Biomass Production Potential In the Southeast: Cellulosic & Oilseed

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Alternative Aviation Fuels: Developing
an Action Plan for the Southeast
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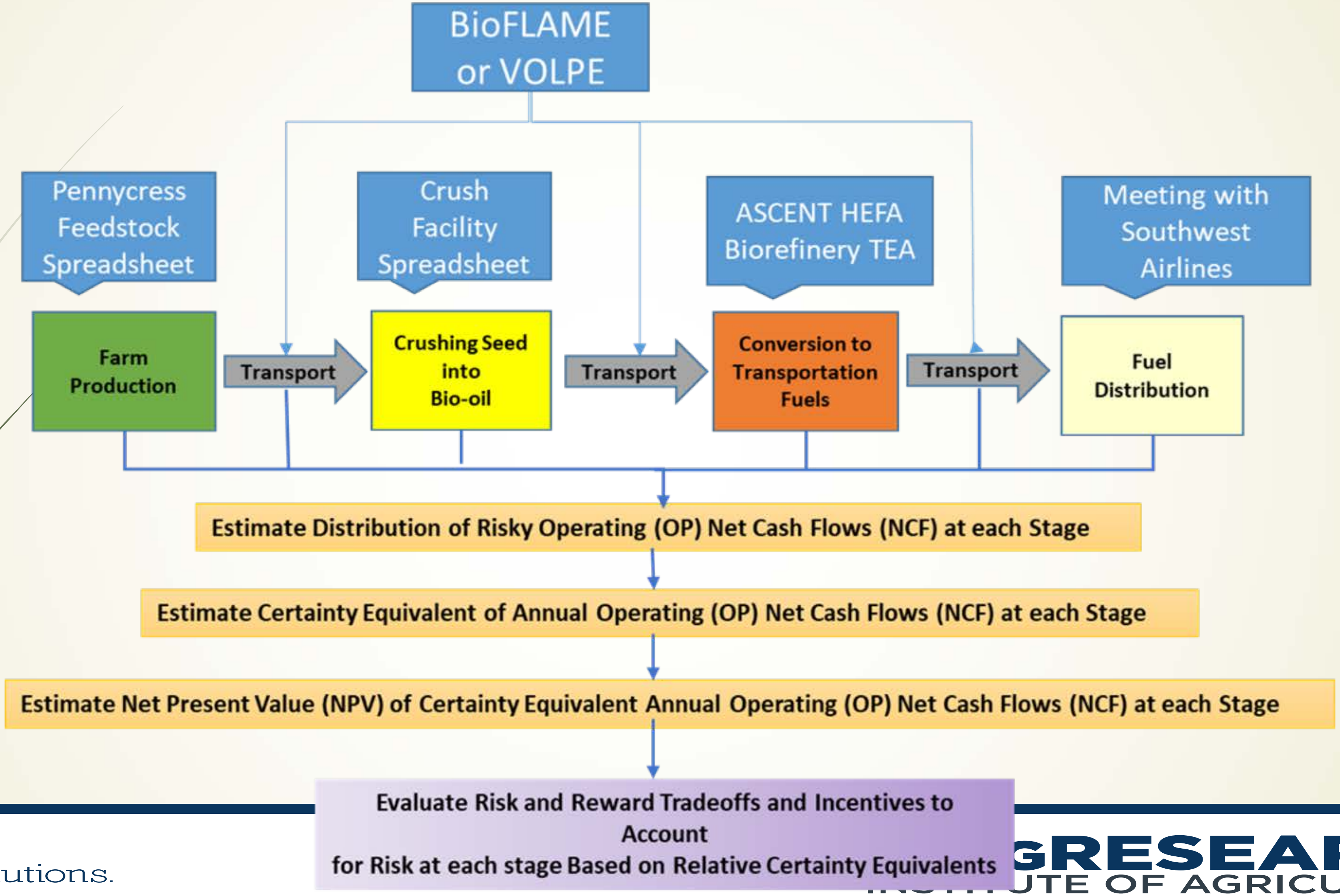
Introduction

- Motivations – Focus on two types of biomass – logging residues and oilseeds
- Objectives – Develop pathways for Sustainable Aviation Fuel (SAF)
- Outcomes and practical applications -- Develop tools and findings that indicate the potential of SAF in the southeastern United States
- Approach – Use tools developed by ASCENT 1 and spatial analysis to determine breakeven points in the entire supply chain and
  - Focus on two areas – Middle Tennessee and Eastern Alabama
  - Incorporate ASCENT assumptions in the analysis
- Pathways include:
  - Oilseed to aviation fuel through HEFA pathway
  - Blend of logging residues with switchgrass through pyrolysis

Feedstock Supply Chain Risk Assessment



Recent Accomplishments and Contributions

- Pennycress oil and pennycress meal revenues represented 66% and 34% of total revenues, respectively (i.e., simple average over the ten year forecast).
- Operating margin, defined as operating income divided by revenues, equals 11.5% over the forecast period. With the exception of the first year of productive life, operating margins for the crushing facility are relatively stable around 11% and 12%.
- The return on investment (ROI) is also relatively stable and has a simple average of 11.1% over the forecast period.

Recent Accomplishments and Contributions

- Unlike other inputs in the model, no assumption for pennycress feedstock cost is made. Instead, a maximum price that a potential crushing facility can pay for feedstock at the facility gate is calculated.
- The maximum pennycress oilseed buying price is $0.**105 pound**$^{-1}$ during the first year of production. This feedstock cost represents 63.6% of the forecast weighted average selling price of pennycress oil and pennycress meal the first year of production. This feedstock cost to weighted average selling price ratio is kept constant through the life of the project so that annual feedstock costs are assumed to vary in tandem with forecast selling prices and inflation rates.
- Thus, buying pennycress seed at $0.**105 pound**$^{-1}$ during the first year of production and buying it at prices equivalent to 63.6% of the weighted average selling price from years two to ten yields an NPV equal to zero for the crushing facility. In other words, this is the willingness-to-pay feedstock price in order debtholders and shareholders in the crushing facility to obtain their expected rate of return (10% on average).

Recent Accomplishments and Contributions

Data and assumptions for the breakeven and one-way sensitivity analysis of maximum pennycress purchase prices for the crushing facility to obtain NPV=0.

Item	Base	Lower bound	Upper bound
Seed to oil conversion rate (% in tons equivalent)	0.329	0.315	0.340
Pennycress oil price (% deviation relative to baseline)	0.0%	-5.0%	5.0%
Pennycress meal price (% deviation relative to baseline)	0.0%	-5.0%	5.0%
Income tax rate (%)	40.0%	40.0%	16.9%
Days inventory	60	90	30
WACC	10.0%	15.0%	7.5%

Tornado Diagram of Crush Facility

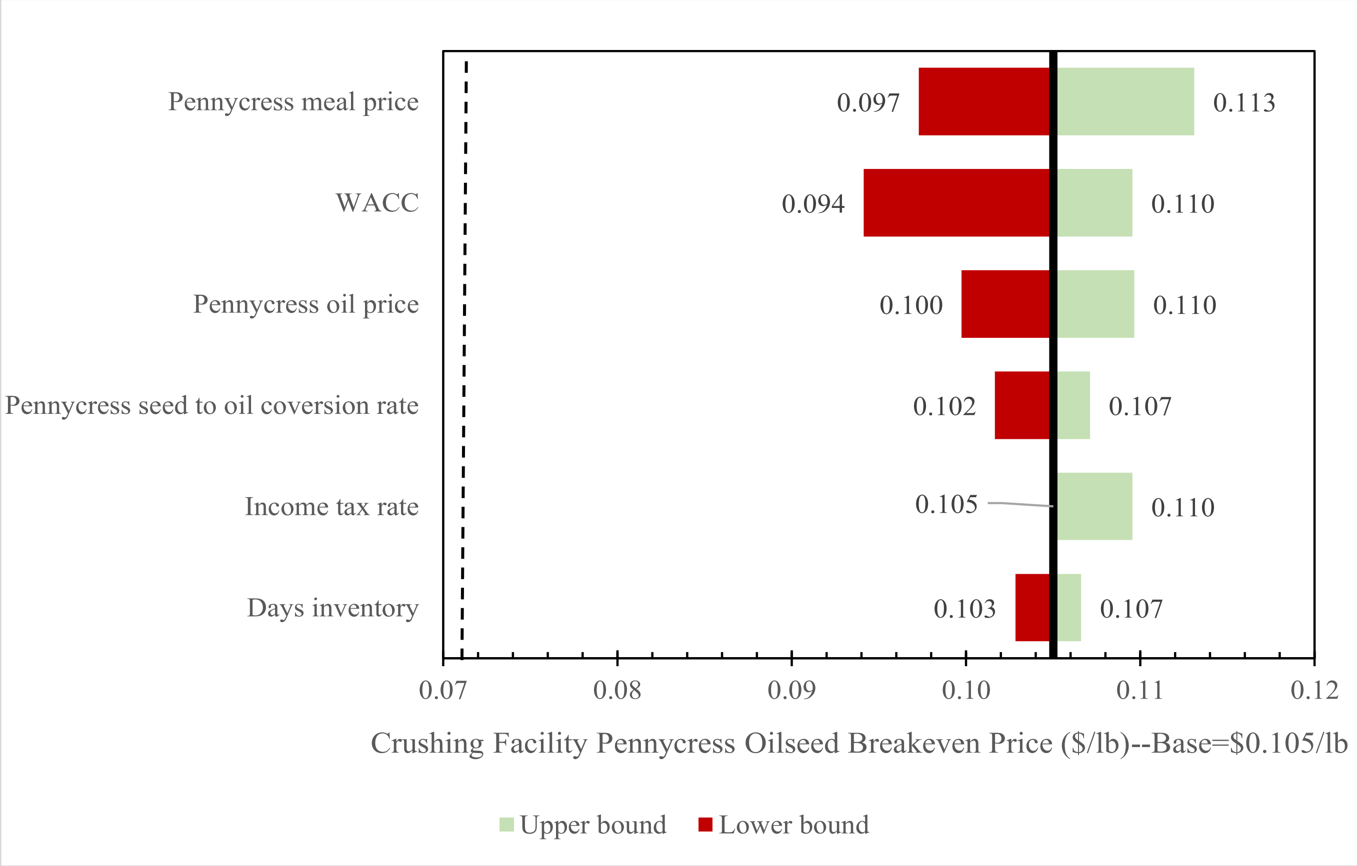


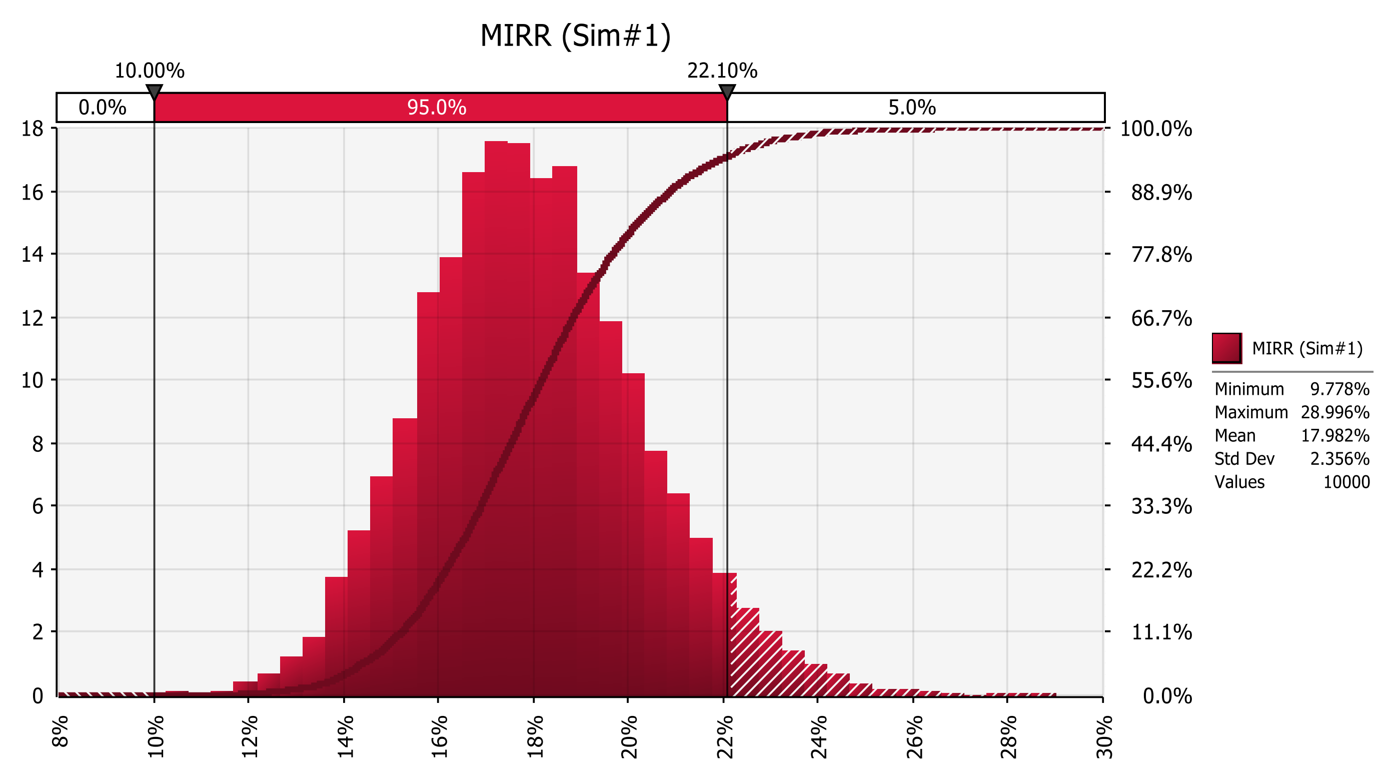
Figure illustrates the estimated maximum (breakeven) buying price and the one-way sensitivity analysis showing lower and upper bound maximum buying prices the first year of production according to assumptions in the preceding table

Some Comments

- The baseline model shows that the maximum pennycress seed buying price for the crushing facility to be a positive NPV project @ 10% cost of capital is around $0.**105 pound^{-1}** .
- 10,000 iterations were then performed on three simulations examining seed purchase prices of 8, 9, 10, and 11 cents/pound using @Risk

Crushing Facility Results: Pennycress price = $0.08/pound

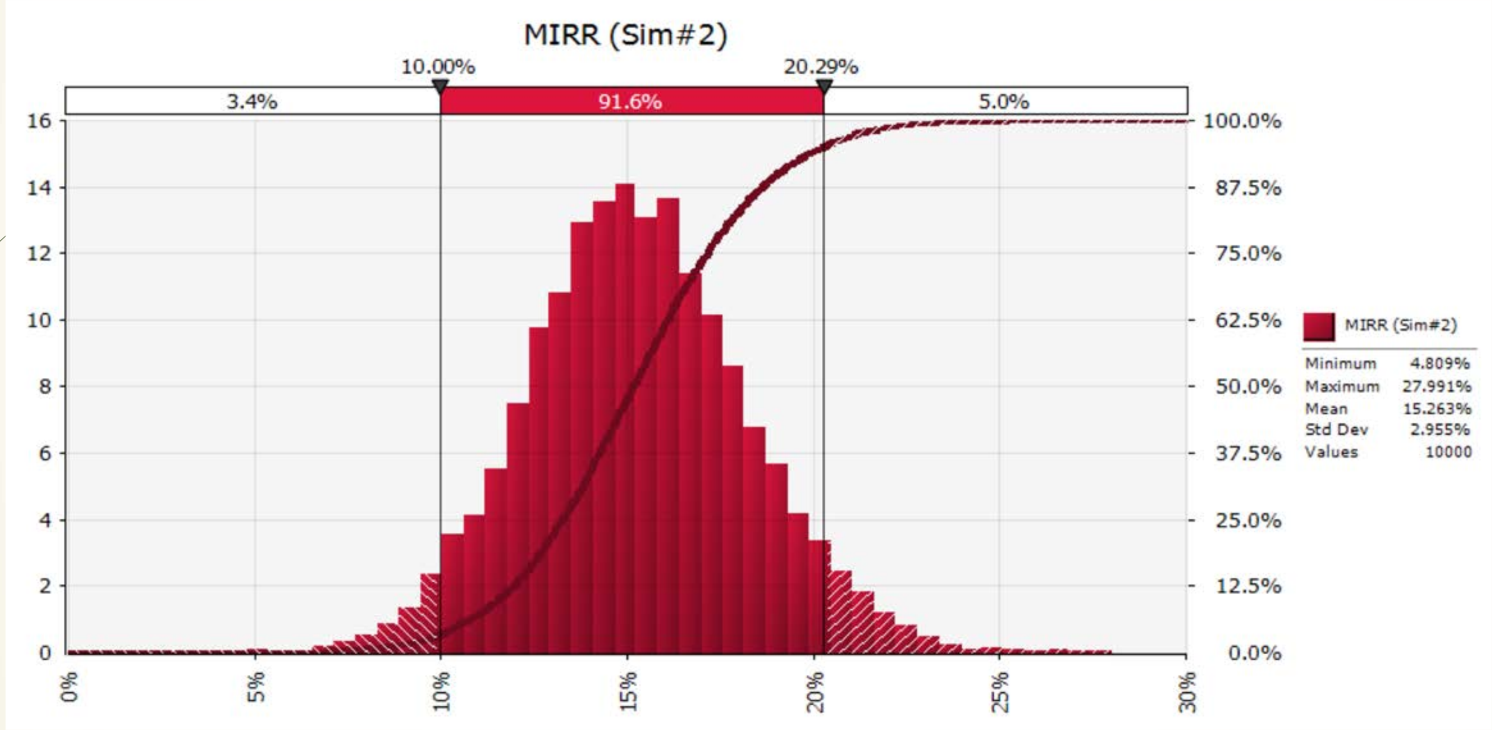
Probability



Percent return on investment

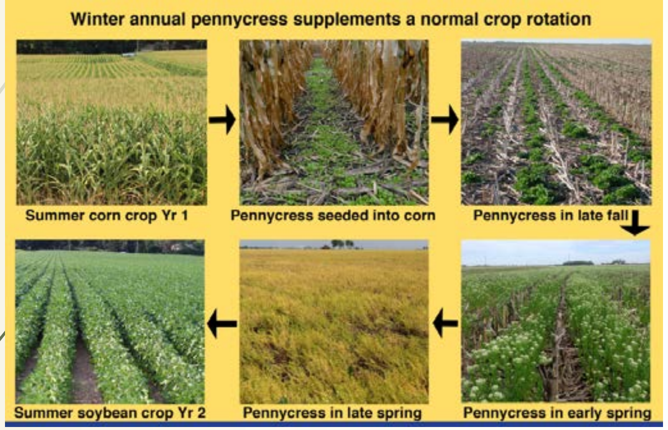
Crushing Facility Results: Pennycress price = $0.10/pound

Probability



Percent return on investment

A Third Crop in Two Years – Corn, Pennycress, and Soybeans

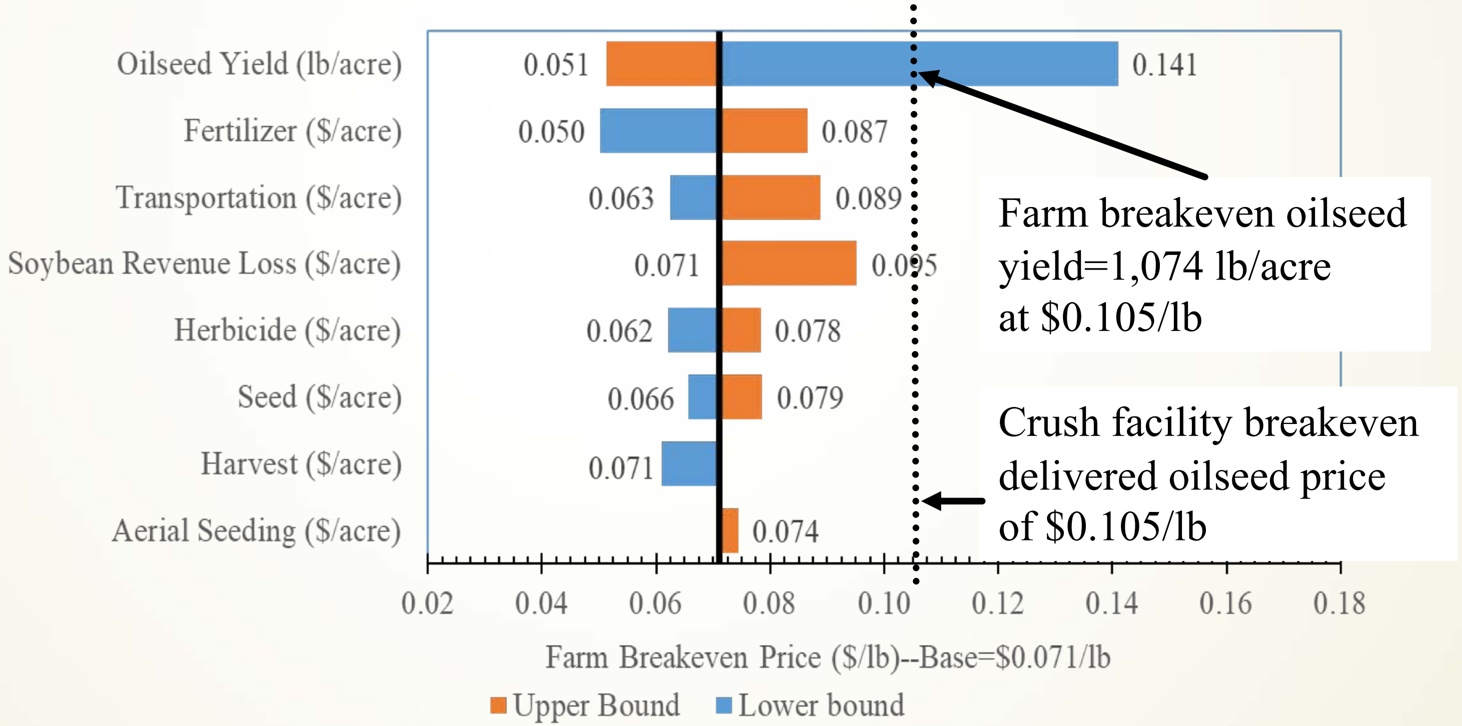


Source: https://public.ornl.gov/site/gallery/highressurvey.cfm

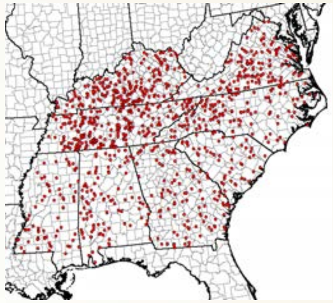
Pennycress Cost of Production Scenarios

Item	Base	Lower bound	Upper Bound
Seed ($/acre)	12.50	5.00	25.00
Aerial seeding ($/acre)	10.00	10.00	16.00
Fertilizer ($/acre)	31.50	0.00	56.50
Herbicide ($/acre)	0.00	-12.97	12.97
Harvest ($/acre)	40.17	25.00	40.17
Transportation ($/acre)	13.43	3.61	39.23
Oilseed yield (lb/acre)	1,600.	800.	2,200.
Soybean revenue loss ($/acre)	0.00	0.00	39.56

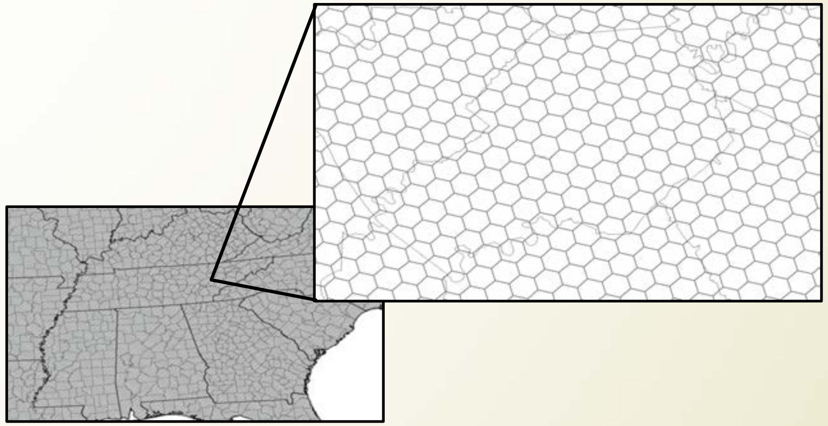
One-Way Sensitivity of Farm-Level Breakeven-Oilseed Prices



BioFLAME

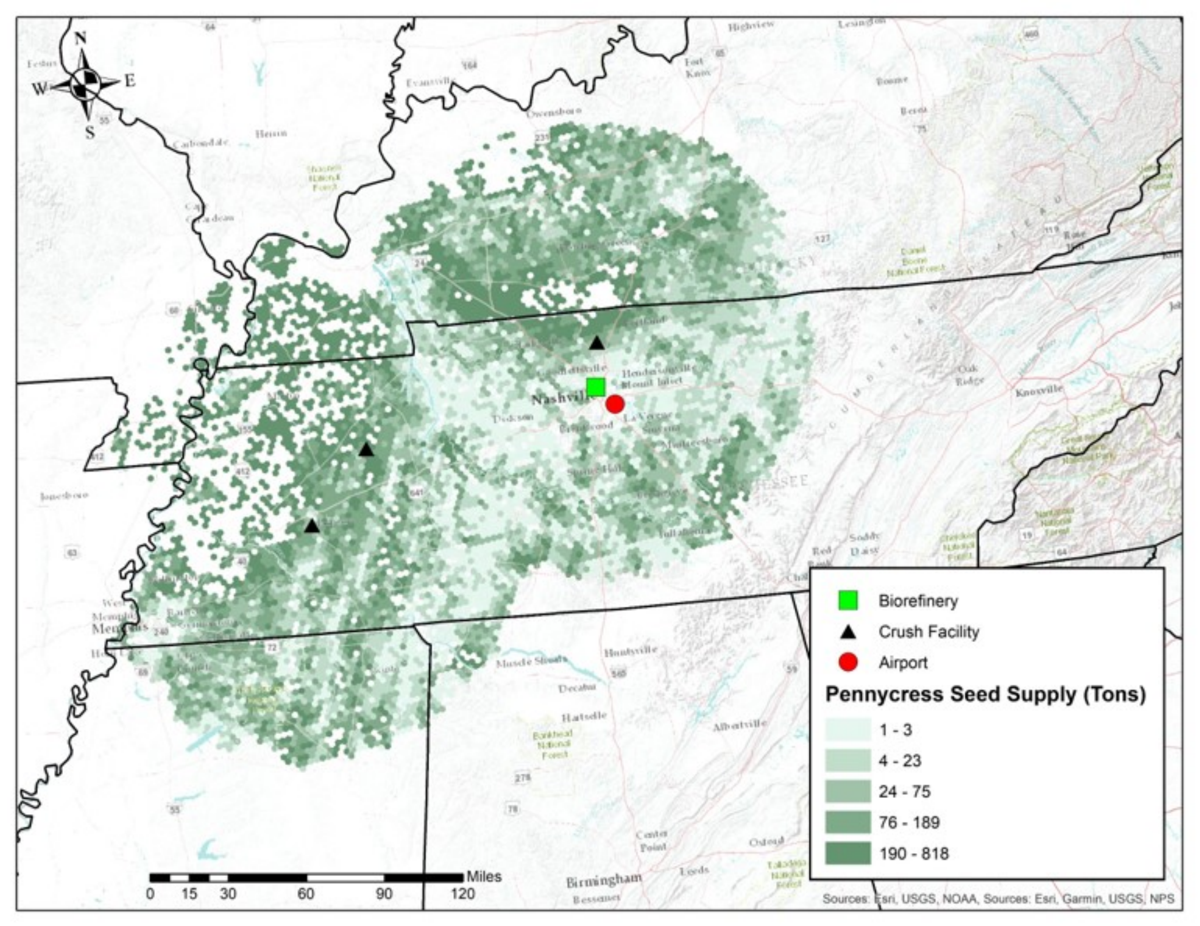


- GIS model
- Site selection
- Uses existing properties with utilities as potential site locations
- Five sq. mile hexagons as feedstock supply regions
- Road network layer
- Site selection depends on
  - Min cost of delivered feedstock
  - Min cost of delivered fuel



BioFLAME Analysis

- Pennycress available area estimated by using the minimum of the corn or soybean acres
- Yield is assumed to be 1600 pounds per acre.
- Each crushing facility required 263,000 tons of pennycress seed supplying 86,600 tons of bio-oil per year.
- Two step optimization process. First step located 7 potential locations of crushing facilities and the second step assuming these sources of supply existed where would the biorefinery be located.



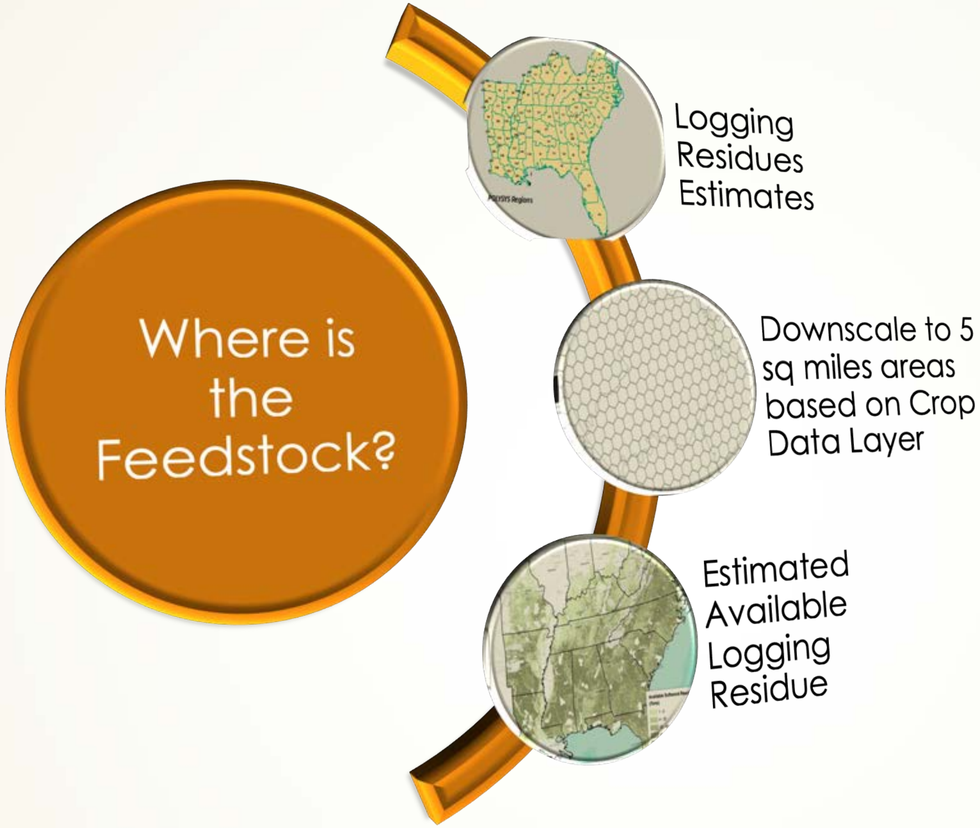
- Biorefinery requires 263,000 tons of bio-oil to produce 36.9 million gallons of jet fuel plus diesel (17.2 Mgal), naphtha 6.5 Mgal), and LPG (7.5 Mgal).
- Have not examined co-product transportation yet.

710,000 bone dry short tons of Blended Feedstock

Yields

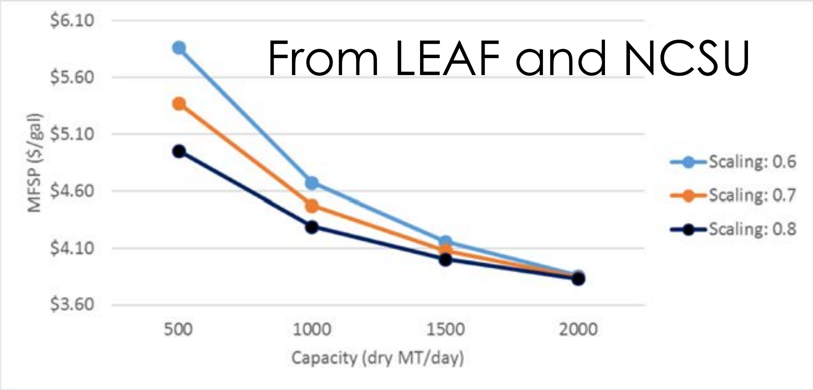
ASCENT Pyrolysis TEA 53.6 mm gal/yr

Gasoline (gal/yr)	**8,676,737**
Jet Fuel (gal/yr)	**23,698,454**
Diesel (gal/yr)	**14,958,580**
Bunker fuel (gal/yr)	**6,330,950**



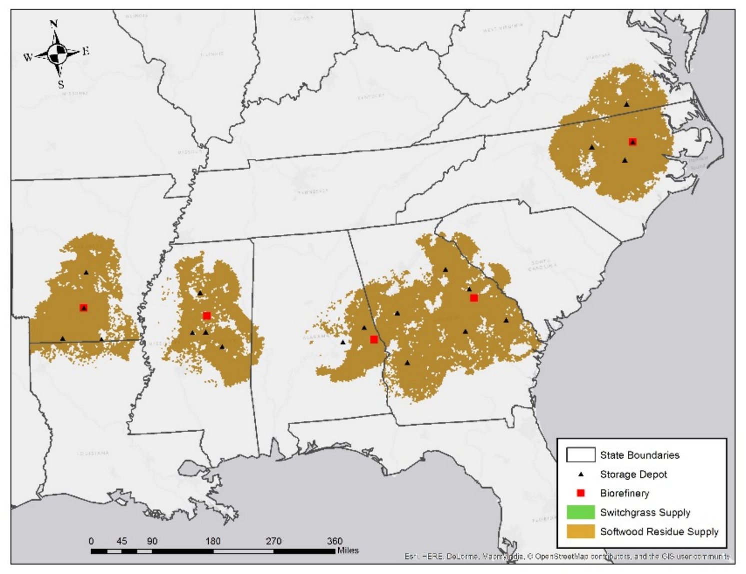
- **Based on ForSEAM results used in the Billion Ton 2016 Analysis**
- **Downscaled to 5 sq. mile hexagon supply regions**
- **Based on 2020 traditional demands,**
- **Public lands excluded,**
- **Includes projected thinning,**
- **Units are expressed in tons/5 sq. mile hexagons**

Locations for 100% Logging Residue scenario, 1000 MT/day



BioFLAME cannot locate biorefineries requiring 545 or 720 K dry tons per year. Within a 100 mile maximum travel distance

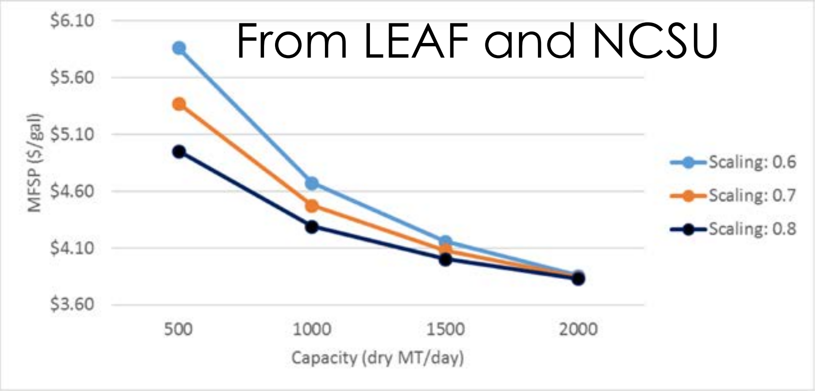
So we are at the small plant without augmenting logging residues, developing Intermediaries of depots, or Increasing distance traveled.

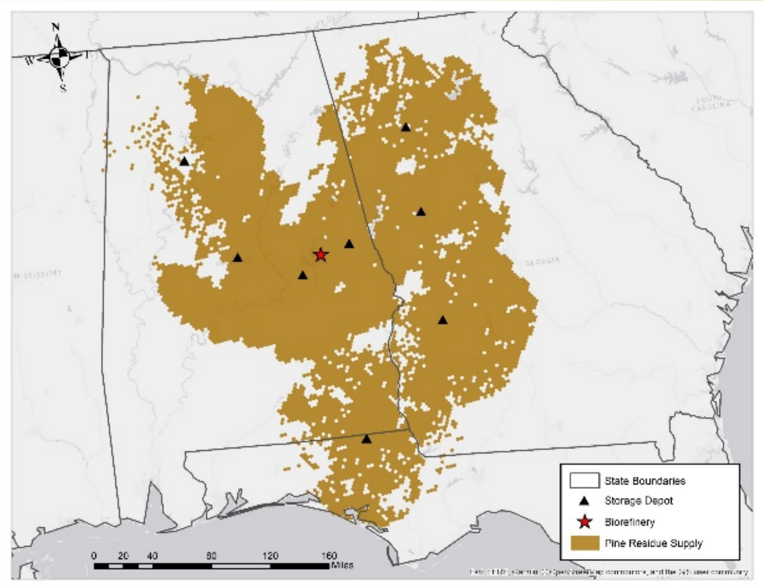


Locations for 100% Logging Residue scenario, 2000 MT/day with Depots

100% Logging Residues

Transportation Cost = $27.38 Per dry ton
Feedstock Cost = $70.98 per dry ton
Average Distance (mi/dt) = 88

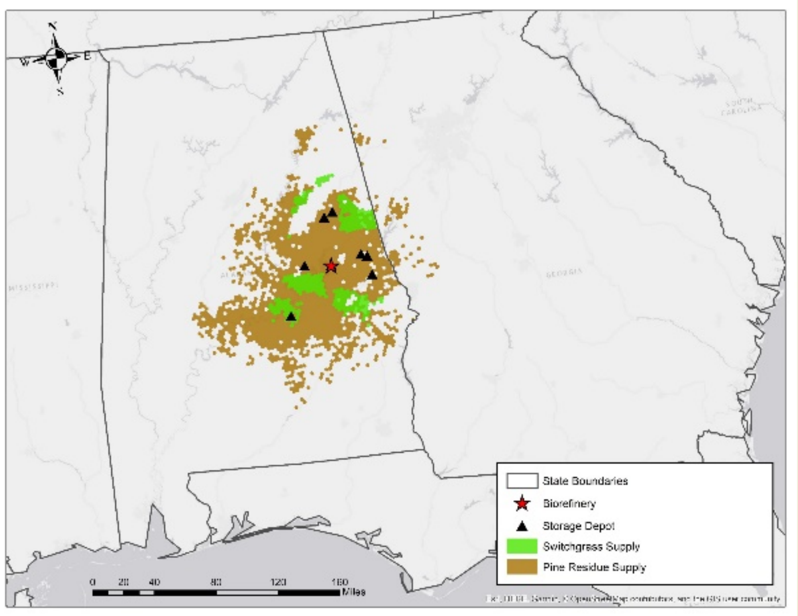


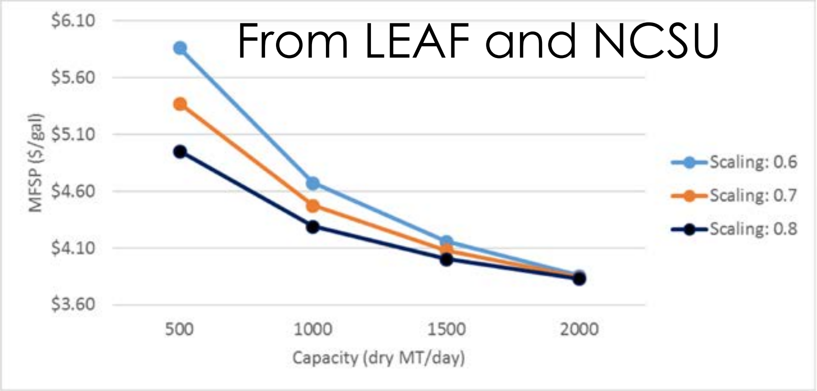


Locations for 25% Logging Residue scenario, 2000 MT/day with Depots

100% Logging Residues

Transportation Cost = $9.44 Per dry ton
Feedstock Cost = $106.67 per dry ton
Average Distance (mi/dt) = 30





	Conversion Rate								
price/ton	40	45	50	55	60	65	70	75	80
40	$1.00	$0.89	$0.80	$0.73	$0.67	$0.62	$0.57	$0.53	$0.50
45	$1.13	$1.00	$0.90	$0.82	$0.75	$0.69	$0.64	$0.60	$0.56
50	$1.25	$1.11	$1.00	$0.91	$0.83	$0.77	$0.71	$0.67	$0.63
55	$1.38	$1.22	$1.10	$1.00	$0.92	$0.85	$0.79	$0.73	$0.69
60	$1.50	$1.33	$1.20	$1.09	$1.00	$0.92	$0.86	$0.80	$0.75
65	$1.63	$1.44	$1.30	$1.18	$1.08	$1.00	$0.93	$0.87	$0.81
70	$1.75	$1.56	$1.40	$1.27	$1.17	$1.08	$1.00	$0.93	$0.88
75	$1.88	$1.67	$1.50	$1.36	$1.25	$1.15	$1.07	$1.00	$0.94
80	$2.00	$1.78	$1.60	$1.45	$1.33	$1.23	$1.14	$1.07	$1.00
85	$2.13	$1.89	$1.70	$1.55	$1.42	$1.31	$1.21	$1.13	$1.06
90	$2.25	$2.00	$1.80	$1.64	$1.50	$1.38	$1.29	$1.20	$1.13
95	$2.38	$2.11	$1.90	$1.73	$1.58	$1.46	$1.36	$1.27	$1.19
100	$2.50	$2.22	$2.00	$1.82	$1.67	$1.54	$1.43	$1.33	$1.25
105	$2.63	$2.33	$2.10	$1.91	$1.75	$1.62	$1.50	$1.40	$1.31
110	$2.75	$2.44	$2.20	$2.00	$1.83	$1.69	$1.57	$1.47	$1.38

○ 25% Logging Residues

□ 100% Logging Residues

Conversion Facility's Techno-Economic Analysis

- HEFA assumes an oil purchase price of $1.12 per kg.
  - According to our analysis this can be achieved
  - Seed costs farmer $0.071/pound if they get 1600 pounds/acre
  - Crush facility can afford to pay $0.105/pound for seed if they get $0.317/pound or $0.699/kg for the oil and $176.7/ton for the meal.
  - ASCENT HEFA technology assume oil feedstock price is $1.12/kg.
- Pyrolysis pathway assumes a cellulosic material purchase of $60/ton in chip form
  - As of this point, this is not possible. Feedstock using only logging residues will exceed $60/dt.

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Participants

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