FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Alternative Jet Fuel Supply Chain Analysis

ASCENT 1

Regional Supply Chain Approaches

Supply Chain for Sustainable Aviation Fuel from Oilseeds in the Inland Northwest

Project Manager: Nathan Brown, FAA
Lead Investigators: M. Wolcott, K. Brandt, N. Martinkus
Graduate Student: Dane Camenzind, WSU

[December 4, 2018]

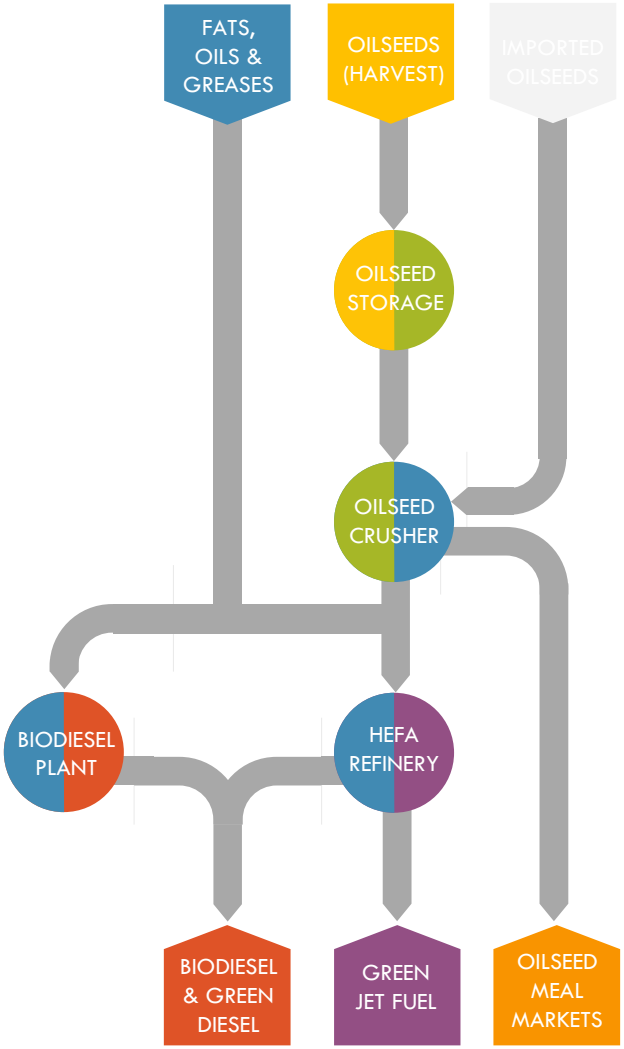
ASCENT
AVIATION SUSTAINABILITY CENTER

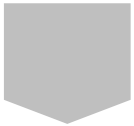
National Pioneer

Regional Market

Feasible Technology

SUPPLY CHAIN MODEL

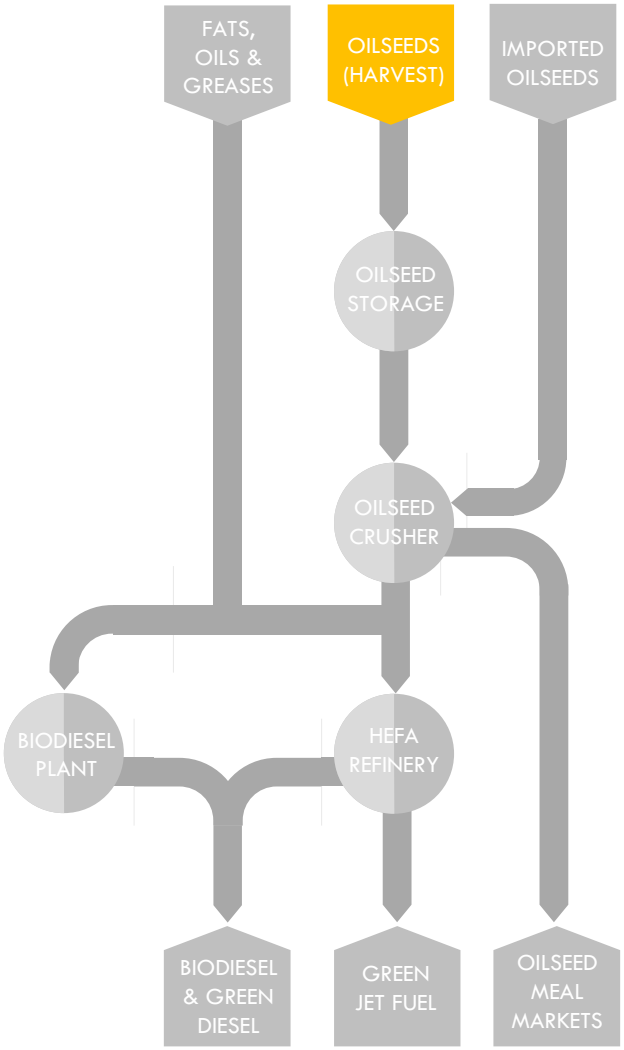




ENTRY NODES

PROCESSING & STORAGE NODES

EXIT NODES



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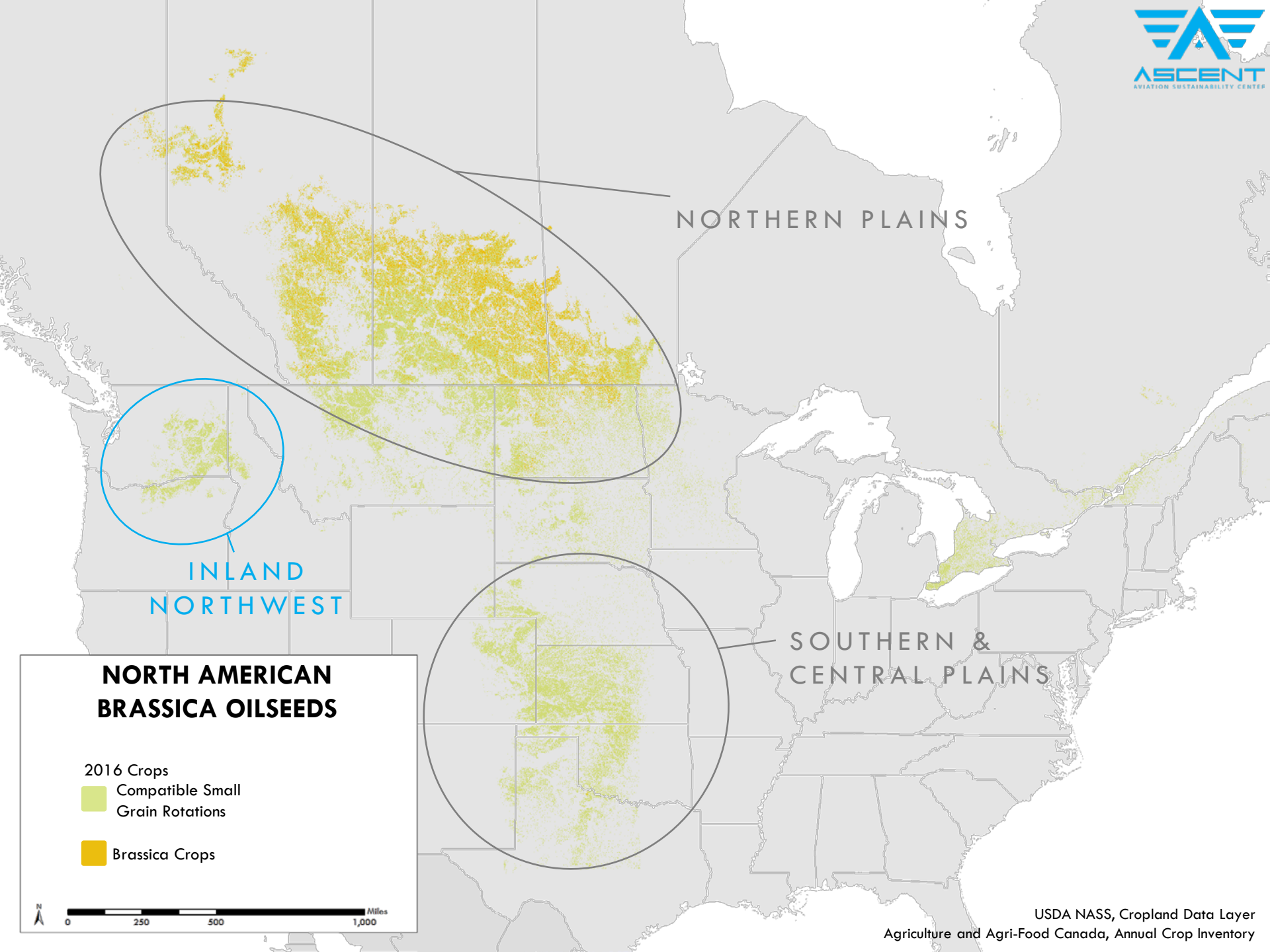
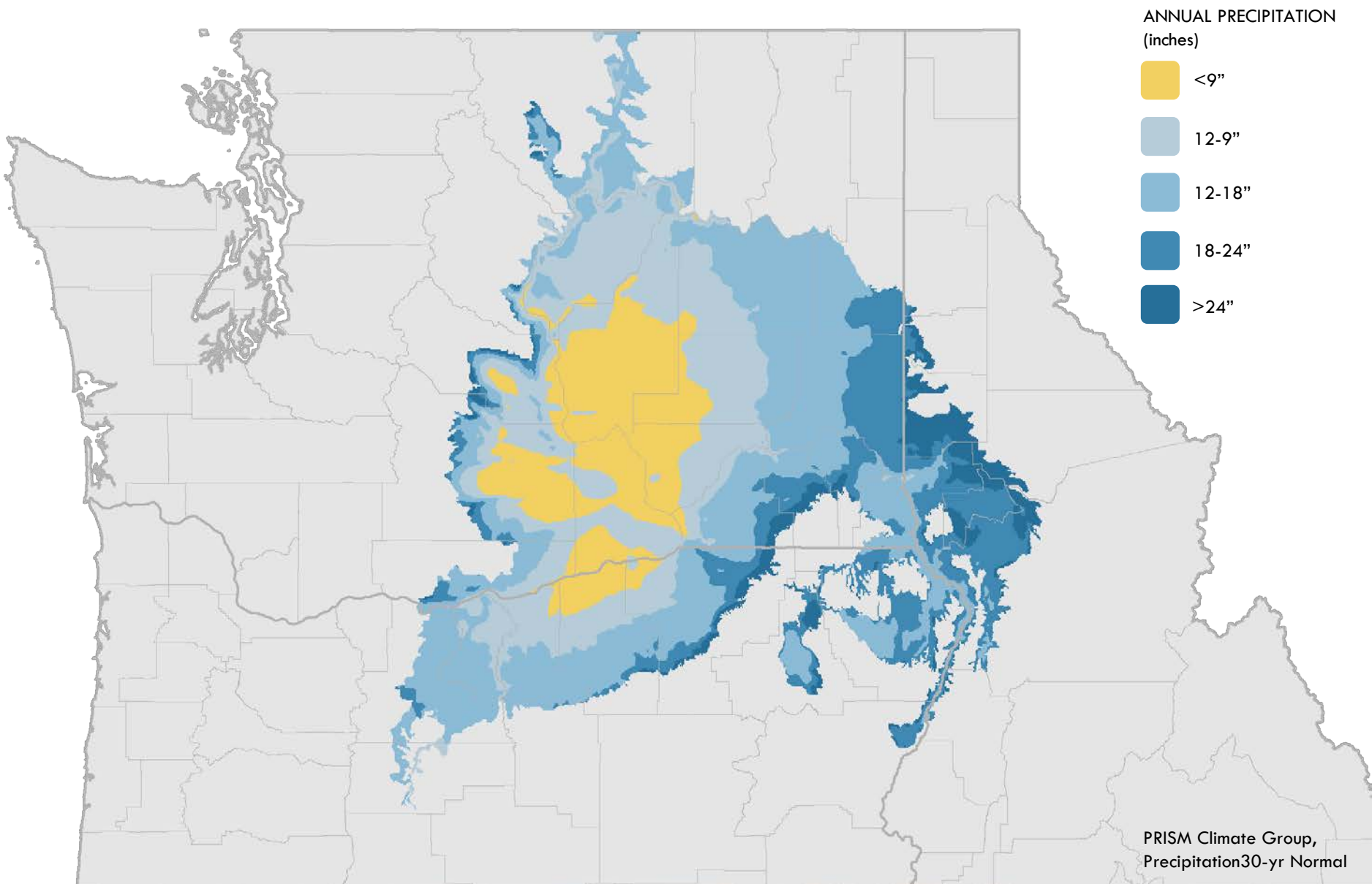

NORTHERN PLAINS
INLAND NORTHWEST
SOUTHERN & CENTRAL PLAINS
NORTH AMERICAN BRASSICA OILSEEDS
2016 Crops
Compatible Small Grain Rotations
Brassica Crops
N
0
250
500
1,000
Miles
USDA NASS, Cropland Data Layer
Agriculture and Agri-Food Canada, Annual Crop Inventory

PRECIPITATION



COMMON CROPS

SMALL GRAINS
- Winter Wheat
- Spring Wheat
- Barley

PULSES
- Peas
- Lentils
- Garbanzo Beans

BRASSICA OILSEEDS
- Canola/Rapeseed
- Mustard
- Camelina
- Carinata

AGROECOLOGICAL CLASSES

GRAIN FALLOW
- >40% fallow

Rotations:
- WW-F
- WW-F-WC-F

TRANSITION
- 10-40% fallow

Rotations:
- WW-SW-F
- WC-SW-F
- WW-SC-F

ANNUAL CROP
- <10% fallow

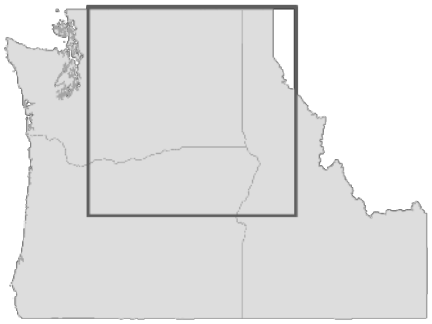
Rotations
- WW-SW-Pulse
- WW-Pulse
- WW-SW-SC
- WC-SW

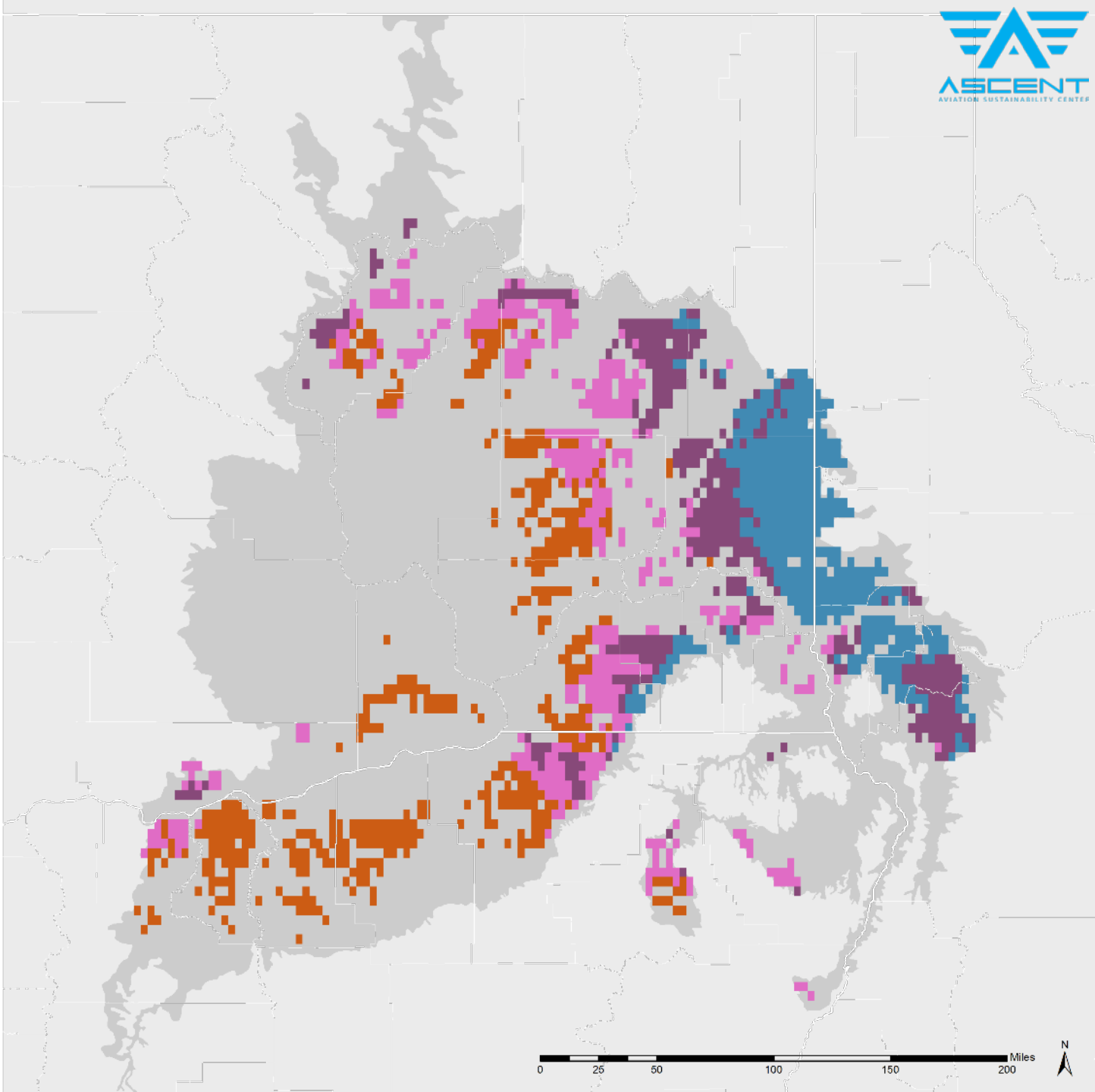
USDA NAIP Imagery

ESTIMATED SPRING CANOLA YIELDS

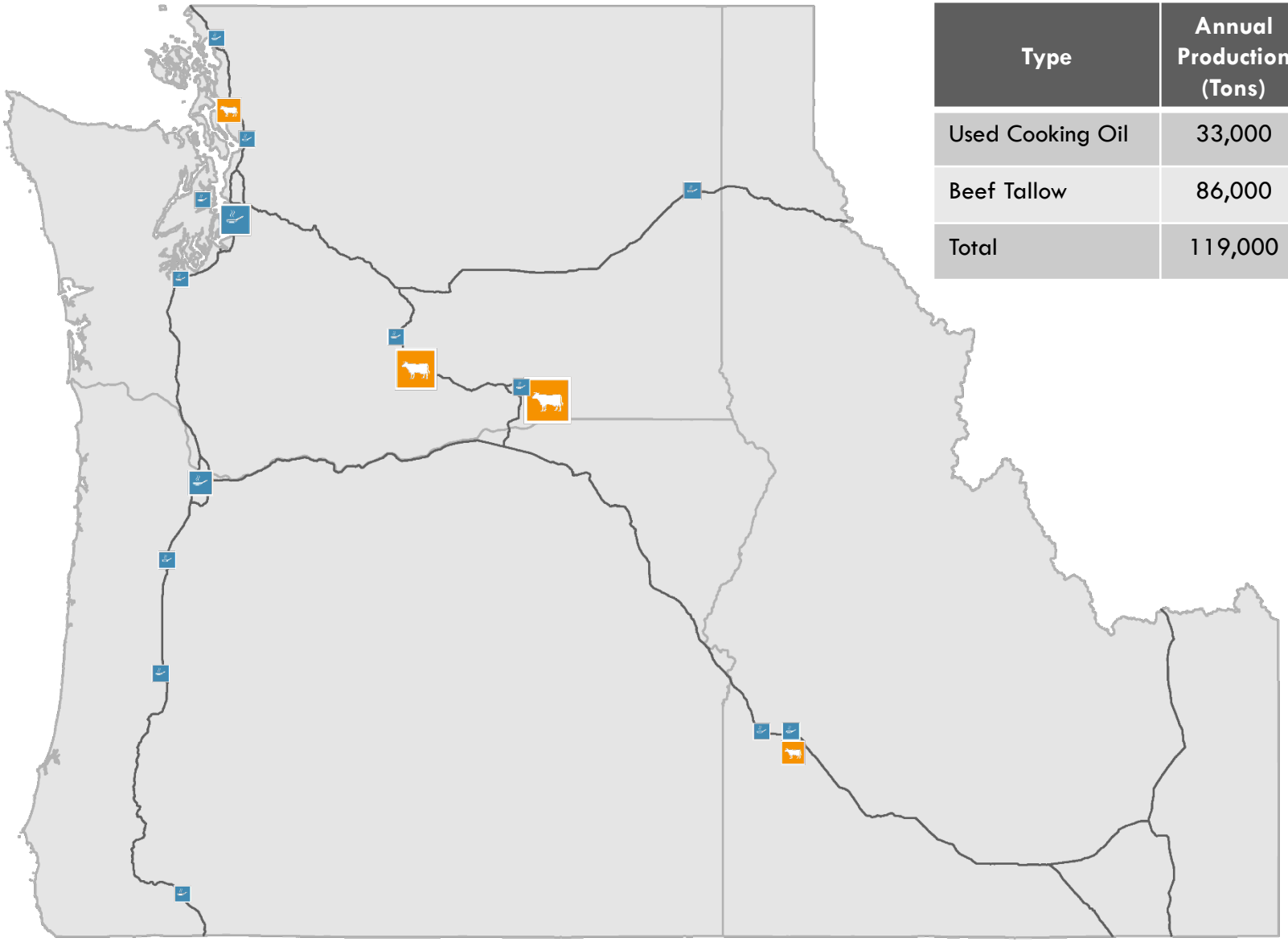
Yield (bushels/acre)

- <20
- 20 - 40
- 40 - 60
- > 60





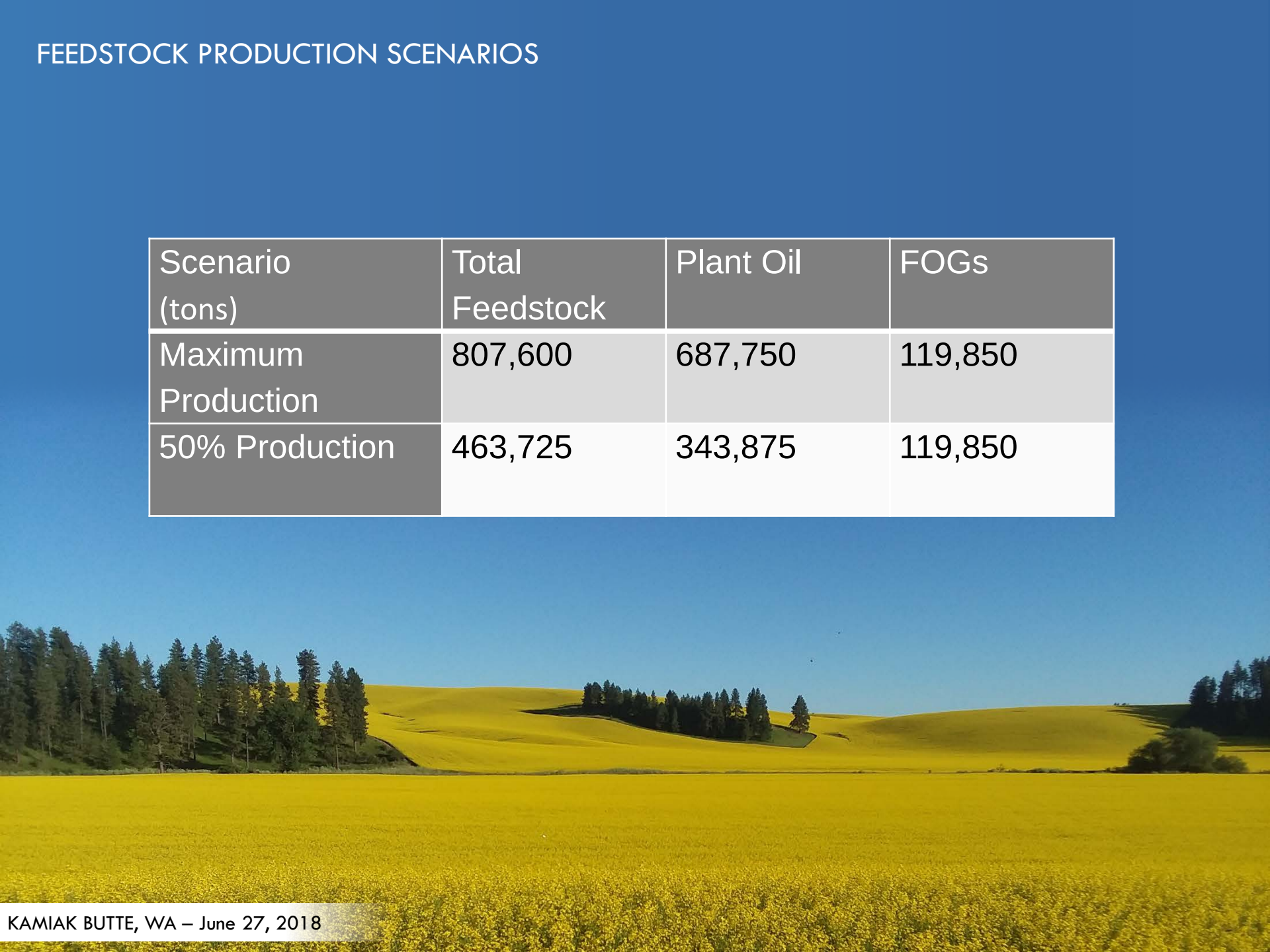
FATS, OILS, & GREASES



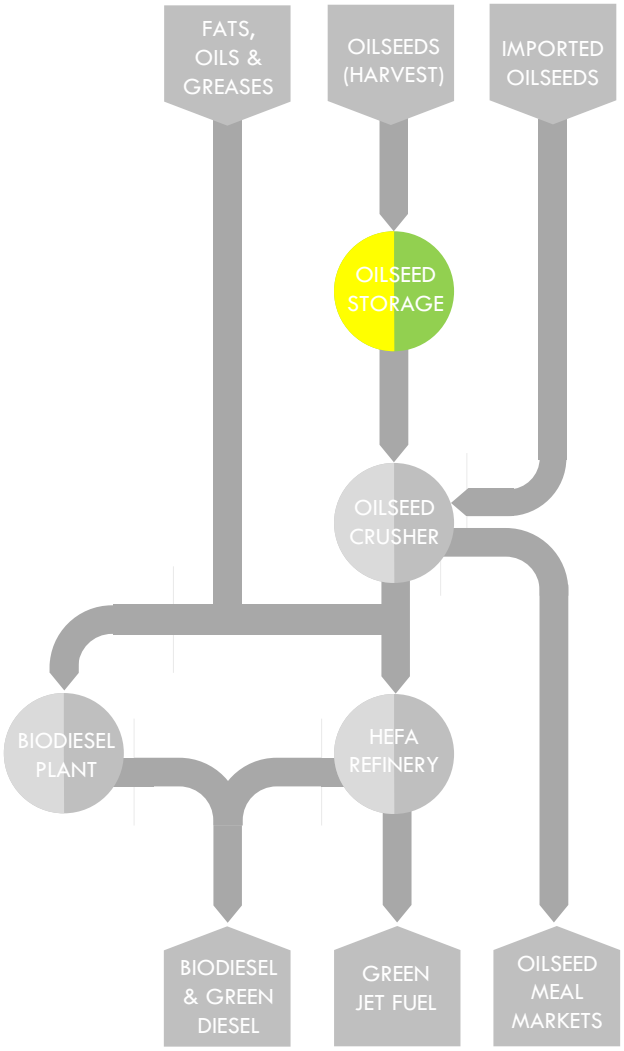
Type	Annual Production (Tons)
Used Cooking Oil	33,000
Beef Tallow	86,000
Total	119,000

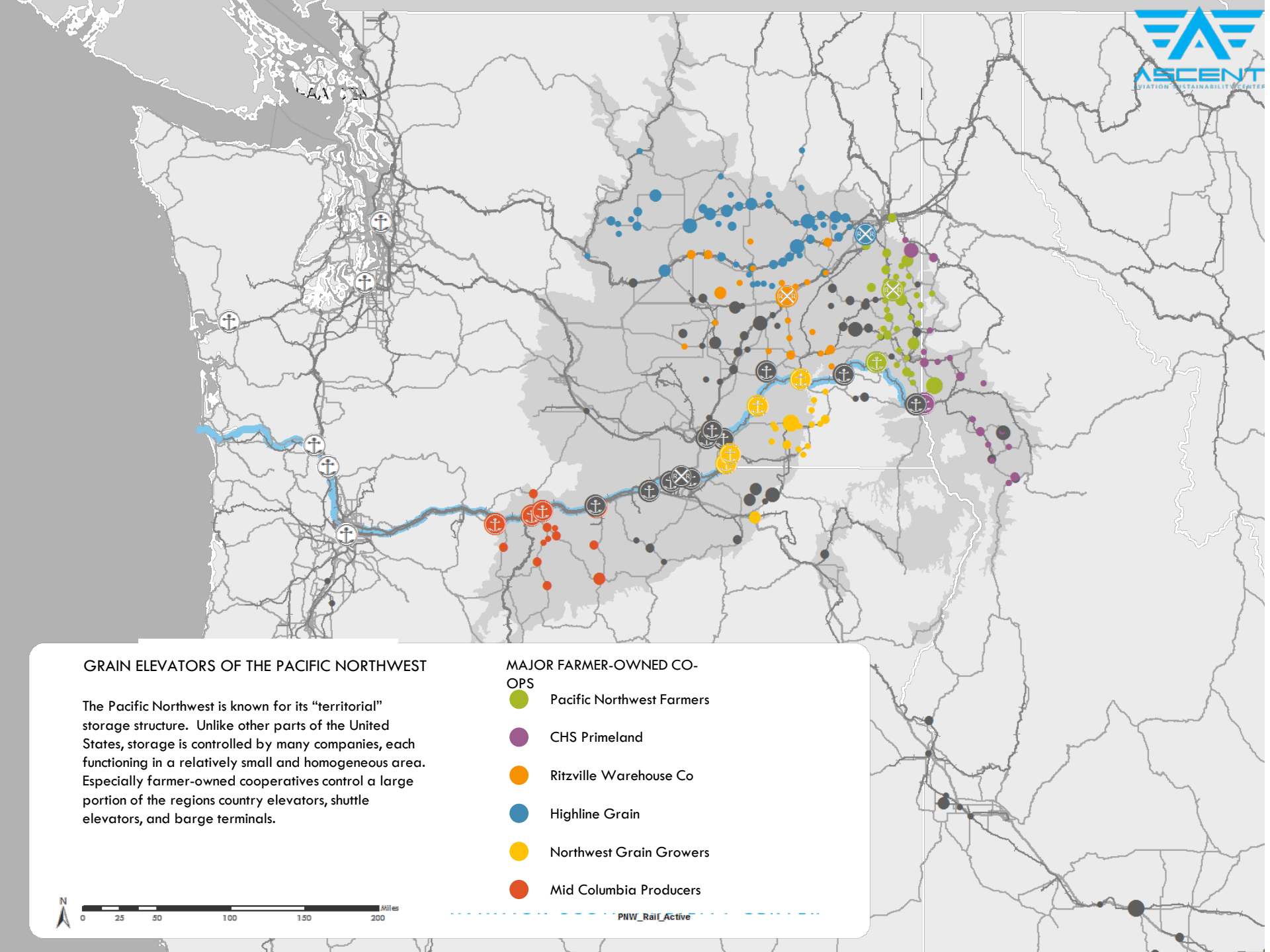
FEEDSTOCK PRODUCTION SCENARIOS

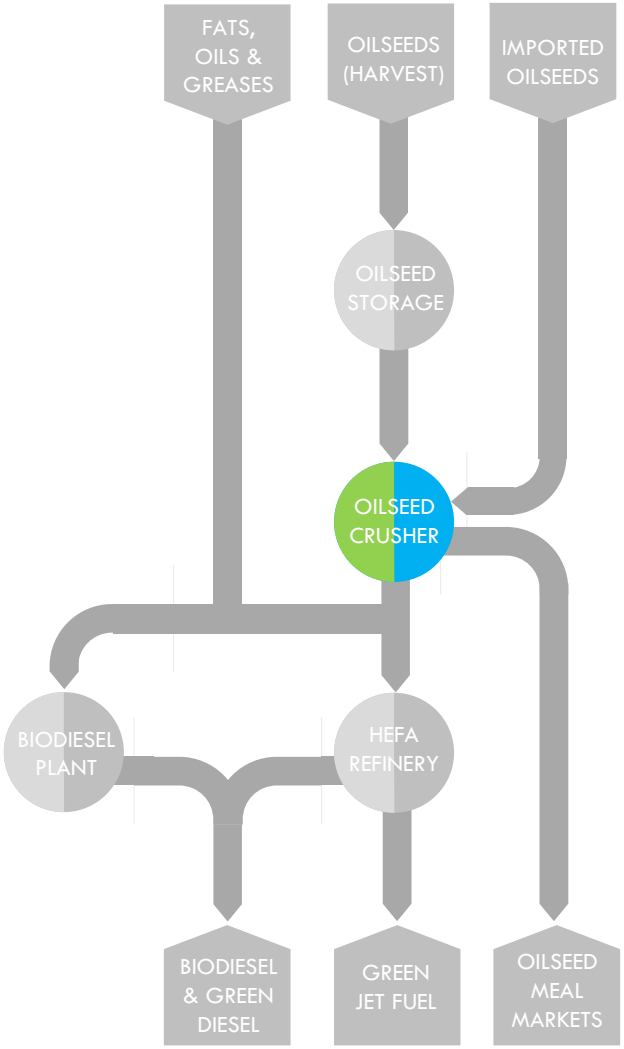
Scenario (tons)	Total Feedstock	Plant Oil	FOGs
Maximum Production	807,600	687,750	119,850
50% Production	463,725	343,875	119,850



KAMIAK BUTTE, WA – June 27, 2018


FATS, OILS & GREASES
OILSEEDS (HARVEST)
IMPORTED OILSEEDS
OILSEED STORAGE
OILSEED CRUSHER
BIODIESEL PLANT
HEFA REFINERY
BIODIESEL & GREEN DIESEL
GREEN JET FUEL
OILSEED MEAL MARKETS


GRAIN ELEVATORS OF THE PACIFIC NORTHWEST
The Pacific Northwest is known for its "territorial" storage structure. Unlike other parts of the United States, storage is controlled by many companies, each functioning in a relatively small and homogeneous area. Especially farmer-owned cooperatives control a large portion of the regions country elevators, shuttle elevators, and barge terminals.
MAJOR FARMER-OWNED CO-OPS
Pacific Northwest Farmers
CHS Primeland
Ritzville Warehouse Co
Highline Grain
Northwest Grain Growers
Mid Columbia Producers
N
0
25
50
100
150
200
Miles
PNW_Rail_Active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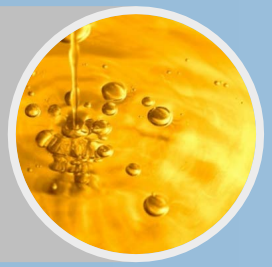
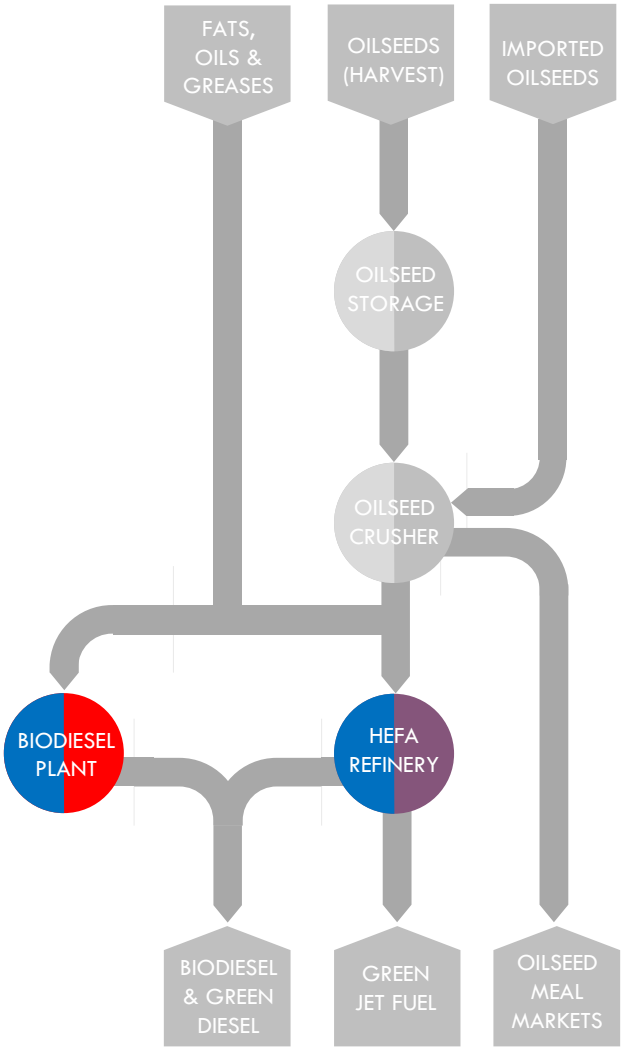
BIODIESEL & GREEN DIESEL
GREEN JET FUEL
OILSEED MEAL MARKETS

CRUSHER TECHNO ECONOMIC ANALYSIS

Type	Annual Capacity (ton/day)	Capital Cost ($/yr)	Electricity (kWh/ton)	Natural Gas (MMbtu/ton)	Other OPEX ($/ton)
Chemical	1,500	31,900,000	126.1	0.1871	5.258
Mechanical	1,000	35,950,000	90.06	0.1897	10.16

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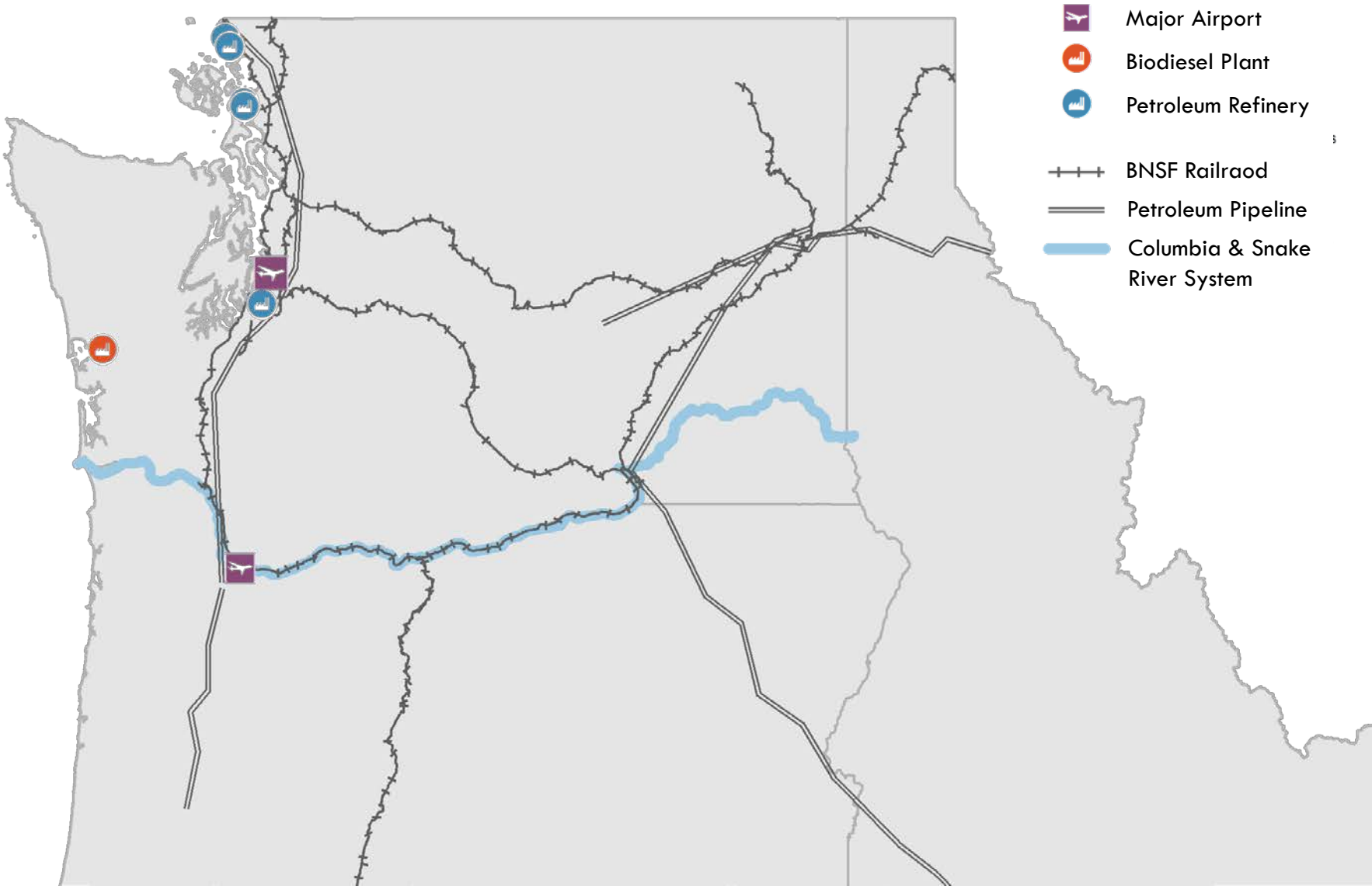
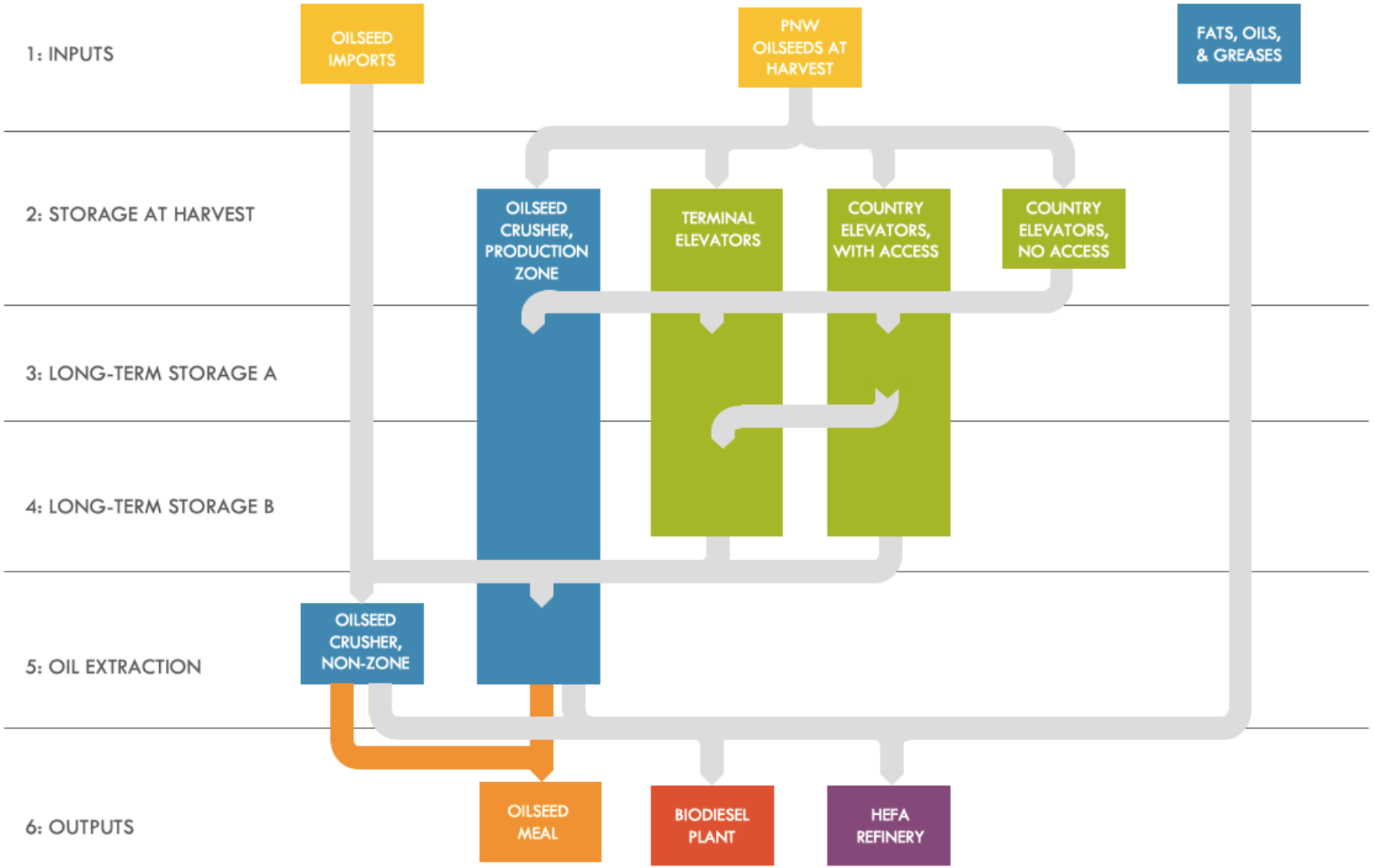
HEFA REFINERY
BIODIESEL & GREEN DIESEL
GREEN JET FUEL
OILSEED MEAL MARKETS

FUELS INFRASTRUCTURE

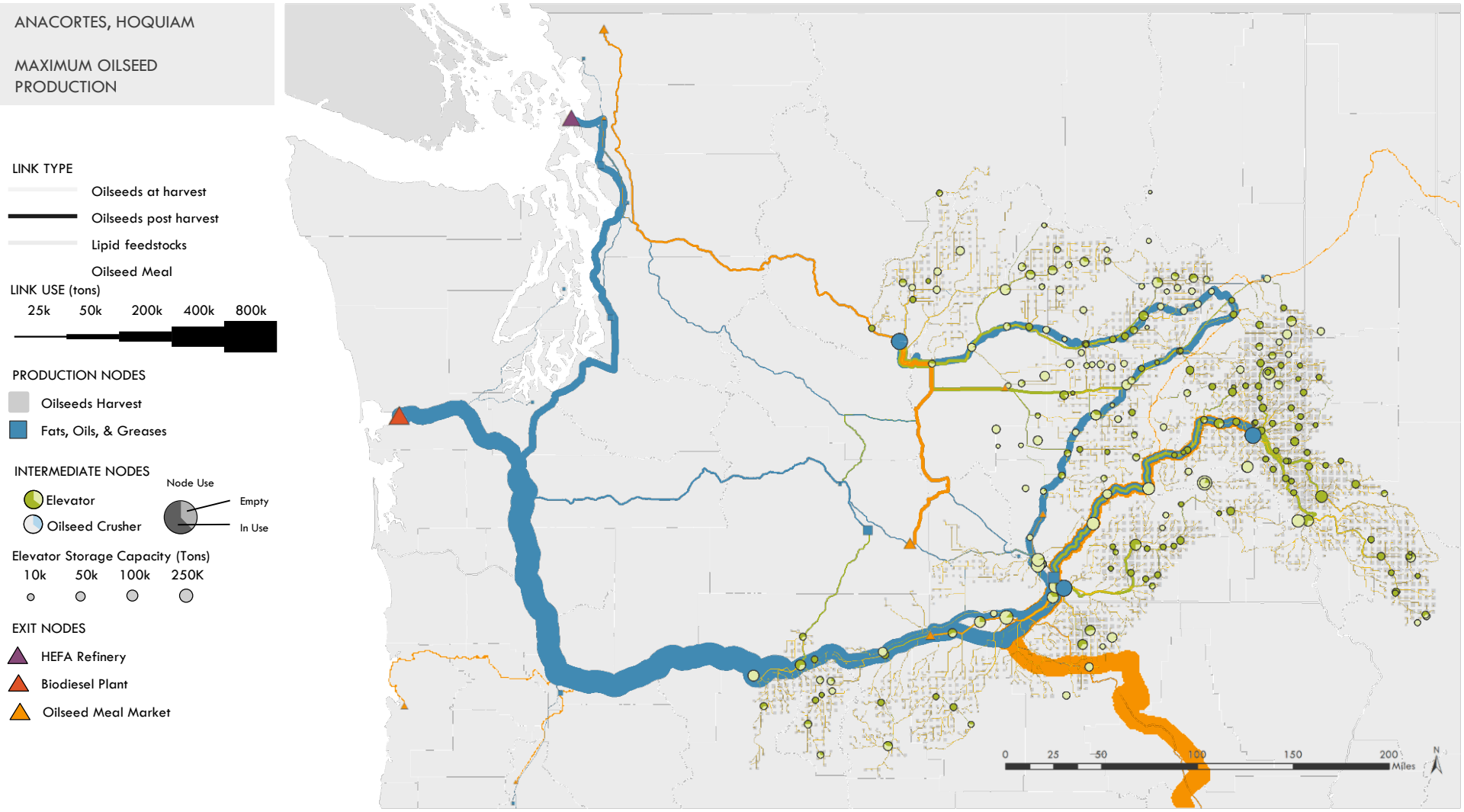


REAL SUPPLY CHAIN MODEL



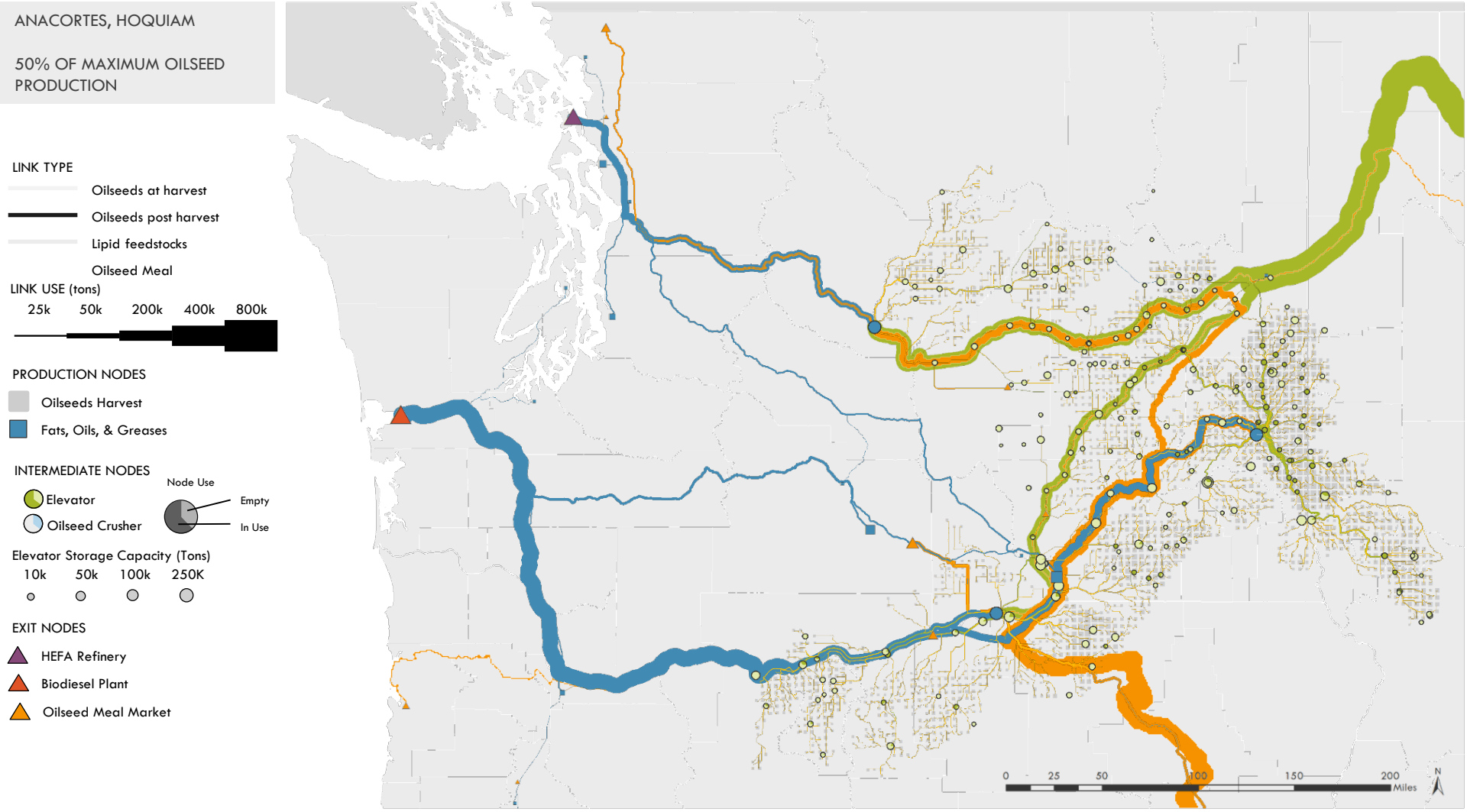
ANACORTES, HOQUIAM

MAXIMUM OILSEED PRODUCTION



ANACORTES, HOQUIAM

50% OF MAXIMUM OILSEED PRODUCTION




QUESTIONS

Regional Supply Chain Analysis for Alternative Jet Fuel Production in the Tropics

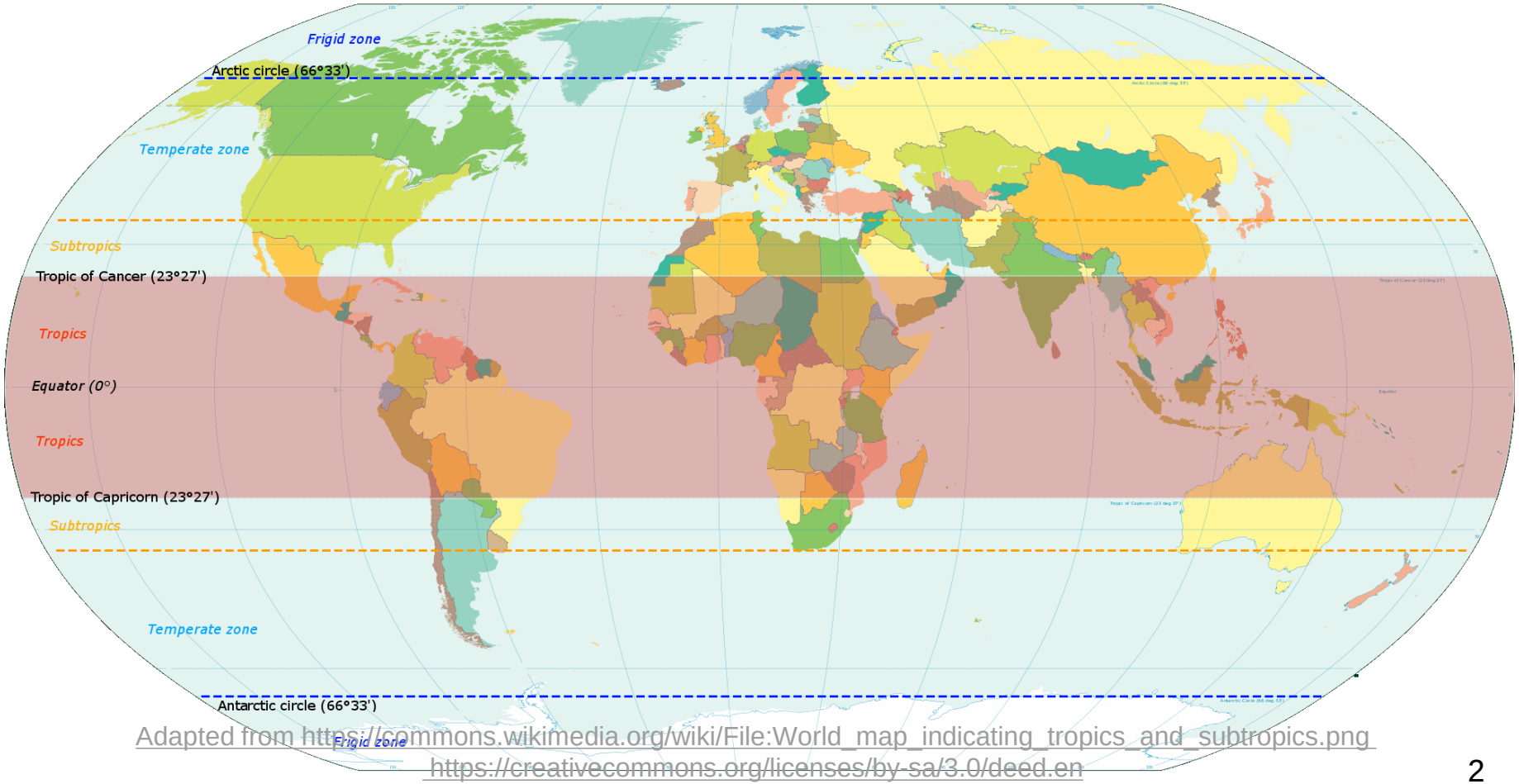
Scott Turn
University of Hawaii

James Hileman, FAA Program Manager
Nathan Brown, FAA Program Manager
Dan Williams, FAA Program Manager

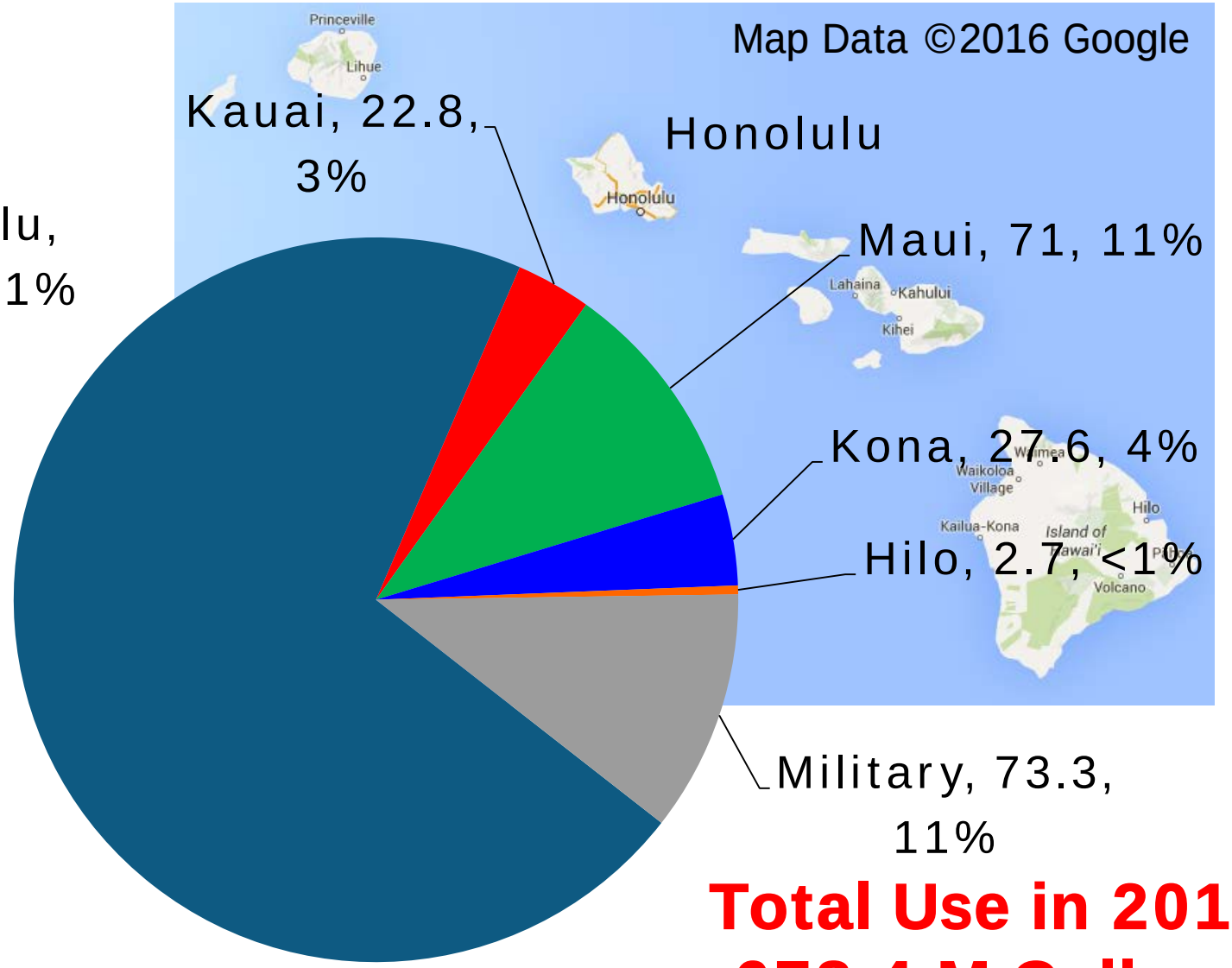
December 5, 2018

Alternative Jet Fuel Supply Chain, Tropical Region Analysis -- Motivation

- The tropics account for 36% of the world's land mass
- Tropics are home to unique biomass materials, production practices/systems, and temporal availabilities

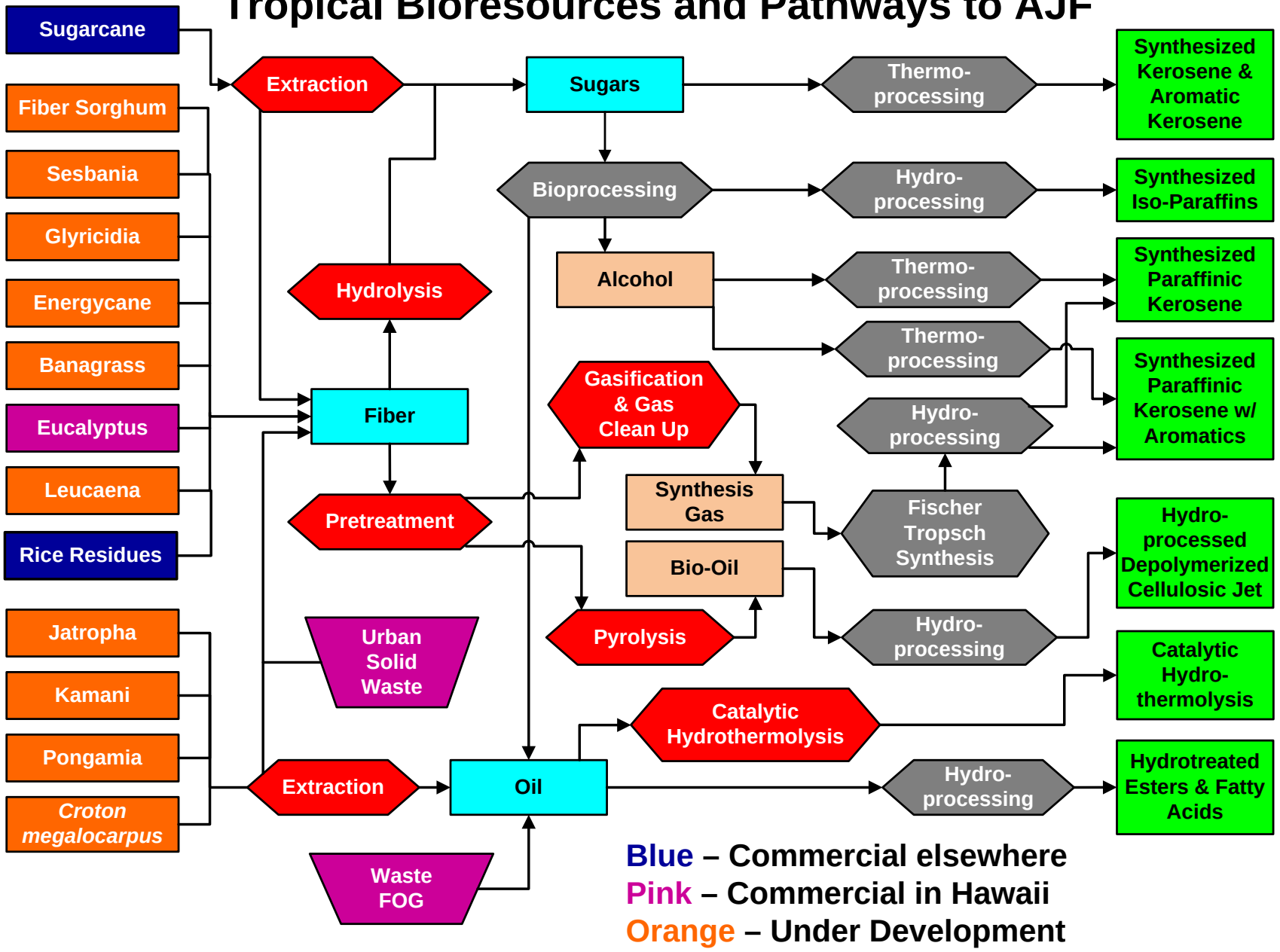


Jet Fuel Use in Hawaii, 2015 Commercial Airports and Military (million gallons)

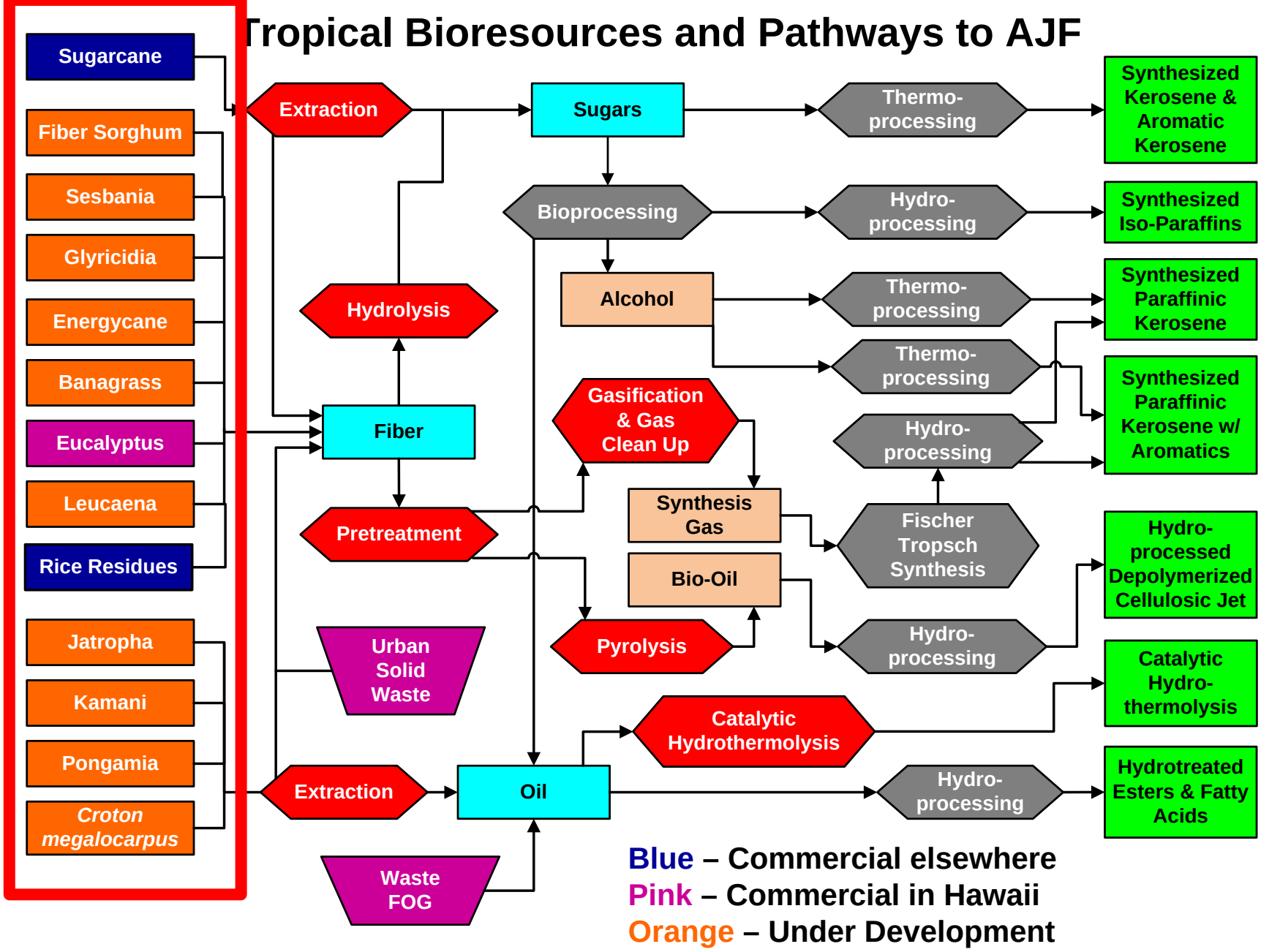


Total Use in 2015
678.4 M Gallons

Tropical Bioresources and Pathways to AJF



Tropical Bioresources and Pathways to AJF



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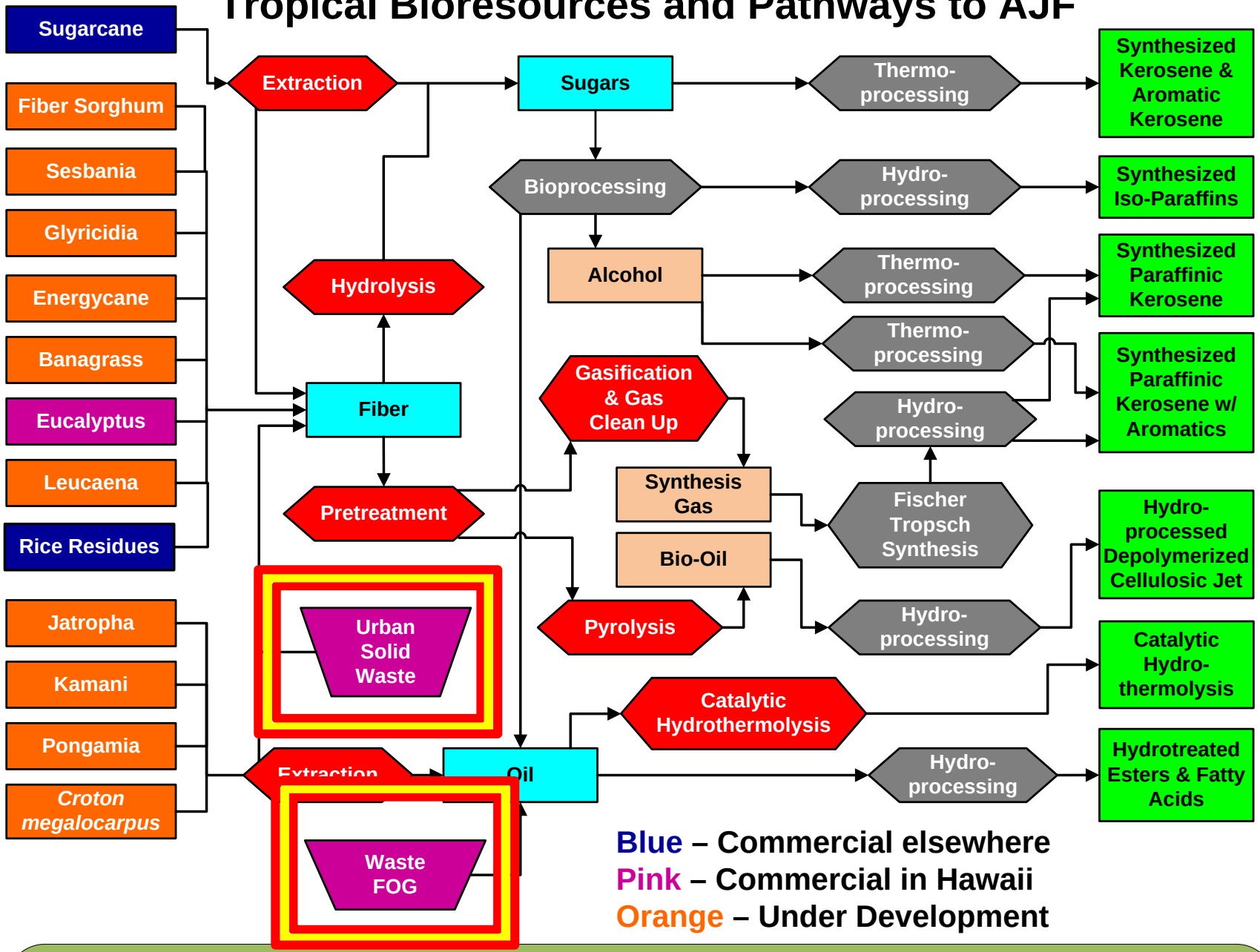

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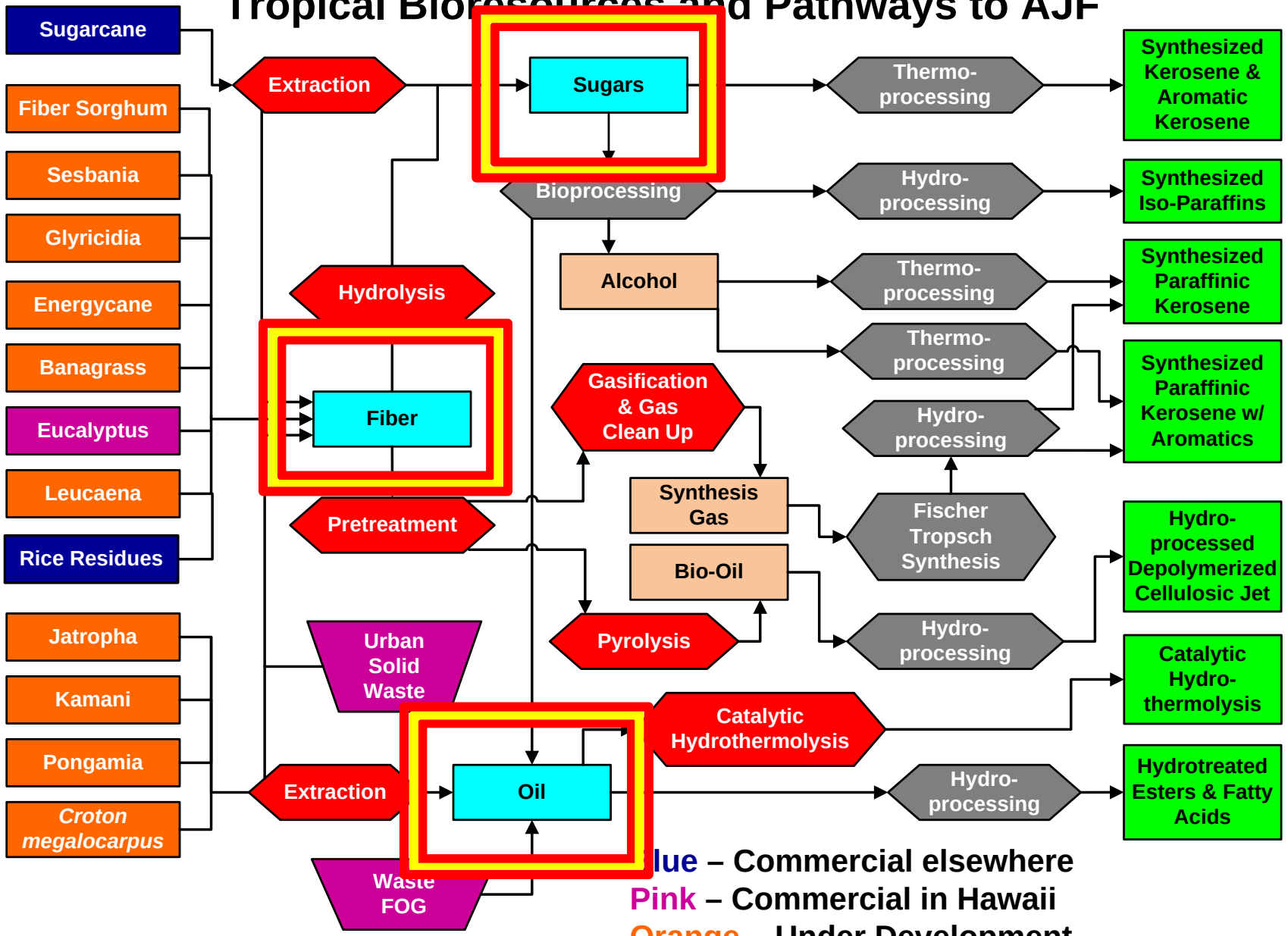

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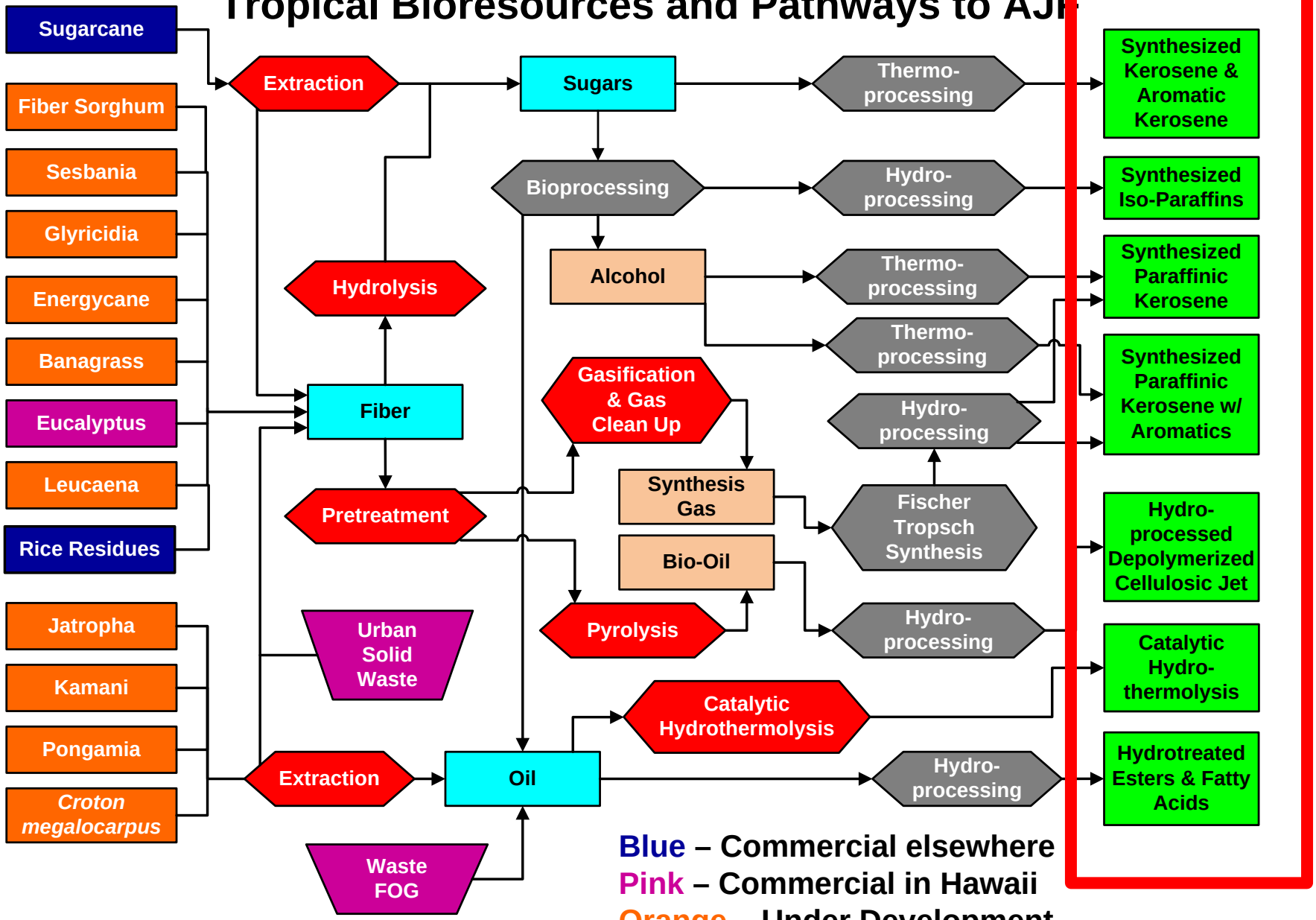

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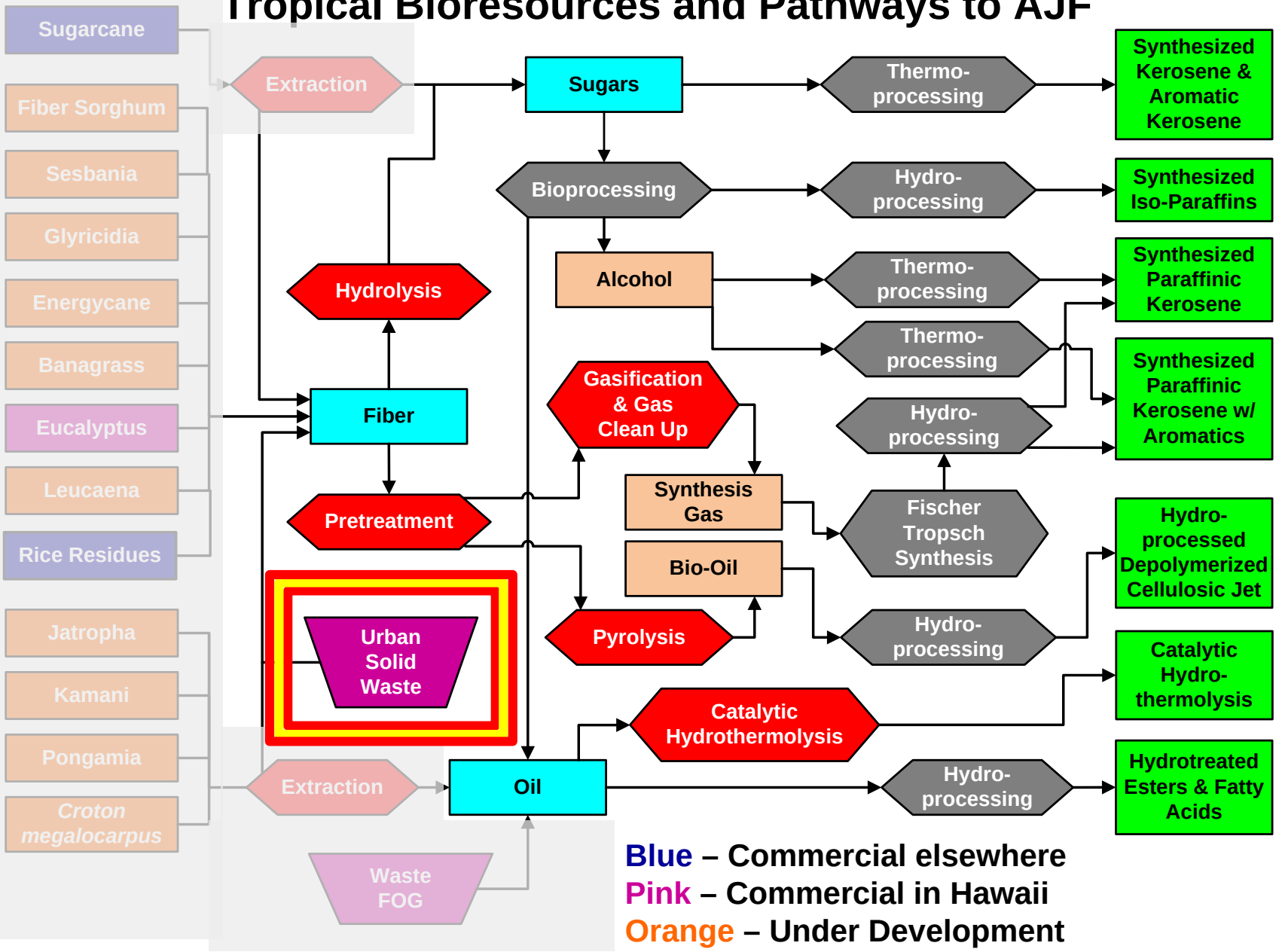


Bioresource | **Intermediate Products & Conversion Technologies** | **Alternative Jet Fuel**

Star★Advertiser B CITY EDITOR: David Butts / dbutts@staradvertiser.com / 529-4310
SUNDAY 9/30/18 ★

local&business

Construction enjoys unexpected growth

Industry spending is forecast to achieve a decade high in '18, but jobs remain static

By Andrew Gomes
agomes@staradvertiser.com

Hawaii's construction industry should provide a little more oomph to the local economy this year than previously expected, according to a report by economists released Friday.

The analysis by the University of Hawaii Economic Research Organization projects that statewide construction spending will reach a decade high of $9 billion this year.

That figure represents a 7 percent increase over $8.4 billion in 2017 — a gain that UHERO last year didn't expect would happen.

A year ago, UHERO researchers forecast that Hawaii construction spending would be flat this year. However, the new forecast for industry growth is in part due to a smaller-than-expected gain last year.

Essentially, more spending on construction is getting stretched out over two years, and a leveling off of work remains on the horizon for an industry that is a major driver of the state's economy.

Spending by contractors building homes, renovating hotels, improving public infrastructure and other work should remain at $9 billion for the next three years, the report forecasts.

"The description is one of relative stability or flatness," said Carl Bonham, UHERO executive director.

Hawaii's peak for construction spending adjusted for inflation was $10.6 billion in 2007. If spending reaches $9 billion this year as UHERO forecasts, it would be the most since $10.2 billion in 2008.

Bonham said construction is particularly difficult to forecast because time frames between when permits are issued and

Please see **UHERO**, *B3*

CONSTRUCTION LIFT

University of Hawaii economists expect local construction industry spending this year to hit a 10-year high.

* forecast

Source: University of Hawaii Economic Research Organization

STAR-ADVERTISER

UHERO
THE ECONOMIC RESEARCH ORGANIZATION AT THE UNIVERSITY OF HAWAI'I

UHERO FORECAST PROJECT

HAWAII CONSTRUCTION FORECAST: PUBLIC EDITION

AFTER PULLBACK, CONSTRUCTION PROSPECTS FIRM

SEPTEMBER 28, 2018

UHERO
THE ECONOMIC RESEARCH ORGANIZATION AT THE UNIVERSITY OF HAWAI'I
UHERO FORECAST PROJECT
HAWAII CONSTRUCTION FORECAST: PUBLIC EDITION
AFTER PULLBACK, CONSTRUCTION PROSPECTS FIRM
SEPTEMBER 28, 2018

PVT Land Company
Nānākuli, Hawaii
http://www.pvtland.com

Map data ©2017 Google

- PVT is the only construction & demolition landfill on Oahu
- Current intake 1,775 tons C&D waste per day
- ~50% of intake converted to feedstock, up to 900 tpd
- Waste-in-place also “mined” for additional “feedstock”
- Feedstock: wood, plastic, cloth, paper, and other organics
- Tipping fee $50 per ton, or $54 per ton for LEED certified

Possible Locations of Value Chain Participants

PVT Land Company

~10 miles between PVT and CIP

Map data ©2017 Google

PVT Land Company LTD.

Joint Base Pearl Harbor-Hickam

Island Energy Refinery

Kalaeloa Airport

Campbell Industrial Park

Par Hawaii Refinery

Daniel K. Inouye Airport

Construction & Demolition Waste-Based AJF Assessment

- Feedstock characterization
  - Fuel properties, physical properties, temporal variability
- Greenhouse gas implications
- Technoeconomic analysis
- Gasification benchscale testing

Summary

- Tropics provide unique biorenewable resources for AJF feedstocks
- Modeling tools provide guidance for locating dedicated energy crops on available land to support regional supply development
- Construction & demolition waste stream characterization and supply chain analysis ongoing

University of Hawaii Contributors

Sharon Chan, Taha Elwir, Curtis Daehler,
Jinxia Fu, Kyle Marcelino, Trevor Morgan,
Richard Ogoshi, Lloyd Paredes,
Sabrina Summers, Leia Tashiro, Adel Youkhana

Questions?

Real World Supply Chain Development

Southeastern United States

Lead investigator: Tim Rials
Project manager: Nate Brown

December 5, 2018
Washington, DC

ASCENT
AVIATION SUSTAINABILITY CENTER

Supply Chain: Lignocellulosic

Country's Largest Energy Crop Acreage

- High yielding, native grass, growing on marginal cropland
- Production contracts with >60 farmers, within 50 miles of Vonore, TN
- In production since 2008, yielding 8 tons/acre today
- Over 90% success in first year stand establishment
- Developed and improving innovations in supply chain logistics

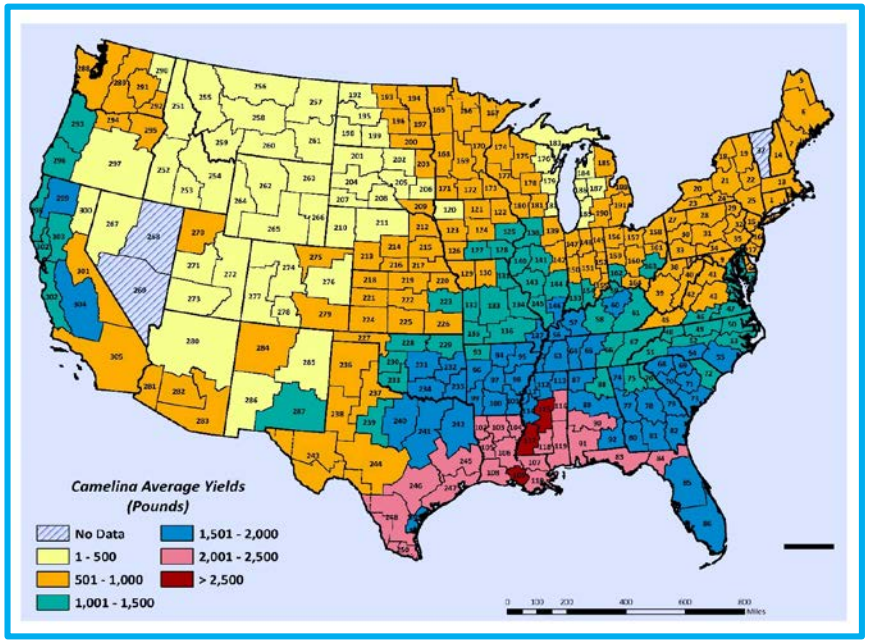
Developed & Operate Unique Biomass RD&D Campus

- Integrated research campus for biomass handling, processing, storage, densification, transportation
- 22-acre campus adjacent to demonstration scale biorefinery
- Considerable flexibility in range of energy crops and processing systems
- Driving efficiencies and innovations between farm gate & biorefinery gate
- Extensive technology partnership and scale-up opportunities

World-Class, Demo-Scale Cellulosic Ethanol Biorefinery

- Demonstration-scale plant, Process Development Unit (PDU), and lab facilities located in Vonore, TN
- Started operations January 2010, processing corn cob, stover, and switchgrass
- Designed to develop technology and engineering packages for the construction of commercial facilities
- Collaboration with DuPont Cellulosic Ethanol, serving as HQ for DuPont's CE business

Sustainable Aviation in the Southeast



SPATIAL ASSESSMENT OF CAMELINA YIELD (COVER CROP)

BURTON ENGLISH, UNIV. OF TENNESSEE

- Additional conversion pathways available for AJF
  - *HEFA, pyrolysis, Fischer-Tropsch, etc.*
- Introduces opportunity to broaden feedstock portfolio
  - *Valuable in meeting diverse landowner goals*
- ASCENT has enabled initial evaluation of oilseed yield potential
  - *Camelina, pennycress, carinata, etc.*

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

“Real World” East Coast Supply Chain Initiatives

December 5, 2018
CAAFI Biannual General Meeting
Washington D.C.

Richard Altman – CAAFI Executive Director Emeritus,
East Coast State Project lead

CAAFI®
COMMERCIAL AVIATION
ALTERNATIVE FUELS INITIATIVE


Canada
DAIRY WASTE
MSW-LIQ
SASSCA
SPARC
SAFE
CITRUS SUBST
Atlantic Ocean
40
70
30

East Coast Project Development Approach

Strong State / Regional Teams and Local Leaders

+

Public / Gov't, Ag. Sector Engagement

+

High value resilient co-products suite + jet fuel

+

Quantified/Maximized Economic and Environmental (Air and Water) Value

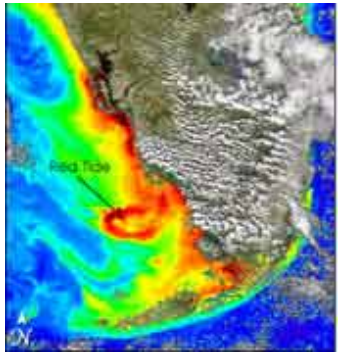
Facilitate Supply Chain Development for Processors /End Customers

SPARC – Supply Chain Team

Southeast Partnership for Advanced Renewables from Carinata

- **Project Lead - UFL (David Wright), NIFA CAP**
- **Key Partners - ARA, Agrisoma, USF, UGA, Auburn, DOT Volpe**
- **Objectives: Enable Maximize Sustainable Development in SE Partner States**
- **Innovative Elements -**
  - **Implement bottoms up FTOT**
  - **Engage State support**
  - **Monetize runoff control gain**

Oyster bed water quantity



Red tide threat to water quality

SASSCA – Forest Industry

Southcentral Atlantic State Supply Chain Alliance

- **Project Lead - Clemson (Pat Layton), NIFA Mini CAP proposal**
- **Key Partners - NCSU, UVA, VaTech, Regional Forest Industry**
- **Objectives: Facilitate sustainable fuel supplies, to east coast, fill slack demand for forest products**
- **Innovative Elements -**
  - **Wood supply precision analysis**
  - **multiple proven process access**
  - **cellulosic ethanol / lignin co-prod**

Growing sawmill waste

Lignin 30% of tree

CCAT– MSW to Fuel in CT

Connecticut Center for Advanced Technology

- **Project Lead – CCAT (Tom Maloney), Multiple USDA RD, Business Dev. grants**
- **Key Partners - multiple processors, CT legacy Waste to power facility MIRA**
- **Objectives: Facilitate conversion of aging RFD facility from electricity production. Enhance revenue 6 X**

MIRA
Materials Innovation and Recycling Authority

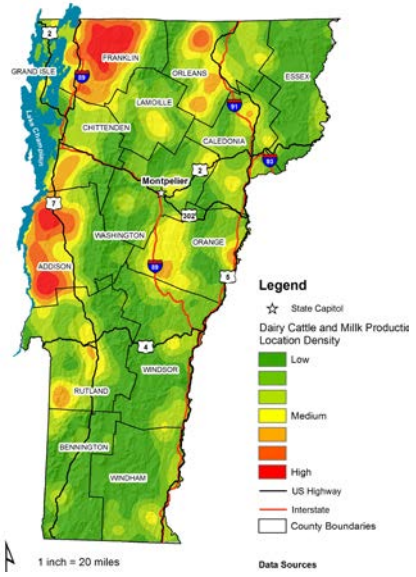
- **Innovative Elements -**
  - **Publicly available MSW**
  - **Refuse Derived fuel facility**
  - **new action needed within 2 – 5 yrs.**

Dairy Waste – A 3rd 24/7 Feedstock

- **Project Lead - GSR (Krivov) , Todd Campbell (ex-USDA) USDA Rural Dev (RBEG and VAPG)**

- **Key Partners - UVM, Cornell, Newtrient, Canadian Interests,**

- **Objectives: Cross border technology scale up, support dairy industry, monetize value.**



- **Innovative Elements -**
  - **Strongest co-product potential**
  - **Organized feedstock industry**
  - **Environmental NGO support for lake pollution mitigation**

TCERDA – Citrus Replacement

Sustainable Fuels Feasibility Study

- **Project Lead - TCERDA (Devries) USDA RBDG grant**

- **Key Partner/ Customers - Amyris, Lanzatech, Gevo, Jet Blue, American, Fedex, Tropicana**

- **Objectives: Energy Crop to replace, Citrus lost to Greening**
- **Innovative Elements -**
  - **Research park run / County focal**
  - **Cattle feed co-product w/ranchers**
  - **Citrus grower engagement**

SAFE – Sustainable Ethanol

Sustainable Aviation Fuel from Ethanol

- **Project Lead - GA Tech (Thomas) USDA NIFA LOI focus**
- **Key Partners / Customers - Lanzatech, UGA, USF, UFL**
- **Objectives: Resilient rotation for sustainable ethanol supplies from agricultural sources for ATJ**
- **Innovative Elements -**
  - **Solely sustainable ethanol focus**
  - **Multiple southeast crop focus**
  - **Processor demand in place**

Louisiana sweet sorghum

Energy beets winter crop