2	0.3	0.6
S	I+C	3 rows	100	100	100	100

Study 80 extends evidence of EA's responsiveness to C. Using basal area per hectare (BAH94) as the best estimator of growth differences, Compost+Lime (C+L) applied at establishment produced more than Fertilizer+Lime (F+L). The Manure+Lime culture (M+L) grew the least. Tested progenies have an advantage as Florida Orchard progenies (AO92 Ave) tended to surpass the Australian accessions (Acc Ave), but there were fast growing progenies in each group (e.g., 4820 and 4871 in the accessions, and 5111 in the Orchard group).

Table 12. Survival at 8 months (S08, in %) in two replications and survival, height, DBH, basal area/ha, and tree quality at 94 months (Sur08 and Sur94 in %, H94 in m, D94 in cm, BAH94 in m²/ha, and Q94) in one replication of Study 80 for four cultures and two EA progeny types.

	Both Reps		Rep 1 Only											
	Sur08		n	Sur08		Sur94	H94		D94		BAH94		Q94	
	n	Ave		Ave	Ave		n	Ave	n	Ave	n	Ave	n	Ave
Cultures														
C + L	358	93.0	155	97.4	72.9	55	8.5	121	9.3	147	18.0	112	3.5	
F + L	358	90.5	156	96.8	49.4			90	9.4	155	14.0	77	3.0	
L Only	358	84.6	156	92.3	51.3			91	10.8	154	14.2	80	2.8	
M + L	360	88.1	156	94.9	64.7	60	8.0	112	8.2	149	12.5	99	3.4	
Progenies														
4820	25	84.0	10	90.0	80.0	3	12.2	10	14.5	10	47.2	8	2.9	
4871	24	87.5	11	100.0	100.0	3	12.4	12	13.3	11	48.0	11	2.6	
<i>Acc Ave</i>				<i>94.9</i>	<i>59.6</i>		<i>8.0</i>		<i>9.0</i>		<i>14.1</i>		<i>3.3</i>	
5111	24	83.3	11	100.0	63.6	3	13.6	7	16.3	11	36.6	7	1.9	
<i>AO92 Ave</i>				<i>97.7</i>	<i>52.8</i>		<i>10.6</i>		<i>11.8</i>		<i>21.3</i>		<i>2.7</i>	
Overall	1434	89.1	623	95.3	59.6	115	8.3	414	9.3	605	14.6	368	3.2	

Our project's target audience of potential users of C with forest crops was reached several ways. The presentation "Compost Use on Forest Crops" at the Compost School on May 5, 2004, at the SWFREC at Immokalee, FL, was heard by ~60 representatives of the agricultural industry, forestry agencies, extension agents, regulatory agencies, and municipalities. One day visits to FORCE were completed on June 22, 2004, and June 21, 2005, by 12 and 19, respectively, Alachua County School science teachers and students in the NSF-sponsored Summer Science Program, two and one, respectively, high school students participating in UF's Summer Science Training Program (SSTP), and two representatives of the Florida Center for Solid and Hazardous Waste Management, who documented the NSF activities through still and video imagery. In July 2004, the two SSTP students successfully completed their research projects, one based on Study 102 and the other based on Study 105, with an award-winning presentation and poster, respectively, to the 97 SSTP students and some 12 SSTP faculty and staff. Most recently, the project was the subject of a poster, presentation, and tour at AGRItunity 2006 held at the Sumter County Fairgrounds on December 2, 2006 and attended by ~200 people.

From January – March 2005, activities included upgrading the irrigation system for the 2004 planting from drip tape to Netafim polyhose with emitters, weeding with DOC assistance, and arranging with Chuck Jett for Fusillade and compost applications and other maintenance, utilizing a tractor and related implements recently acquired by FORCE for this project. On March 18, an onsite review was conducted for Chuck Jett and Jose Rivera. On October 2, 2006, Peter McClure of Evans Properties toured the FORCE study to view opportunities for combining organics application with SRWCs.

Future Activities

Second Quarter 2007. Studies 102, 102A, and 105 will be remeasured as appropriate. Portions of Studies 102 and 102A will be felled for biomass sampling and coppice initiation. Further analyses of project data will be conducted, and foliar and groundwater nutrient analyses are planned. “Compost Benefits for Using Fast Growing Trees in Various Applications in Florida” will be an oral presentation at Recycle Florida Today’s Annual Conference in Orlando on June 5, 2007.

Subsequent Quarters. With the project renewed through March 21, 2008, measurements of tree height, DBH, pest incidence, survival, and/or weather induced responses may be taken semiannually in Studies 102, 105, 107, and other appropriate studies so that analyses will be current. The on-site environmental impacts of C application will be monitored in Study 102. As part of our overall analyses of the importance of input costs, progeny, planting configurations, rotation age, yields, harvesting options, the decision to coppice or not coppice, stumpage and transportation prices, and market options in using C on forest crops, yields and costs for **EA**, **EG**, **TD**, and **PD** will be updated.

Status of Project Deliverables

Quarterly Reports – First-, 2nd-, 3rd-, 4th-, 5th-, 6th-, 7th-, 8th-, 9th-, 10th, 11th, 12th, and 13th-Quarterly Reports completed.

National Science Foundation supported Summer Program for High School Students – one day visitations to FORCE for tour and study measurement, with subsequent analysis and interpretation, were completed on June 22, 2004, and June 21, 2005.

Website contributions – periodic FORCE, FCSHWM, and other site updates based on reports are planned.

Factsheet - “Guide to the Use of Compost on Forest Crops” is planned for early 2008.

Field Day – An educational opportunity for the approximately 7,000 visitors annually to the UF/IFAS/SFRC Austin Cary Memorial Forest near Gainesville to learn about C use is in place through the strategically positioned Study SRWC-86 and associated kiosk and self-guided tour that documents C applied to **TD**. On December 7, 2005, a presentation on and tour of the project were part of the Composting Workshop held at FORCE. The poster, presentation, and tour at AGRItunity 2006 on December 2, 2006, informed as many as 200 people about the project. Following development of the factsheet and project renewal, an UF/IFAS/SFRC extension sponsored Field Day announced statewide may be conducted in late 2007 to early 2008 as a half-day, on-site tour of the facility and demonstration planting.

Additional funding – Four preproposal\proposals for supplemental funding were unsuccessful: a three-year, \$2 million preproposal submitted to USDA Biomass Research and Development Initiative in February 2004; a three-year, \$500 thousand preproposal submitted to USDA Biomass Research and Development Initiative in December 2005; the proposal “Windbreaks for Florida’s Agriculture” to the University of Florida’s RGP for \$100,000 in May 2006; the one year, \$50,000 2006 IFAS Innovative Research Grant Proposal “Windbreaks for Citrus Groves: Disease Management and Windscar Protection.” A similar proposal “Protecting Florida Citrus Trees and Fruit with Windbreaks” to the Florida Citrus Production Research Advisory Council submitted in July 2006 for \$75,000 over three years is currently in review; if funded, this would provide opportunity to assess compost influences on windbreak establishment and development.

Project Presentations

“Short-rotation woody crop production utilizing compost from municipal solid and agricultural waste” at the Status, Trends, and Future of the South's Forest and Agricultural Biomass Conference, August 29-31, 2005, Athens, GA;

“Silviculture applications with MSW compost” at the BioCycle Southeast Conference in Charlotte, NC, on November 15, 2005, and in BioCycle;

“Short Rotation Woody Crops” at the American Farm Bureau Federation Annual Convention at Nashville, TN, on January 8, 2006;

“Compost Benefits for Short Rotation Woody Crops” at the 14th USCC Conference in January 2006;

“SRWC-Based Phytoremediation Systems for Florida and the Lower Southeast” at the 7th Biennial Meeting of the Short Rotation Woody Crops Operations Working Group in Pasco, WA, on September 26, 2006; and

“Compost Use for Woody Crops” component of the one-day pre-conference workshop “Compost Use in Agriculture, Horticulture and Landscaping” at the 15th USCC Conference in Orlando on January 21, 2007.

“Compost Benefits for Fast Growing Trees Used in Windbreaks” at the 15th USCC Conference in Orlando on January 23, 2007.

“Compost Benefits for Using Fast Growing Trees in Various Applications in Florida” at Recycle Florida Today’s Annual Conference in Orlando on June 5, 2007.

Project and Related Publications

Rockwood, DL, DR Carter, GR Alker, and DM Morse. 2002. C utilization for forest crops in Florida. In: Proc. Recycle Organics '02, Composting in the Southeast Conf. and Exposition, October 6-9, 2002, Palm Harbor, FL. CD

Rahmani, M, DL Rockwood, DR Carter, and WH Smith. 2003. Co-utilization potential for biomass in Florida. In: Proc. International Conf. on Co-utilization of Domestic Fuels, February 5-6, 2003, Gainesville FL.

Rockwood, DL, GR Alker, RW Cardellino, C Lin, N Brown, T Spriggs, S. Tsangaris, JG Isebrands, RB Hall, R Lange, and B Nwokike. 2003. Fast-Growing Trees for Heavy Metal and Chlorinated Solvent Phytoremediation. In: Proc. 7th Bioremediation Symposium, June 2-5, 2003, Orlando, FL. CD

Rockwood, DL, CV Naidu, DR Carter, M Rahmani, T Spriggs, C Lin, G R Alker, JG Isebrands, and SA Segrest. 2004. Short-rotation woody crops and phytoremediation: Opportunities for agroforestry? In: Advances in Agroforestry 1: New Vistas in Agroforestry – A Compendium for the 1st World Congress of Agroforestry, 2004, Kluwer Academic Publishers, Dordrecht, p. 51-63.

Stricker, JA, GR Alker, DL Rockwood, GM Prine, DR Carter, and SA Segrest. 2000. Short Rotation Woody Crops for Florida. Short Rotation Woody Crops Operations Working Group. Third Biennial Conference. October 10-13. Syracuse, NY.

Rockwood DL, B Becker, A Lindner, A Pacheco, C Lin, N Brown, T Spriggs, S. Tsangaris, J Isebrands, R Hall, R Lange, E Aitchison, and B Nwokike. 2005. Genetic testing prerequisites for effective tree-based phytoremediation systems. In: Magar VS and Kelley ME (Eds.), In Situ and On-Site Bioremediation-2005. Proceedings of the Eighth International In Situ and On-Site Bioremediation Symposium, June 6-9, 2005, Baltimore, MD, Battelle Press, Columbus, OH.

Becker, B, D Rockwood, B Tamang, and E Maehr. 2005. Short-rotation woody crop production utilizing compost from municipal solid and agricultural waste. In: Status, Trends, and Future of the South's Forest and Agricultural Biomass, August 29-31, 2005, Athens, GA.

Rockwood, DL, and DR Carter, 2005. Silviculture applications with MSW compost. BioCycle46(10): 42.

Rockwood, DL, B Becker, MP Ozores-Hampton, and PA Stansly. 2006. Compost benefits for short rotation

woody crops. In: Proceedings of the 14th USCC Conference, January 22-25, 2006. (in press)

Becker, B, D Rockwood, B Tamang, E Maehr, and L Ma. 2006. SRWC-based phytoremediation systems for Florida and the Lower Southeast. Proc. 7th Biennial Meeting of the Short Rotation Woody Crops Working Group, September 25-28, 2006, Pasco, Washington.

Rockwood DL, B Becker, B Tamang, M Andreau, MP Ozores-Hampton, and CK Chandler. 2007. Compost benefits for fast growing trees used in windbreaks. In: Proc. 15th US Composting Council Conf., January 21-24, 2007, Orlando, Florida. (in press)

Partner Organizations

Florida Center for Solid and Hazardous Waste Management (FCSHWM), UF

Soil and Water Science Department, UF

UF/IFAS Southwest Florida Research and Education Center (SWFREC), Immokalee, FL

UF/IFAS Gulf Coast Research and Education Center (GCREC), Wimauma, FL

UF/IFAS Plant Science and Education Center, Citra, FL

Knight's Sawmill, Cross City, FL

Withlacoochee State Forest, Florida Division of Forestry

The Common Purpose Institute, Temple Terrace, FL

The Florida Institute of Phosphate Research