Project 01E

Alternative Jet Fuel Supply Chain Analysis – Amendment 16

University of Tennessee

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Cost Share Partner(s): University of Tennessee and The Center for Natural Capital

Objectives:

1. Assess and inventory regional forest and agricultural biomass feedstock options.
2. Develop national lipid analysis.
3. Lay the groundwork for lipid and/or biomass in Tennessee (TN) and Southeastern U.S.
4. Biorefinery infrastructure and siting (supporting role)

Project Benefits:

To realize the potential of SAF, the pace of commercialization must be accelerated. Funding this project will accelerate the adoption of SAF by generating strategic information and educating stakeholders on production pathways that can increase economic efficiency, enhance sustainability awareness, leverage economies of scope and scale, and reduce renewable fuel costs.

Research Approach:

1. **Develop a portfolio of potential feedstocks that could be used in developing SAF**
2. Provide an analysis on the crop potential using POLYSYS.
3. Provide spatial layers of feedstock volume to BOX and work with FTOT personnel.
4. Provide an environmental impact analysis exploring the impacts of the feedstock on soil erosion, chemical use, and carbon emissions.
5. **Provide regional Deployment Plans for Central Appalachia, Nashville and Memphis airports, and other areas in the southeast**
6. Investigate economic impacts of potential SAF supply chains in 179 Bureau of Economic Analysis Regions.

To research each of these require POLYSYS at the national level and BioFLAME or BeSTSA at the regional level.

Major Accomplishments (through Dec. 2021):

- A stakeholder group has been established for the Central Appalachian area and meets virtually each month. The purpose of the stakeholder group is to inform members about the potential of the SAF industry and to assist in the development of the Regional Deployment Proposal.
- **POLYSYS has been rerun to evaluate the potential of cellulosic feedstocks for SAF.**
- **POLYSYS has been run to determine the potential of oilseed cover crops in the conterminous 48 states.**
- Evaluated and developed mechanism to evaluate tradeoffs between efficiency and environmental impact.
- **Analysis of a potential pathway to achieve SAF goals set forth by the SAF Grand Challenge.**

Future Work / Schedule:

Continue to investigate and provide analysis from the information above.

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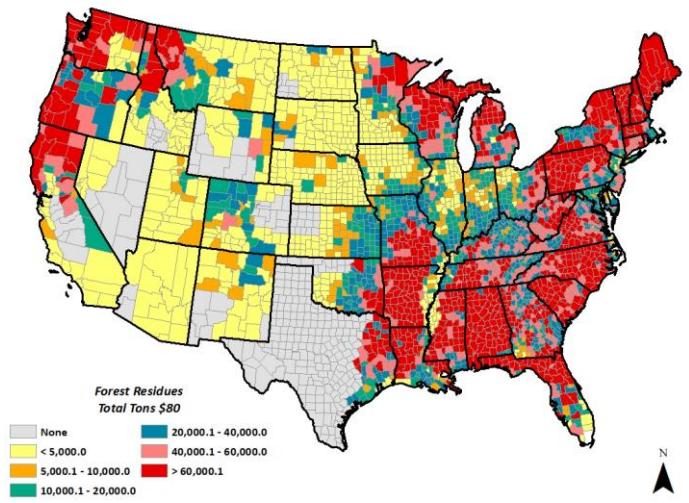
Cellulosic Analysis – Feedstocks Involved

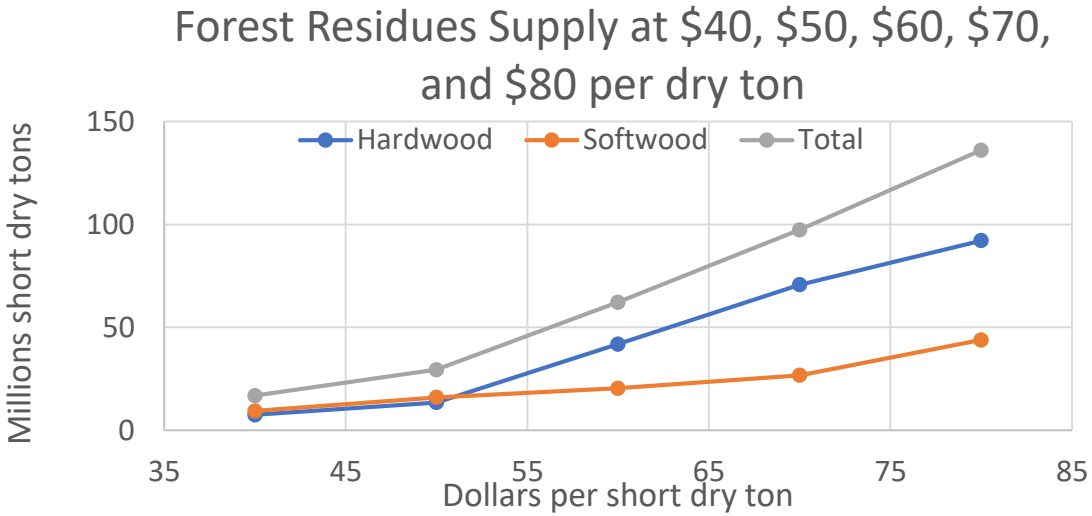
- Crop Residues
  - Stover
    - Corn
    - Sorghum
  - Straw
    - Wheat
    - Barley
    - Oats
  - Stubble
    - Soybeans
    - Cotton

- Forest Residues
  - Logging Residues
  - Whole Tree from thinnings
  - Whole tree Pulpwood
  - Whole Tree Non-commercial
- Dedicated Energy Crops
  - Hybrid poplar, willow
  - Energy Cane
  - Herbaceous -- switchgrass and miscanthus

Analysis conducted at six different prices $30 per ton to $80 per ton using POLYSYS.

Cellulosic Analysis – Forest Residues @ $80/ton



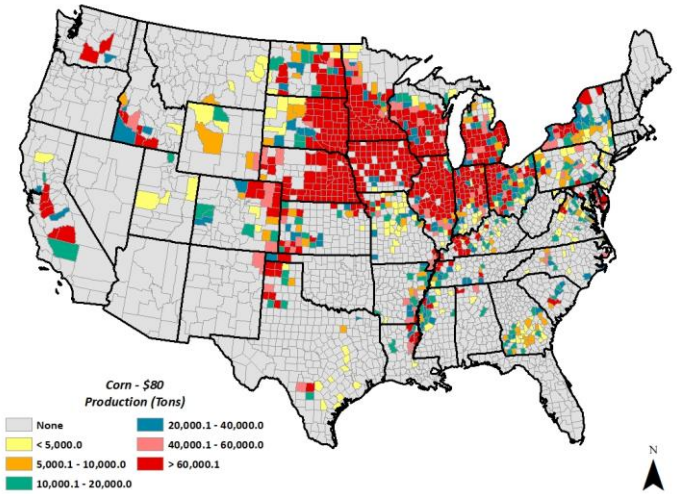


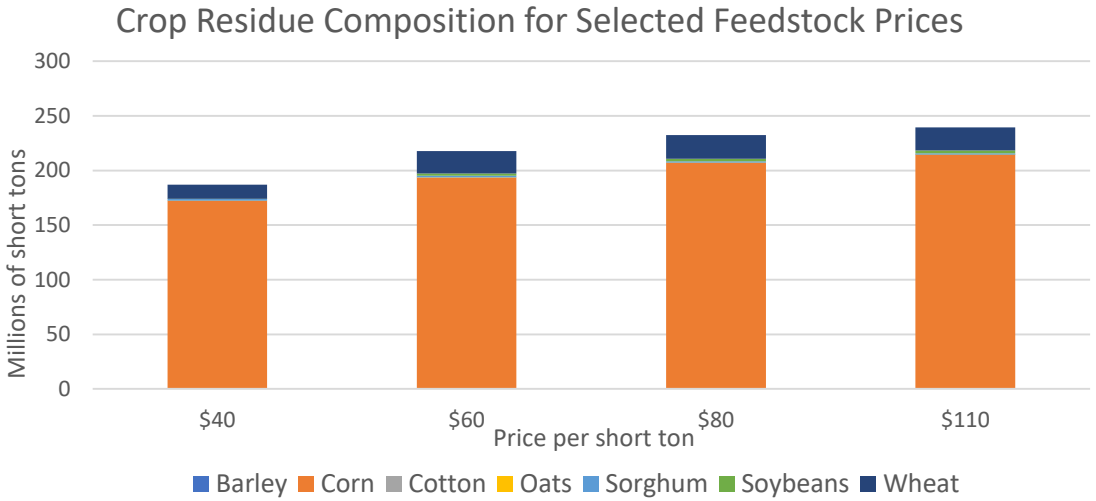
Top 15 States

	Hardwood	Softwood	Mixed	Total (short tons)
Maine	6,226,053	2,887,569	173,454	9,287,076
N. Carolina	4,379,329	2,854,609	1,957,846	9,191,784
Alabama	4,944,341	2,020,635	1,636,589	8,601,565
Georgia	4,689,971	2,211,279	1,427,757	8,329,008
Arkansas	4,022,888	2,606,649	911,441	7,540,979
Pennsylvania	6,329,479	99,164	95,031	6,523,674
Mississippi	3,891,067	1,483,691	928,293	6,303,051
Michigan	4,830,128	907,910	211,619	5,949,656
Louisiana	2,769,034	2,483,887	646,813	5,899,734
Florida	1,821,939	3,514,567	536,473	5,872,979
Virginia	3,646,262	1,056,964	823,884	5,527,109
Missouri	4,699,321	222,597	249,550	5,171,468
S, Carolina	2,135,422	2,028,052	819,476	4,982,950
Tennessee	4,157,315	470,486	285,449	4,913,250
Kentucky	3,439,988	140,879	93,014	3,673,881

- Costs do not include transportation
- Costs include stumpage, harvest/gathering, and chipping into a truck
- Output from POLYSYS analysis
- Four Primary Regions Southeast, Northeast, Lake States, and Pacific Northwest
- Southeast united States dominate the top 15 list with NC, AL, GA, AK, potentially supplying 25% of the estimated tonnage.

Cellulosic Analysis – Crop Residues @ $80/ton



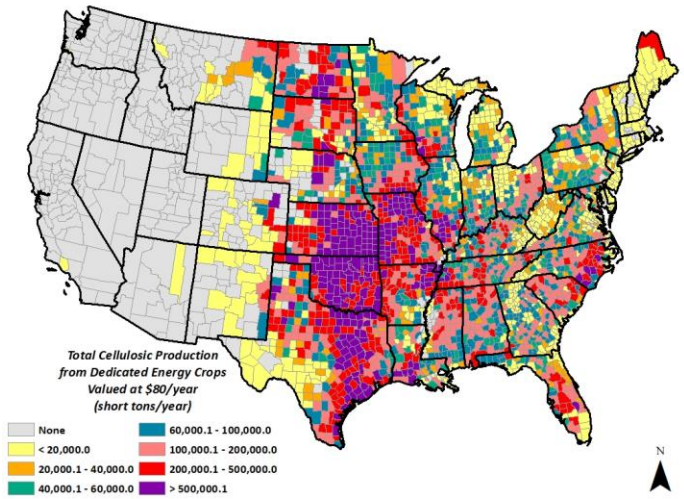


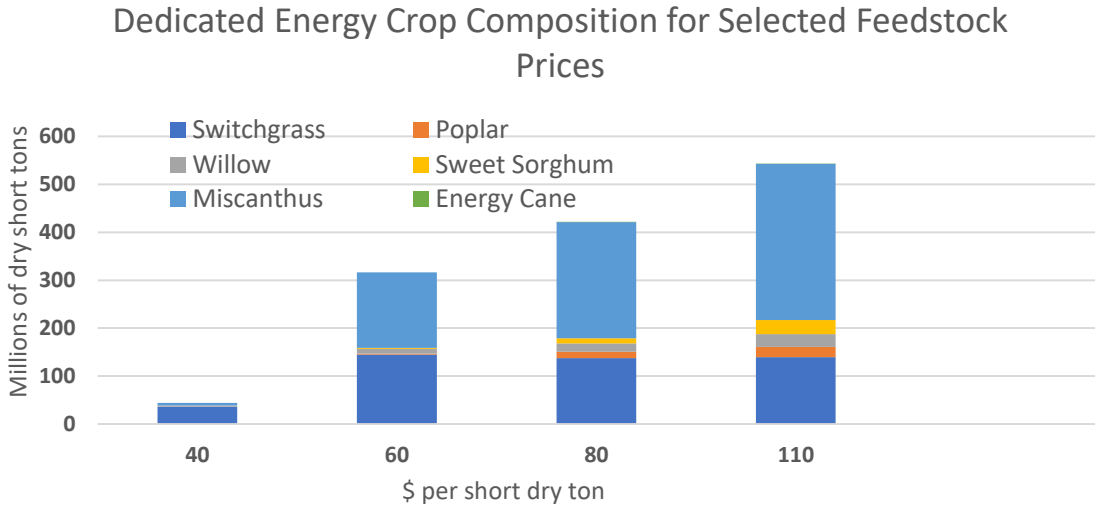
Top 15 States

State	Quantity of short tons	State	Quantity of short tons
IA	37,472,325	ND	7,663,310
NE	35,154,789	KS	6,389,044
MN	33,438,417	MI	6,269,059
IL	24,557,793	KY	3,233,967
SD	18,986,816	CO	3,198,962
IN	11,520,675	TX	3,180,938
OH	10,087,396	MT	2,396,200
WI	9,597,022	National Total	232,263,961

- Costs include harvest/gathering, baling and moving bales to on-farm storage
- Costs do not include transportation
- Output from POLYSYS analysis
- Three Primary Regions Cornbelt, Lake States, and Northern Great Plains
- Crop residues consist of 88% corn stover, and 9% wheat straw.
- Arkansas, Montana, North Dakota, new Mexico, and Utah crop residue composition consists of more than 50% wheat straw.

Cellulosic Analysis – Dedicated Energy Crops @ $80/ton: Herbaceous





Top 15 States

State	Herbaceous	Woody	Other	Total
Kansas	65,165,501	2,335,032	3,325,255	70,825,788
Texas	58,908,627	7,409,901	599,485	66,918,014
Missouri	48,255,261	2,935,164	2,612,945	53,803,370
Oklahoma	46,838,635	3,164,155	922,754	50,925,544
Arkansas	19,925,858	619,305	220,953	20,766,116
Illinois	18,120,906	148,632	720,352	18,989,890
Iowa	14,605,784	683,974	0	15,289,758
Tennessee	13,817,602	431,192	549,544	14,798,338
N. Carolina	10,685,811	619,302	807,968	12,113,081
N. Dakota	10,605,372	922,116	0	11,527,488
Mississippi	10,380,955	471,912	565,127	11,417,994
Kentucky	10,976,431	238,699	0	11,215,130
Nebraska	10,203,889	39,387	0	10,243,277
Louisiana	7,454,880	1,431,992	1,053,941	9,940,813
S. Dakota	9,248,827	226,431	0	9,475,258

- Costs include establishment, maintenance, harvest/gathering, baling/chipping and moving material to on- farm storage/truck
- Costs do not include transportation
- Output from POLYSYS analysis -- $30 to $$80 initially then expanded to $110 to see what else might be possible
- Three primary regions Southern Plains, Corn Belt, and Northern Great Plains with 464 million tons of biomass estimated available at $80 per short dry ton.
- Dedicated energy crops consist of mostly of herbaceous (90%, 7% woody, and the rest in Energy cane or sweet sorghum at $80 per short dry ton ans switchgrass enters at $30 per short dry ton.
- New England, South, and Pacific Northwest regions have proportions of woody biomass at greater than 10%

Oilseed Cover Crop Analysis – Feedstocks Involved

Corn/Oilseed/Soybeans

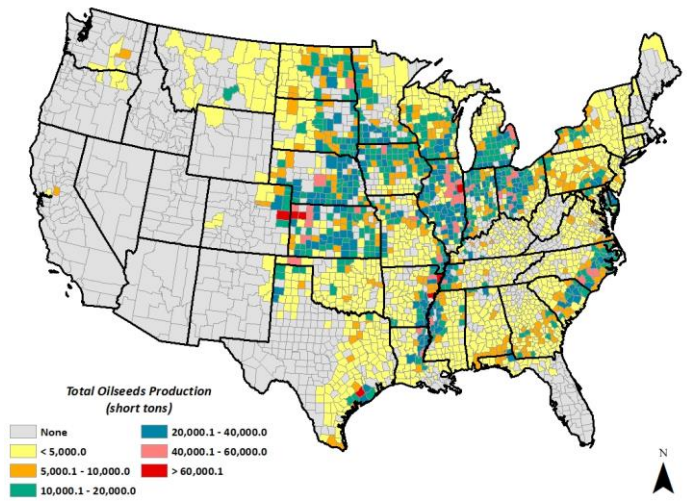
- The Oilseed Crops considered include
  - Carinata
  - Camelina
  - Pennycress
- The soybean yield following the harvest of the oilseed crop was reduced by 6.5%
- Land available restricted to current use. [min(corn, soybeans)

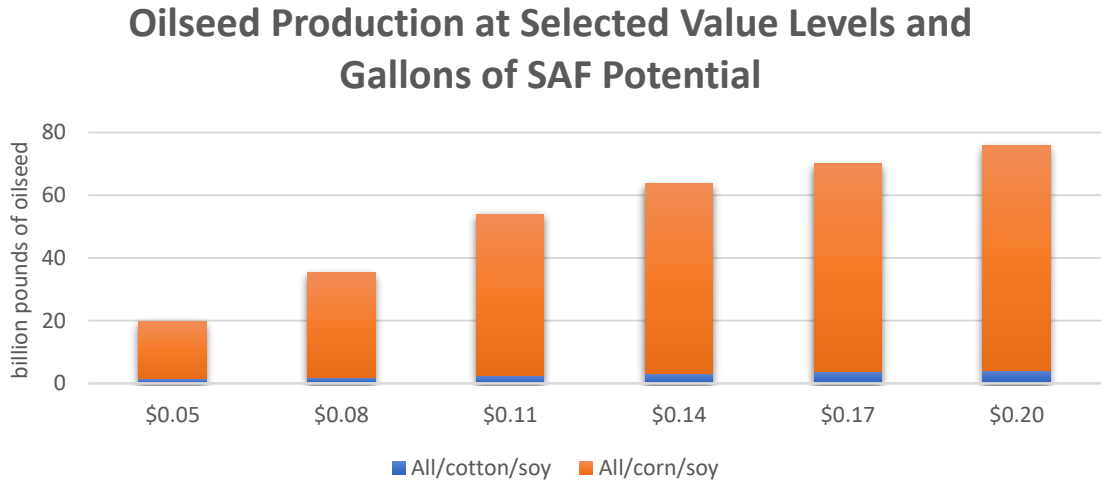
Cotton/Oilseed/Soybeans

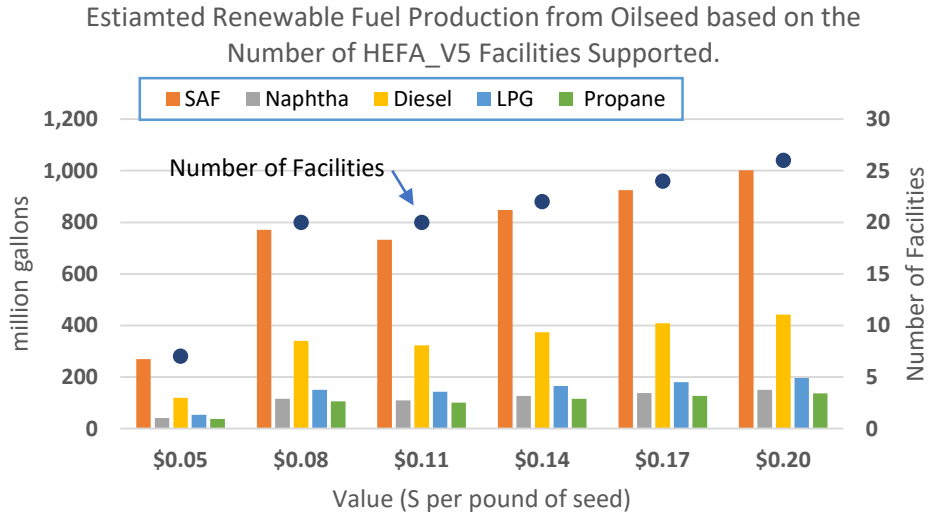
- The Oilseed Crops considered include
  - Carinata
  - Camelina
  - Pennycress
- The soybean yield following the harvest of the oilseed crop was reduced by 6.5%
- Land available restricted to current use. [min(cot, soybeans)

Analysis conducted at six different prices $0.05 per pound to $0.20 per pound using POLYSYS.

Oilseed Analysis – Cover Crop - $0.11 per pound

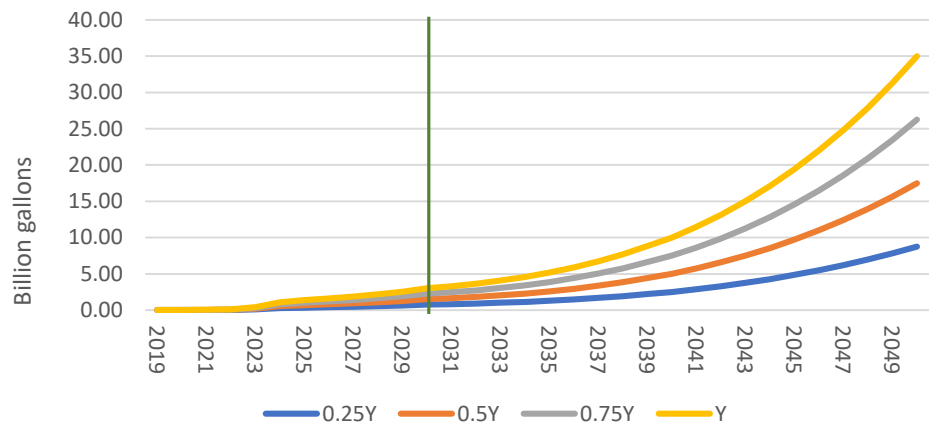






- At $0.11 per pound, a potential production of 34 billion pounds converting to nearly 5 million short tons of oil could occur resulting in 750 million gallons of SAF plus other renewable fuels assuming 20 HEFA facilities requiring 259,000 short tons annually.
- Primary cover crop is pennycress (77%) followed by camelina (17%) and carinata (6%)

Preliminary Analysis for SAF Grand Challenge



Crop Price	Change from baseline (2030) 25% TARGET $	25% TARGET %	50% TARGET $	50% TARGET %	75% TARGET $	75% TARGET %	100% TARGET $	100% TARGET %
Corn ($/bu)	-0.06	-1.64%	-0.06	-1.64%	-0.06	-1.64%	-0.06	-1.64%
Grain Sorghum ($/bu)	-0.01	-0.29%	-0.01	-0.29%	-0.01	-0.29%	-0.01	-0.29%
Oats ($/bu)	-0.02	-0.67%	-0.02	-0.67%	-0.02	-0.67%	-0.02	-0.67%
Barley ($/bu)	-0.01	-0.22%	-0.01	-0.22%	-0.01	-0.22%	-0.01	-0.22%
Wheat ($/bu)	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Soybeans ($/bu)	0.08	0.84%	0.08	0.84%	0.08	0.84%	0.08	0.84%
Cotton ($/lb)	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Rice ($/cwt)	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%
Hay ($/ton)	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%

Harvested Land	Change from baseline (2030) 25% TARGET Million acres	25% TARGET %	50% TARGET Million acres	50% TARGET %	75% TARGET Million acres	75% TARGET %	100% TARGET Million acres	100% TARGET %
Corn	0.33	0.40%	0.33	0.40%	0.33	0.40%	0.33	0.40%
Grain Sorghum	0.01	0.19%	0.01	0.19%	0.01	0.19%	0.01	0.19%
Oats	-0.01	-1.11%	-0.01	-1.11%	-0.01	-1.11%	-0.01	-1.11%
Barley	-0.01	-0.42%	-0.01	-0.42%	-0.01	-0.42%	-0.01	-0.42%
Wheat	-0.04	-0.10%	-0.04	-0.10%	-0.04	-0.10%	-0.04	-0.10%
Soybeans	-0.27	-0.32%	-0.27	-0.32%	-0.27	-0.32%	-0.27	-0.32%
Cotton	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Rice	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Hay	0	0.00%	0	0.00%	0	0.00%	0	0.00%

- Corn acreage increases at the area of soybeans & other crops due to more corn stover used for SAF
- Increasing corn acreage leads to lower corn price and higher soybean price
- Meeting 2030 target does not shake crop market much
- Cover crops are not considered as feedstock in this analysis

Next Steps

- **Complete the analysis and write-up of task 1 focused on lignocellulosic feedstocks using GFT conversion technology;**
- **Complete the analysis and write-up of task 2 focused on cover crop feedstocks, crushing facilities, and HEFA conversion technology;**
- **Complete Regional Deployment Proposal for SAF fuel supply chains in the Central Appalachia region;**
- **Develop work force analysis of the Central Appalachia region;**
- **Supply feedstocks to FTOT for the Memphis, Central Appalachia, and Southeast analysis;**
- **Respond to other ASCENT team members inquiries into feedstock characteristics, cost, and location questions.**
- **Continue to work with FAA, WSU, Purdue, and Penn State on Grand Challenge analysis.**

Publications

- Markel, E*, B. C. English, C. M. Hellwinckel, and R. J. Menard. 2019. Potential for Pennycress to Support a Renewable Jet Fuel Industry. Ecology, Pollution and Environmental Science, SciEnvironm 1:121.
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