Economics of the Switchgrass Supply Chain: Enterprise Budgets and Production Cost Analyses

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TRANSITION TO A BIO ECONOMY

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Impacts of a Bioeconomy of a Dedicated Energy Crop

- Introducing a dedicated energy crop onto 22.8 million acres of cropland, pasture, and fallow areas in the U.S. Southeast by 2025 could:
  - increase farm income by $37.5 billion/year,
  - add 1 million jobs for the construction and operation of conversion facilities, and
  - could increase overall annual economic activity by $99 billion (English, 2006).
- While these figures are impressive, they don't take into account other potential benefits of increased domestic energy production from renewable resources such as:
  - enhanced national security,
  - improved environmental amenities such as water quality, wildlife habitat, and
  - decreased greenhouse gas emissions.

Currently, to Jump Start the Adoption Process

- We realize that massive quantities of high quality, low cost dedicated energy feedstock will need to be produced, harvested, stored, and delivered to conversion facilities throughout the calendar year (De La Torre Ugarte et al., 2007; Perlack et al. 2005).
- Tennessee's legislature led by Governor Bredesen passed the Tennessee Biofuel Initiative in 2007 committing over $40 million to capitalize the establishment of a cellulosic ethanol facility, along with another $30 million to provide farmer incentives, research, and operating expenses.
- Additional biomass provisions at the Federal level
  - Biomass Crop Assistance Program (BCAP) found in the 2008 Farm Bill (USDA, 2008)
  - the $400 million in funding for integrated biomass conversion facilities found in the American Recovery and Reinvestment Act of 2009 (USDOE, 2009)

Objectives of this Paper

- Examine the economics of the supply chain for perennial dedicated energy crops, specifically switchgrass (*Panicum Virgatum*).
  - Crop Enterprise Budgets
  - Cost of Production Analyses
- Identify what we Know and what we do not know under the assumption that
  - For switchgrass cropping systems to become commercially viable, the price paid to producers per ton of biomass must be high enough to bid land away from traditional farm enterprises in quantities necessary to ensure a constant, year-round supply of biomass to the biorefinery doorstep.
  - A precondition for this to occur is that the biomass price must exceed the cost to produce, harvest, store, and deliver the biomass to the biorefinery doorstep as well as cover the opportunity costs involved in land conversion.

Methods

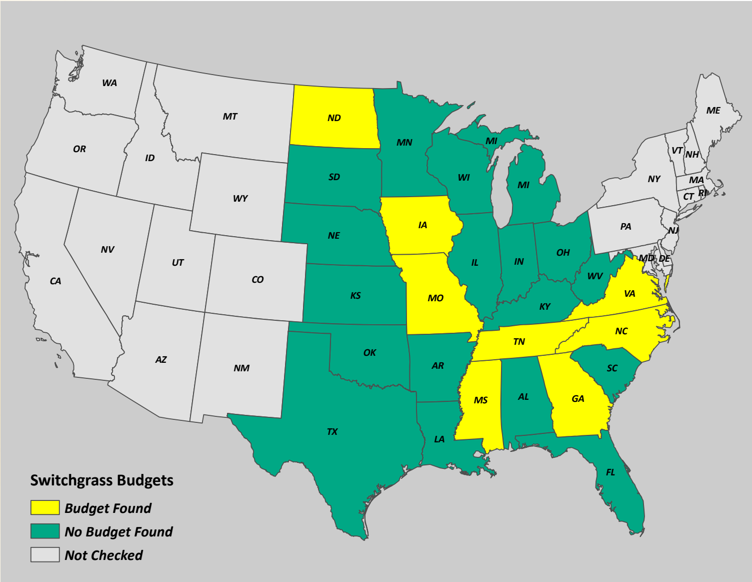
- In completing the study,
  - existing university enterprise budgets and cost of production economic analyses are reviewed,
  - key economic concepts that arise along the switchgrass supply chain are identified, and
  - important issues and shortcomings are highlighted for future analyses.

What are Enterprise Budgets

- Enterprise budgets allow farm managers to compare costs and returns of alternative crop or livestock activities and evaluate the technology, resources, and management abilities required for each option.
- They typically include a revenue statement, estimated variable costs for a fixed enterprise size (e.g. per acre or per head), and a machinery and labor schedule.
- With the exception of land, fixed and overhead costs are rarely included.
- Net returns are interpreted with respect to the costs considered and generally don't account for management or risk.
- Activities whose production cycle extends beyond a single calendar year and whose cost or benefit streams vary require separate enterprise budgets for each stage of production.

A Review of Switchgrass Enterprise Budgets

- Surveyed 26 Universities and Institutions in the South and Midwest
- Identified 7 switchgrass enterprise budgets for producing switchgrass as a feedstock at the primarily budget website for Extension in that state.



Budget Characterization

- Not all budgets are the same
  - Annual production budget
  - Establishment budget plus Maintenance and Harvest budgets
  - Reseeding assumptions
  - Storage
  - Transportation

Budget Characterization

- Not all budgets are the same
  - Yields are specified on some and not on others
  - Time frame varied from 3 years to 25 years
  - Herbicide costs varied from $0 to $26.
  - Harvest method varied and in some while costs were assumed, the method was not specified
  - Estimated cost/ton varied and of course what costs were covered in that estimate varied.

Budget Characterization

Budget/ Study	State	Estimated Cost of Production ($/ton)
Ferland (2001)	Georgia	$60
Whitten (2007)	Mississippi	NS[a]
Green and Benson (2008)	North Carolina	$61 without est.
Garland (2008)	Tennessee	NS
Virginia Cooper. Ext. (2007)	Virginia	NS
Duffy (2008)	Iowa	$114[b]
Carpenter and Brees (2008)	Missouri	$66
Bangsund et al. (2008)	North Dakota	$47-$76

[a] NS = Not specified

[b] Iowa budget includes establishment, reseeding, production, storage, and transportation

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Cost of Production Analyses

- A summary of five economic analyses whose objective was to determine switchgrass cost of production on a per ton basis was conducted.
- Two of these studies report production costs at the farm gate, while the other report farm gate and delivered costs.

Cost of Production Analysis

Study	Yield Level(s) Assumed	Stand Lifespan(s)	Land Cost	Harvest method	Estimated Cost of Production
	tons/acre	Years	$/acre	yes/no	$/ton
Khanna et al. (2008)	9.4	10	$78	Large rectangular bales	$44 (farm gate, w/o land cost) $89 (delivered)
Mooney et al. (2009)	6.2 — 7.9	5 and 10	$68	Large round bales	$42-63 (farm gate, 10-year lifespan)
Perrin et al. (2008)	2.6 — 3.5	5 and 10	Various	Mixed	$42-71 (farm gate, 10-year lifespan)
Epplin et al. (2007)	NS[a]	NS	$60	Large rectangular bales	$36-52 (farm gate) $49-65 (delivered)
Wang (2009)	6.0-7.8	NS	Varied by productivity	Mixed	$66-77 (delivered)

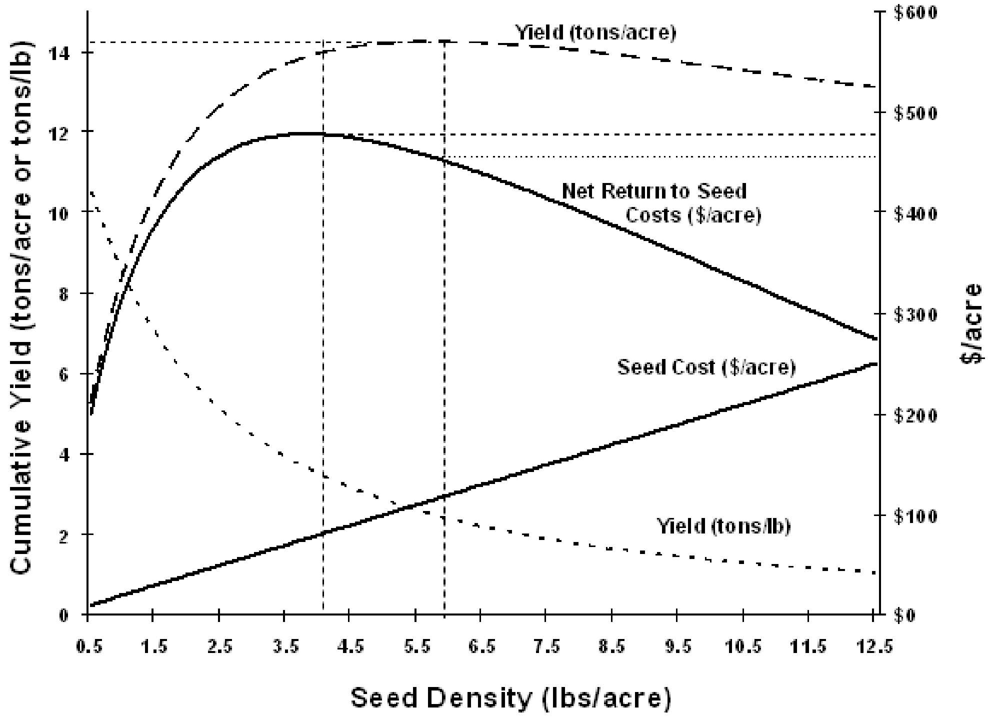
[a] NS = Not specified

Economics of the Switchgrass Supply Chain – Stand Establishment

- Seed
  - Previous research suggested that, beyond a certain plant density threshold, switchgrass yield is unresponsive to increased plant population density (Schmer et al., 2005; Vogel and Masters, 2001).
  - UT recommended 2 years ago 8 pounds/acre

Economics of the Switchgrass Supply Chain – Stand Establishment

Figure 1. Relationship between cumulative yield, seed density, and net return to seed cost for a moderately drained sloping upland landscape in West Tennessee based on 2004-2006 production data. Source: Mooney et al. (2008)



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Economics of the Switchgrass Supply Chain – Stand Establishment

- Weed Control
  - Annual grass weeds are potentially more problematic than broadleaf weeds because they more easily canopy the emerging switchgrass seedlings and because current chemical controls may damage the switchgrass in addition to the weeds.
  - The economics of weed control in switchgrass are poorly understood. In multiple field experiments conducted by the University of Tennessee Switchgrass Project, strong stands have emerged by the third year of production even where severe weed infestations occurred during the first two years of production and weed control was absent.
  - The question of whether the benefits of chemical control during establishment, in terms of yield losses avoided, are sufficient to pay for their expense remains to be answered.
  - The impact of harvesting weeds in addition to switchgrass on conversion is also difficult to answer.
  - At the same time, convincing producers of this might be a significant challenge and also this practice may increase weed pressure on other crops.

Economics of the Switchgrass Supply Chain – Stand Establishment

- The matter of revenue during stand establishment
  - Conventional thinking right now is that the stand will not mature until year 3
  - Yields are non existent or low in the initial year.
  - How should this be treated. Is this an opportunity cost?

The Matter of Reseeding

- Switchgrass at the current time may be difficult to establish.
  - My experience (3 establishment years)
    - 0% out of 32.5 acres
    - 12% of 92.5 acres
    - 25% of 720 acres
  - What about the opportunity costs that this imposes on the farmer (delay in mature yields)?

Switchgrass Maintenance

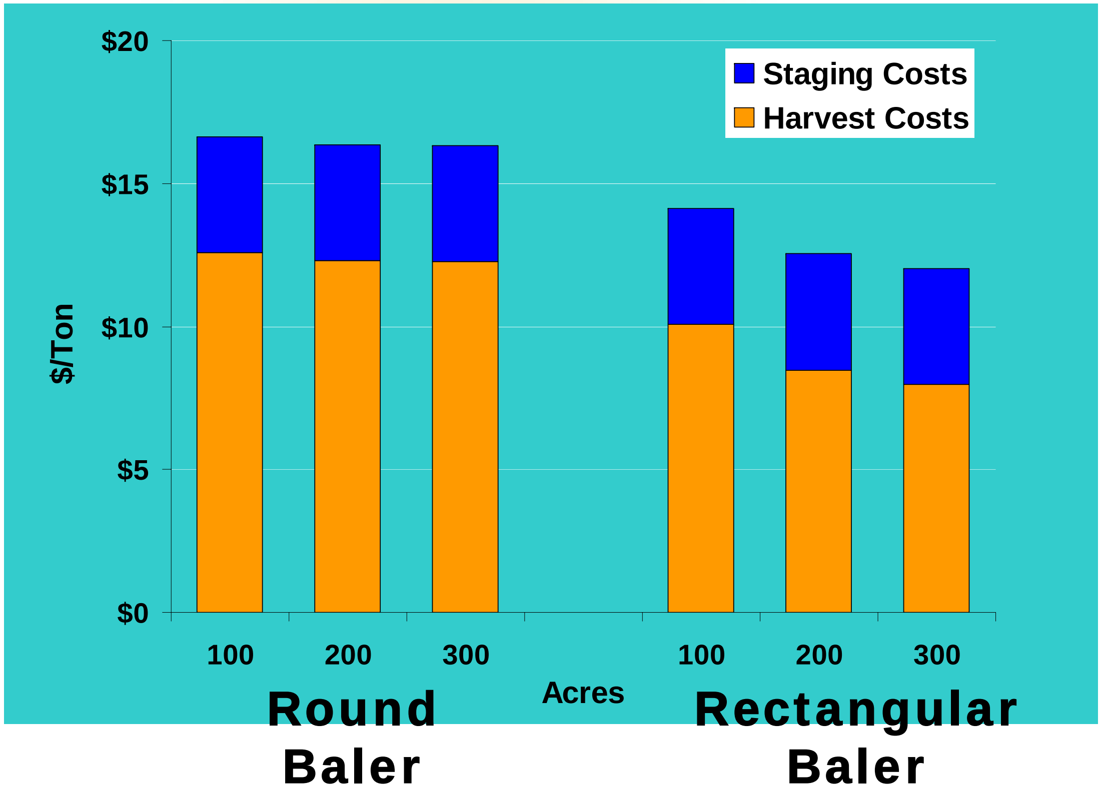
- P & K assumptions differ widely
- Parrish et al. (2003) recommended no P&K since he found that switchgrass does not respond to P&K unless at soil tests low.
- Yet P & K are removed at harvest
  - One plot area went from medium test to low after 3 years and P&K was applied then.
  - A farmer applied P&K at removal rates against UT recommendations even when soils tested high.

Determination of Unit Production Costs

Table 3. Example Calculation to Determine the Cost Per Ton of Switchgrass Produced on a Moderately Drained Sloping Upland Environment, (Mooney et al., 2008)

	Year (time period)					5-Year Stand Lifespan (2004 USD)			
						NPV of Production Costs (@ 8% discount rate)		Annualized Total Production Cost	
	2004	2005	2006	2007	2008				
Item	**(t =1)**	**(t = 2)**	**(t =3)**	**(t =4)**	**(t = 5)**	**$/**	**%**	**$/Year**	**$/Ton**
Yield (dry tons/acre)	1.08	4.18	8.83	8.83	8.83				
Establishment Costs	$222	$0	$0	$0	$0	**$222**	**15%**	**$51**	**$8.11**
Maintenance Costs (weed control / fertilizers)	$0	$40	$40	$40	$40	**$132**	**9%**	**$31**	**$4.82**
Harvest Costs	$46	$114	$216	$216	$216	**$666**	**46%**	**$154**	**$24.32**
Land Costs	$100	$100	$100	$100	$100	**$431**	**30%**	**$100**	**$15.74**
Total Production Costs	$368	$254	$356	$356	$356	**$1,452**	**100%**	**$337**	**$53.03**

Harvest and Storage – System used and acres covered matters



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Storage Losses and Impact to Chemical Composition

- Will affect the value of the product
- Are really unknowns

Bale Type	Cover system	% DML[a] after storage of:			
		100 Days	200 Days	300 Days	400 Days
Round	None	6.0	15.7	14.0	9.7
Round	Tarp	0.0	6.1	4.6	7.0
Rectangular	None	27.2	52.5	52.1	64.8
Rectangular	Tarp	25.7	20.8	12.5	13.7

Bales placed in storage Jan 24, 2008
Source: English, Larson, and Tyler, 2009 unpublished data

What System are we Concerned With?

Harvest is initiated after the first frost and continues until initial greening up in the spring. The material that is harvested and transported to the plant for immediate use would be done using the large rectangular bale system.

Any bales that are not to be used during this harvest window would be harvested using a round bale system. Bales to be stored for a period of time less than 90 days would not require protection and those bales harvested and stored for a period of more than 90 days would require protection (e.g. tarp and stored on wood pallets).

Conclusions

- To accurately determine the cost of production at the farm-level, full economic cost analyses will be needed that clearly state the assumptions used with respect to assumed yield level, stand lifespan, opportunity costs, and the discounting of cost and revenue streams.

Conclusions

- Second, integrated harvest, storage, and delivery systems must be developed to ensure a flow of high quality, low cost biomass to conversion facilities year round.
  - Harvest and storage costs will vary by method (i.e., round bales, square bales) and may differentially impact costs of other supply chain elements (e.g., handling, pre-processing), indicating a need to evaluate separate supply chain components within a systems framework.
  - Optimal systems that minimize the cost of biomass delivered to the biorefinery gate will likely consist of a mix of harvest/storage solutions that will vary as a function of harvest method, precipitation, time in storage, and refinery capacity.