Farm Level Agricultural Resource Evaluation (FLARE) Model

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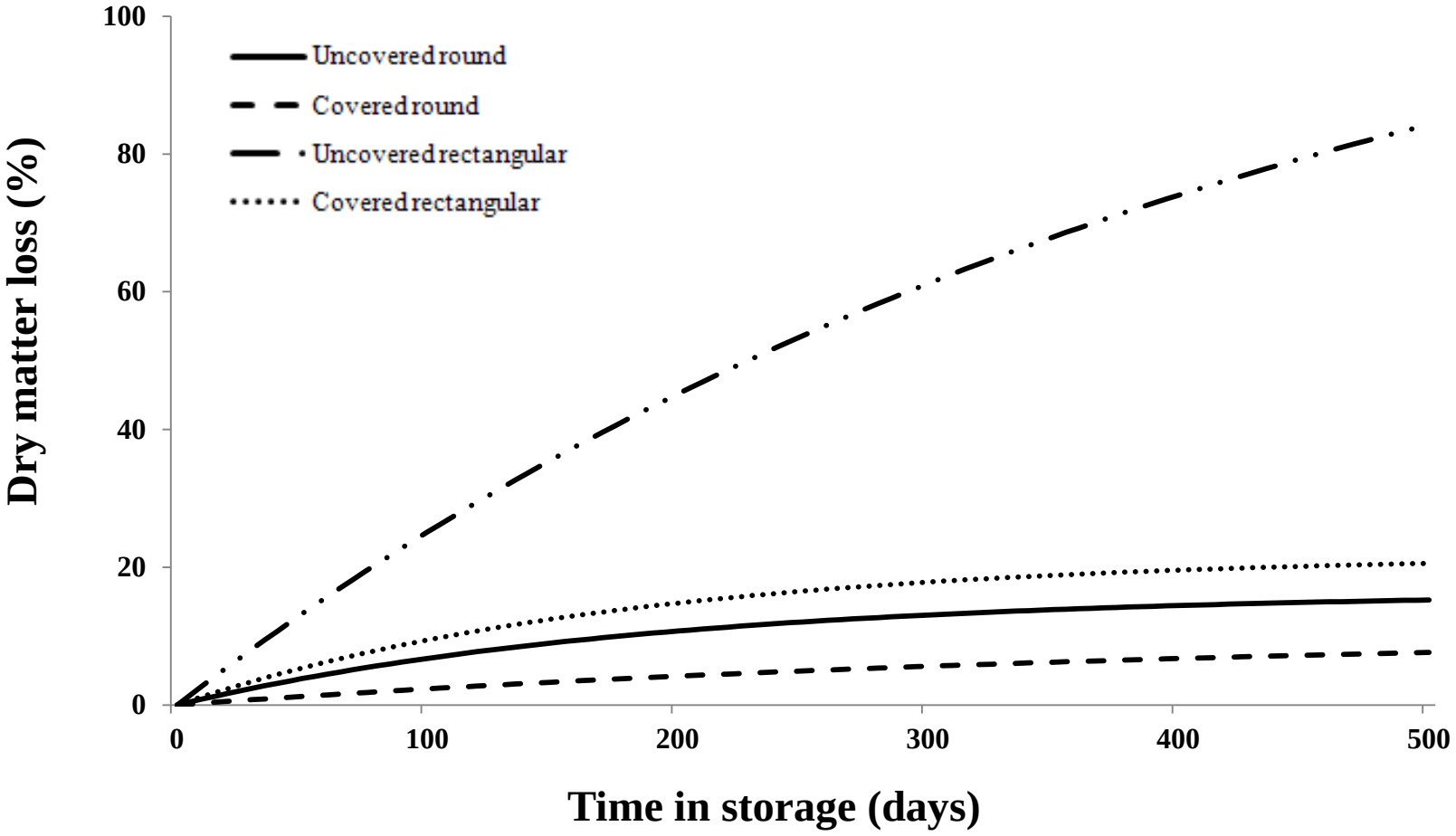
Farm Level Agricultural Resource Evaluation (FLARE) Model

- **It has two main parts:**
  1. A set of farm level enterprise budgeting, breakeven, and sensitivity analysis models, and
  2. A set of representative whole farm simulation and optimization models.
- **The suite of economic models are used to evaluate alternative biomass:**
  1. Production technologies,
  2. Production enterprises, and
  3. Contracting and incentive arrangements.
- **Farm enterprise and whole farm levels are the units of analysis.**

Farm Enterprise Models

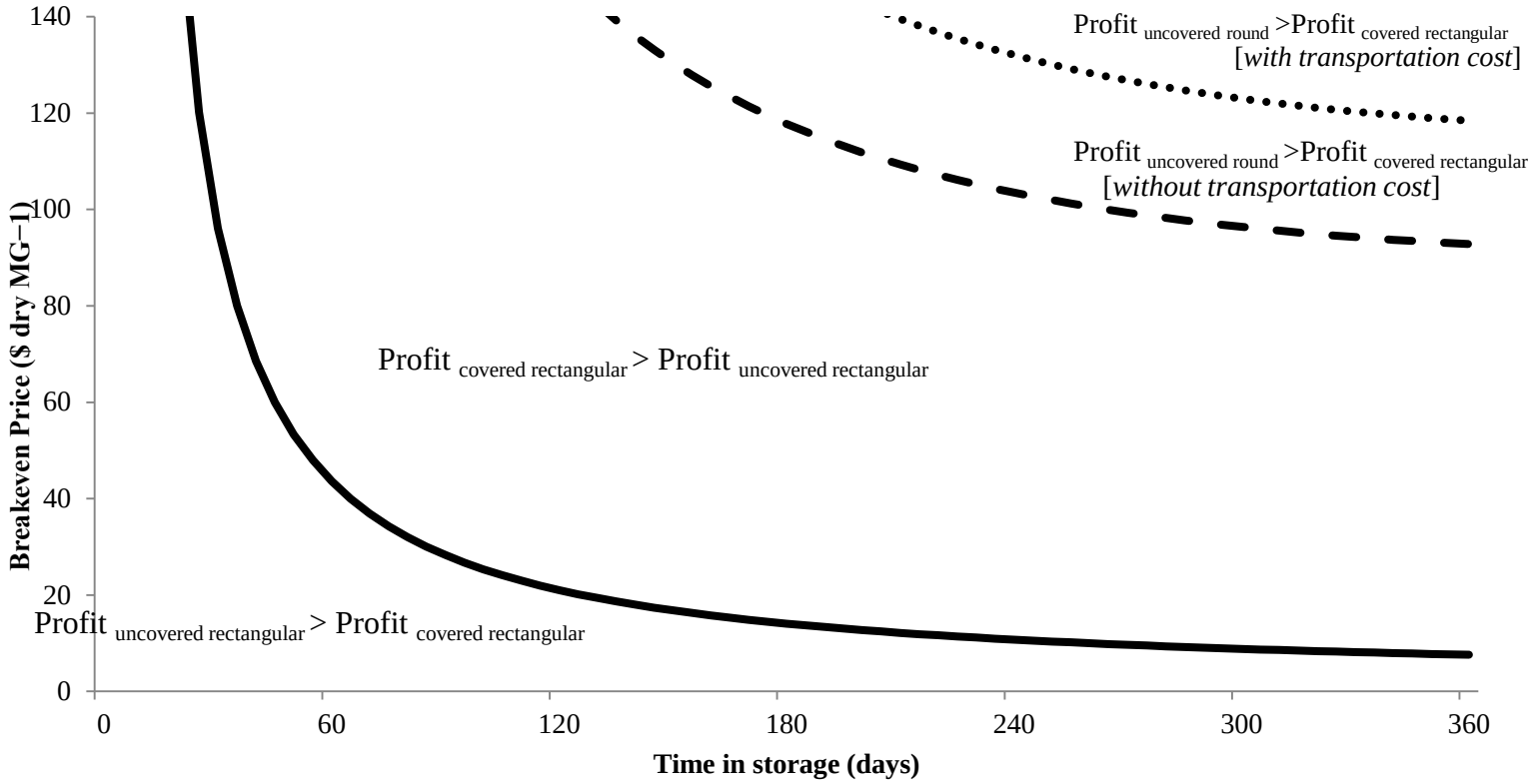
- **Used to evaluate alternative biomass production, harvest, storage and logistics practices primarily from experiment data:**
  - **Switchgrass, and**
  - **Energy sorghum.**
- **Examples:**
  - **Alternative seeding rates and N rates for switchgrass (Mooney et al., 2009).**
  - **Alternative harvest and storage methods for switchgrass (Larson et al., 2010; Mooney et al., 2012).**
  - **Alternative contracting arrangements and BCAP incentive effects on risk and return for switchgrass production (Griffith et al., 2012, forthcoming).**

Predicted dry matter (DM) loss for switchgrass stored outdoors, switchgrass bale experiment, Milan, TN, 2008-2009



Breakeven Cost of Storage

Mooney et al., Biomass & Bioenergy, 2012



Profit uncovered rectangular (defender) = Profit covered rectangular (challenger)

Profit covered rectangular (defender) = Profit uncovered round (challenger) [without transportation costs]

Profit covered rectangular (defender) vs. Profit uncovered round (challenger) [with transportation costs]

Representative Whole Farm Models

- **Currently developed representative whole farm models:**
  - East Tennessee beef cattle and crop farm (Griffith, MS Thesis, 2009).
  - Middle Tennessee beef cattle farm (Watts, MS Thesis, 2012).
  - West Tennessee diversified crop farm (He et al., 2008).
- **Used to evaluate changes in land use and optimal enterprise mix with biomass crop production at the farm level given:**
  - Alternative contract arrangements,
  - Farmer risk preferences, and
  - Resource constraints, e.g., soil types, labor, capital, etc.
  - Other constraints, e.g., risk preferences.

Representative Crop Farm Model in Northwest Tennessee

- **Soils and Crop Area:**
  - 2,400 acre farm has three major soil types/landscapes common to northwest Tennessee:
    - Collins (0% slope with no fragipan),
    - Memphis (1% slope with 42" depth to fragipan), and
    - Loring (3% slope with 30" depth to fragipan).
  - The area of the farm in each soil type was determined using data from the USDA-NRCS soil survey database (USDA-NRCS, 2005).
    - 1,200 acres of Collins soils,
    - 528 acres of Loring soils, and
    - 672 acres of Memphis soils.
  - Major tillage practice in northwest Tennessee is no tillage and was used to simulate yields and estimate production costs for all crop activities on the farm (Tennessee Department of Agriculture, 2007).

Representative Crop Farm Model in Northwest Tennessee

- **Base crop production alternatives:**
  - Continuous corn,
  - Continuous soybeans,
  - Continuous winter wheat (grain or grain and straw bales),
  - Soybean-corn rotation, and
  - Soybean-corn-corn rotation,
  - Soybeans-wheat double-crop (grain or grain and straw bales).

Biomass Energy Crop Contract Scenarios

- **Representative farm was assumed to have the opportunity to provide biomass feedstocks to a local single-user facility that produces ethanol:**
  - Wheat straw,
  - Corn stover, and
  - Switchgrass.
- **Contract Alternatives:**
  - Spot Market Type Contract
  - Standard Marketing Contract
  - Acreage Contract
  - Gross Revenue Contract
  - Above contracts with and without a planting incentive for the perennial switchgrass, i.e., processor pays for seed costs.

Spot Market Contract (SPOT)

- Assumes processor purchased biomass based on current energy price equivalent.
- Straw and stover prices adjusted downward from the switchgrass price to account for lower energy content:
  - Wheat straw: Mean=$27.68/dt, std dev=$9.29/dt,
  - Corn stover: Mean $29.44/dt, std dev=$15.50/dt, and
  - Switchgrass: Mean $34.77/dt, std dev=$7.43/dt.
- The SPOT contract assumes that all of the output price, yield, and production cost risk from biomass production is borne by the farmer.

Standard Marketing Contract (STANDARD)

- Assumes processor pays the producer a guaranteed price on a proportion of expected production (Musser, Mapp, and Barry, 1984; Paulson and Babcock, 2007).
  - $30/dt-80/dt in $5/dt increments simulated for switchgrass.
- A penalty for production underage is assessed using the SPOT price.
- Production in excess of the guaranteed price proportion is sold at the SPOT price.
- With the STANDARD contract, a portion of the price risk on expected production is shifted from the producer to the processor.
- Yield and production cost risk from biomass production is borne by the farmer.

Acrerage Contract (ACREAGE)

- Assumes processor provides a guaranteed annual price on the actual biomass produced in each year on the contracted biomass acreage (Paulson and Babcock, 2007).
  - $30/dt-80/dt in $5/dt increments simulated for switchgrass.
- Yield and production cost risk from biomass production is borne by the farmer.

Gross Revenue Contract (REVENUE)

- Assumes processor provides a guaranteed annual gross revenue per acre from biomass based on a guaranteed contract price times expected yield per acre over the life of the contract (Garland, 2007).
  - $30/dt-80/dt in $5/dt increments simulated for switchgrass.
- Contract provides the greatest potential risk benefits to the farmer because all of the biomass price and yield risk is assumed by the processor.
- The gross revenue contract and the planting incentive are two potential switchgrass production incentives that are being consider for contract production for the pilot cellulosic ethanol plant being constructed in Vonore, TN, for Tennessee Biofuels Initiative (Garland, 2007).

Net Revenues

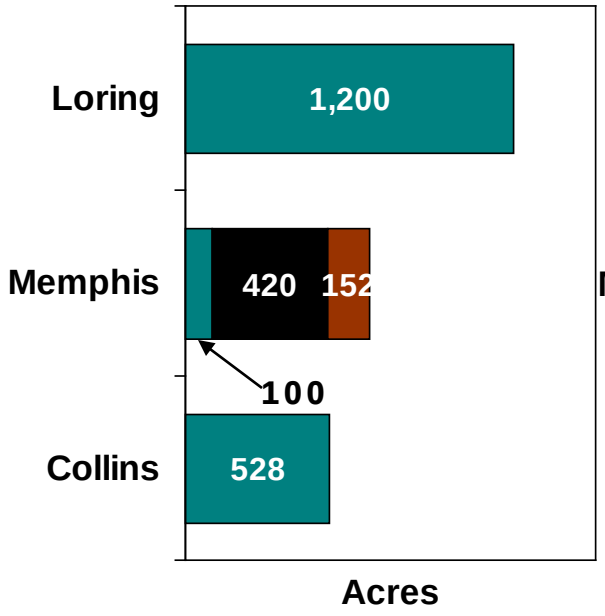
- 100 years of yields for each crop alternative were simulated for each crop and soil type using ALMANAC and 100 years of daily weather data.
- 100 years of correlated crop, fertilizer nitrogen, and diesel fuel prices for each crop alternative were simulated using @RISK:
  - Tennessee average yearly corn, soybean, and wheat prices were used to calculate distribution parameters for each crop price distribution (Tennessee Department of Agriculture).
  - Price data for estimating the nitrogen fertilizer and diesel fuel distribution parameters were obtained from *Agricultural Statistics* (USDA-NASS).
  - Net energy-equivalent to wholesale gasoline biomass prices (accounts for energy to convert to ethanol) were used to calculate prices and distribution parameters for @RISK Wang et al., 1999; U.S. DOE).
  - Prices were inflated to 2006 dollars by the Implicit Gross Domestic Product Price Deflator (U.S. Congress, Council of Economic Advisors, 2007).
  - Inflated prices then were detrended using procedures described by Pelletier to remove the long-term downward trend in real crop prices.
- Production costs from Tennessee Extension budgets.

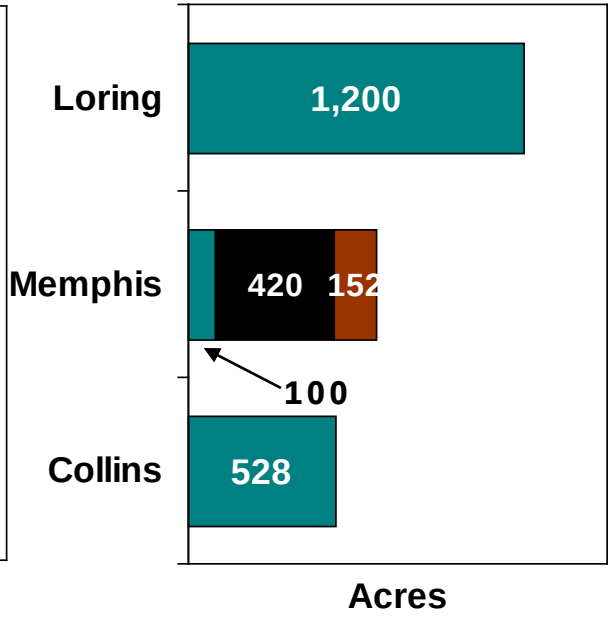
Representative Farm risk Programming Model

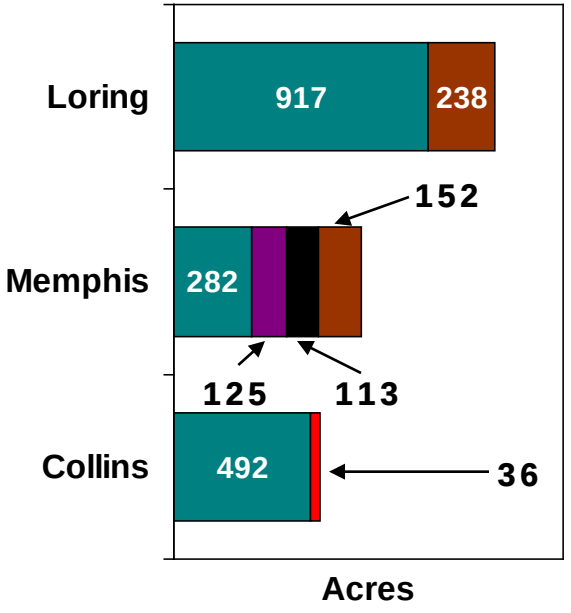
- Net revenue means and variance-covariance matrix constructed using potential crop activities.
- The main resource constraints were for soil type, labor and straw and stover harvest periods.
- Land for each soil type was restricted to 1,200 acres of Collins soils, 528 acres of Loring soils, and 672 acres of Memphis soils.
- Six bimonthly labor periods were specified in the model. Labor requirements by period were from University of Tennessee crop budgets (Gerloff, 2007a; 200b). Labor availability by period was for a family of four (Johnson, 1991).
- It was assumed that the farm could hire an additional 2,000 hours of labor per year at $8.50/hour (Gerloff, 2007a;2007b). Hired labor was assumed to have an efficiency of 90% (Musser et al., 1984).

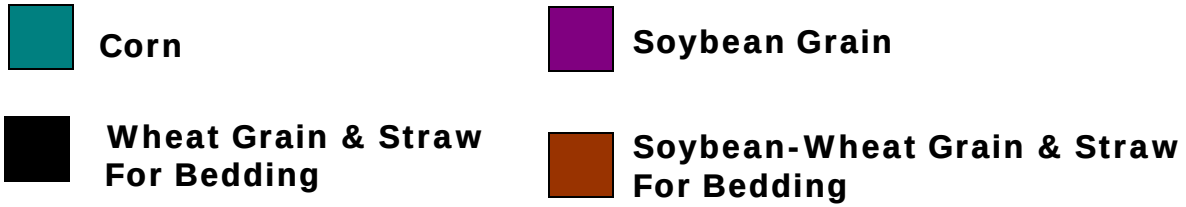
Base and SPOT Contract Scenario Results

Statistic	No Biomass Crops	With Biomass Crops	
		Risk Neutral	Risk Averse
Mean NR	$472,175	$472,175	449,666
Std Dev NR	$152,926	$152,926	$139,154
Biomass	------	0 dt	324dt



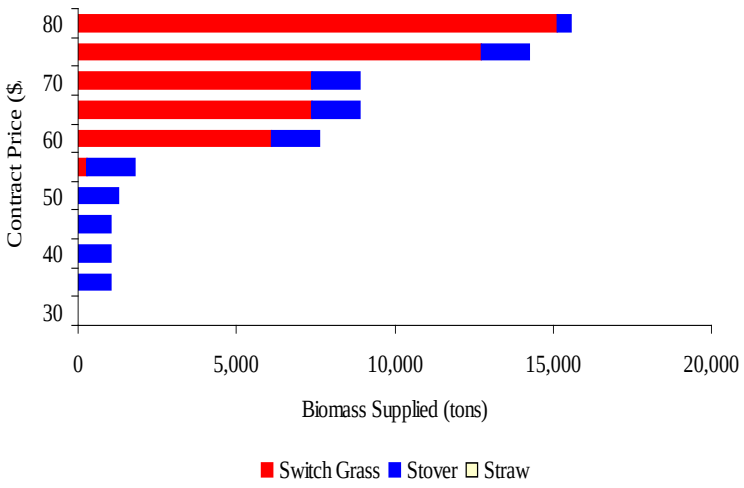






Biomass Supplied Under the STANDARD Contract Results

Risk Neutral Decision Maker--STANDARD Contract on 75% of Expected Yield with No Planting Incentive



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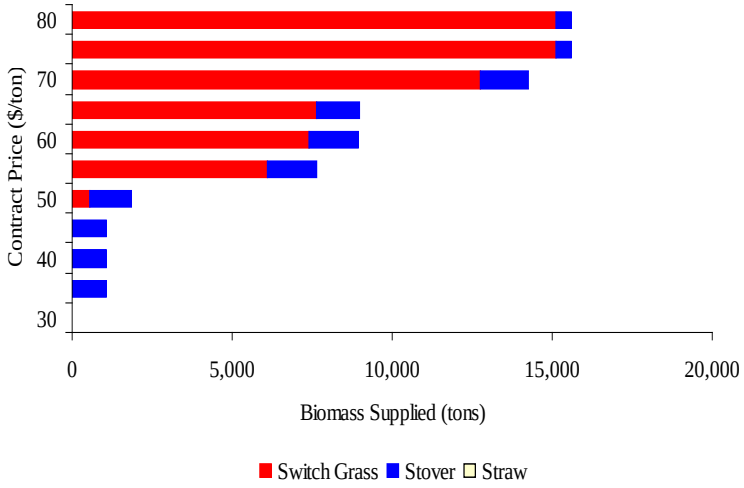
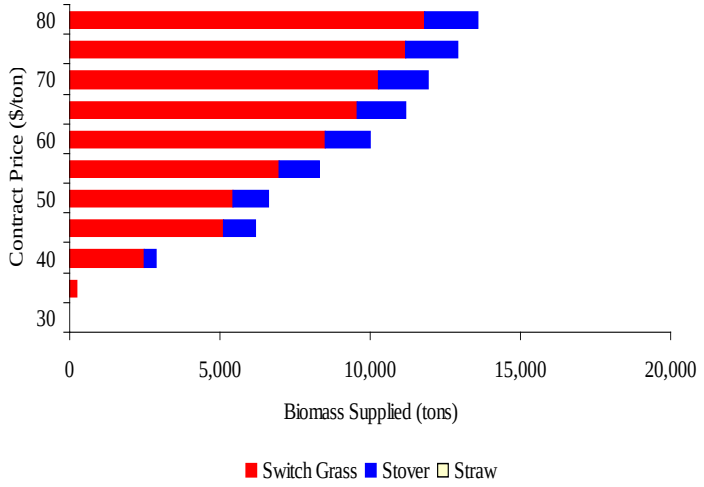


Risk Averse (ρ= 0.000017)Decision Maker--Standard Contract on 75% of Expected Yield with No Planting Incentive



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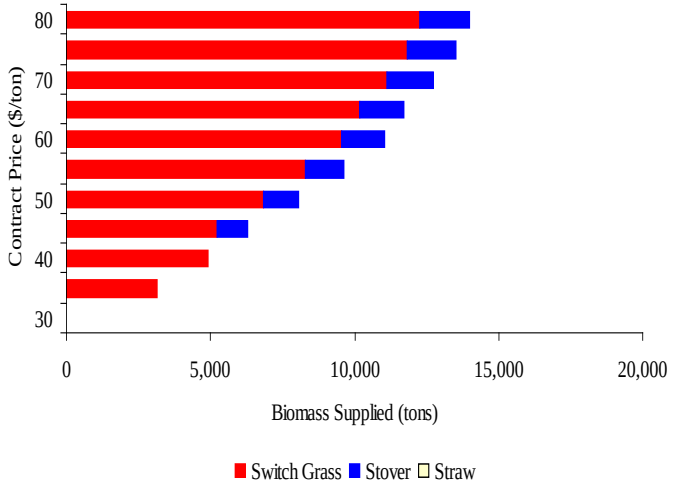
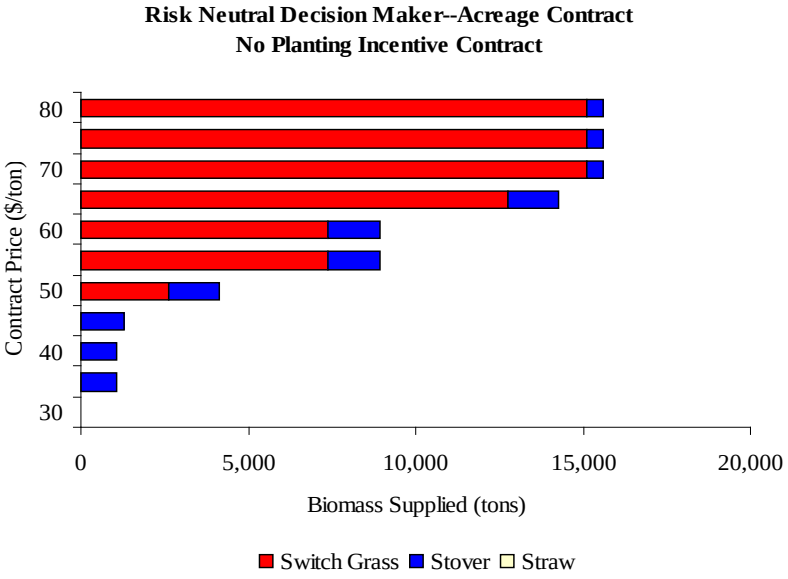
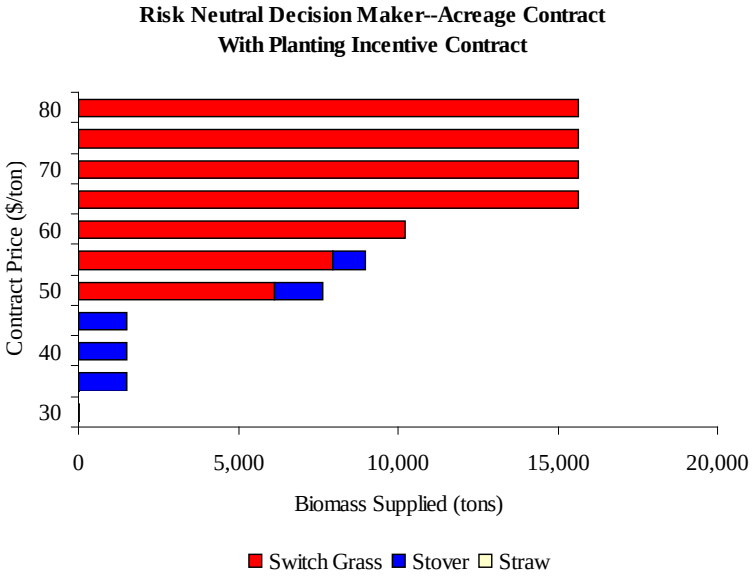
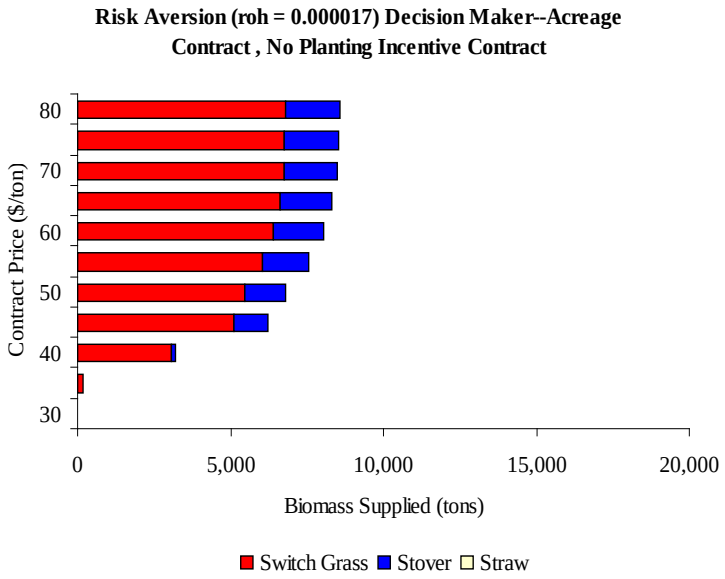
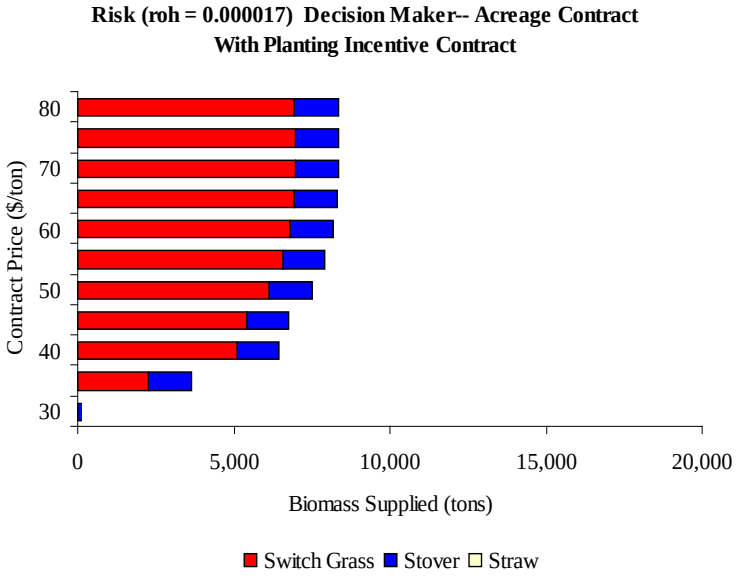


Biomass Supplied Under the ACREAGE Contract Results



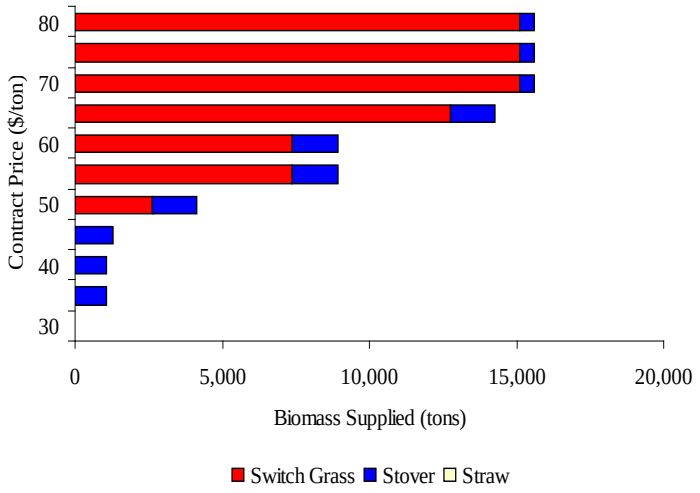




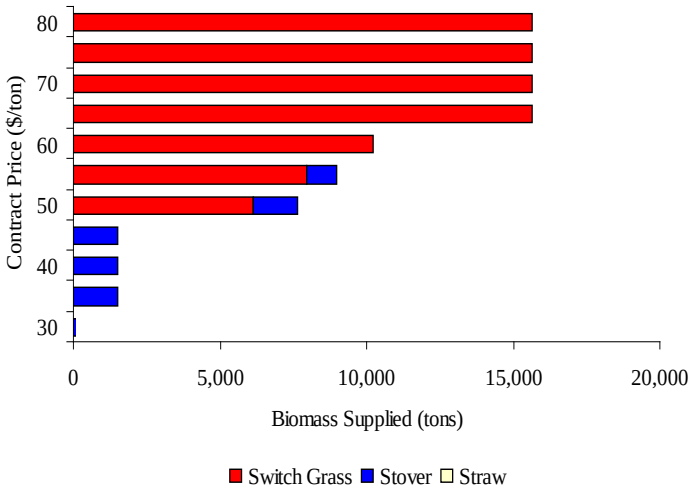


Biomass Supplied Under the REVENUE Contract Results

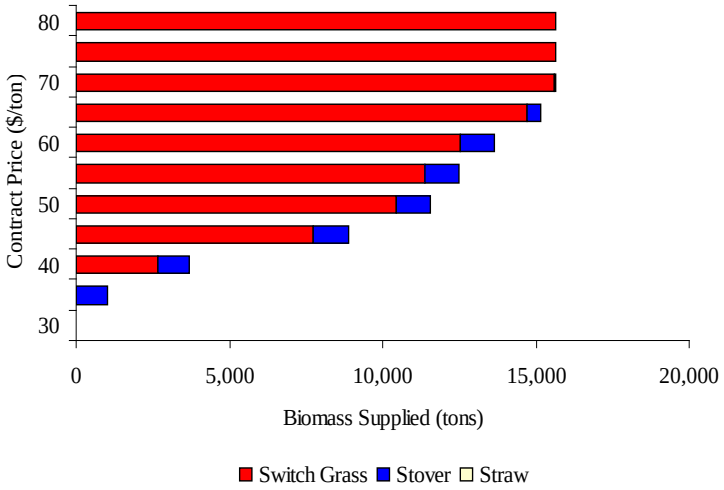
Risk Neutral Decision Maker--Gross Revenue Contract
No Planting Incentive Contract



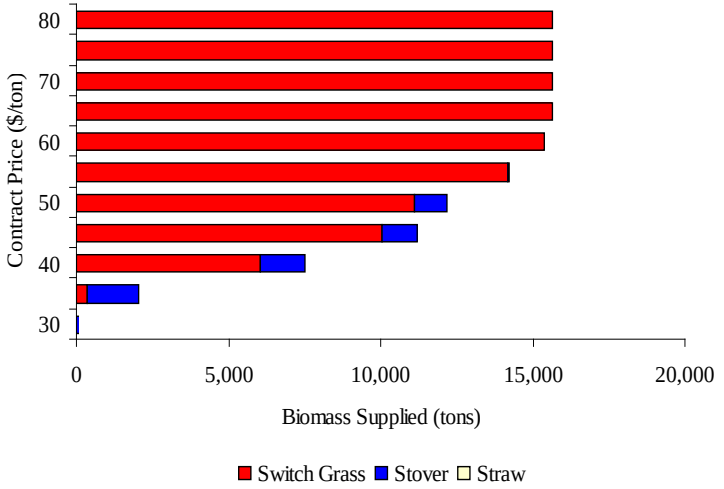
Risk Neutral Decision Maker--Gross Revenue Contract
With Planting Incentive Contract



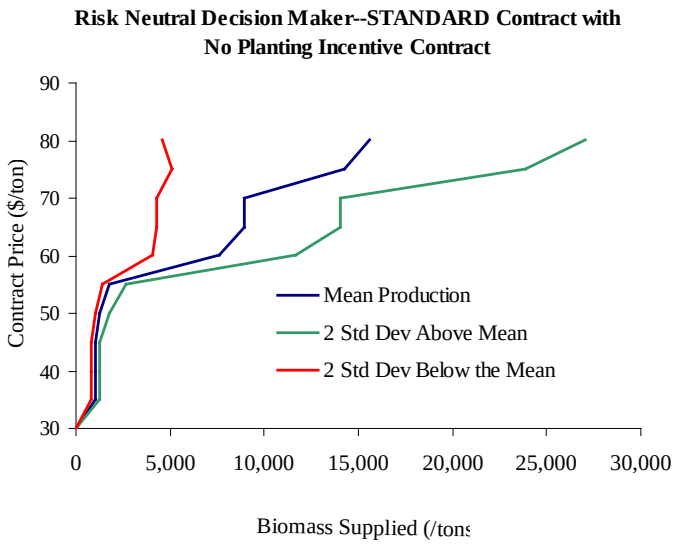
Risk (roh = 0.000017) Decision Maker--Gross Revenue Contract
No Planting Incentive Contract

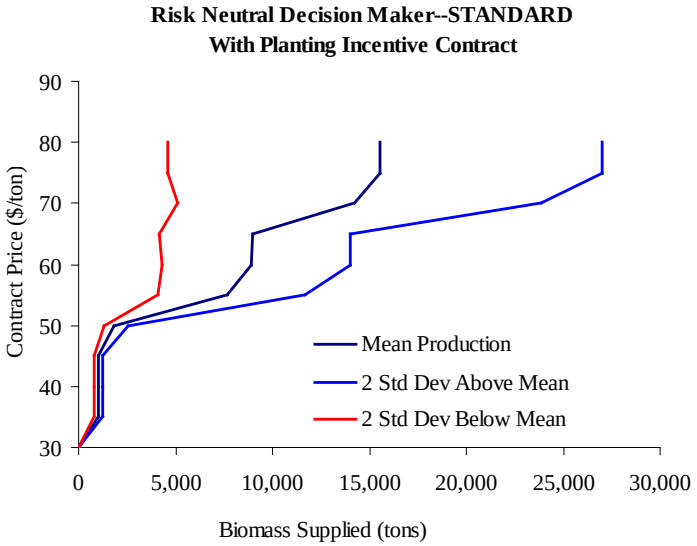


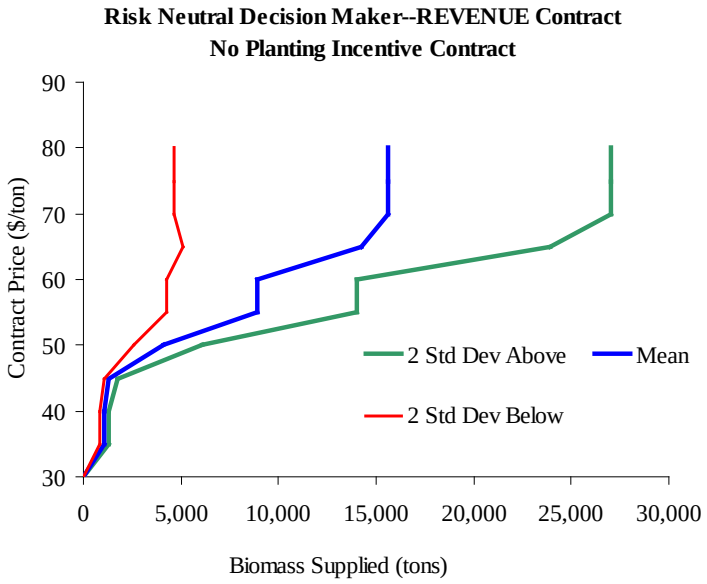
Risk (roh = 0.000017) Decision Maker-- Gross Revenue Contract
With Planting Incentive Contract

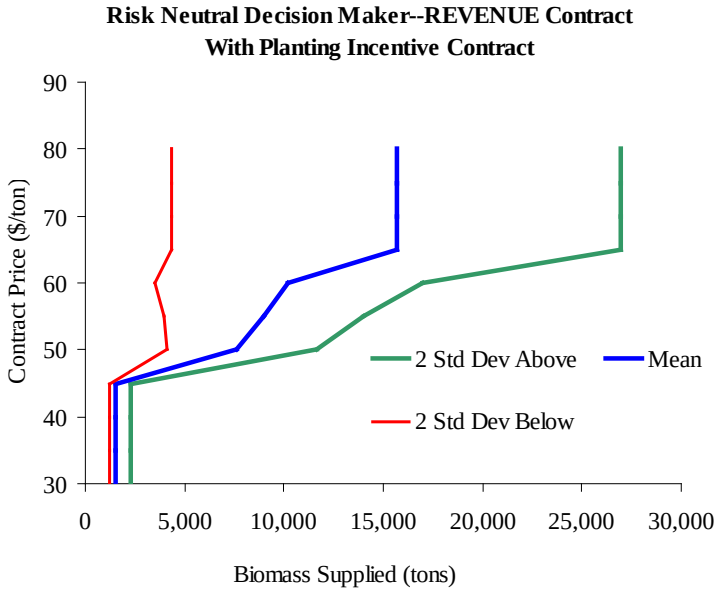


Variability of Biomass Supplied









Use of FLARE Model Outputs

- **Budget coefficients and cost relationships for production, harvest, storage and transportation activities in a feedstock supply chain**
  - BESTA biomass feedstock supply chain model,
  - BioFLAME biorefinery siting model, and
  - IMPLAN economics impact model.
- **Land use:**
  - SWAT soil water model.
- **Input use:**
  - BESTA biomass feedstock supply chain model,
  - BioFLAME biorefinery siting model,
  - IMPLAN economics impact model, and
  - SWAT soil water model.
- **Production constraints:**
  - BESTA biomass feedstock supply chain model,
  - BioFLAME biorefinery siting model,
  - IMPLAN economics impact model, and
  - SWAT soil water model.