FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Laying the Groundwork for Sustainable Aviation Fuel (SAF): Southeastern US Analysis

ASCENT 1

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Alexandria, VA

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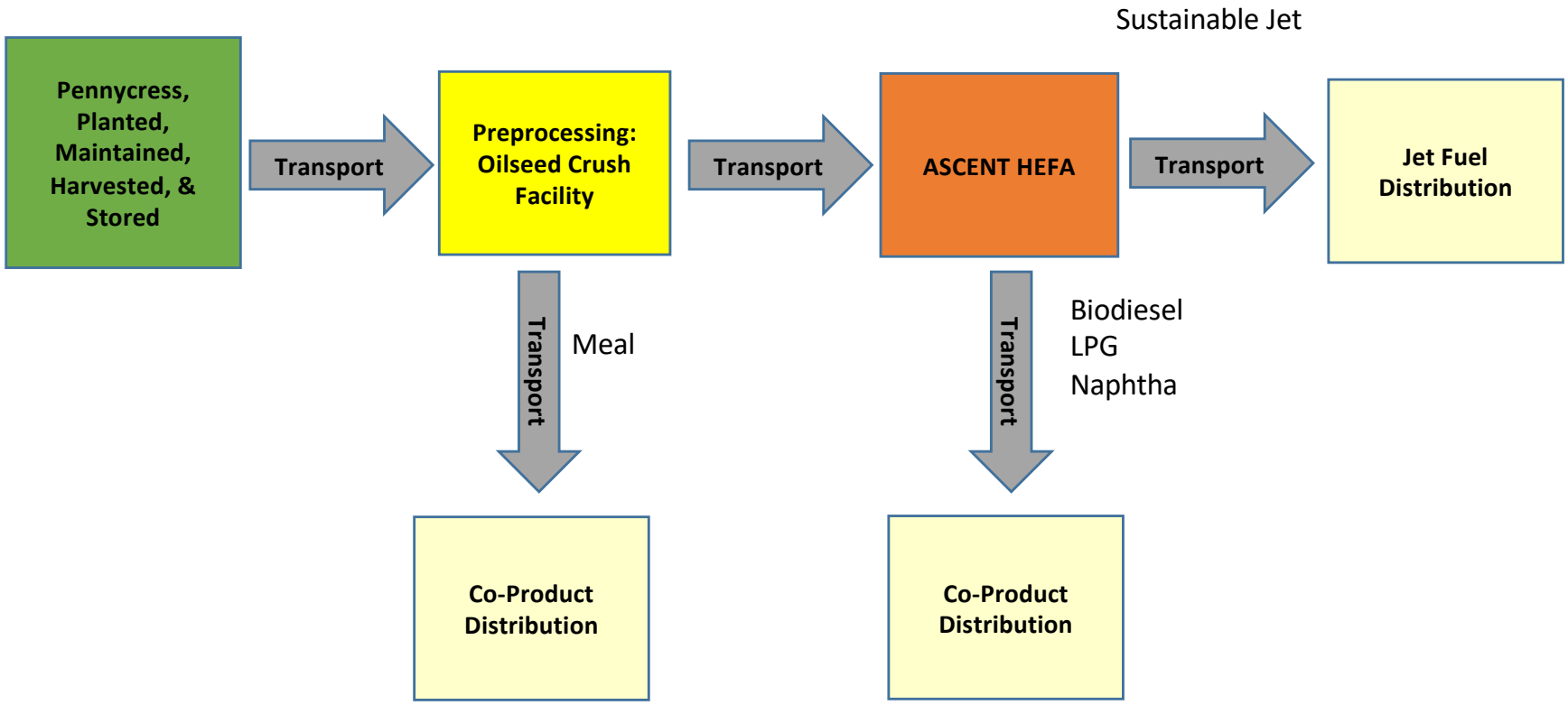
Team Members

Team Member	Activity	Team Member Role
Tim Rials	Co-PD; Expert Advisory Board, Lead	PD. Faculty
Burton C. English	Lead Co-PD, Expert Advisory Board, Feedstock Analysis, Pathway Analysis	PI, Faculty
Edward Yu	Feedstock Logistics, Lead	Co PI, Faculty
Kim Jensen	Market Analysis, Lead	Co-PI, Faculty
Jada Thompson	Market Analysis	Co PI, Faculty
James Larson	Risk Analysis, Lead	Co PI, Faculty
David Hughes	Work Force Analysis, Lead; Stakeholders, Lead; Social and Human Capital; Expert Advisory Board;	Co PI, Faculty
Carlos Trejo-Pech	Finance, Lead	Co-PI, Faculty
Christopher Boyer	Sustainability, Co-Lead	Co-PI, Faculty
Christopher Clark	Legal, Lead; and Sustainability, Co-Lead	Co-PI, Faculty

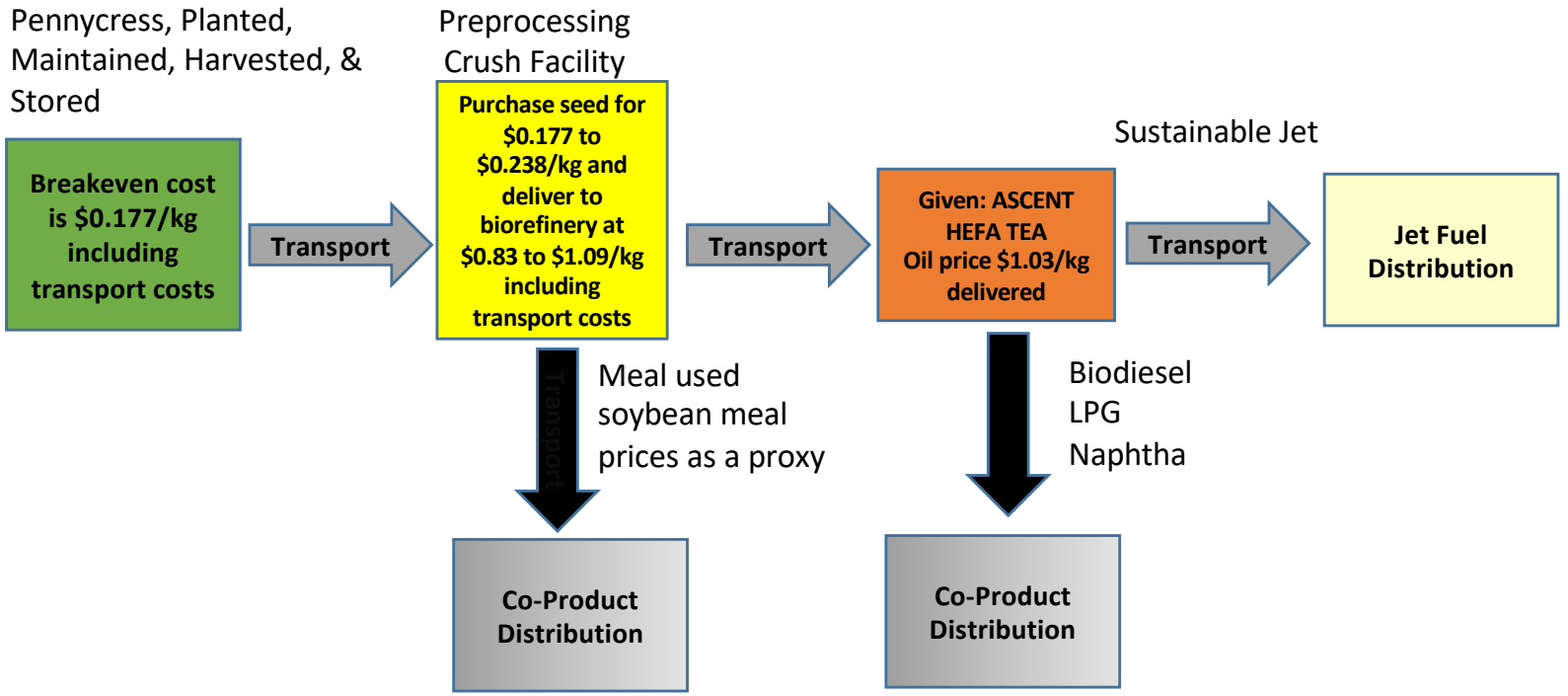
Project Objectives and Progress

- Provide feedstock information to the ASCENT team
  - Done for herbaceous lignocellulosics, pine, logging residues,, crop residues, and pennycress
  - Still working on environmental impacts
- Evaluate SAF pathways for the southeast U.S.
  - Oilseeds for Nashville and Memphis
  - Pine, switchgrass, and blend of the two for location in Alabama
  - Hardwoods in Central Appalachia for a multitude of airports (to Be Funded)
- Develop Regional Development Plans for the three pathways incorporating stakeholder feedback
- Evaluate oilseed potential nationally
  - Pennycress analysis completed and published
  - Need to add other oilseed feedstocks to the analysis
- Economic impact analysis
  - Tools developed to quickly evaluate the economic analysis of projects through out the US.

Pennycress Supply Chain Risk Assessment



Pennycress Supply Chain Risk Assessment

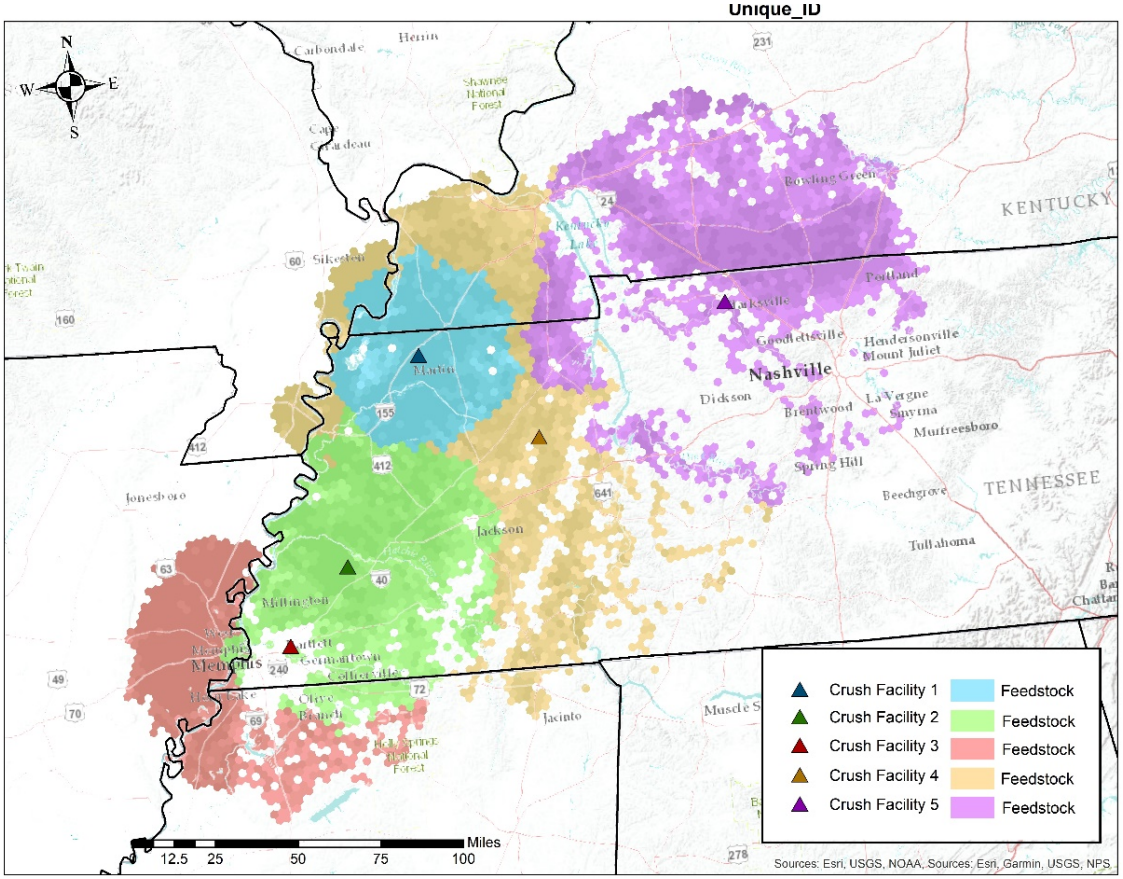


Trejo-Pech, C., J. A. Larson, B. C. English, and T. E. Yu. 2019. Cost and Profitability Analysis of a Prospective Pennycress to Sustainable Aviation Fuel Supply Chain in Southern USA. Energies, 12, no. 16: 3055.

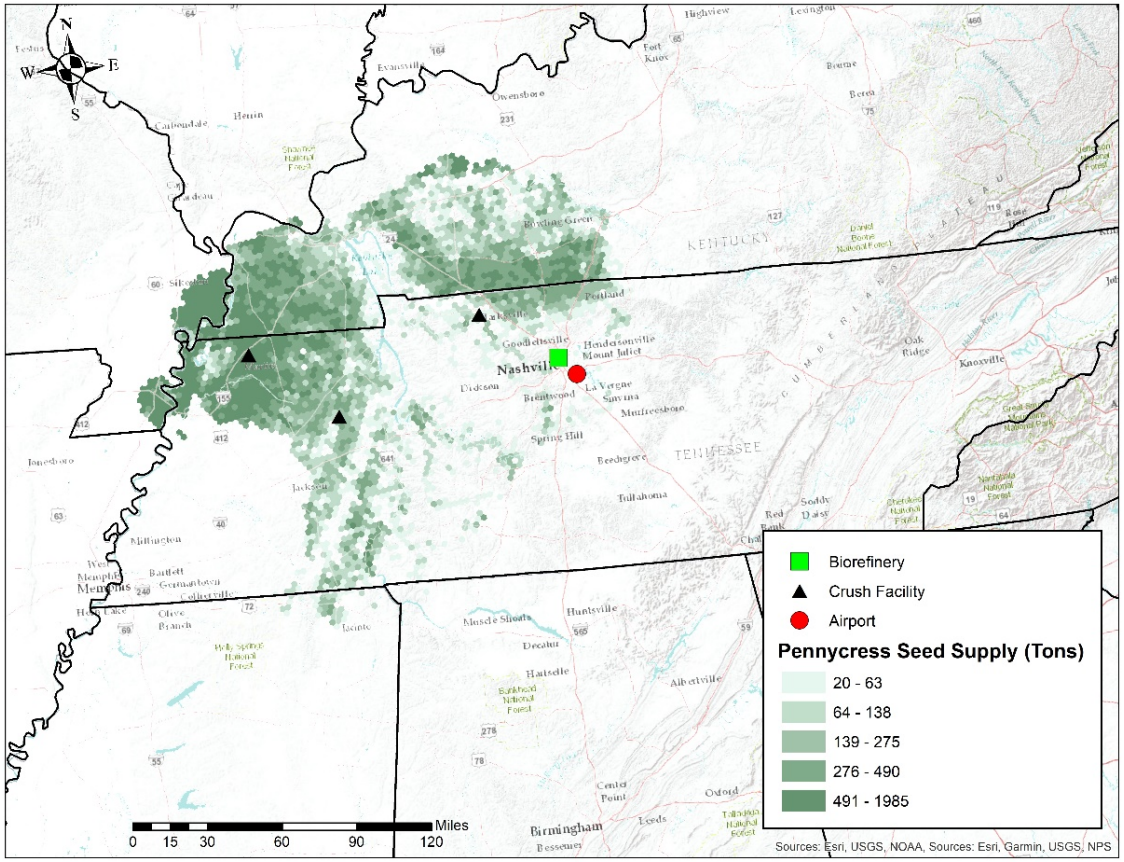
BioFLAME was used

- Three step process
  - Step 1: Locate the Crush facilities such that feedstock costs are minimized
  - Step 2: Determine the crushing facilities that minimize the feedstock and transportation costs to the International Nashville Airport
  - Step 3: Work transportation costs into the Pennycress production and Crush facility spreadsheets to determine the cost of delivering feedstock to the biorefinery.

Map of the Crushing Facility Locations along with feedstock production locations



Feedstock Supply Chain for SAF at the Nashville International Airport



Economic Impact -- Investment

Investment type	Investment Required	Impacts	
		Direct	Total
	Million $ (Labor)	Employment (jobs)	
Crushing Facilities	$20	333	527
Biorefinery	$84	1,267	2,915
Total		1,600	3,442
		Economic Activity (Million $)	
Crushing Facilities	$66	$39	$67
Biorefinery	$204	$175	$409
Total	$270	$214	$476

Economic Impact -- Annual Operations

Investment type	Annual Expenditures	Impacts	
		Direct	Total
		Economic Activity (Million $)	
Agricultural Operations	$49	$49	$80
Crushing Facilities	$20	$12	$19
Biorefinery	$35	$17	$31
Transportation	$10	$10	$17
Profit	$38	$38	$67
RIN	$82	$82	$154
Total	$234	$208	$369

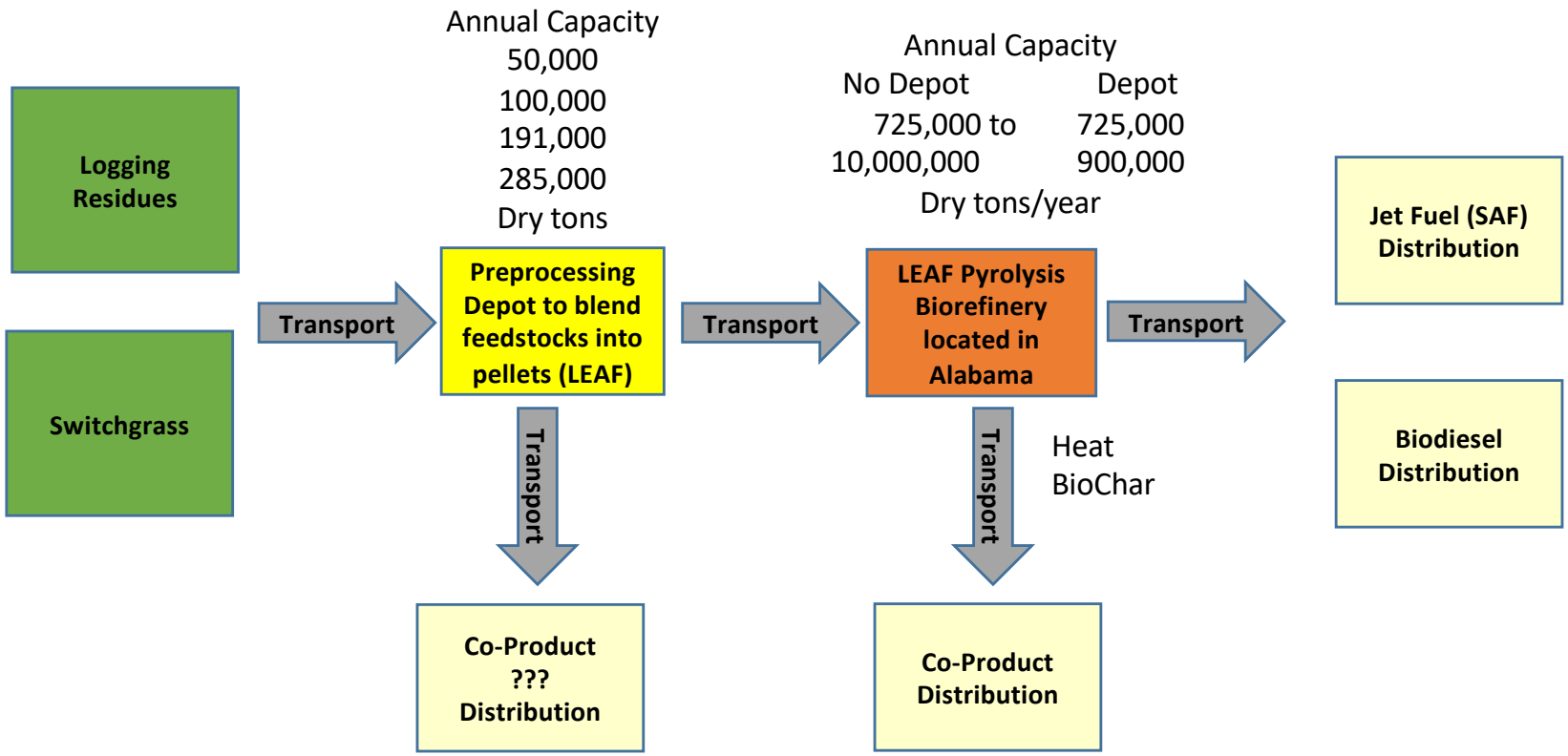
Economic Impact – Annual Operations (Labor)

Investment type	Annual Expenditures	Impacts	
		Direct	Total
	Million $	Employment (jobs)	
Agricultural Operations	$21	496	727
Crushing Facilities	$3	49	90
Biorefinery	$8	115	211
Transportation	$5	116	172
Profit	$38	0	226
RIN	NA	0	512
Total	$76	775	1,939

Products to Date

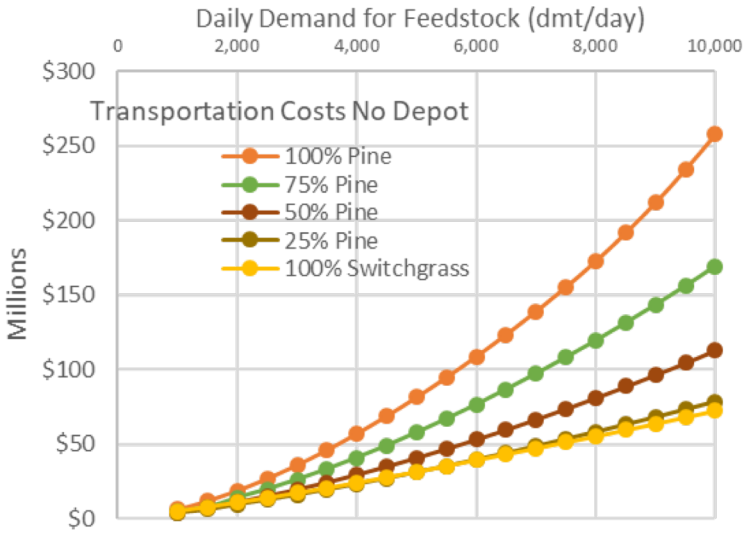
- Two spreadsheets
  - Pennycress
  - Crushing Facility
- Journal Article
- Planned article on risk with this facility
- Planned article on economic impacts of this system (perhaps incorporating sustainability and social capital also)

Wood/Switchgrass Supply Chain Risk Assessment

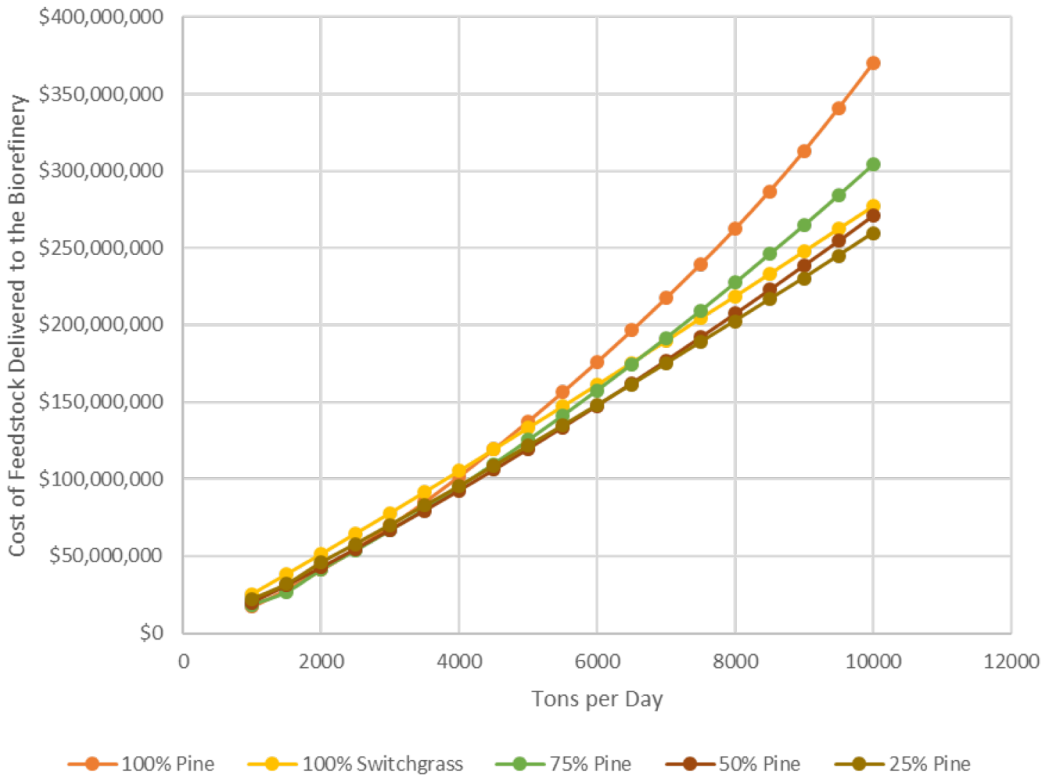


Logistics of Enhanced Attribute Feedstock (LEAF)

No Depot



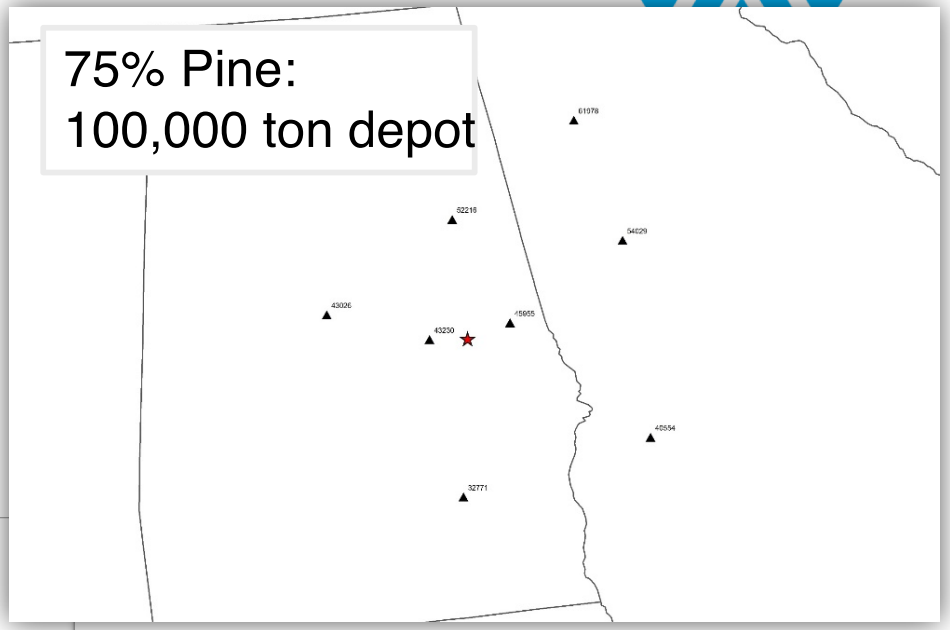
Plant Cap	Annual Capacity	
Tons/day	Metric Ton	Short Tons
1,000	328,500	362,007
1,500	492,750	543,011
2,000	657,000	724,014
2,500	821,250	905,018
3,000	985,500	1,086,021
3,500	1,149,750	1,267,025
4,000	1,314,000	1,448,028
4,500	1,478,250	1,629,032
5,000	1,642,500	1,810,035
5,500	1,806,750	1,991,039
6,000	1,971,000	2,172,042
6,500	2,135,250	2,353,046
7,000	2,299,500	2,534,049
7,500	2,463,750	2,715,053
8,000	2,628,000	2,896,056
8,500	2,792,250	3,077,060
9,000	2,956,500	3,258,063
9,500	3,120,750	3,439,067
10,000	3,285,000	3,620,070
Assumes 90% operating efficiency		

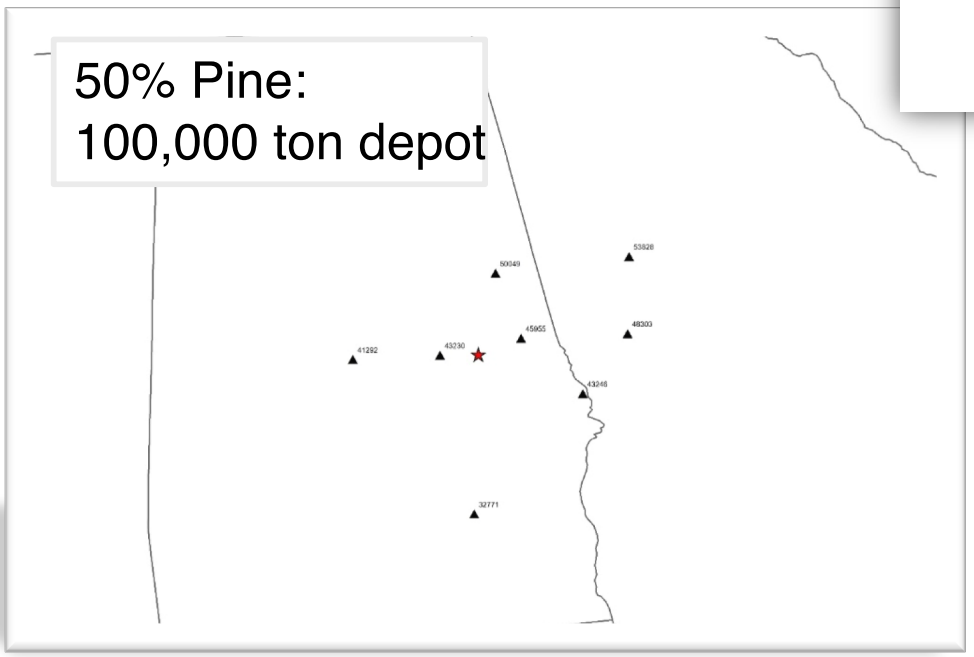


Average miles a ton travels give a specific plant capacity and blend rate (Southern Eastern Alabama)

Average miles each ton travels by mixture and plant capacity with No Depots					
Plant	Average Transportation Distance				
Capacity	100% Pine	100% Switchgrass	75% Pine	50% Pine	25% Pine
Tons/day			Miles		
1000	55	19	37	24	18
1500	71	22	40	31	19
2000	84	24	56	37	25
2500	96	26	64	42	28
3000	107	28	72	46	30
3500	117	30	78	50	33
4000	127	32	85	54	35
4500	136	34	91	58	37
5000	145	35	97	61	39
5500	154	37	102	65	41
6000	162	39	108	68	43
6500	169	40	113	71	45
7000	177	41	118	74	47
7500	185	42	123	77	48
8000	192	43	127	80	50
8500	201	44	132	82	52
9000	210	45	136	85	53
9500	220	46	141	88	54
10000	229	47	145	90	56

With Depot:
725,000 mdt/year





Sustainable Aviation in the Southeast

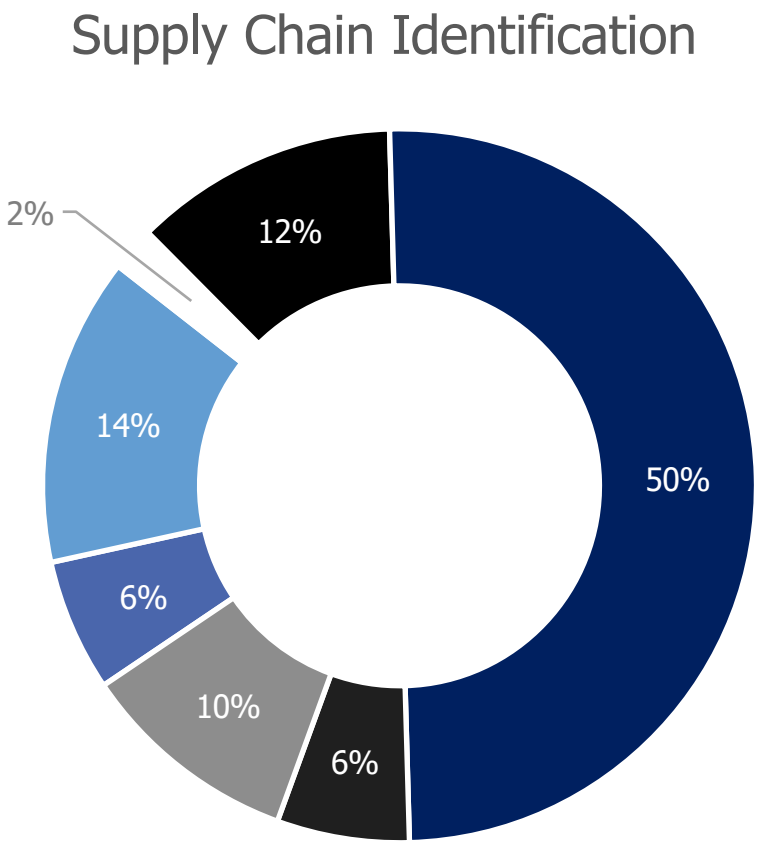
The Aviation Sustainability Center at the University of Tennessee is pleased to announce a workshop on **"Sustainable Aviation In the Southeast: Moving From Strategic to Tactical"**. The 1-½ day meeting will be held in Knoxville, TN. The program will gather information on logistical challenges to building a complete and flexible supply chain for the industry. Topics to be addressed include:

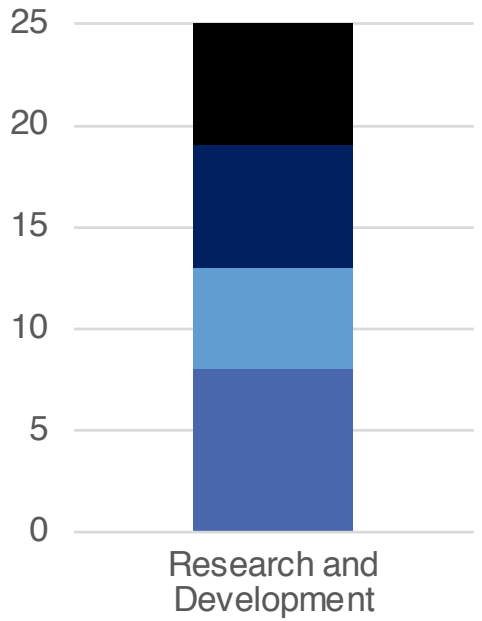
- **Fuel production technology pathways**
- **The resource base for biomass and oilseed crops**
- **Feedstock supply chain limitations and required developments**
- **Product distribution infrastructure barriers**

April 24-25, 2019

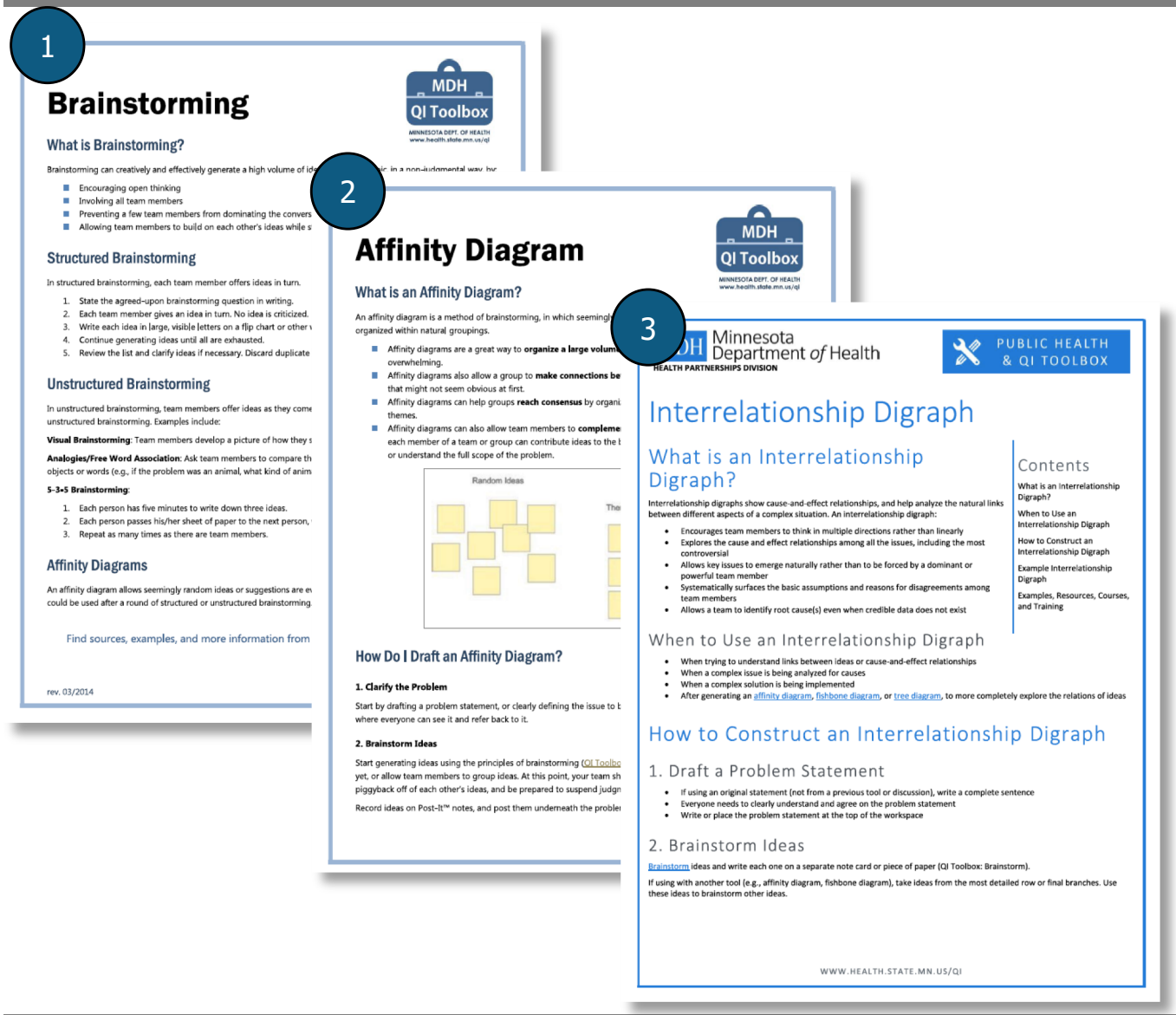
The University of Tennessee
Institute of Agriculture
Knoxville, Tennessee

Workshop Participants: The Numbers



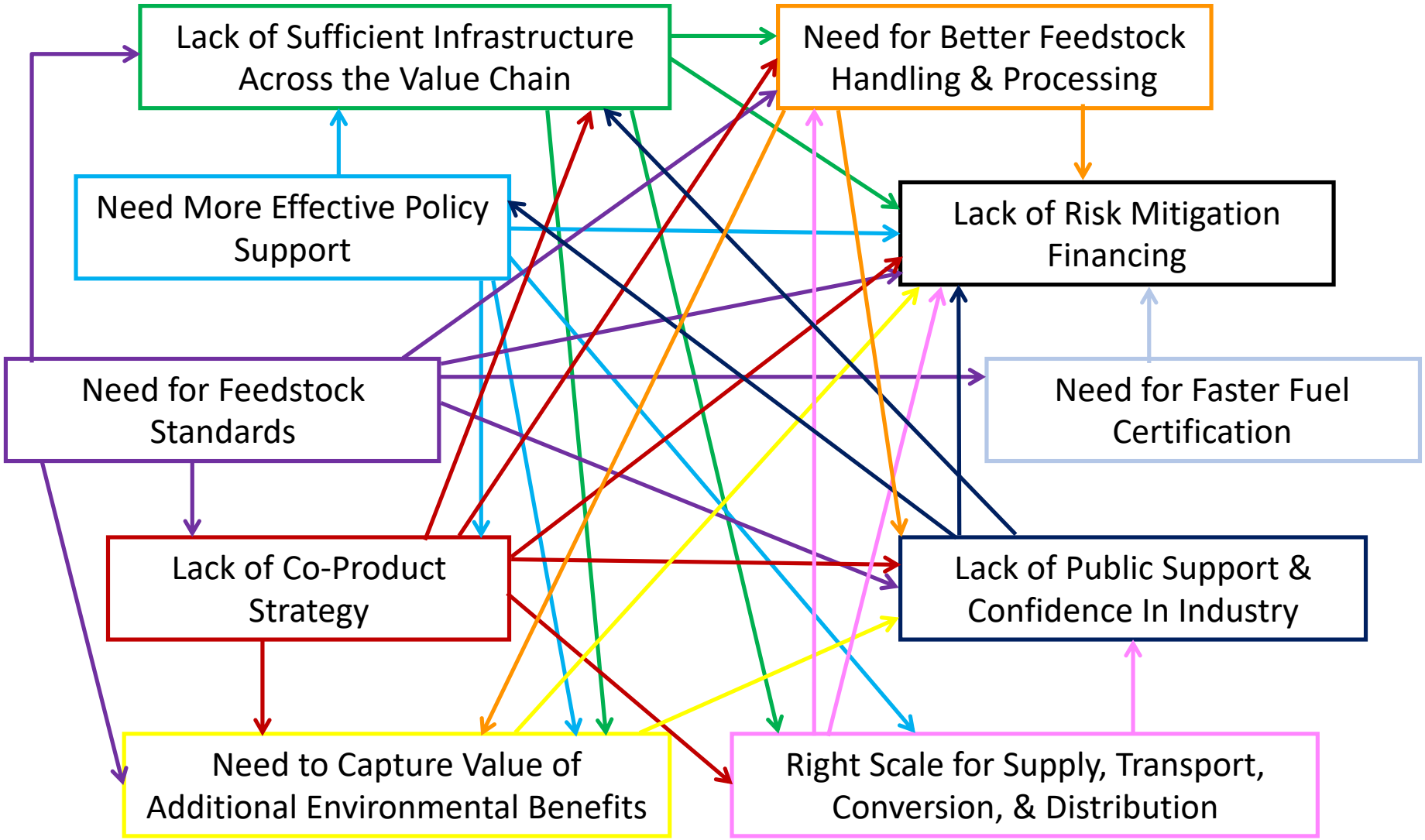


Workshop Participants: The Numbers

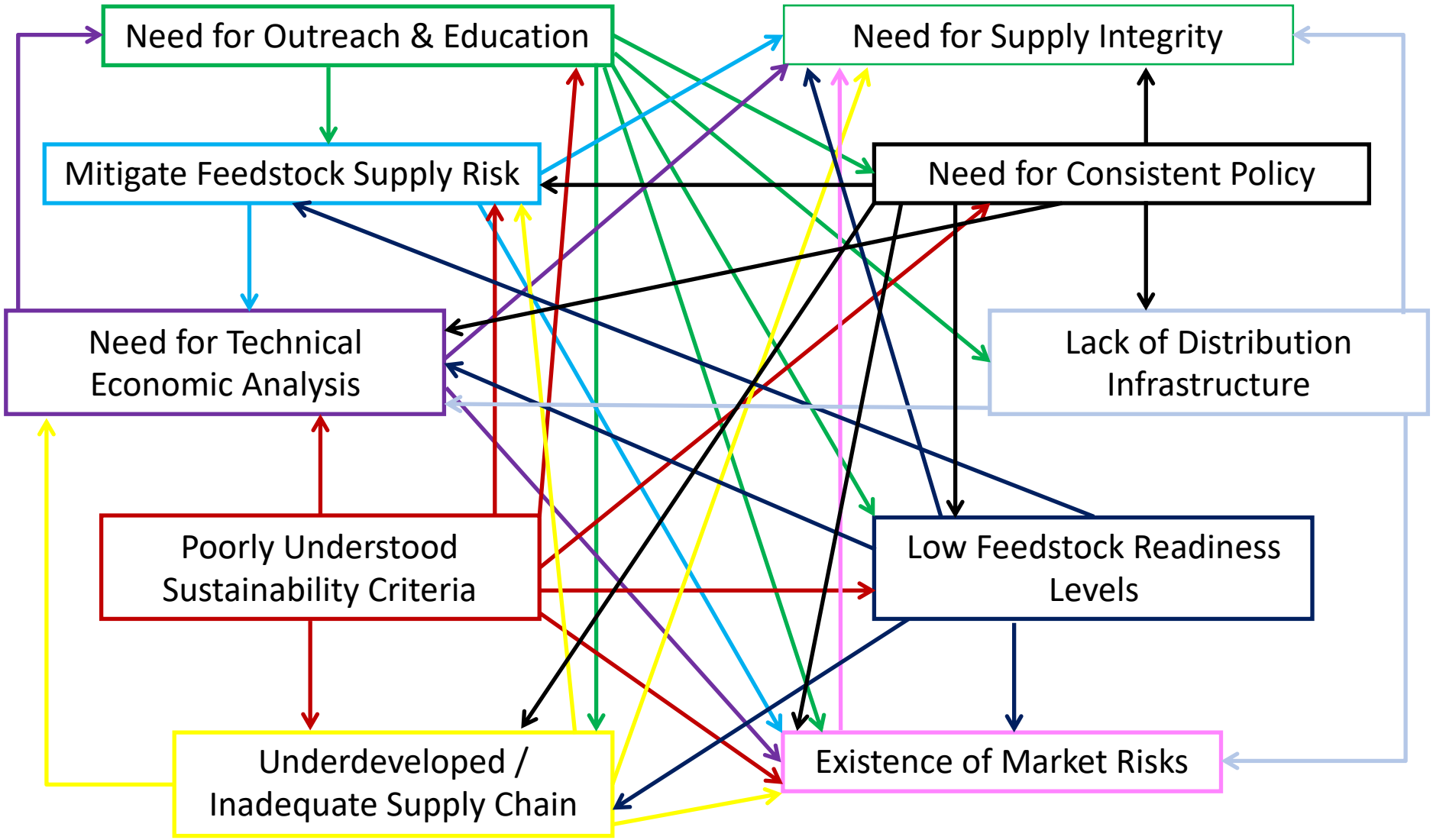


- More than 50 invited leaders from the region met to discuss critical barriers to increasing availability of SAF in the SE
- Groups were split with 20-25 individuals per group
  - Lignocellulosic group led by Chris Tindal
  - Oilseed group led by Christina Sanders and Daniel Mueller
- The group included individuals experienced in the different unit operations that make up the biofuel supply chain, and brought industry, university, and government perspectives to the dialogue

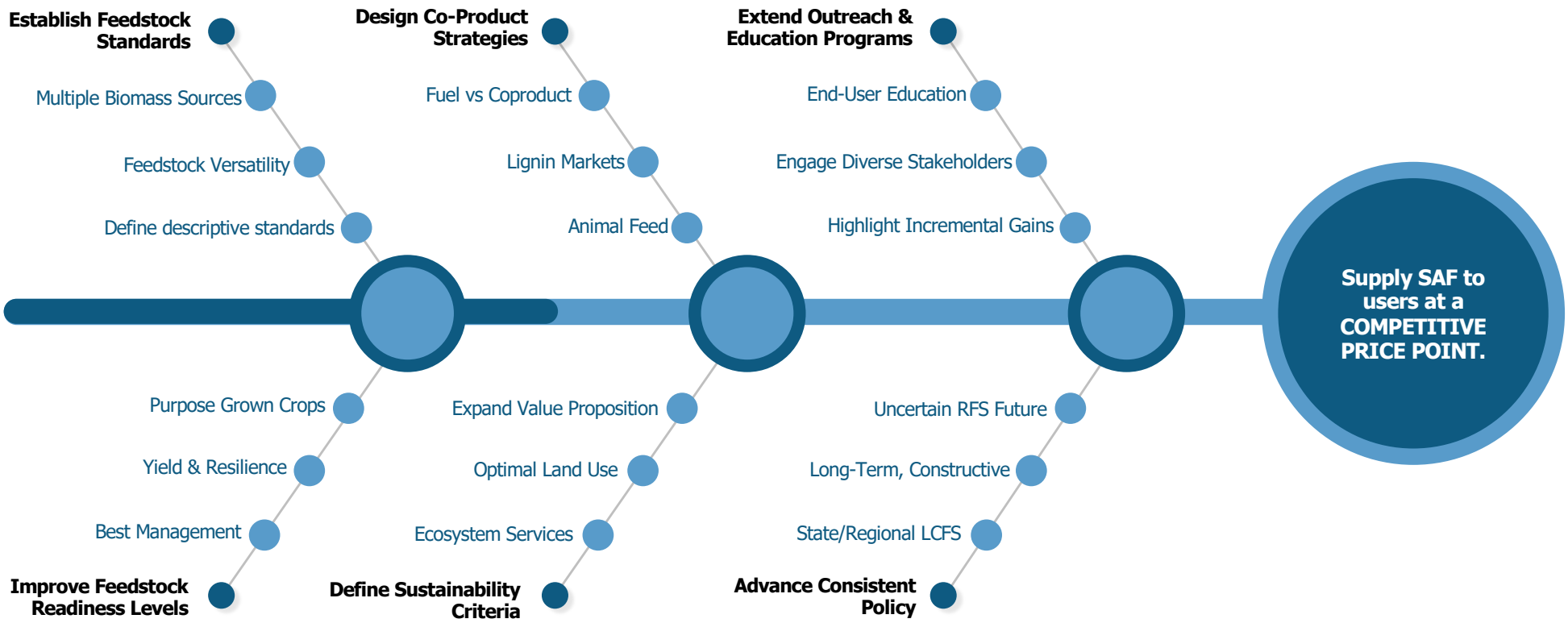
Lignocellulosic Pathway Barriers



Oilseed Pathway Barriers



Top Tier SAF Challenge Areas - SE



Moving Forward

To maintain the momentum established during the workshop, six of the top barriers were selected as near-term targets for the alliance to address. The individual teams will work to better define the barrier and develop strategic approaches to reduce the challenges they present.

Addressing the Need for Consistent Policy
- Rodney Hadley
- Valerie Thomas
- Charles Etter
- Dave Meyer
- Nate Brown

Addressing Poorly Understood Sustainability Criteria
- Rodney Hadley
- Valerie Thomas
- Jesse Nikkel
- Dave Meyer
- Tim Theiss

Advancing the Need for Outreach and Education
- Rodney Hadley
- Charles Etter
- Christina Sanders

Lack of Co-Product Strategy
- Gerald Tuskan
- Niki Labbé
- Nour Abdoulmoumine
- Dave Lanning
- Richard Molsbee
- Phil Weathers

Addressing Low Feedstock Readiness Level
- Burt English
- Niki Labbé
- Nour Abdoulmoumine
- Dave Meyer
- Dave Lanning
- Randy Rousseau
- Gerald Tuskan

Addressing Low Feedstock Readiness Level
- To be developed

Other Components

- Initiated risk analysis similar to that conducted at Purdue on the oilseed feedstock supply chain.
- Initiated the Social Capital Analysis for Nashville
- Conducted consumer study regarding biochar and its use in potting soil
- Initiated a Tennessee variety yield analysis for oilseed crops
- Started sustainability analysis on oilseed covercrops using Virginia Dale's (ORNL) methodology

Questions