National Institute of Food and Agriculture

- The Bioenergy, Bioproduct Bioeconomy (B3) Portfolio historically provides unique approaches to building supply chains and value propositions through research, education, and Extension
- Supports Bioeconomy through competitive and capacity grant programs

- **AFRI**: Agriculture and Food Research Initiative
  - **Coordinated Agricultural Projects** (CAPs)
    - Integrate research, development, demonstration, education/workforce development, Extension/outreach/tech transfer
    - Regional biomass supply chains linked to bioeconomic value propositions (biofuels, biobased chemicals and products)
  - **Foundational Program** grants address bioproducts (e.g. lignin, nano-cellulosics), policy, social and environmental impacts, crop development and evaluation
- **SBIR**: Small Business Innovation Research
- **USDA & DOE Joint Solicitations**
  - Plant Feedstock Genomics Program (with DOE-OS-BER)
  - Biorefinery Optimization (with DOE-BETO)
  - Biomass Research and Development Initiative (with DOE-BETO)

USDA NIFA
April 20, 2017 in Washington, DC

World's First Commercial Cellulosic Biofuels Flight

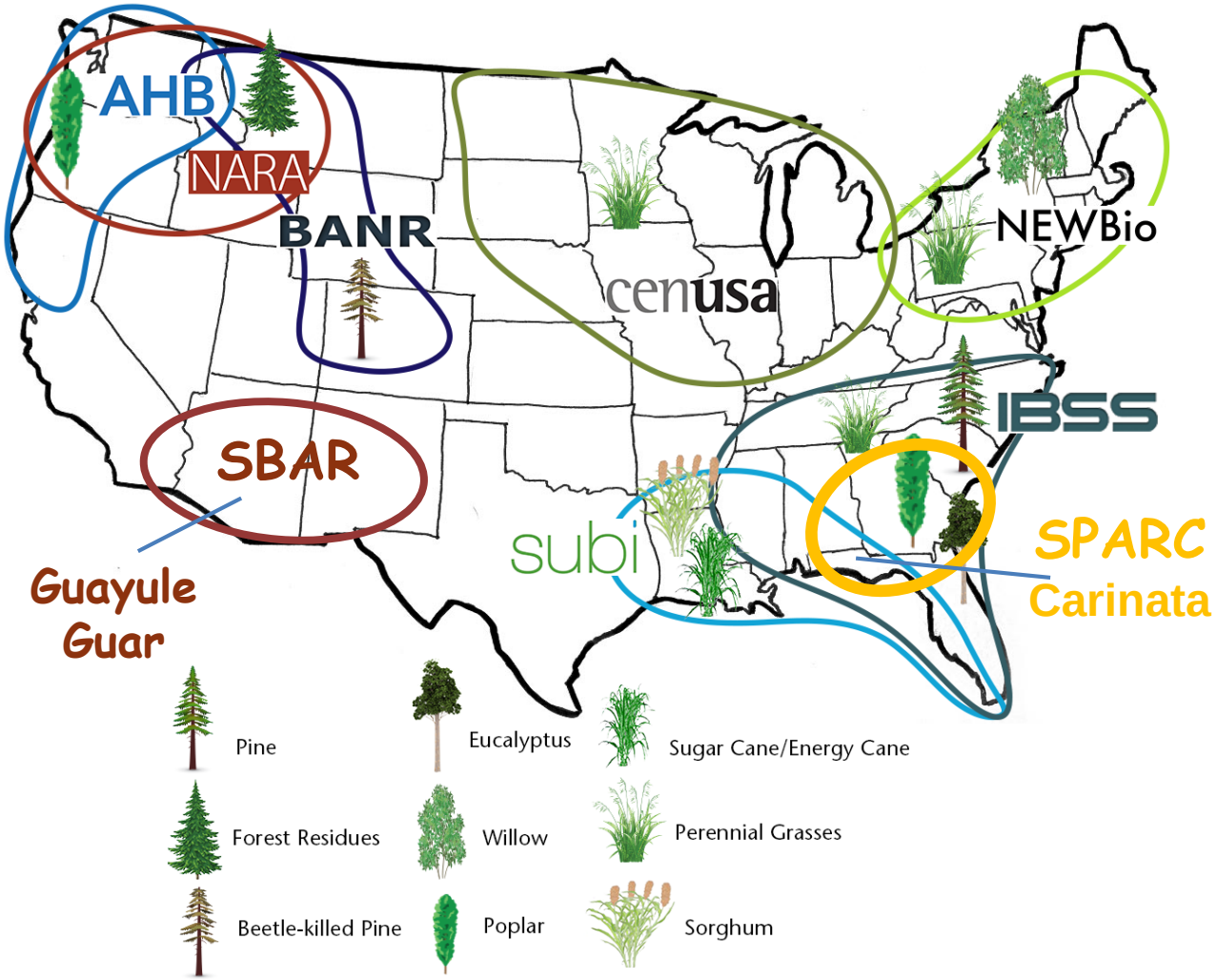
Two NEW AFRI CAPs Join the Community

SPARC led by University of Florida

- Partnering with Agrisoma and ARA
- Targeting alternative jet fuel and animal feed from the oilseed crop Brassica carinata (Carinata)

SBAR led by University of Arizona

- Partnering with Bridgestone America and Eastman Chemicals
- Targeting natural rubber, industrial chemicals, and alternative jet fuel from the dry land crops guayule (why-oo-ley) and guar.



CAP Feedstocks and Project Regions

USDA NIFA CAP

CAAFI Webinar
October 13, 2017

David Wright

Based on a True Story of

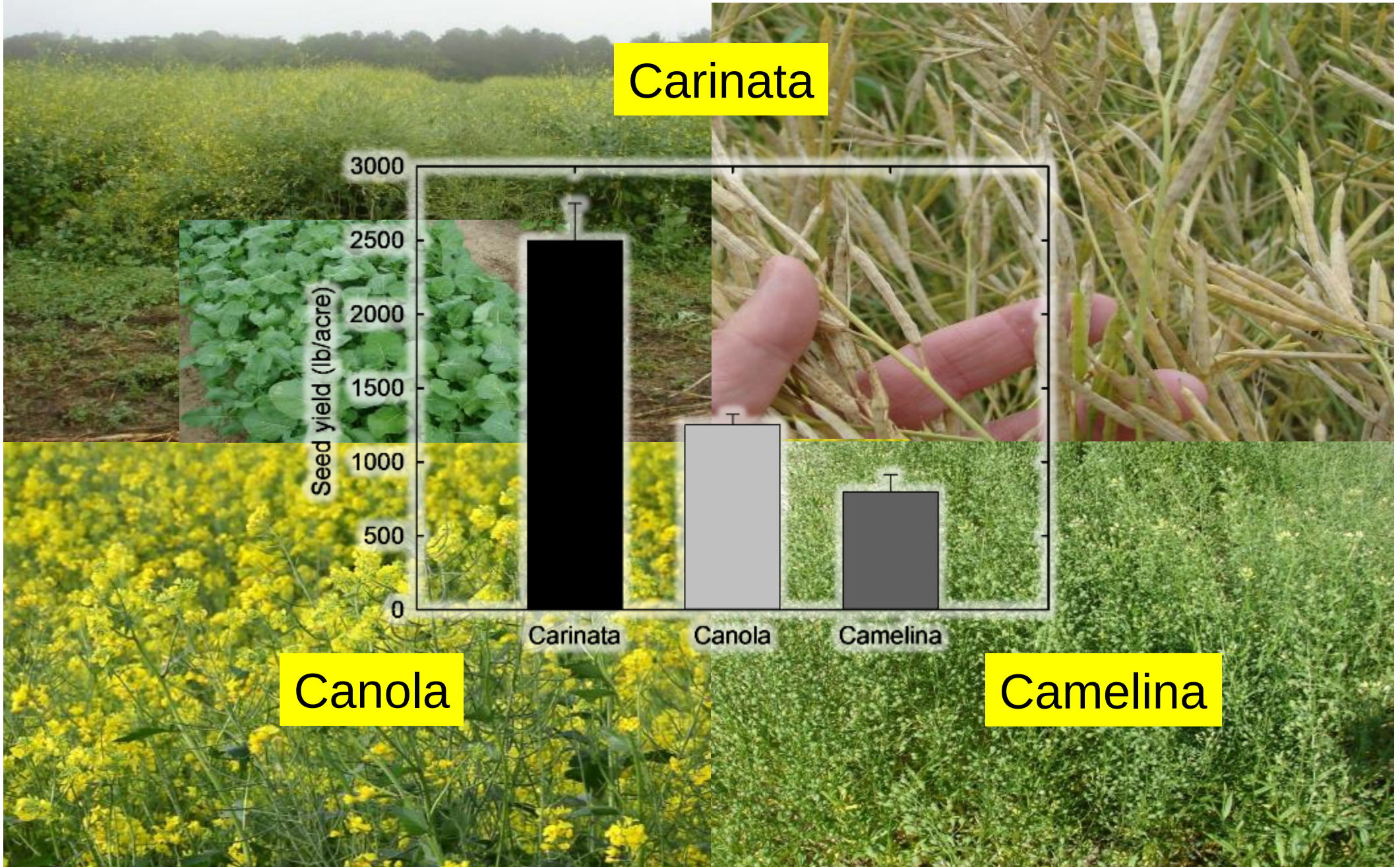
Growing Jet Fuel on the Farm

http://sparc-cap.org/

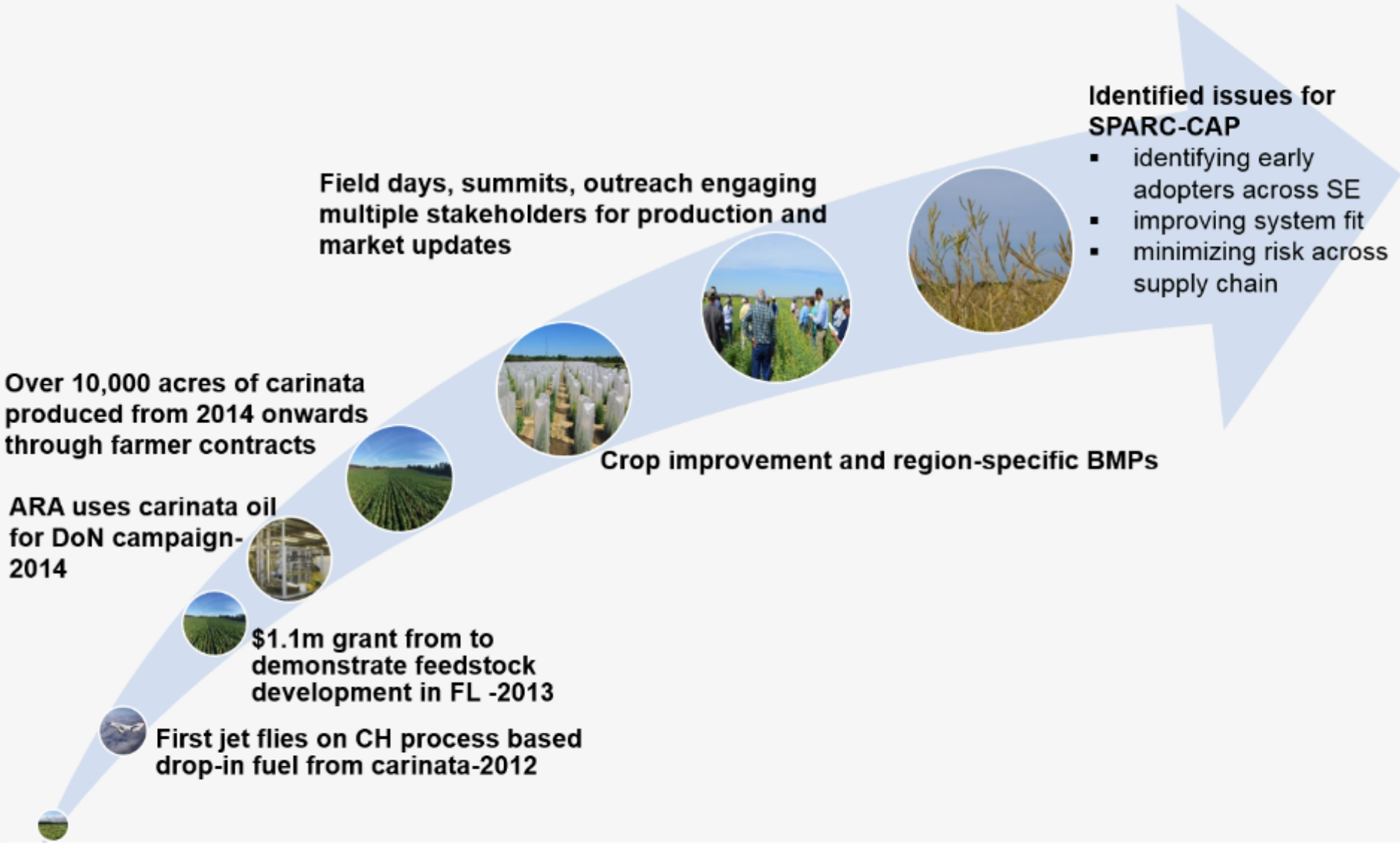
SPARC

Southeast Partnership for Advanced Renewables from Carinata

Winter Oilseed Crops in the Southeast



Laying the foundation for SPARC



SPARC

What is Carinata?

Mustard family (Brassicaceae)

Carinata Characteristics

Closely related to rapeseed

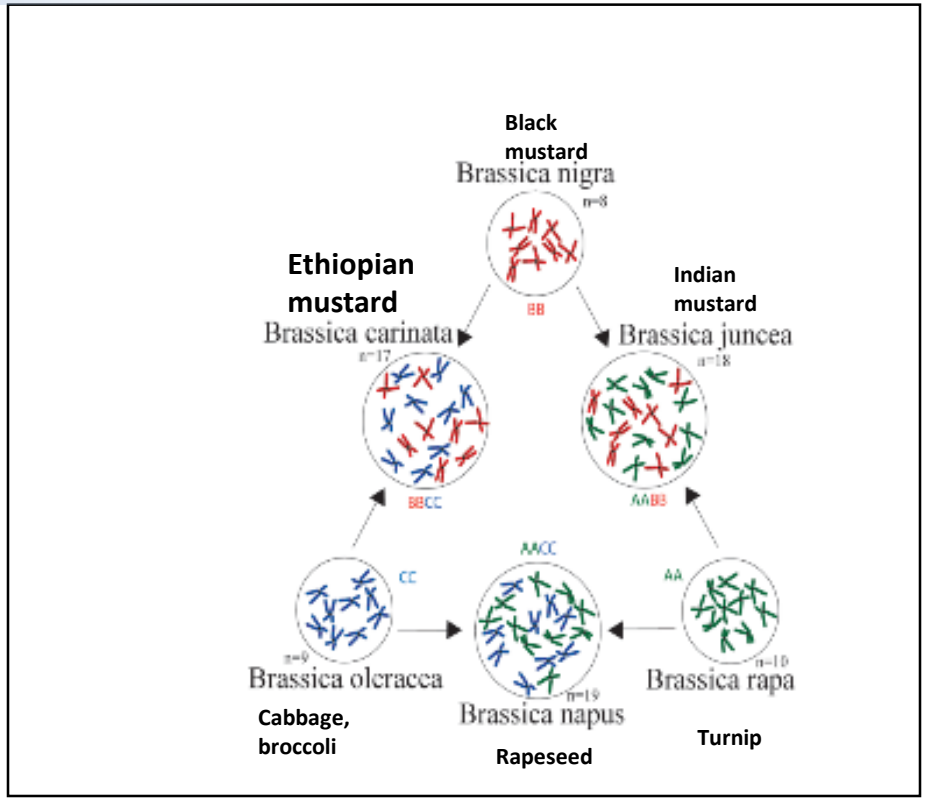
Cold, heat, and drought tolerance

High oil content

Oil is high in erucic acid

Non-food oilseed crop

High protein seed meal

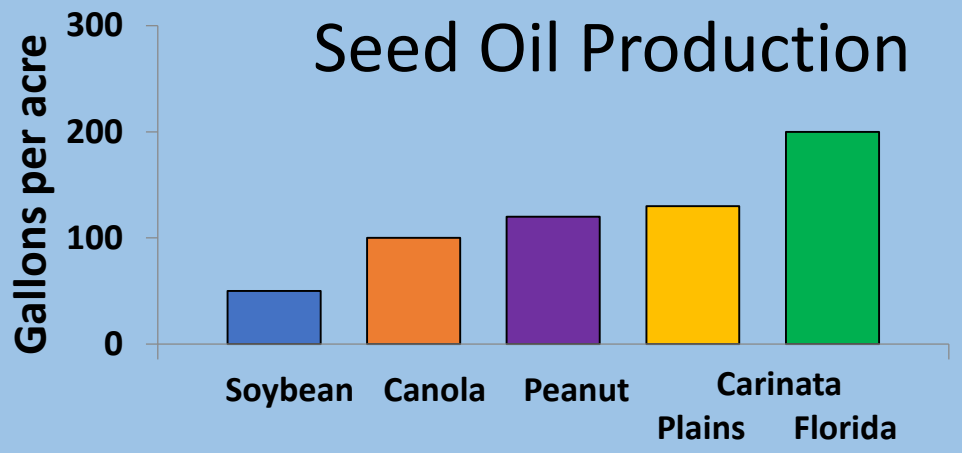


http://en.wikipedia.org/wiki/Triangle_of_U

Oilseed Crops for Bioenergy

B. carinata (Ethiopian mustard) is an excellent non-food oilseed crop for biofuels

***Carinata seed is high in oil and produces more oil/acre**



	~ % Seed Oil
Peanut	50
Canola	43
Carinata	42-45
Soybean	18
Cotton	16
Corn	3

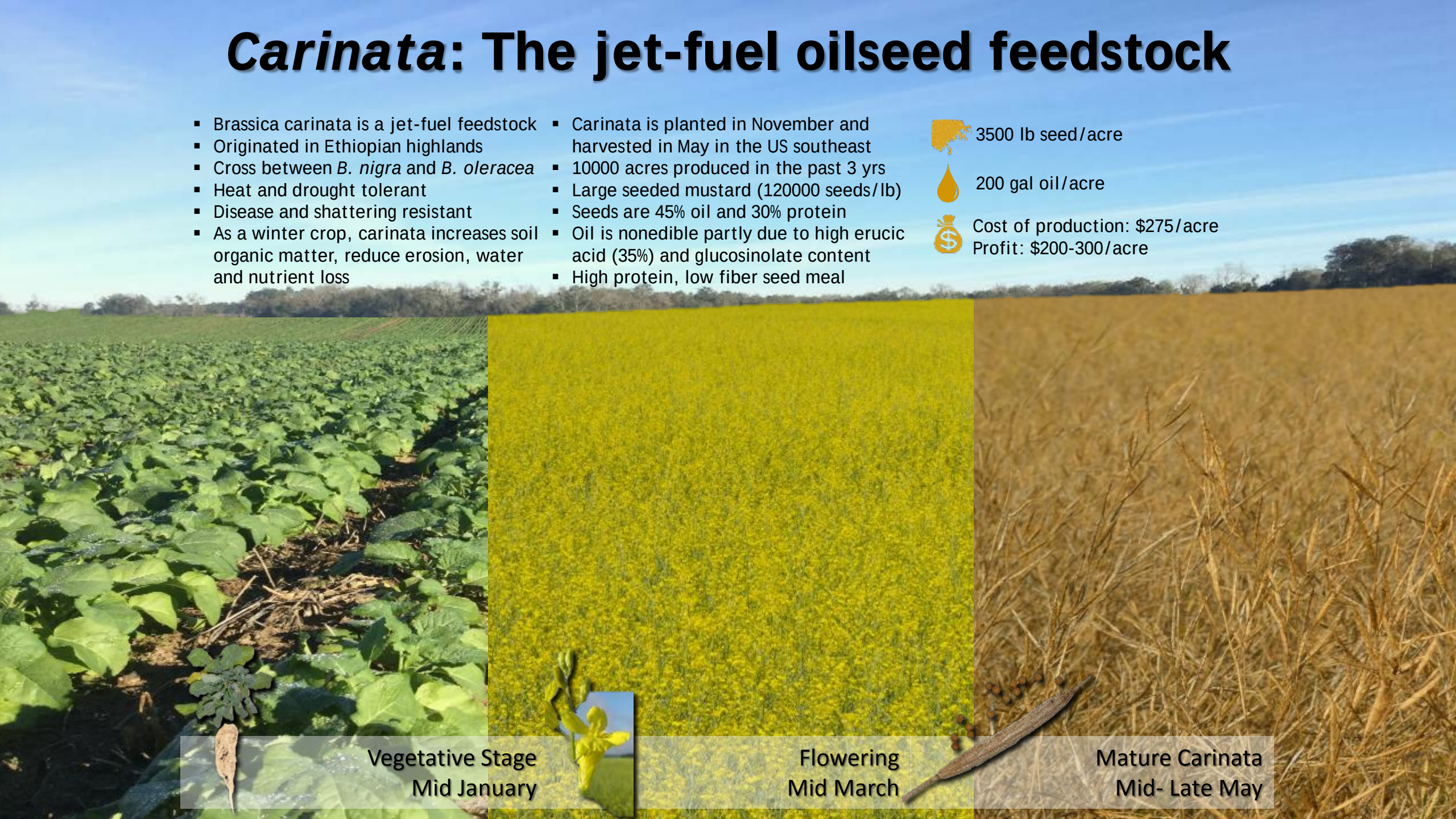
Carinata: The jet-fuel oilseed feedstock

- Brassica carinata is a jet-fuel feedstock
- Originated in Ethiopian highlands
- Cross between *B. nigra* and *B. oleracea*
- Heat and drought tolerant
- Disease and shattering resistant
- As a winter crop, carinata increases soil organic matter, reduce erosion, water and nutrient loss
- Carinata is planted in November and harvested in May in the US southeast
- 10000 acres produced in the past 3 yrs
- Large seeded mustard (120000 seeds/lb)
- Seeds are 45% oil and 30% protein
- Oil is nonedible partly due to high erucic acid (35%) and glucosinolate content
- High protein, low fiber seed meal

3500 lb seed/acre

200 gal oil/acre

Cost of production: $275/acre
Profit: $200-300/acre



Why Carinata?

Crop timing conducive for production and consistent feedstock supply

- Planted on fallowed underutilized lands
- Planted in fall and harvested in spring in the southeast
- Low water footprint
- Double cropped for increased farmer revenue-leaving May-October for summer crop

Southeast US Crop Acreage

	Florida	Georgia	Alabama	South Carolina
Crop Acres	9,250,000	10,150,000	9,033,000	4,900,000
Summer Production	Tomato, Vegetables	Cotton, Peanut, Corn Soy	Cotton, Soy, Peanut	Peanut, Cotton
Rotation/ Double Crop Options	Winter into vegetable crops (~1MM acres)	Winter rotations into Cotton, Peanut	Winter into Soy and Cotton	Winter into Peanut, Cotton

- Winter crop that fits in existing crop rotation scenarios with potential of 2 to 4 M acres of the 15 M acres in the 6 team states, enabling sustainable fuel and bioproducts production

- Has seen significant developments over the last 7 years that demonstrates this crop is on the verge of broad commercialization

- Has superior agronomic properties and oil and fuel characteristics; high value seed meal for feed and bioproducts (SE has a need for high protein meal)

- SPARC's strategic industry partnerships and efforts intended to move carinata to an **FSRL 8**, and integrated with a CHJ conversion to **FRL 9** enabling commercialization initiation at significant scale (FSRL scale 1-9 with 1 being ID of feedstock, etc. and 9 being commercialization)

Production Goals

3500 lb seed/acre

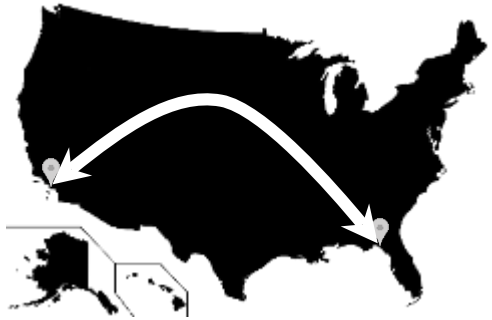
200 gal oil/acre

$200-300 profit/acre

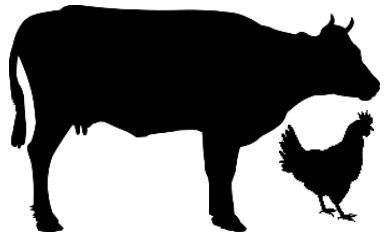
What's in a bag of carinata seed?

Seed sold to farmers in 50 lb bags to plant 10 acres.

One bag of seed can produce 18 tons of seed.



18 tons of seed produces 2000 gallons of jet fuel which can fly most fully loaded regional jets for 9 hours of flight, from North Florida to California and back.



The amount of feed (meal) can produce 3600 pounds of beef or 6200 pounds of poultry.

SPARC Teams and Objectives

Feedstock Development

RDL Ag Services LLC

Activities

- Optimum geno-pheno-type identification for various SE US regions
- Fertility management
- System fit of carinata in the SE cropping system context
- Weed management and product development
- Disease and pest management
- Systems modeling

Fuel and Co-product Development

Activities

- Hydrothermal cleanup
- Production of unblended drop-in fuels
- Co-product production and testing

SPARC
Southeast Partnership for Advanced Renewables from Carinata

Outreach, Education, Workforce Development

Activities

- Link research and extension for feedback and project improvement
- Document drivers of adoption, assess stakeholder needs
- Develop extension learning tools
- Stakeholder engagement
- K-12, undergraduate and graduate education in bioenergy
- Internships and career development in the field of bioenergy and bioeconomy

Meal Efficeincy

Activities

- Nutritional evaluation in poultry
- Glucosinolates in carinata meal and performance in cattle
- Recovery of co-product streams from carinata meal

System Metrics

Dawson, GA

RDL Ag Services LLC

RCB Altman LLC

Activities

- Economic analysis
- Watershed modeling
- Life Cycle Analysis

Supply Chain

RCB Altman LLC

Activities

- Feasibility analysis for post-harvest logistics, infrastructure development
- Secure resilient 24/7 feedstock supply

Established Carinata Value Chain

Develop, test and introduce Carinata to farmers




Biofuels: 18% Gross Margin
- Low carbon markets driving margins
- Significant Capex required
- Feedstock costs & Regulatory key determinants of GM

Biofuels Customers

Seed Farming Logistics Crush




Oil

Meal




Meal Customers

50%+ Stable Gross Margin
- Significant IP controlling product
- Effective Inventory Management
- Low working capital
- Low capex requirements

30% Highly Variable Gross Margin
- Highest Risk portion of Value Chain
- Net Return to Farmer impacted by weather
- Upside is 30% GM , downside can be negative
- Farmers look for crop options to mitigate commodity swings

5-8% Gross Margin
- Relatively stable GM, Volume Dependant
- Established Significant infrastructure & working capital investment
- Multiple locations and service
- Commodity business, low technology

11% Gross Margin
- GM variable, can go negative
- Meal value key component in crush equation
- Significant Capex investment
- Large established capital infrastructure
- Low differentiation

Feedlots: 5-20% Gross Margin
- Commodity feedlots low GM%
- Speciality (e.g., Dairy) can drive to higher GM%
- Differentiation is key: Sustainable, non-GMO

AGRIsoma

SPARC

Biofuels ISOCONVERSION Process (BIC)

Converts fats, oils, and greases from plants, animals, or algae into “drop-in” renewable fuels

ARA

Catalytic Hydrothermolysis (CH)

- Supercritical water
- Produces crude oil containing the same hydrocarbon types as petroleum crude

2 Minutes
Converts fats oils and greases to crude oil

CLG
Chevron Lummus Global

Hydrotreating

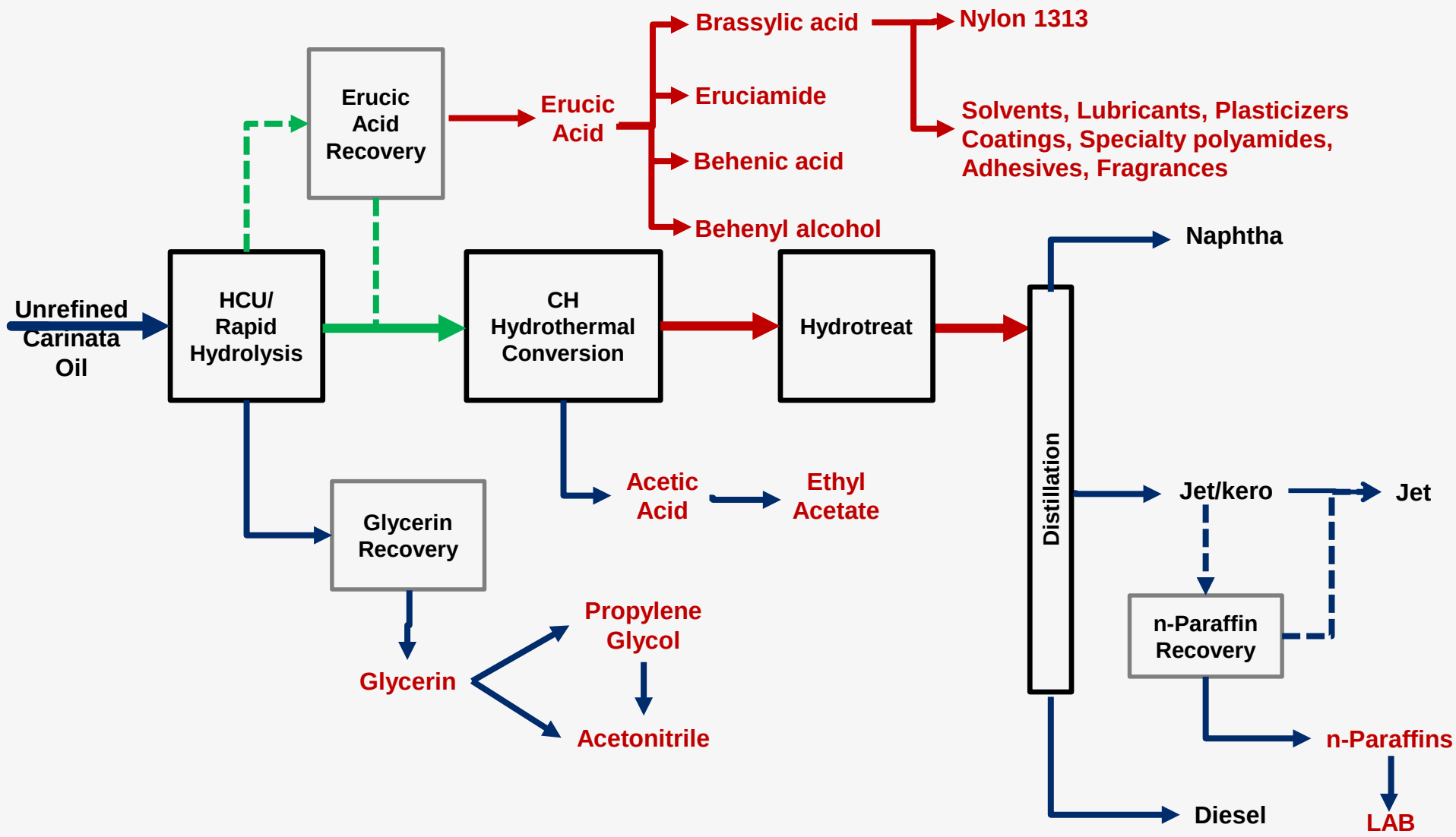
- Saturates olefins
- Removes residual oxygenates

Conventional
Refinery Processes

Fractionation

- Produces finished fuels
- Jet and diesel that meet
- Meets petroleum specs without blending
- Renewable chemicals, and naphtha

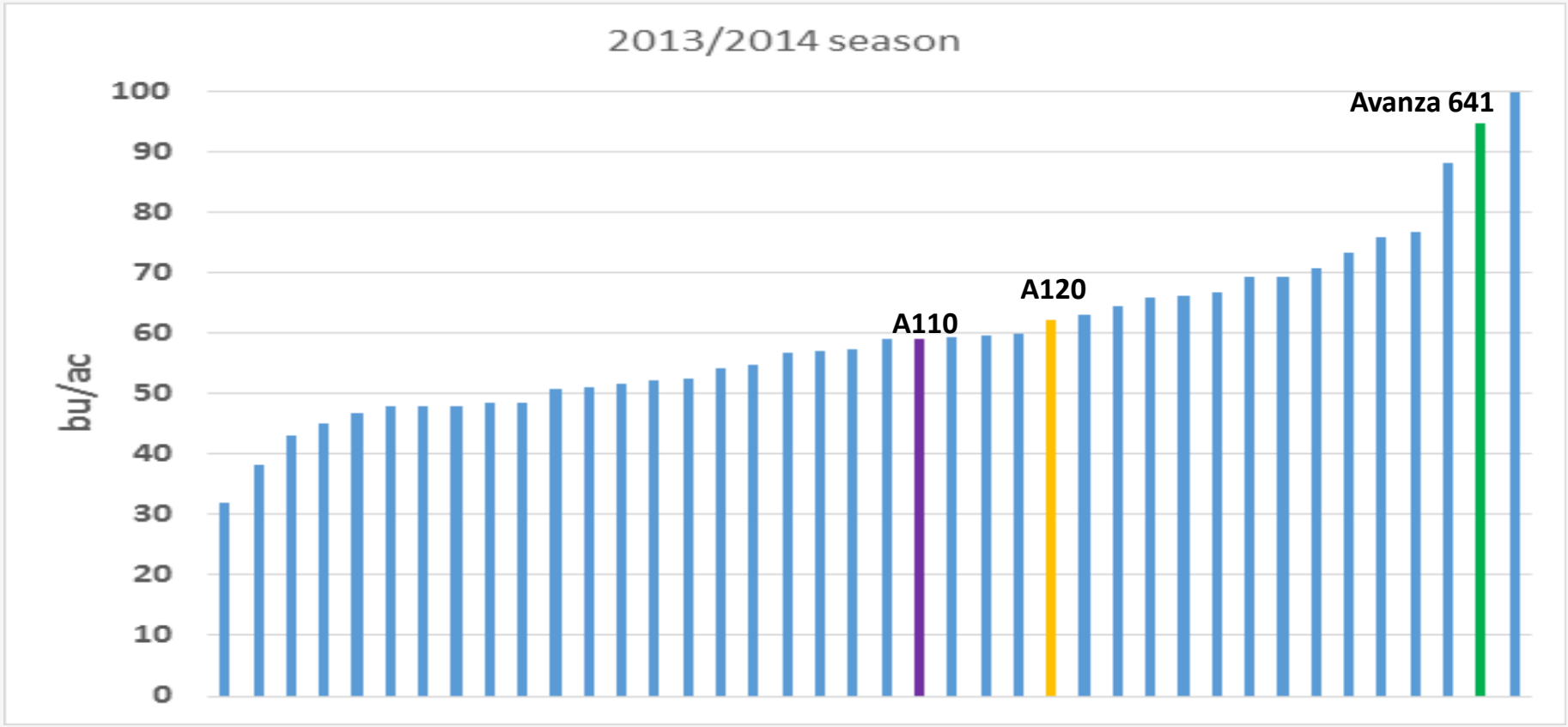
ARA's Oil Conversion and Co-products



Ongoing Activities….

Advancing carinata genetics

Value of variety or genotype testing –each evaluated for maturity, cold tolerance, yield and oil content and quality

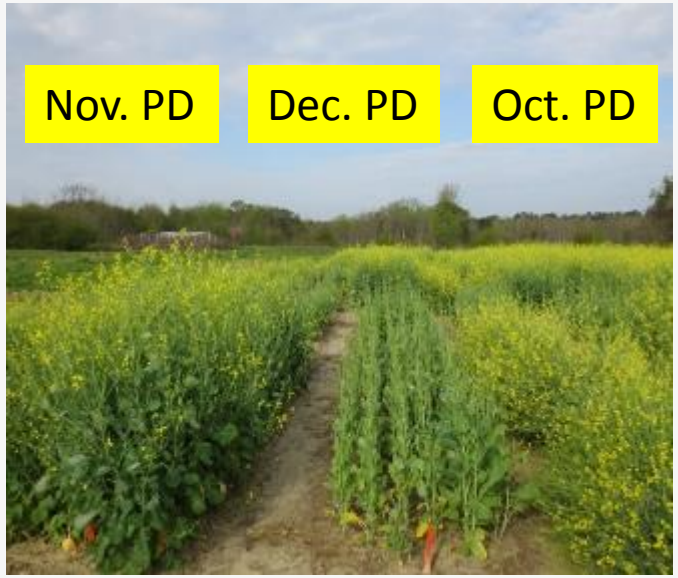


AGRIsoma

SPARC

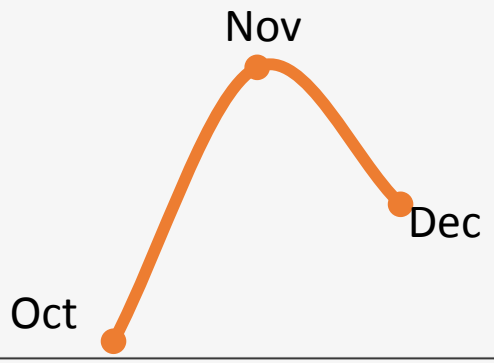
Carinata Best Management Practices

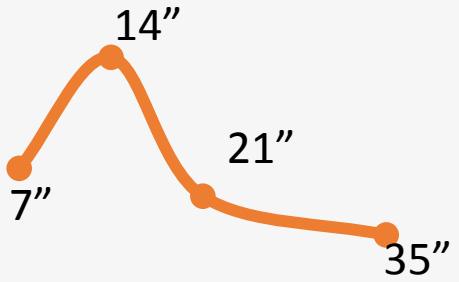
Planting date

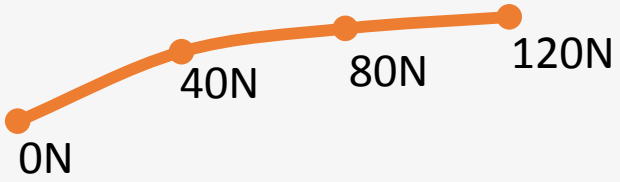


Row spacing

Nitrogen nutrition



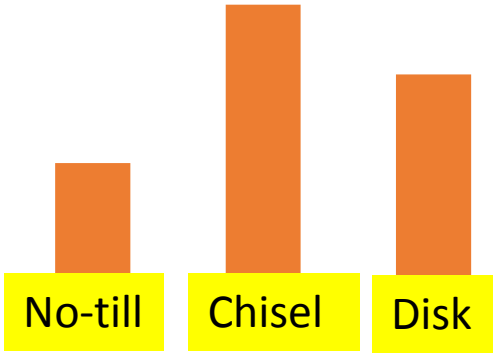




SPARC

Carinata Best Management Practices

Tillage



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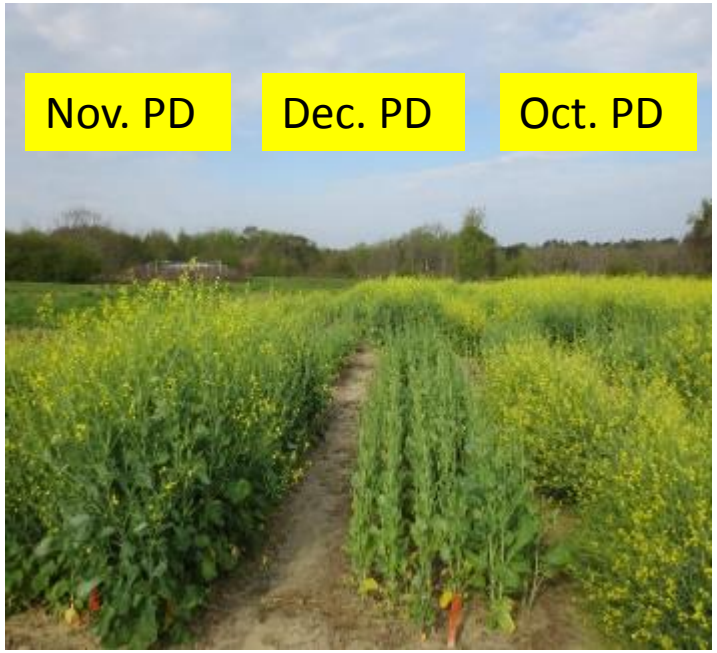
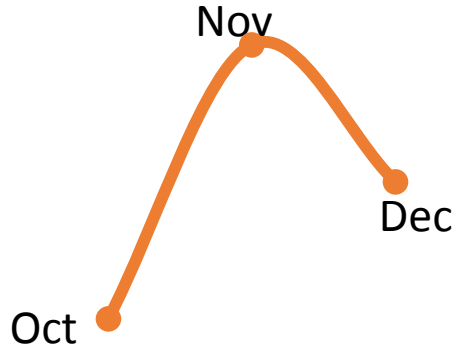




Extension Efforts

Regional Production Meetings

Research & Production Summits

Plot Tours

Farm Field Days/Tours

SPARC

Research translated to initiation of commercialization

Partnering with John Deere on combine setup

First shipment of carinata loaded at Cargill's port facility in Tampa from SE production

SPARC

Carinata Feedstock Readiness Level
(FSRL, Scale 1 – 9)*

Categories	Current Status	Through SPARC
Production	3.2	8
Linkage to Conversion	6.2	9
Market	4.2	8
Policy	1.5	4.2

* From concept (1) to full commercialization (9)

SPARC

SPARC Vision for Commercial Deployment

Demonstrate capacity

- Refine feedstock production and expansion for maximum productivity
- Develop risk mitigation and optimization tools to support scaling
- Establish communities of practice and stakeholder consortia spurring sustained interest and investment

Increase Demand

- Provide renewable fuel and co-product samples to multiple endusers
- Demonstrate value of meal based co-products
- Demonstrate value along entire supply chain

Ramp up capacity

- Policy informed by scientific process and stakeholder engagement
- Scale SE US carinata production
- Drive infrastructure establishment to support carinata enterprise

Build resilient supply chain

- Develop comprehensive support system- from producer to end user
- Ensure economic value and low risk across supply chain through robust supply chain modeling
- Build workforce to sustain carinata supply chain

SPARC

SPARC-Challenges

- Maximizing yields within the SE US- commercialization and sustainability closely linked to yields
- Scaling up adoption-several barriers exist (rotational fit, markets, production know-how etc.)
- Limited regional infrastructure- adoption will justify infrastructure development (excellent commercial involvement)
- Policy around carinata incentives still to evolve-very early stages

SPARC Thank you!

CAAFI Webinar, October 13, 2017

SBAR

Sustainable Bioeconomy for Arid Regions

Kimberly Ogden
University of Arizona

CAAFI Presentation
10/13/17

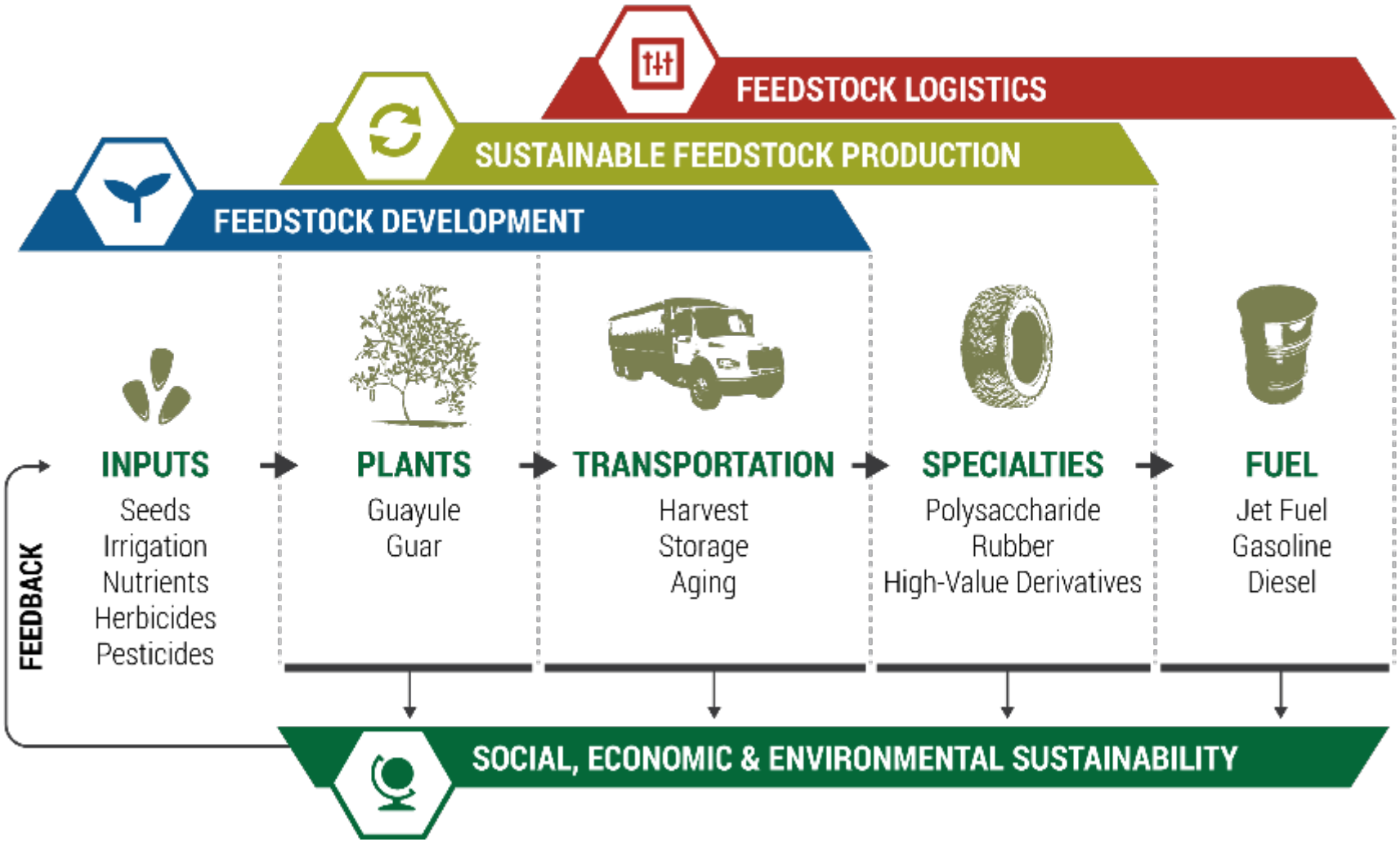
Funded by the AFRI CAP Program

United States Department of Agriculture

National Institute of Food and Agriculture

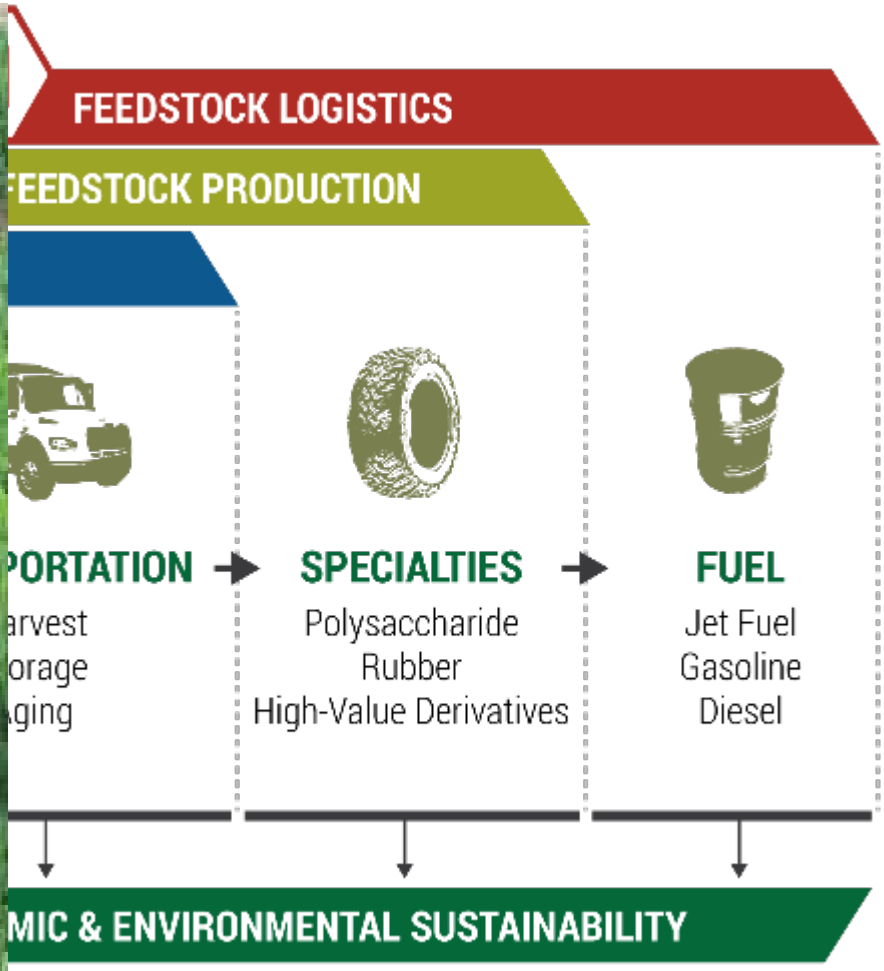
SBAR

Sustainable Bioeconomy for Arid Regions



SBAR

Sustainable Bioeconomy for Arid Regions

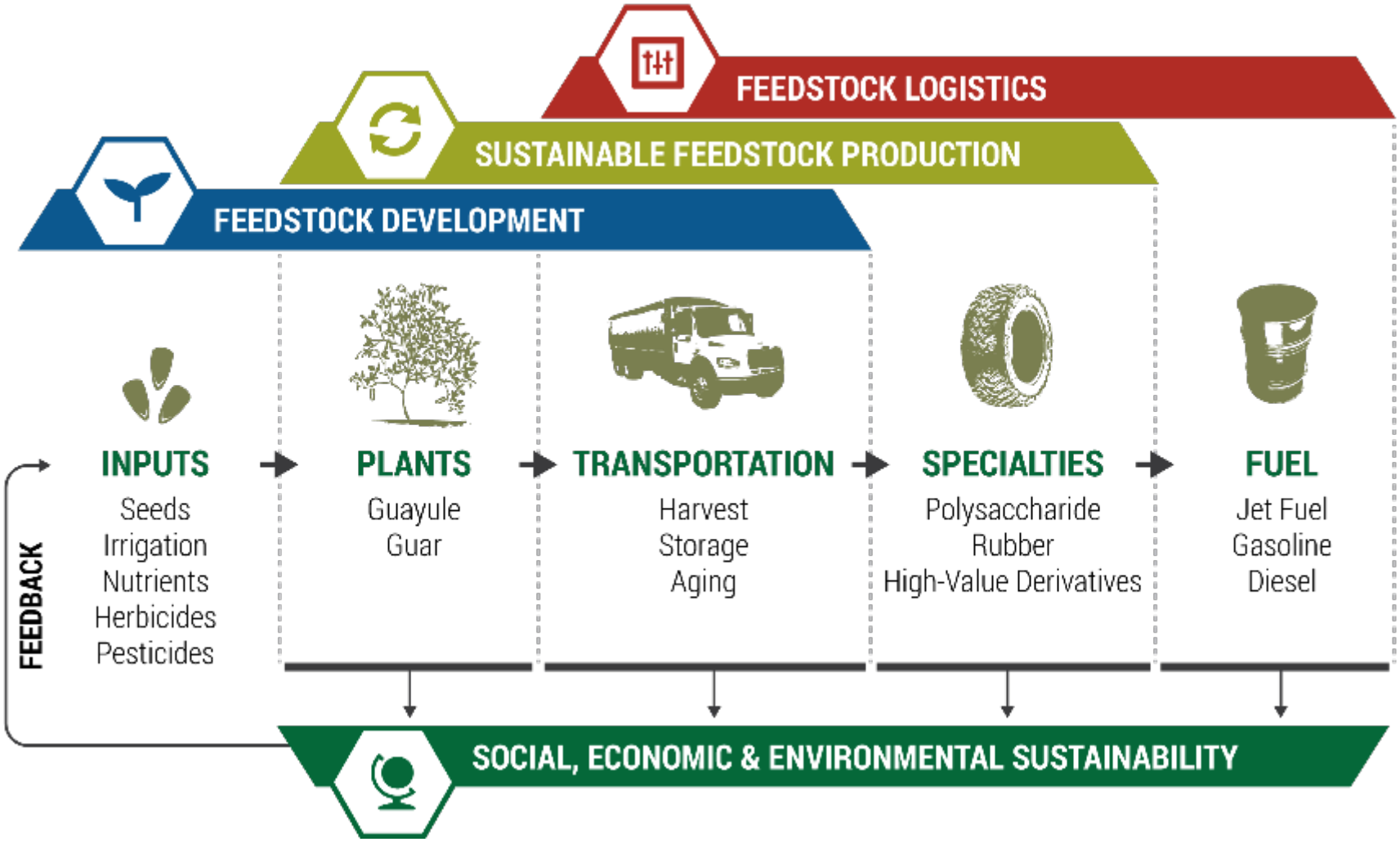


SBAR

Sustainable Bioeconomy for Arid Regions

SBAR

Sustainable Bioeconomy for Arid Regions



Impacts

Center of Excellence

- Add value to the bioeconomy for rural, arid regions through production of rubber, fuel, guar gum, and high value products
- Long term sustainability of water usage in Southwest through cultivation of drought resistant crops
- Increase student diversity in STEM fields

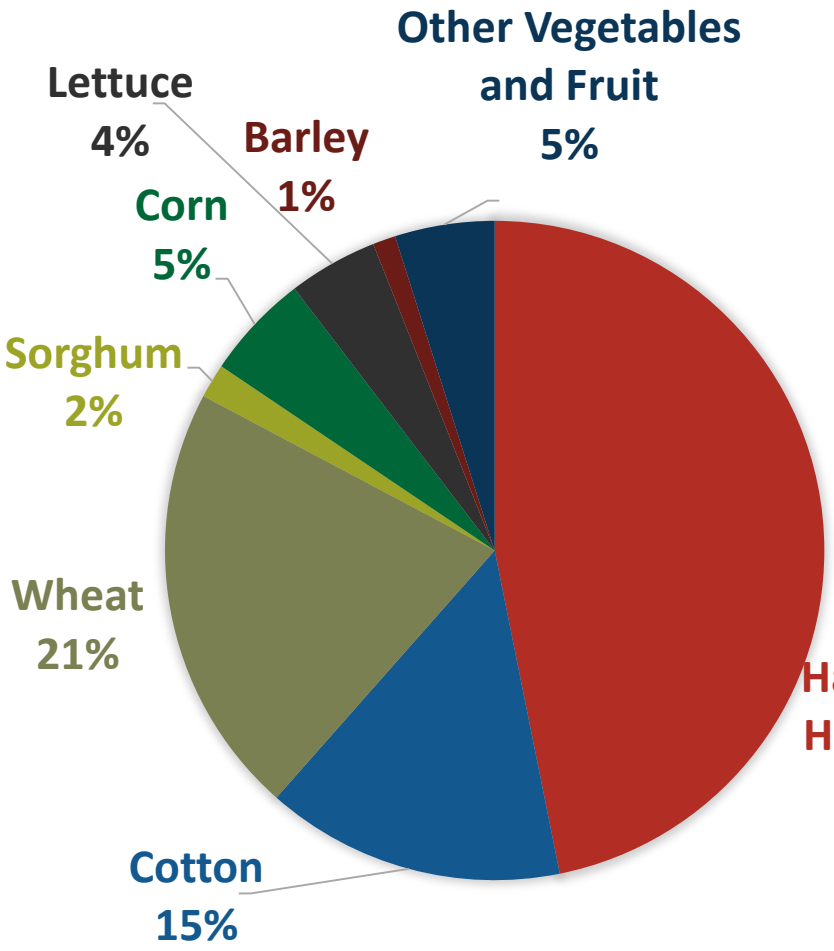
SBAR Presentation Outline

- Background to SW and the feedstocks
- Feedstock Development
- Sustainable Feedstock Production
- Feedstock Logistics
- Extension, Education and Outreach

Agriculture in the Southwest

Sustainability

HARVESTED ACRES IN ARIZONA 2015 (USDA/NASS)



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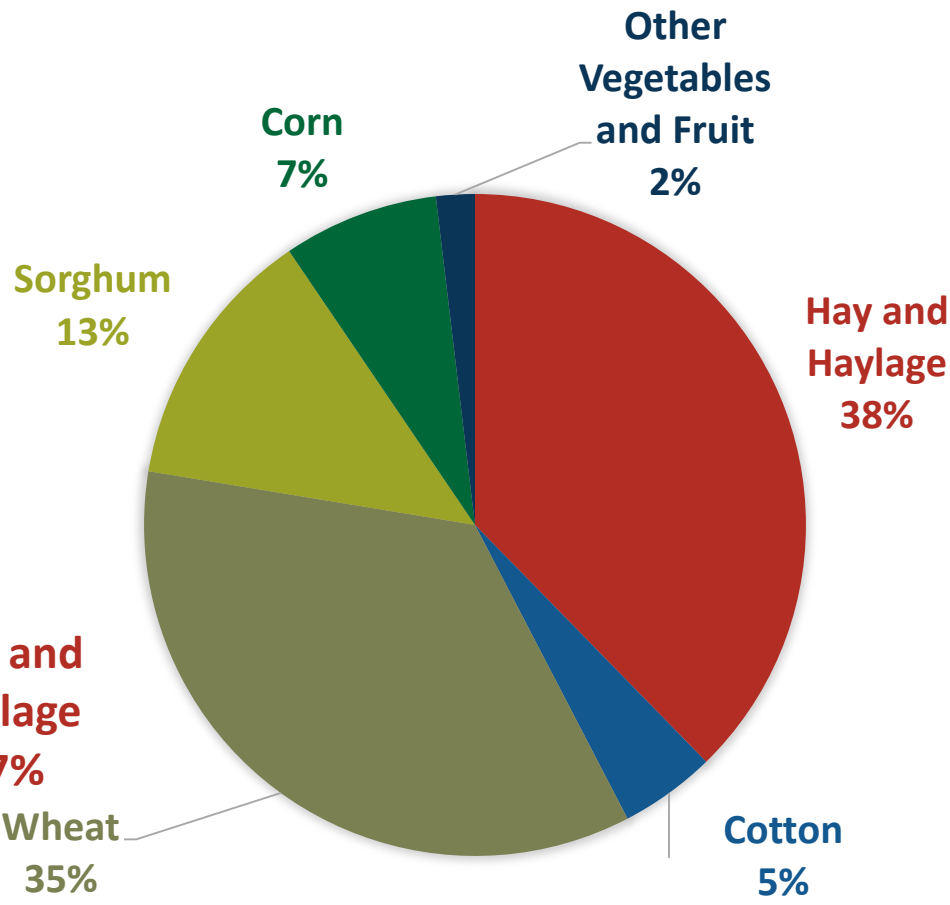

Agriculture in the Southwest

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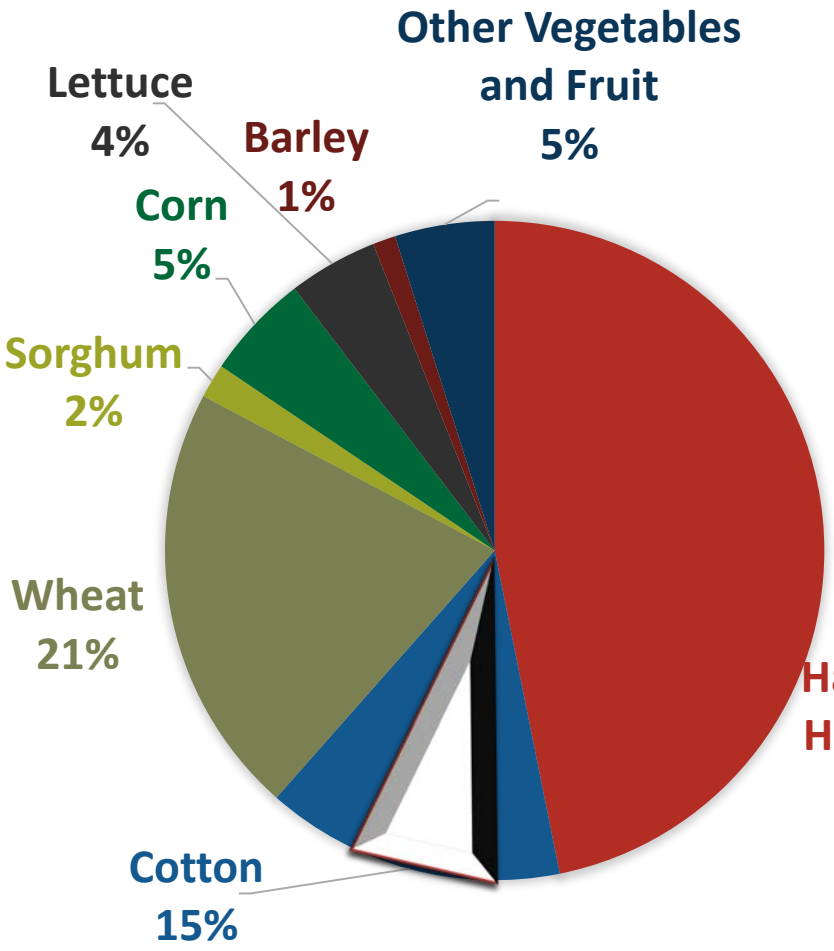

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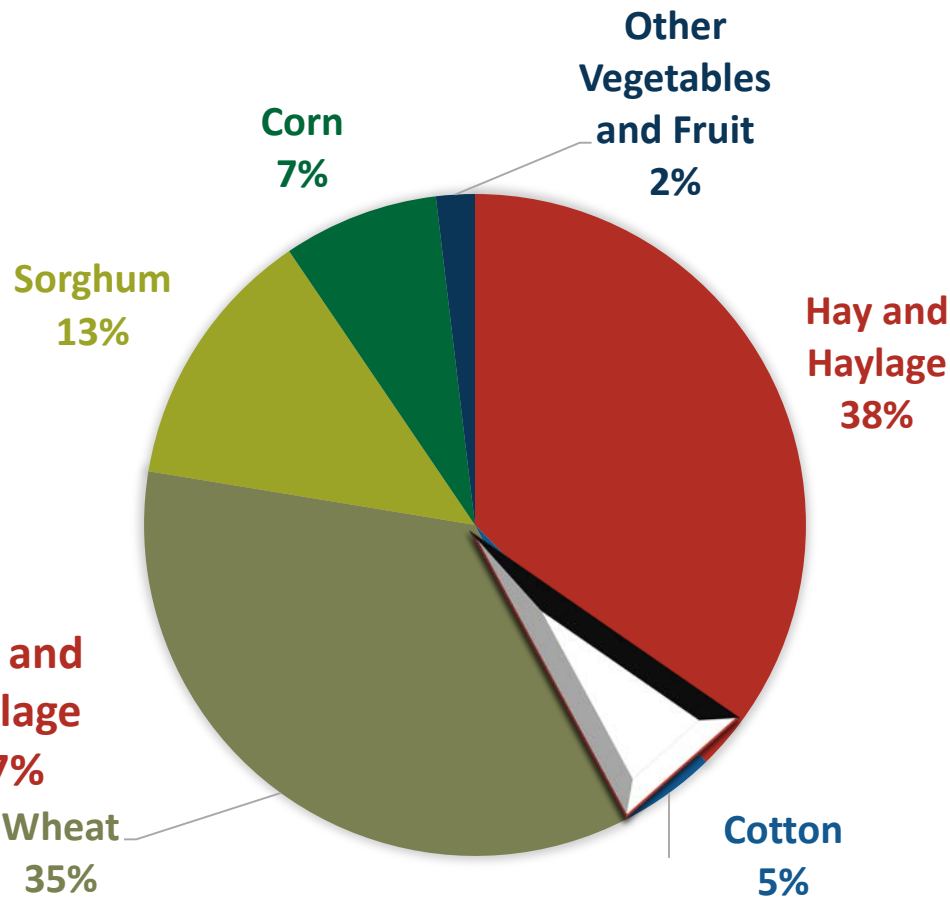

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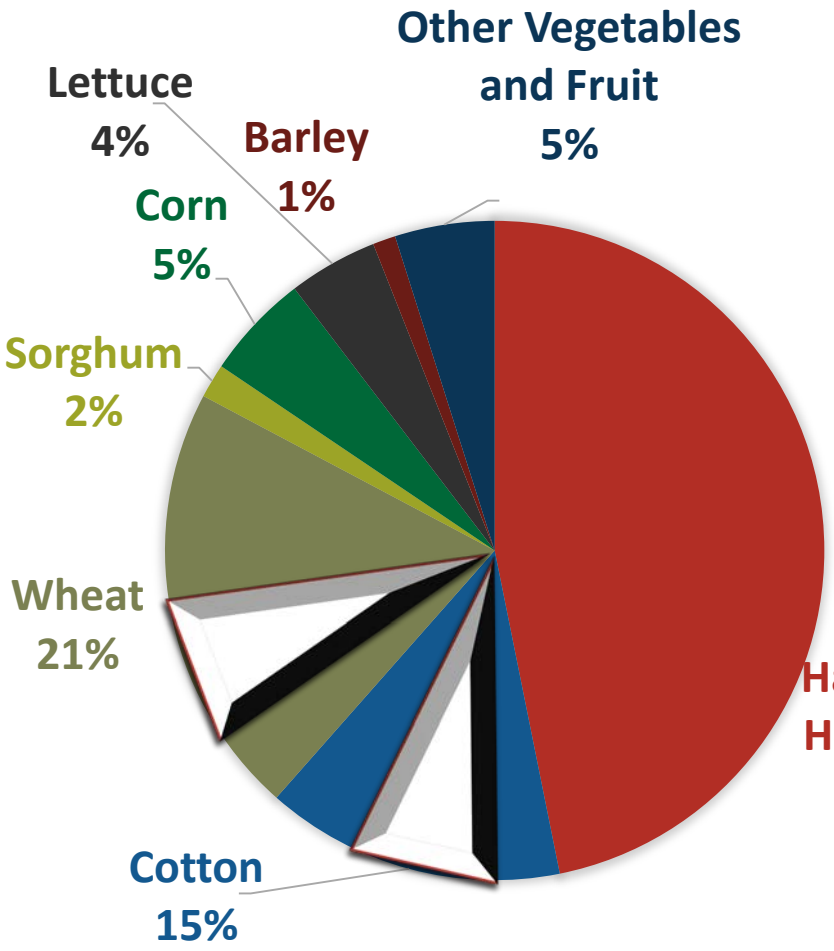

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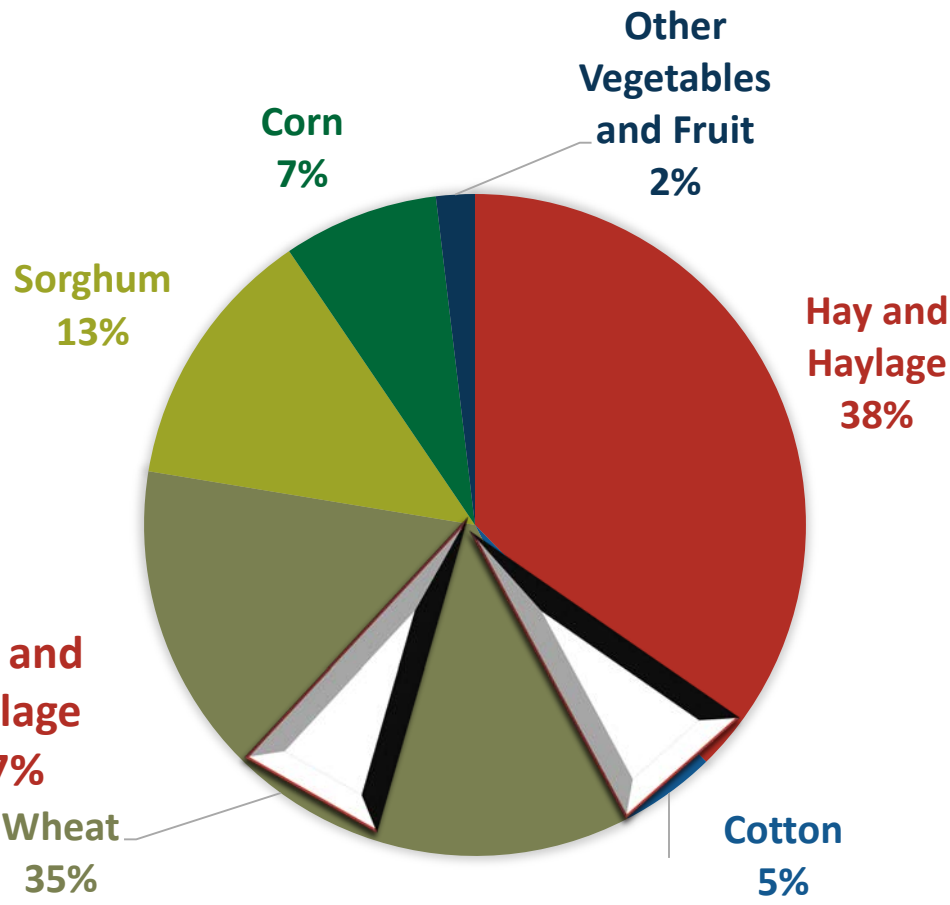

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Sustainability

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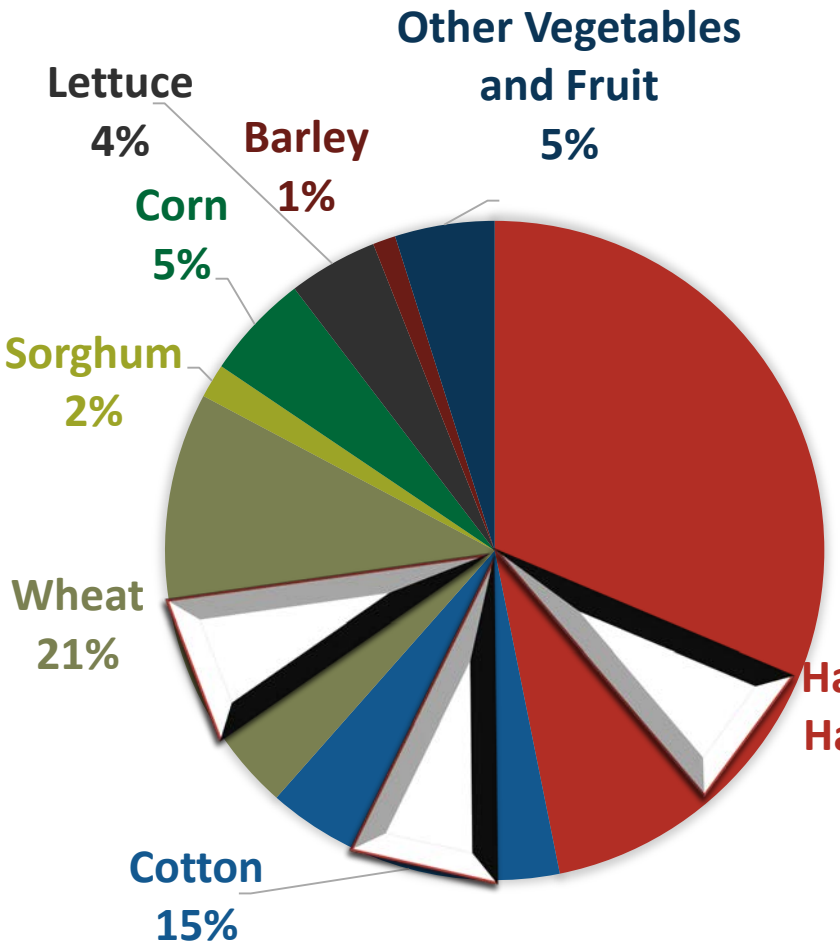

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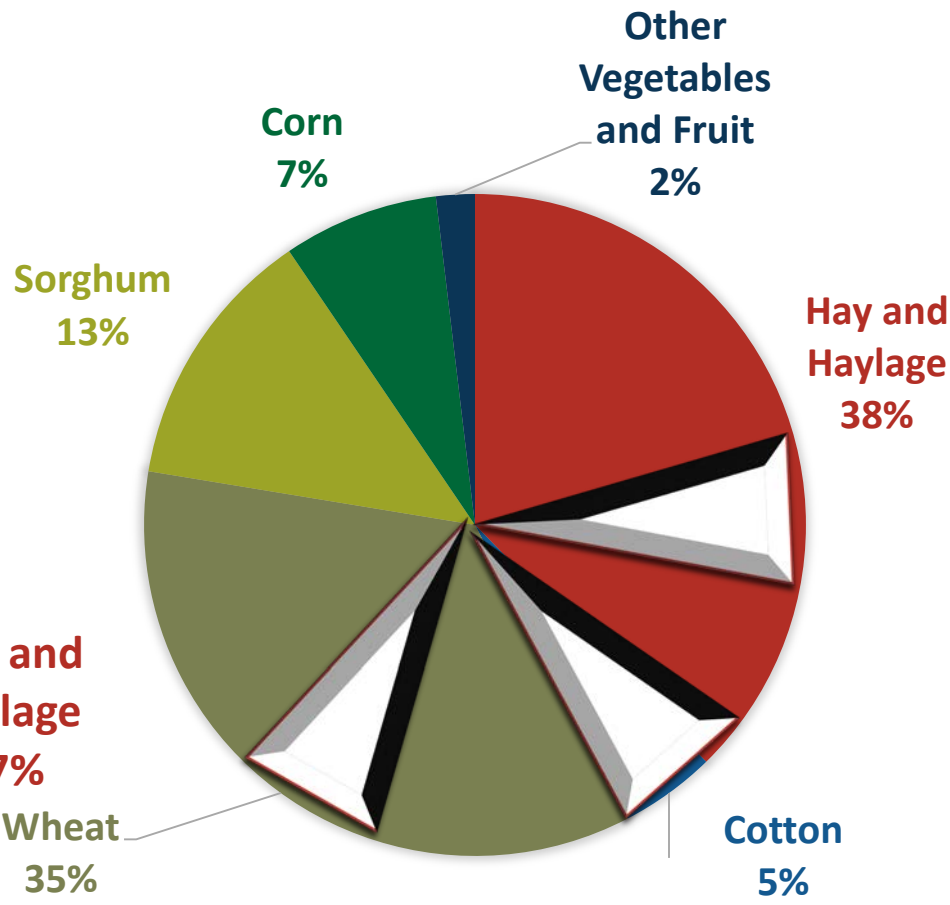
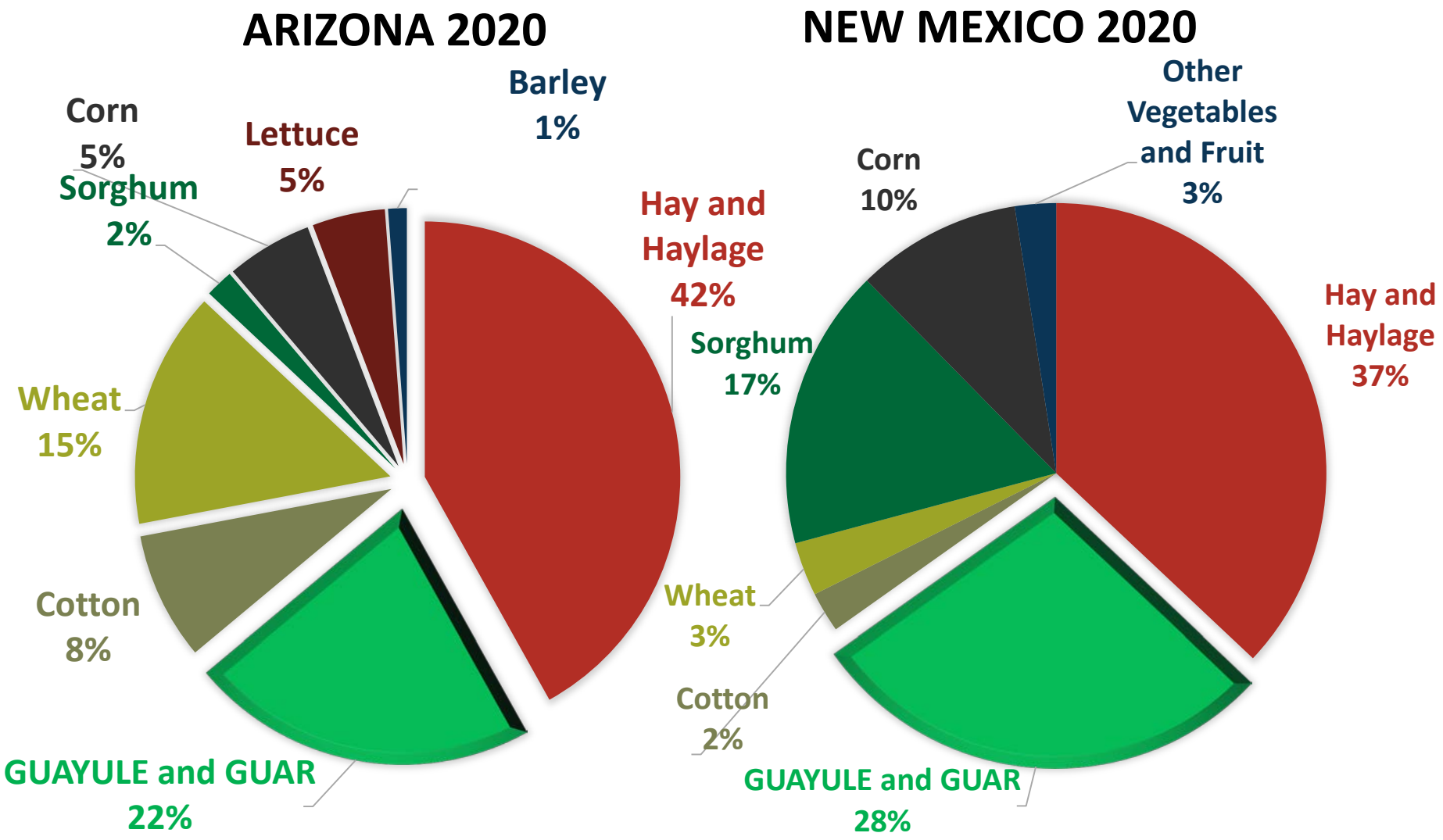


Sustainability

Agriculture in the Southwest



Sustainability

Suitable Land

	Guayule	Guar
Estimated Available, Suitable Land in Region (ha)	110,000 ha (5 years in AZ)	240,000

3 million ha in SW US (Long term)

Guayule

Sustainability

Bio-fractionation

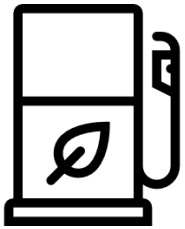
Natural Rubber
440,000 MT/yr

Bagasse
3.65 Million MT/yr

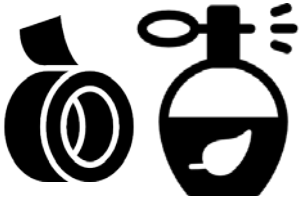
Resin
285,000 MT/yr

Products

$3.10 kg^{-1}



$3 gal^{-1}



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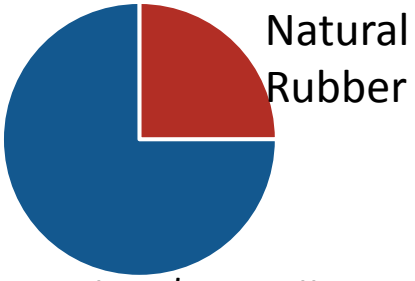
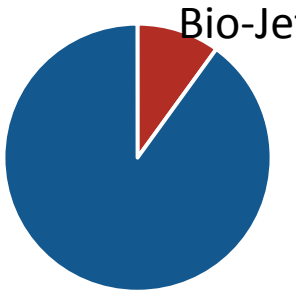
Market Size



Total Market $5.6 Billion



Total Market $88 Billion

Adhesives (10 billion),
Tackifiers (billions),
Fragrances (billions),
Pharmaceutical (100s billion)

Feedstock Readiness Level Guayule

Sustainability

Feedstock: Guayule Region: AZ/SW US

FSRL Scoring Summary	Production	Market	Policy	Rubber Conversion	Linkage to Conversion
Current Status	6.2	5.3	4.2	4.3	4.3
Anticipated Status	7	6.2	5.4	7	6

BRIDGESTONE

Guar

Sustainability

Bio-fractionation

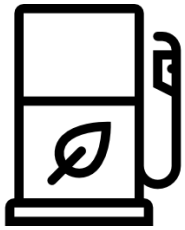
Seeds
340,000 MT/yr

Bagasse
1 Million MT/yr

Products

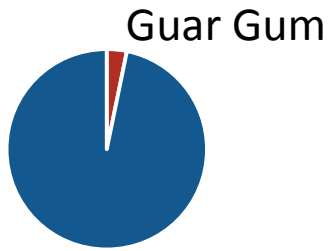
$3.30 to $26 kg^{-1}

$0.10 kg^{-1}

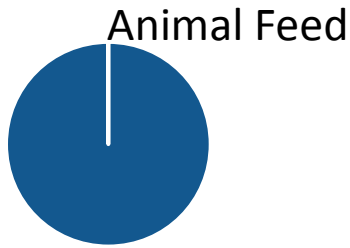


$3 gal^{-1}

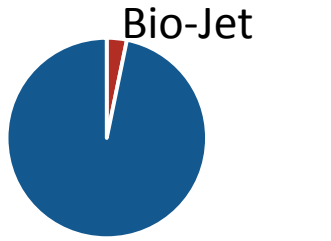
Market Size



95,000 MT/yr



245,000 MT/yr



Total Market $88 Billion

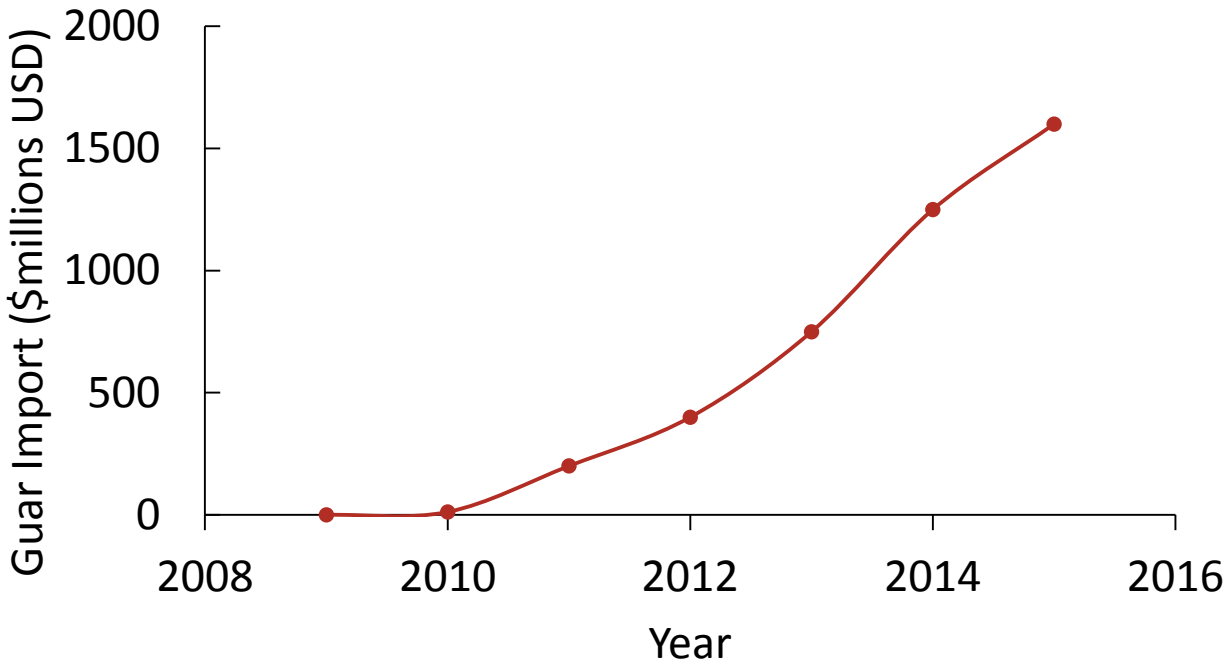
Feedstock Readiness Level - Guar

Sustainability

Feedstock: Guar

Region: AZ/SW US

FSRL Scoring Summary	Production	Market	Policy	Guar Gum Conversion	Linkage to Conversion
Current Status	2.3	2.2	4.2	5.1	1
Anticipated Status	4.1	4.1	5.4	7	4.1



Overview

Feedstock Development

Objectives
1.1 Shrub biomass Improvement
1.2 High-throughput phenotyping
1.3 Superior genotypes of guayule and guar for regional growers

Outcomes

Feedstock Development

Expected Outcomes
Improved shrub biomass.
Better understanding of the reproduction for guayule accessions.
Deployment of guayule and guar genotypes to growers.
Optimum planting dates for guar.
Selection tools developed.
Better understanding flowering control in guayule.

Overview

Sustainable Feedstock Production

Objectives
2.1 Agronomics: nutrients, salinity, herbicides, irrigation
2.2 Soil quality and health – sustainability
2.3 Identify Economic co-products

Drip Irrigated Guayule

Outcomes

Sustainable Feedstock Production

Expected Outcomes
Web app: irrigation, fertilizer, salinity, and pest management
Herbicide SLN registrations for DS guayule
Understanding of microbial community populations that support optimal production
Guayule & Guar Best Management Practices
Yield increases in guayule and guar
Identify natural products – commercialization

Drip tape installation

Overview

Feedstock Logistics

Objectives
3.1 Understand timing effects on quality
3.2 Optimize shipping and handling
3.3 Demonstrate bagasse to fuel

Guayule bales ready for transport for processing

Transportation Plan

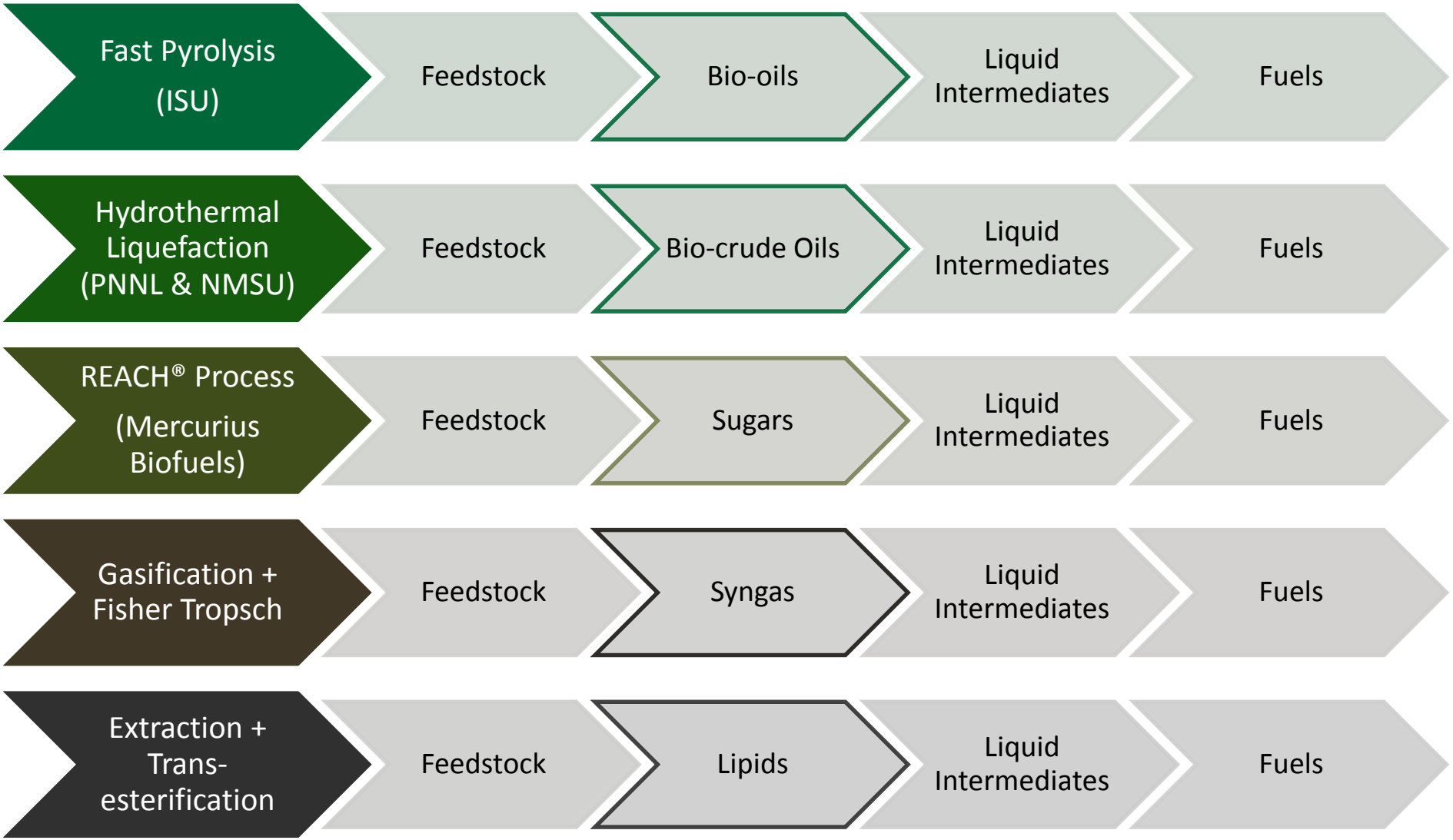
Feedstock Logistics

- Model shipping and handling system
  - Mixed integer optimization
  - Decomposition-based algorithms
- Compare to existing models
  - Volpe's Biofuel Transportation Analysis Tool
  - ORNL's feedstock data and visualization tools
- Optimize harvest, collection levels, storage, and transportation routes

Guayule Harvest

Bagasse to Fuel Routes

Feedstock Logistics



Technology Readiness of Conversion Partners

Feedstock Logistics

Process	Fast Pyrolysis	Hydrothermal Liquefaction	REACH ®
Initial TRL	5	5	4
Final TRL	6	6	5

Modular Hydrothermal Liquefaction System at PNNL

Fast Pyrolysis PDU at Iowa State University

Outcomes

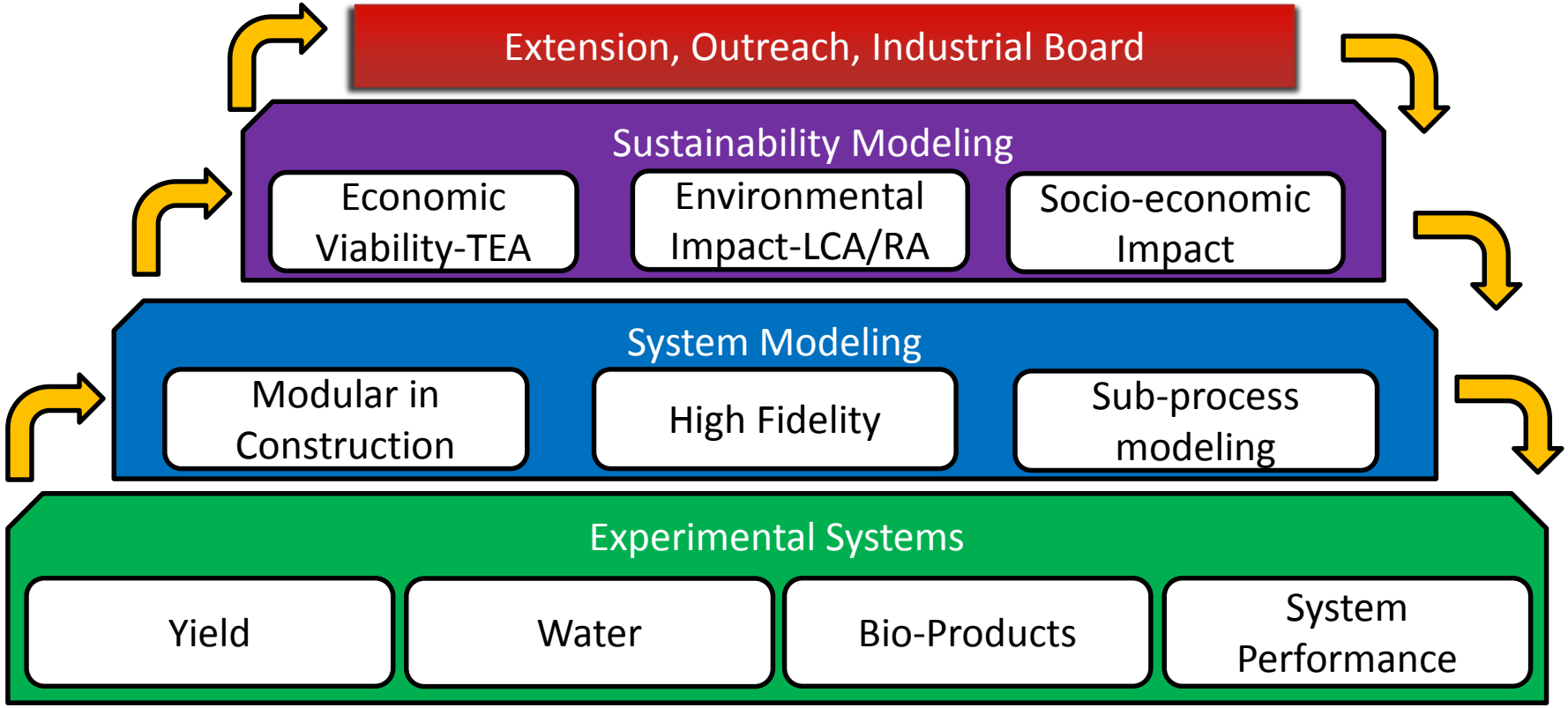
Feedstock Logistics

Expected Outcomes
Feedstock chemical profiles by time and handling
Transportation model optimized for guar and guayule
Feedstocks linked to conversion technologies
Data to sustainability model

Hydrothermal Liquefaction PDU at NMSU

Connecting Research and Extension

Sustainability

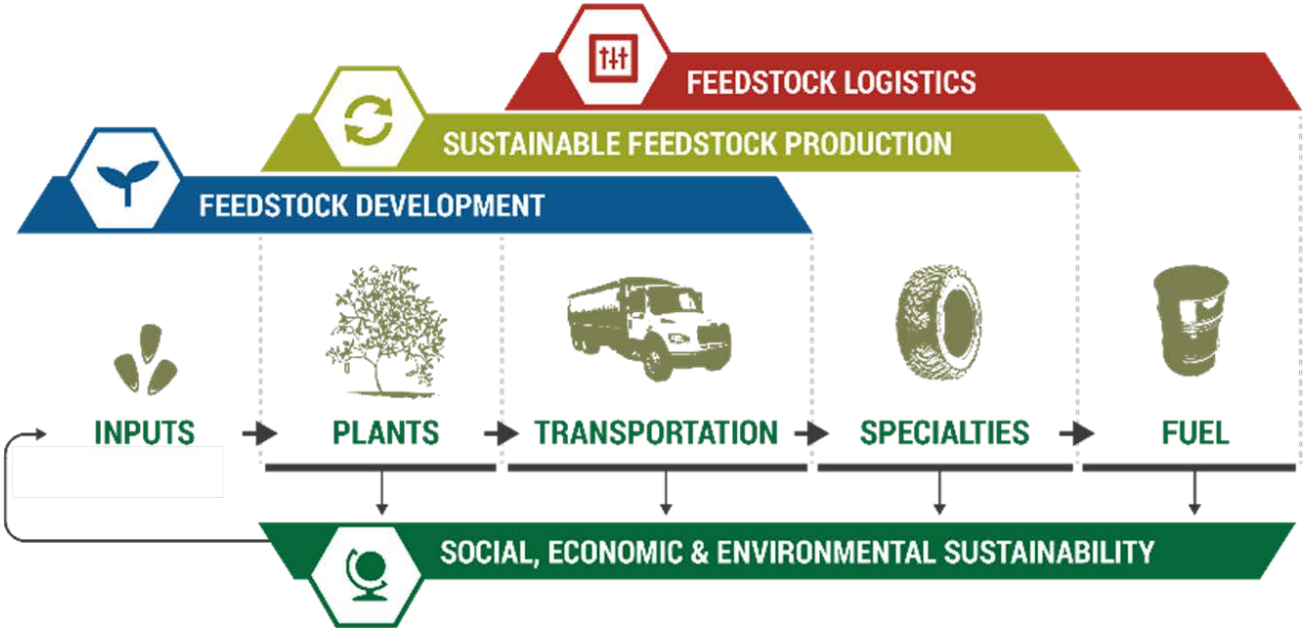


Objectives
4.1: System model for sustainability assessment
4.2: Utilize data for model validation and provide data feedback
4.3: Interface with regional growers

Outcomes

Sustainability

Expected Outcomes
Coupling of Sustainability, Experimental, Extension
Web-delivered analysis tool
Socio-economic Impact



Overview

Extension, Education and Outreach

Objectives
5.1 Produce Extension materials
5.2 Show-and-tell for growers
5.3 Train the trainers
5.4 Develop bioeconomy K-12 modules
5.5 Involve youth through 4-H and camps.

Impacts

Center of Excellence

- Add value to the bioeconomy for rural, arid regions through production of rubber, fuel, guar gum, and high value products
- Long term sustainability of water usage in Southwest through cultivation of drought resistant crops
- Increase student diversity in STEM fields