SUMTER COUNTY COMPOST FOR FOREST CROPS
Comprehensive Quarterly Report – January 1, 2006

by
D. L. Rockwood and D. R. Carter
School of Forest Resources and Conservation,
University of Florida, Gainesville, FL, 32611-0410
352-846-0897, Fax: 352 846-1277, dlr@ifas.ufl.edu

Abstract

This three-year 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 at FORCE was doubled in size by planting over 2,000 trees in four cultural treatments in the first quarter. This FORCE study also was visited and utilized by Alachua County School science teachers and students participating in a NSF-funded summer science program. 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 October 2005, 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.

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 three 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
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 progenies, 4 clones, and 10 hybrids
92	Ft. Meade, FL	3/02	**PE, TD**	2,600 trees from 36 pure and hybrid progenies, 3 progenies and 6 accessions + 3 cultures
94	Lakeland, FL	12/01	**PE, TD**	1,700 trees from 33 pure and hybrid progenies, 9 progenies 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;

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 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: Clones

Ken8, ST66, ST72, ST124, ST148, ST163, ST240, ST259, ST261, S7C1, and S13C20 for **PD**, Progenies 2814, 3019, 3198, 3309, 3680, 3879, 3951, 4204, and 4340 for **EG**, and Progenies 5025, 5033, 5035, 5050, 5068, 5091, 5107, 5108, and WC14 for **EA**.

From December 2003 to April 2004, the study at FORCE was doubled in size (Rows 15-28 in 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 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.

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.

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 (105-1, 134-1, 50B-3, 72C-7, 84A-6, 90-3, 91B-4, S13C20), **EA** by four progenies (5021, 5035, 5050, 5108), and **EG** 16 progenies (1016, 2310, 2814, 3204, 3431, 3467, 3469, 3816, 3951, 3971, 4047, 4064, 4199, 4204, 4272, 4328). 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).

Other established studies (Table 1) will provide supplemental comparisons for using C. Studies 72, 74, 79, and 86 include C and no C treatments, with Study 86 having received C in 2003 and projected to receive annual additions of up to 200 yd^3 of C for the duration of this project. 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, and December 13, 2005.

Results and Discussion

As summarized in Table 2, species and cultural treatments are having significant impacts on growth of **EA**, **EG**, **PD**, and **TD** in Studies 102, 102A, 106, and 107. To date, the most encouraging species and cultural treatment combinations include **EA**, **EG**, and **PD** receiving C or F along with I (Figure 3). **PD** is the most vigorous species when C is combined with I, and **EA** and **EG** are 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).

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 2). 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 (Table 2).

Preliminary culture recommendations for maximum growth of individual species at this time are: I+C for **PD** and **TD** and I+F for **EA** and **EG**. 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, as done in Study 102A, is better than late planting, as done in Studies 102 and 107, for insuring adequate survival, particularly of the freeze susceptible **EG**.

Within species variation is important to maximizing response to C amendments. In comparison to the species averages given in Table 2, the spread of genotype means around these averages was often large. For example, the best **EA** and **EG** progenies and **PD** clones were as much as 50% larger than their species averages. In the case of **EG**, freeze resilient progenies had much better survival in Study 102.

Our project's target audience of potential users of C with forest crops was reached in two 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.

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. Funding was arranged for the 2005 NSF-sponsored Summer Science Program, involving a one day visit to FORCE on June 21, 2005, by participating Alachua County School science teachers and students.

Table 2. 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	0.91*C*
	110	1.86a	1.89a	3.06a	1.40a	2.23*A*
	101	1.87a	2.08a	1.82b	1.05b	1.83*B*
	All	1.48AB	1.66AB	2.12A	1.10B	1.71
V08	100	3.6b	2.7b	2.2b	1.6b	2.7*C*
	110	2.0a	1.3a	1.2a	0.3a	1.3*A*
	101	1.9a	1.3a	1.6a	0.7a	1.5*B*
	All	2.5C	1.7B	1.6B	0.8A	1.8
S08	100	92.0a	79.7a	71.8a	75.7a	79.2*A*
	110	80.8b	71.7a	71.4a	89.0a	76.0*A*
	101	85.0ab	83.8a	69.4a	79.2a	77.7*A*
	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

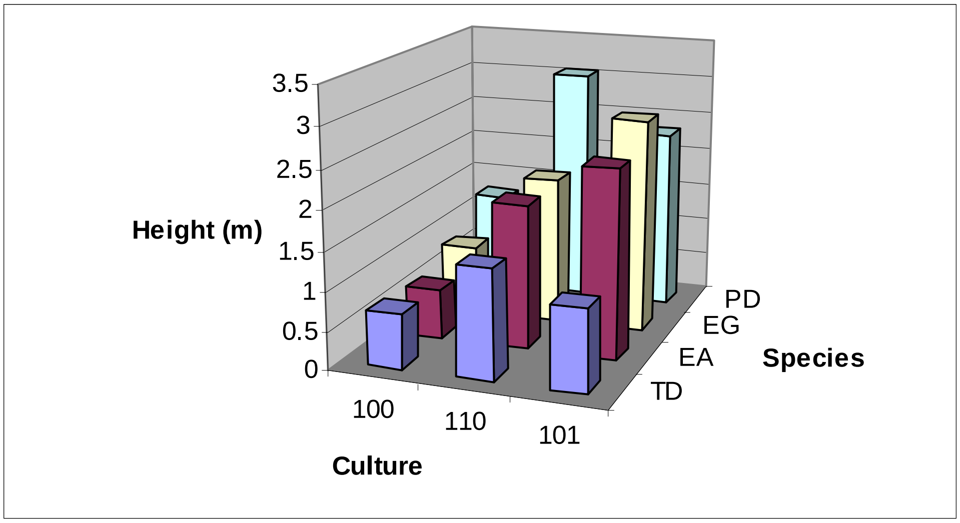

Figure 3. Age 8 month tree height by species and culture (100=I only, 110=I+C, 101=I+F) in Study 102A.

Future Activities

First Quarter 2006. Compost will be applied to portions of Studies 102 and 102A. Further analyses of project data will be conducted.

Subsequent Quarters. Measurements of tree height, dbh, pest incidence, survival, and/or weather induced responses will be taken as frequently as 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 and Annual Reports – First-, 2nd-, 3rd-, 4th-, 5th-, 6th-, 7th-, and 8th-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. A similar one day visitation is planned for 2006.

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 by the last year of the project.

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. Following development of the factsheet, an UF/IFAS/SFRC extension sponsored Field Day announced statewide will be conducted as a half-day, on-site tour of the facility and demonstration planting.

Publications – project publications/presentations include “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 Amercan Farm Bureau Federation Annual Convention at Nashville, TN, on January 8, 2006; and “Compost Benefits for Short Rotation Woody Crops” at the 14th

USCC Conference in January 2006.

Additional funding – our three-year, $2 million preproposal submitted to USDA Biomass Research and Development Initiative in February 2004 was not selected for full proposal development; a three-year, $500 thousand preproposal was submitted to USDA Biomass Research and Development Initiative in December 2005.

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: Advhance in Agroforestry 1: New Vistas in Agroforestry – A Compendium for the 1st World Congress of Agroforestry, 2004, Kluewer 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 Eigth 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. (accepted)

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
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