CIR 1516

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IFAS Extension

Assessing the Economic Feasibility of Short-Rotation Woody Crops in Florida[1]

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Plantations of short-rotation woody crops (SRWCs) use fast-growing tree species that coppice, i.e., resprout from the stump, for repeated harvests that minimize planting costs. Under coppice management, 3-5 growth stages (coppices) can be harvested during the SWRC life (rotation or cycle), with each coppice lasting 2-10 years. SRWCs can produce wood for biomass, mulch, pulpwood, and other products, while also providing environmental services. For example, SRWC plantations can be irrigated with municipal wastewater or fertilized with treated biosolids or municipal compost, simultaneously increasing biomass production, reducing fertilizer costs, and intercepting nitrates and phosphates to reduce nutrient loading in waterways (Rosenqvist *et al.*, 1997; Labrecque *et al.*, 1997; Aronsson & Perttu, 2001; Rockwood *et al.*, 2004; Licht & Isebrands, 2005; Langholtz *et al.*, 2005; Mirck *et al.*, 2005). SRWCs can also help build soil organic matter, recycle nutrients, and maintain vegetative cover to restore ecological functions of mined lands and other degraded lands (Stricker *et al.*, 1993; Bungart & Huttl, 2001; Rockwood *et al.*, 2006) . SRWCs established on agricultural lands as shelterbelts or buffer zones to protect riparian areas are likely to reduce soil erosion and runoff of agricultural inputs and improve wildlife habitat (Joslin & Schoenholtz, 1997; Tolbert & Wright, 1998; Thornton *et al.*, 1998). In spite of these benefits, SRWC production is not always economically viable, and evaluating the economics of SRWC production is not easy.

Because SRWCs can have multiple coppices per rotation, evaluating the economics of SRWCs is more complicated than that of conventional forestry. For example, in the evaluation of a pine plantation, the future value of harvested timber is discounted to the year of planting, and planting costs are subtracted to calculate the net present value (NPV) of one harvest rotation. NPV is then used to calculate land expectation value (LEV), i.e. the value of the land assuming the adoption of this forestry practice. However, in the case of SRWC systems, multiple coppices require that the value of every coppice is discounted to the beginning of the rotation. Furthermore, the costs associated with establishment of each rotation and coppice stage must be discounted differently, and determining the optimum harvest scheduling and replanting age is also more

1. This document is Circular 1516, one of a series of the School of Forest Resources and Conservation, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. First published: May 2007. Please visit the EDIS Web site at http://edis.ifas.ufl.edu.
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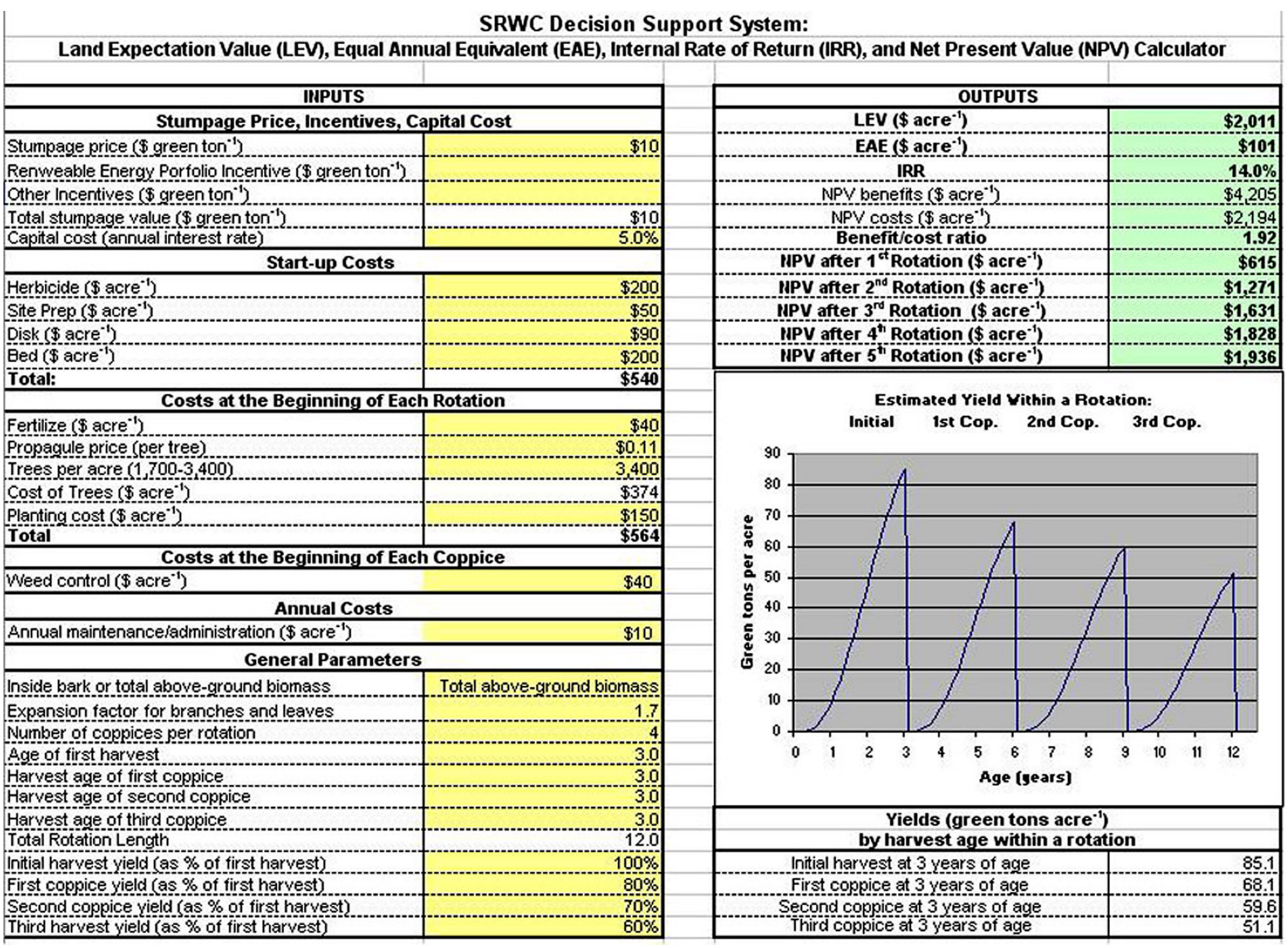
complicated than for conventional forestry. Theory behind economic evaluation and optimization of SRWCs is described by Medema & Lyon (1985),Tait (1986), and Smart & Burgess (2000) . Economics of SRWC systems in Florida are evaluated by Langholtz *et al.* (2005;2007).

The Florida Institute of Phosphate Research (FIPR) has supported research in the development of SRWCs as commercial tree crops on phosphate mined lands in Florida. A product of this research is a SRWC Decision Support System (DSS) that can be used to evaluate the economic viability of SRWC systems. The DSS allows a user to input operational costs, planting densities, stumpage prices and other variables and calculate NPVs, LEV, equal annual equivalent (EAE), internal rate of return (IRR), and benefit/cost ratio of a SRWC system. The DSS is in the form of a Microsoft® Excel spreadsheet (Figure 1).

The DSS allows users to enter variables in yellow cells in the "Inputs" section on the left side of the worksheet and view results in green cells in the "Outputs" section on the right. Input variables include stumpage price, capital cost, and costs of each start-up, rotation, coppice, and year. The user can specify what portion of total biomass is harvested, the number of coppices, and their harvest ages. Financial incentives for renewable energy or other environmental benefits can be incorporated on a per-ton basis in the stumpage price. The DSS uses growth and yield functions developed from measurements of two planting densities of *Eucalyptus amplifolia* in a field trial of SRWCs on a phosphate mine clay settling area (CSA) near Lakeland, FL. Yields for each growth stage are displayed, and can be modified by adjusting the initial planting density or by adjusting yields under



INPUTS	
Stumpage Price, Incentives, Capital Cost	
Stumpage price (\$ green ton^{-1})	$10
Renweable Energy Porfolio Incentive (\$ green ton^{-1})	
Other Incentives (\$ green ton^{-1})	
Total stumpage value (\$ green ton^{-1})	$10
Capital cost (annual interest rate)	5.0%
Start-up Costs	
Herbicide (\$ acre^{-1})	$200
Site Prep (\$ acre^{-1})	$50
Disk (\$ acre^{-1})	$90
Bed (\$ acre^{-1})	$200
Total:	**$540**
Costs at the Beginning of Each Rotation	
Fertilize (\$ acre^{-1})	$40
Propagule price (per tree)	$0.11
Trees per acre (1,700-3,400)	3,400
Cost of Trees (\$ acre^{-1})	$374
Planting cost (\$ acre^{-1})	$150
Total	**$564**
Costs at the Beginning of Each Coppice	
Weed control (\$ acre^{-1})	$40
Annual Costs	
Annual maintenance/administration (\$ acre^{-1})	$10
General Parameters	
Inside bark or total above-ground biomass	Total above-ground biomass
Expansion factor for branches and leaves	1.7
Number of coppices per rotation	4
Age of first harvest	3.0
Harvest age of first coppice	3.0
Harvest age of second coppice	3.0
Harvest age of third coppice	3.0
Total Rotation Length	12.0
Initial harvest yield (as % of first harvest)	100%
First coppice yield (as % of first harvest)	80%
Second coppice yield (as % of first harvest)	70%
Third harvest yield (as % of first harvest)	60%

OUTPUTS	
LEV (\$ acre^{-1})	**$2,011**
EAE (\$ acre^{-1})	**$101**
IRR	**14.0%**
NPV benefits (\$ acre^{-1})	$4,205
NPV costs (\$ acre^{-1})	$2,194
Benefit/cost ratio	**1.92**
NPV after 1st Rotation (\$ acre^{-1})	**$615**
NPV after 2nd Rotation (\$ acre^{-1})	**$1,271**
NPV after 3rd Rotation (\$ acre^{-1})	**$1,631**
NPV after 4th Rotation (\$ acre^{-1})	**$1,828**
NPV after 5th Rotation (\$ acre^{-1})	**$1,936**

Yields (green tons acre^{-1}) by harvest age within a rotation	
Initial harvest at 3 years of age	85.1
First coppice at 3 years of age	68.1
Second coppice at 3 years of age	59.6
Third coppice at 3 years of age	51.1

Figure 1. The SRWC Decision Support System spreadsheet.

the general parameters. Ranges of values used to assess SRWC production on CSAs are shown in Table 1.

Under all possible combinations of the assumptions in Table 1, the profitability of *E. amplifolia* on CSAs varies widely, with LEVs ranging from -\$909 to \$6,740 acre^{-1}. Under the base case scenario identified in Table 1, the resulting LEV is \$308 acre^{-1} assuming an interest rate of 10% and \$2,633 acre^{-1} assuming an interest rate of 4%. LEV, EAE, and IRR results of the base case scenario under a range of discount rates and stumpage prices are shown in Table 2.

This DSS does not automatically determine optimum harvest ages or the optimum number of stages per cycle, which both require dual optimization of continuous functions. DSS users can either input probable harvest and replanting ages and "zero in" inputs to maximize economic returns, or contact the authors to arrange a customized DSS. The DSS in either Excel or MathCad format could be modified to incorporate alternative growth and yield functions that might be developed for other SRWC species or conditions. For more information see the FIPR report "Commercial Tree Crops for Phosphate Mined Lands", Rockwood et al. (in press).

Acknowledgements

We acknowledge the assistance of Steve Segrest of the Common Purpose Institute and funding by the Florida Institute of Phosphate Research.

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Table 1. Ranges of values used in the DSS to assess SRWCs on a phosphate mine clay settling area.

Input category	Range of DSS Inputs applied for
Start-up costs	\$364 - \$728* acre $^{-1}$ (\$900 - \$1,800 ha $^{-1}$)
Costs at the beginning of each rotation	\$243 - \$486* acre $^{-1}$ (\$600 - \$1,200 ha $^{-1}$)
Costs at the beginning of each coppice	\$0 - 81 acre $^{-1}$ (\$0* - \$200 ha $^{-1}$)
Discount rate	4%, 7%, and 10%
Stumpage price	\$4, \$9, and \$14 green ton $^{-1}$ (\$10, \$20 and \$30 dry Mg $^{-1}$)
Planting density	1,700-3,400* Trees acre $^{-1}$ (4,200-8,400 Trees ha $^{-1}$)
Coppice yields	Variable, though likely to decrease about 20%* with each coppice

*Base case scenario.

Table 2. DSS calculated land expectation value (LEV, \$ acre $^{-1}$), equal annual equivalent (EAE, \$ acre $^{-1}$), and internal rate of return (IRR, %) for three discount rates (%) and three stumpage prices (\$ green ton $^{-1}$) assuming base case scenarios defined in Table 1.

	Discount Rate	Stumpage Price		
		$4.54	$9.07	$13.61
LEV	4	$251	$2,633	$5,245
	7	-$323	$977	$2,373
	10	-$556	$308	$1,237
EAE	4	$10	$105	$210
	7	-$23	$68	$166
	10	-$56	$31	$124
IRR	4	5.0%	12.4%	18.3%
	7	5.0%	12.4%	18.3%
	10	5.0%	12.4%	18.3%