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Eucalyptus and Corymbia Species for Pulpwood, Mulchwood, Energywood, Windbreaks, and/or Phytoremediation[1]

D. L. Rockwood and G. F. Peter[2]

Introduction

In Florida, *Eucalyptus* species grow faster than our native tree species. *E. grandis* (*EG*), *E. grandis x E. urophylla* (*EH*), *E. benthamii* (*EB*), and *E. amplifolia* (*EA*), in particular, are fast-growing trees that, when planted on suitable sites and managed properly, produce commercial products such as mulchwood, pulpwood, energywood, and bioproducts. *Eucalyptus* can also phytoremediate, i.e., remediate environmental problems (Table 1). *Eucalyptus* species are not invasive, having been planted commercially in Florida since the 1960s without spreading from managed plantations. *EG* and *EA***,** along with *Corymbia torelliana* (*CT*), also may be used as windbreaks for citrus and vegetables. This circular describes potential applications and presents planting guidelines for these species.

Applications

Applications for *EG, EH, EB, EA*, and *CT* in Florida ranging from traditional and innovative forest products to phytoremediation systems and windbreaks are demonstrated in various locations (Table 1).

Forest Products

Commercial markets for *Eucalyptus* wood currently exist for landscape mulch and pulpwood and may be developed for oriented strand board, specialty pulp, and medium-density fiberboard. The color, texture, and durability of mulch produced from *EG* and *EA* compare very favorably to those of cypress mulch. *EG* and *EH* in southern Florida and *EB* and *EA* in northern Florida may be harvested for landscape mulch. About 50,000 acres of *Eucalyptus* plantations could perpetually supply the feedstock needs of the Florida mulch industry.

Considerable *Eucalyptus* pulp is imported into the United States. Florida-grown *EG, EH, EB,* and *EA* have very acceptable properties for pulp and paper making, and hardwood pulpwood demand and price are strong in the Southeast. Still, *Eucalyptus* plantations grown for pulpwood need to be in close proximity to existing pulpmills in northern Florida. *EG* used for specialty pulp could be greater distances from pulpmills.

Energy and Bioproducts

Trees can be bioenergy and bioproduct feedstocks. Energywood may be utilized for electricity generation by many utilities in Florida by cofiring with coal, for example. Some utilities in central and southern Florida use woody biomass to produce electricity and steam. Woody biomass also has numerous other energy-related applications including direct combustion, thermo-chemical gasification, methane,

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2. D. L. Rockwood, Ph.D., professor emeritus, School of Forest Resources and Conservation; and G. F. Peter, associate professor, School of Forest Resources and Conservation; UF/IFAS Extension, Gainesville, FL 32611.

alcohol, and other bioproducts including biochar, diesel fuel, and graphene. Trees grown for energy applications may qualify for tax credits.

Windbreaks

The rapid growth and evergreen nature of *EG*, *EA*, and *CT* make them ideal for quickly establishing effective windbreaks around citrus and vegetables. With a wind-slowing effect extending approximately 10 times tree height, after six years these species can easily provide wind and disease protection for crops up to 600 feet downwind from the windbreak. *EA* and *EG* windbreaks tend to open at the bottom as the trees grow and lower branches self-prune; *CT* windbreaks typically stay full as the trees grow. Mixed species and coppicing can maximize early and continuous windbreak effectiveness.

Phytoremediation Systems

The rapid year-round growth of *EG* and *EA* is advantageous for phytoremediation applications such as a) effluent from sewage treatment facilities, b) stormwater in urban and industrial areas, and c) agricultural irrigation water. Water and nutrient uptakes by *EG* and *EA* depend on climatic limits, tree age and vigor, and the timing and extent of the wastewater applications. The upper limit on annual water uptake is approximately 65 inches. Annual nutrient accumulations by vigorous *EG* may reach 190, 35, 95, 80, and 25 pounds/acre of N, P, K, Ca, and Mg, respectively. In phytoremediation systems, *Eucalyptus* should be managed to reach full canopy development as rapidly as possible and to maintain active growth. They should be harvested as soon as productivity diminishes; they regenerate through vigorous coppicing (sprouting from the stump). At the accelerated growth rates *EA* and *EG* can achieve in phytoremediation applications, plantings as small as two acres could be commercially harvested in three to four years. *Eucalyptus* production combined with wastewater recycling thus has many mutual advantages, such as increasing tree growth, recycling nutrients, and renovating wastewater while at the same time producing mulch, pulpwood, or energywood.

Planting Guidelines

Successful establishment and management of *EG*, *EH*, *EB*, *EA*, and *CT* have several aspects (Table 2).

Growing Region

No single species is the most productive in all regions of Florida nor most suitable for all applications. Species choice by region (Figure 1) reflects freeze hardiness differences, particularly in northern Florida. Improved *EB* and *EA* are freeze hardy enough for all of Florida. The limited hardiness of *EG* restricts use of improved seedlings to southern and central Florida, but *EG* cultivars may also be used in northern Florida. *EH* and *CT* have freeze tolerance appropriate for central and southern Florida.

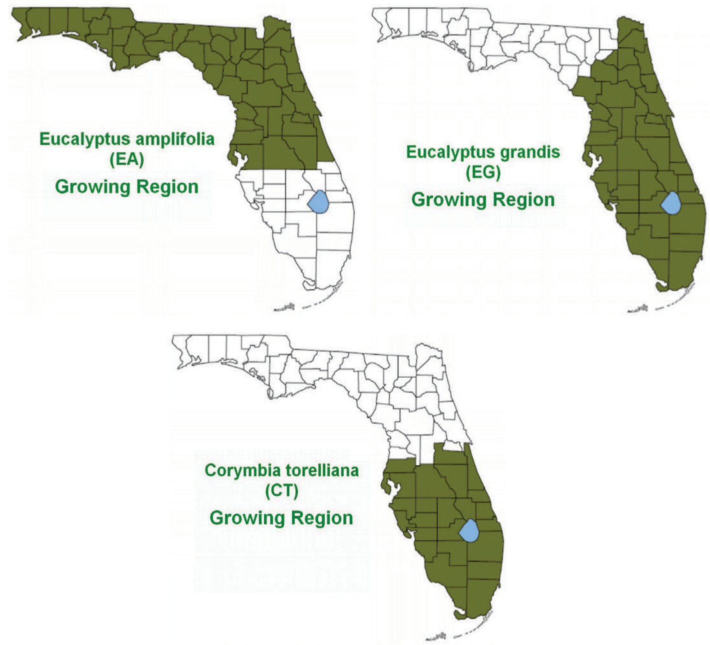

Figure 1. Climate-defined growing regions in Florida for *E. amplifolia* (EA), *E. benthamii* (EB), *E. grandis* (EG), *E grandis x E. europhylla* hybrid (EH), and *C. torelliana* (CT).

Site Requirements

EA, *EB*, *EG*, *EH,* and *CT* all grow best on agricultural lands. Lands recently in agricultural use or marginal for agricultural production are typically ideal. *EA* requires high quality land with relatively high pH. *EG* and *CT* have a wide site tolerance. *EG* and *EH* grow very well on sandy or organic soils and grow more rapidly than *EA*, *EB,* and *CT* on most sites.

All species may be grown on poorer sites if amendments are added to raise nutrient levels and/or pH. *EG*, for example, grows well on low-phosphorus sites when ground rock phosphate is applied. All these species are very responsive to fertilizer amendment. Some *EG* cultivars have acceptable flood tolerance.

Cultural Practices

On poorly drained flatwood sites or in phytoremediation applications involving flooding, bedding is essential. Beds should be at least one foot high and allowed to settle for about three months before the trees are planted.

All species survive and grow best when competing vegetation is well controlled during the first two years. The initial site preparation, if bedding is involved, is usually sufficient for vegetation control during the first growing season. Preemergent herbicides provide good first season wood control. With good tree growth during the first year, the trees typically dominate other vegetation for the rest of the rotation. *Without adequate vegetation control during the first year, eucalypts will grow very slowly and are likely to fail.*

Planting Stock

Superior genotypes have been identified within each species through two (*CT*), two (*EA*), and five (*EG*) generations of genetic testing and selection. These superior genotypes have far better growth and frost resilience than untested trees of the same species.

EA, *EB*, *EG*, *EH*, and *CT* can all be propagated as containerized trees. Superior *EG* seed is readily available, and *EA* and *CT* seed is increasingly available. *EG* is also currently available as vegetatively propagated cultivars G3, G4, and G5, and EH cultivars may be available. While the cultivars cost ~$.60 each compared to ~$.45 per seedling, their numerous attributes typically justify their higher cost.

EA, *EG*, and *CT* should be planted at the onset of the summer rainy season when soil moisture is ample. Use of water-absorbing gel can initiate or extend the planting season by about a month. Eucalypts planted too late will not reach a size that conveys some resistance to freeze damage.

Management

Management intensity and rotation length vary with species, site, and application. For example, through the 1980s, culture of *EG* for pulpwood on up to 15,000 acres of flatwoods sites in southern Florida had low intensity and consisted of 1) planting about 600 trees per acre, 2) basic application of ground rock phosphate and minimal weed control through bedding, 3) 8–10 year rotation, and 4) two to three rotations.

For the fastest-growing species grown for energywood, the time from planting to harvest may be two years or less if planted on a high-quality site or intensively managed at close spacing (for instance, *EG* planted on muck soils at 4,000 trees/acre). To maximize production, management may include intensive culture (environmentally safe site amendment, irrigation, and weed control practices).

For mulchwood production, an intermediate planting density of about 1,000 trees/acre with a rotation of some six years could produce trees of suitable size. However, *EG* grown for mulchwood at Palmdale (Table 1) is managed with relatively low intensity, but superior planting stock is used.

EA, *EB*, *EG*, *EH*, and *CT* all coppice (sprout from the stump) after harvest. In the coppice rotation, tree growth may exceed first rotation growth by some 20% and shorten the time to the second harvest by at least one year, but the time of harvest is critical to coppicing success. *EA* and *EH* coppice well throughout the year, while *EG* and *CT* harvests must be done during the winter to ensure good coppicing. Coppice cycles may be repeated up to six times. Windfall risk, e.g., from hurricanes, can be managed by a combination of genetics, site, culture, and rotation length options.

References

Andreu, M. G., B. Tamang, M. H. Friedman, and D. L. Rockwood. 2008. *The Benefits of Windbreaks for Florida Growers*. FOR192. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/FR253

Andreu, M. G., B. Tamang, D. L. Rockwood, and M. H. Friedman. 2009. *Potential Woody Species and Species Attributes for Windbreaks in Florida*. FOR224. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fr286

Brown, M. J., J. Nowak, and J. T. Vogt. 2017. Florida's forests, 2013. Resour. Bull. SRS–213. Asheville, NC, U.S. Department of Agriculture Forest Service, Southern Research Station. 94 p. www.srs.fs.usda.gov/pubs/55489

Fabbro, K. W., and D. L. Rockwood. 2016**.** Optimal management and productivity of *Eucalyptus grandis* on former phosphate mined and citrus lands in central and southern Florida: Influence of genetics and spacing. In: Proceedings 18th. Biennial Southern Silvicultural Research Conference, March 2–5, 2015, Knoxville, TN. e-Gen. Tech. Rpt. SRS-212. p.510–517. http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs212.pdf

Geary, T. F., G. F. Meskimen, and E. C. Franklin. 1983. Growing *eucalyptus* in Florida for industrial wood production. USDA Forest Service Gen Tech. Rpt. SE-23, 43p. http://www.srs.fs.fed.us/pubs/1135

Langholtz, M., D. Carter, J. Alavalapati, and D. Rockwood. 2007. "The economic feasibility of reclaiming phosphate mined lands with short-rotation woody crops in Florida." *J For Econ.* 12(4): 237–249.

Langholtz, M., D. R. Carter, and D. L. Rockwood. 2007. *Assessing the Economic Feasibility of Short-Rotation Woody Crops in Florida*. Circular 1516. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/FR169.

Langholtz, M., D. R. Carter, D. L. Rockwood, J. R. R. Alavalapati, and A. E. S. Green. 2005. "Effect of dendroremediation incentives on the profitability of short-rotation woody cropping of *Eucalyptus grandis*." *Forest Policy and Economics* 7(5): 806–817.

Meskimen, G. F., D. L. Rockwood, and K. V. Reddy. 1987. Development of *Eucalyptus* clones for a summer rainfall environment with periodic severe frosts. New Forests 3: 197–205.

Minogue, P. J. , M. Miwa, D. L. Rockwood, and C. L. Mackowiak. 2012. Removal of nitrogen and phosphorus by *Eucalyptus* and *Populus* at a tertiary treated municipal wastewater sprayfield. International Journal of Phytoremediation Volume 14, 2012 - Issue 10. https://www.tandfonline.com/doi/abs/10.1080/15226514.2011.649435

Nieves, I. U., M. T. Mullinnix, M. T. Fernández-Sandoval, Z. Tian, D. L. Rockwood, and L. O. Ingram. 2014. Evaluation of four different cultivars of *Eucalyptus grandis* for the production of ethanol in a liquefaction plus simultaneous saccharification and co-fermentation (L+SScF) process using ethanologenic bacteria *Escherichia coli* SY100. In Proc: Symposium on Biotechology for Fuels and Chemicals, April 28–May 1, 2014, Clearwater Beach, FL. (poster) https://sim.confex.com/sim/36th/webprogram/Paper26586.html

Osiecka, A., and P. Minogue. 2015. *Herbicides for Weed Control in Eucalyptus Culture*. FOR310. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fr378

Pisano, S. M., and D. L. Rockwood. 1997. Stormwater phytoremediation potential of *Eucalyptus*. In: Proceedings 5th. Biennial Stormwater Research Conference, Nov. 5–7, 1997, Tampa, FL. Southwest Florida Water Management District, Brooksville, FL. p. 32–42.

Rockwood, D. L. 2012. History and status of Eucalyptus improvement in Florida. International Journal of Forestry Research, Volume 2012 (2012), Article ID 607879, 10 pages. https://www.hindawi.com/journals/ijfr/2012/607879/abs/

Rockwood, D. L. 2013. Eucalyptus July 2013. In: New Plants for Florida 2013 Update. http://research.ifas.ufl.edu/files/2012plants/Eucalyptus.pdf

Rockwood, D. L., B. Becker, and . 2012. "Municipal solid waste compost benefits on short rotation woody crops." *Compost Sci. Utilization* 20(2): 67–72. http://www.tandfonline.com/doi/abs/10.1080/1065657X.2012.10737027#.VbzxZrPbJdg

Rockwood, D. L., and R. L. Bowman. 2017**.** "Medically related products obtainable from Eucalyptus trees." *International Biology Review* 1(3) p. 1-10. http://www.journals.ke-i.org/index.php/ibr/article/view/1615/1559

Rockwood, D. L., D. R. Carter, M. H. Langholtz, and J. A. Stricker. 2006. "*Eucalyptus* and *Populus* short rotation woody crops for phosphate mined lands in Florida USA." *Biomass & Bioenergy* 30 (8,9): 728–734.

Rockwood, D. L., D. R. Carter, and J. A. Stricker. 2008. Commercial tree crops on phosphate mined lands. Florida Institute of Phosphate Research. FIPR Publication #03-141-225. www.fipr.state.fl.us/publication/commercial-tree-crops-for-phosphate-mined-lands/

Rockwood, D. L., R. J. Dinus, J. M. Kramer, T. J. McDonough, C. A. Raymond, J. V. Owen, and J. T. Devalerio. 1993. Genetic variation for rooting, growth, frost hardiness, and wood, fiber, and pulping properties in Florida-grown *Eucalyptus amplifolia*. In: Proc. 22nd. Southern For. Tree Improvement Conf., June 14–17, 1993, Atlanta, GA. p. 81–88.

Rockwood, D. L., R. J. Dinus, J. M. Kramer, and T. J. McDonough. 1995. Genetic variation in wood, pulping, and paper properties of *Eucalyptus amplifolia* and *E grandis* grown in Florida USA. In: Proc. CRC-IUFRO Conf. Eucalypt Plantations: Improvement of Fibre Yield and Quality, Feb 19–24, 1995, Hobart, Tasmania, Australia. p. 53–59.

Rockwood, D. L., J. G. Isebrands, and P. J. Minogue. 2013. Chapter 22. Phytoremediation trees for biofuel. In: *Biofuel Crops,* P. B. Singh (Editor), CABI, p. 474-490. http://www.cabi.org/bookshop/book/9781845938857

Rockwood, D. L., L. Q. Ma, G. R. Alker, C. Tu, and R. W. Cardellino. 2001. Phytoremediation of contaminated sites using wood biomass. Final Report to the Florida Center for Solid and Hazardous Waste Management, June 2001. 95p., www.hinkleycenter.org/images/stories/publications/01_03Rockwood.pdf

Rockwood, D. L., C. V. Naidu, D. R. Carter, M. Rahmani, T. Spriggs, C. Lin, G. R. Alker, J. G. Isebrands, and S. A. Segrest. 2004. Short-rotation woody crops and phytoremediation: Opportunities for agroforestry? In: *New Vistas in Agroforestry, A Compendium for the 1st World Congress of Agroforestry 2004,* P. K. R. Nair, M. R. Rao, and L. E. Buck (Editors), Kluwer Academic Publishers, Dordrecht, The Netherlands. p. 51–63. https://www.researchgate.net/profile/Donald_Rockwood/publication/226436007_Short-Rotation_Woody_Crops_and_Phytoremediation_Opportunities_for_Agroforestry/links/5626d1bc08ae4d9e5c4d47dd.pdf

Rockwood, D. L., N. N. Pathak, and P. C. Satapathy. 1993. Woody biomass production systems for Florida. Biomass & Bioenergy 5(1): 23–34.

Rockwood, D. L., G. F. Peter, L. Groom, T. Elder, A. Sharma, and J. Y. Zhu. 2012. Energy production options for *Eucalyptus grandis* cultivars in Florida. In: Proceedings Forest Products Society 66th International Convention, Washington, DC, June 3-5, p.14. (Abstract).

Rockwood, D. L., G. F. Peter, M. H. Langholtz, B. Becker, A. Clark III, and J. Bryan. 2005. Genetically improved eucalypts for novel applications and sites in Florida. In: Proc. 28th South. For. Tree Improvement Conf., June 21–23, 2005, Raleigh, NC. p. 64–75. http://www.ces.ncsu.edu/nreos/forest/feop/Agenda2005/SFTIC/proceedings.pdf

Rockwood, D. L., S. M. Pisano, and W. V. McConnell. 1996. Superior cottonwood and *Eucalyptus* clones for biomass production in wastewater bioremediation systems. Proc. Bioenergy 96, 7th National Bioenergy Conference, September 15–20, 1996, Nashville, TN. p. 254–261. https://www.osti.gov/biblio/478644

Rockwood, D. L., A. W. Rudie, S. A. Ralph, J. Zhu, and J. E. Winandy. 2008. Energy product options for *Eucalyptus* species grown as short rotation woody crops. Int. J. Mol. Sci. 9:1361–1378. http://www.mdpi.org/ijms/papers/i9081361.pdf

Rockwood, D. L., G. H. Snyder, and R. R. Sprinkle. 1994. Woody biomass production in waste recycling systems. Proc. Bioenergy 94, 6th National Bioenergy Conference, October 2–6, 1994, Reno/Sparks, NV. p. 351–358.

Rockwood D. L., and B. Tamang. 2010. Description and performance of four *Eucalyptus grandis* cultivars released by IFAS/UF in 2009. Proceedings Florida State Horticultural Society 123:330-332. https://fshs.org/proceedings-o/2010-vol-123/FSHS%20vol%20123/330-332.pdf

Segrest, S. A., D. L. Rockwood, J. A. Stricker, and G. R. Alker. 2001. Partnering to cofire woody biomass in central Florida. In: Abstracts 5th Biomass Conference of the Americas: Biomass Conf. 2p. http://infohouse.p2ric.org/ref/35/34283.pdf

Segrest, S. A., D. L. Rockwood, J. A. Stricker, and A. E. S. Green. 1998. Biomass cofiring with coal at Lakeland Utilities. Southeastern Regional Biomass Energy Program Publication No. 219287-1, TVA, Muscle Shoals, AL. 50p. https://www.researchgate.net/profile/Donald_Rockwood/publication/253733654_Biomass_Co-Firing_with_Coal_at_Lakeland_Utilities/links/5516c84d0cf2b5d6a0f0738d/Biomass-Co-Firing-with-Coal-at-Lakeland-Utilities.pdf

Tamang, B., M. G. Andreu, M. H. Friedman, and D. L. Rockwood. 2009. Windbreak designs and planting for Florida agricultural fields. Florida Cooperative Extension Service Circular FOR227. 6p.

Tamang B., M. G. Andreu, M. H. Friedman, and D. L. Rockwood. 2009. Management of field windbreaks. Florida Cooperative Extension Service Circular FOR288. 6p.

Tamang, B, D. Rockwood, M. Langholtz, E. Maehr, B. Becker, and S. Segrest. 2008. "Fast-growing trees for cogongrass (*Imperata cylindrica*) suppression and enhanced colonization of understory plant species on a phosphate-mine clay settling area." *Ecological Engineering* 32:329–336.

Tamang, B., V. Steel, and M. Cunningham. Evaluation of Eucalyptus varieties for commercial applications in the southeastern United States. In: Proceedings 33rd. Southern Forest Tree Improvement Conference, June 8–11, 2015, Hot Springs, AR. p. 58. http://sftic.uga.edu/f/2015%2033rd%20SFTIC%20Proceedings.pdf#page=72

Zalesny, R. S., Jr., M. W. Cunningham, R. B. Hall, J. Mirck, D. L. Rockwood, J. A. Stanturf, and T. A. Volk. 2011. Chapter 2. Woody Biomass from Short Rotation Energy Crops. In ACS Symposium Book: *Sustainable Production of Fuels, Chemicals, and Fibers from Forest Biomass* (Zhu, J., et al.). p. 27–63. http://pubs.acs.org/doi/abs/10.1021/bk-2011-1067.ch002

Table 1. Location and description of EG, EH, EA, EB, and CT applications in Florida.

Application	Species	Location	Description
Phytoremediation	EA	Tallahassee	Trees planted on landfill cap
Phytoremediation	EG, EA	Tampa	Trees in 1.5-acre stormwater pond
Energywood	EA, EG	Gainesville	Cultivars in seed orchard/clone bank
Energywood	EA, EG, CT	Perry	Progenies and cultivars on sandy loam at various spacings
Energywood	EA, EB	Gainesville	Progenies and cultivars on sandy loam at three spacings and 10 cultures
Energywood	EG, EH, CT	Ft Pierce	Cultivars and progenies on sandy soil at various spacings
Energywood	EG, EH	Ft Meade	Cultivars on clay settling areas at various spacings
Mulchwood	EG	Palmdale	Trees planted at 12 x 7′ on bedded flatwoods
Mulchwood	EH	Hobe Sound	Cultivar planted at 10 x 4′ and 10 x 7′ on former citrus beds
Windbreak	EA, EG, CT	Balm	Trees planted around agricultural fields
Windbreak	CT	Clewiston	Trees planted around vegetable fields
Windbreak	EA, EG	Citra	Trees planted around citrus grove
Windbreak	EG, CT	Ft Pierce	Trees planted around citrus grove
Windbreak	EG	Winter Garden	Trees planted around citrus grove

Table 2. Guidelines for the establishment and management of EG, EH, EA, EB, and CT in Florida.

Species	EG, EH	EA, EB	CT
Applications[1]	E, M, P, R, W, B	E, M, P, R, W, B	W, B
Growing Region	Southern, central, and possibly northern FL	Northern and central FL	Southern and central FL
Site Requirements	Ag land or flatwoods	Ag or forest land SI[2] ≥65; pH>5.5	Ag land or flatwoods
Culture	Disk on muck; chop, burn, ½-ton ground rock phosphate/acre, and bed on flatwoods; add N up to 270 lbs/acre or equivalent biosolids on flatwoods; plant in summer	Disk and herbicide; add 15–20 tons/acre of compost or N and P up to 250 lbs/acre or equivalent biosolids; Plant in spring or summer	Disk and herbicide; add N and P up to 250 lbs/acre or equivalent biosolids; plant in spring or summer
Planting Stock	Improved seedlings or commercial cultivars[3]	Improved seedlings	Improved seedlings
Growth	46 ft tall in 2.5 yrs on muck; 33 ft in 2 yrs and 55 ft in 5 yrs on flatwoods	46 ft in 3 yrs on ag lands	30 ft in 2 yrs on ag lands
Rotation	2 yrs on muck; 5 yrs on flatwoods	2–5 yrs	–
Coppicing (sprout from the stump)	Good in winter, poor in summer; 33 ft. in 1.75 yrs on muck, 66 ft in 5 yrs on flatwoods	Excellent in winter and summer; 16 ft. in 6 mos on ag lands	Good in winter and spring; 10 ft. in 6 mos on ag lands
Productivity (dry tons/acre/yr)	Up to 16	Up to 11	–

[1] E = energywood, M = Mulch, P = Pulpwood, R = Remediation, W = Windbreak, B = Bioproducts
[2] Site Index (base age 25 years) for slash pine
[3] UF cultivars G3, G4, G5, or ArborGen cultivar EH1 as appropriate for site and climate