Project 001(E) Alternative Jet Fuel Supply Chain Analysis

University of Tennessee

Project Lead Investigator

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University Participants

University of Tennessee

- PI: Burton English, Professor
- FAA Award Number: 11712069
- Period of Performance: October 1, 2018 to September 30, 2019
- Task(s):
  - Task 1.1: Assess and inventory regional forest and agricultural biomass feedstock options
  - Task 1.2: Delineate the sustainability impacts associated with various feedstock choices including land-use effects
  - Task 3: Lay the groundwork for regional deployment and production of lipids and/or biomass in Tennessee and the Southeast United States
  - Task 4: Support biorefinery infrastructure and siting

Project Funding Level

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Total Estimated Project Funding: $664,056/$260,000
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Faculty salary was provided by The University of Tennessee, Institute of Agriculture, in support of the project.

Investigation Team

- Tim Rials, Project Director/Principal Investigator (PD/PI)
- Burton English, Co-Principal Investigator (Co-PD/PI)
- Chris Clark, Faculty
- R. Jamey Menard (Tasks 1 and 3), Other Professional
- Brad Wilson (Task 3), Other Professional (geographic information system)
- Kim Jensen, Faculty
- David Hughes, Faculty
- Jim Larson, Faculty
- Edward Yu, Faculty
- Evan Markel (Task 1.1), Graduate Student
- Katryn Pasaribu (Task 1.1), Graduate Student
- Umama Rahman (Task 1.1), Master's Graduate Student
- Bijay Sharma (Task 1.1), Graduate Student
- McKenzie Thomas (Task 3), Master's Graduate Student
- Latif Patwary (Task 1.2), Master's Graduate Student
- Alan Robertson (Tasks 1 and 3), Master's Graduate Student

- Gill MacKenzie (Task 3), Master's Graduate Student

Project Overview

The University of Tennessee will lead the feedstock production (Task 1) component of the project. This component targets the need to assess and inventory regional forest and agricultural biomass feedstock options and delineate the sustainability impacts associated with various feedstock choices, including land-use effects. The University of Tennessee will lead the analysis of national lipid supply availability by using the Policy Analysis System (POLYSYS) model to develop information on the potential impacts and feasibility of using lipids to supply aviation fuel. The team at the University of Tennessee will facilitate regional deployment and production of jet fuel by laying the groundwork and developing a regional proposal for deployment. The team also supports activities in Task 3 by providing information and insights regarding feedstocks, along with potential regional demand centers for aviation fuels and coproducts, and information on current supply chain infrastructure, as required.

Additionally, the University of Tennessee hosted a workshop on sustainable aviation fuels (SAFs). The meeting was held April 24–25, 2019, in Knoxville, Tennessee. More than 50 invited leaders from the region met to discuss critical barriers to increasing the availability of SAF in the Southeast. 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.

Major goals included the following:
1. Developing a rotation based oil seed crop scenario and evaluate potential with POLYSYS
2. Developing a database on infrastructure and needs for the Southeast
3. Organizing and convening for a workshop on the alternative jet fuel supply chain for southeastern stakeholders
4. Initiatiang an aviation fuel supply chain study in the Southeast
5. Continuing with sustainability work for both goals 1 and 4

Task 1.1 - Assess and Inventory Regional Forest and Agricultural Biomass Feedstock Options

University of Tennessee

Objective(s)

Because the markets for lignocellulosic biomass (LCB) feedstock, i.e., grasses, short-rotation woody crops, and agricultural residues, are currently not well established, evaluating the feasibility of supplying those LCB feedstocks is important. The opportunity cost of converting the current agricultural lands to LCB feedstock production will be estimated. In addition, the production, harvest, storage, and transportation costs of the feedstocks are included in the assessment. A variety of potential crop and biomass sources will be considered in the feedstock path, including:

- **Oilseed crops:**
  - Mustard/Crambe (*Sinapsis alba/Crambe abyssinicia*)
  - Pennycress (*Thlaspi arvense*)
  - Rapeseed/Canola (*Brassica napus/B. campestris*)
  - Safflower (*Carthamus tinctorius*)
  - Sunflower (*Helianthus spp.*)
  - Soybean (*Glycine max*)
  - Camelina (*Camelina sativa*)
  - Carinata
- **Perennial grasses**:
  - Switchgrass (*Panicum virgatum*)
  - Miscanthus (*Miscanthus sinensis*)
  - Energy cane (*Saccharum complex*)
- **Short-rotation woody crops**:
  - Poplar (*Populus species*)
  - Willow (*Salix species*)
  - Loblolly pine (*Pinus taeda*)
  - Sweetgum (*Liquidambar styraciflua*)

    - Sycamore (*Plantanus occidentalis*)
- **Agricultural residue**:
    - Wheat straw
    - Corn stover
- **Forest residue**:
    - Logging and processing residue

POLYSYS will be used to estimate and assess the supply and availability of these feedstock options at the regional and national levels. This U.S. agricultural sector model forecasts changes in commodity prices and net farm income over time.

County-level estimates of all live total woody biomass, as well as the average annual growth, removal, and mortality, will be obtained from the Forest Inventory and Analysis (FIA) Database. Mill residue data will be obtained from the U.S. Forest Service FIA Timber Product Output data. The ForSEAM model will be used to estimate and predict logging residues. ForSEAM uses U.S. Forest Service FIA data to project timber supply on the basis of the United States Forest Products Model (USFPM) demand projections. Specific tasks related to this objective are outlined below. These supply curves will be placed in POLYSYS, and estimates into the future will be made.

1. Complete the economic viability analysis on switchgrass, short-rotation woody crops, crop residues, forest residues, and cover crops to assist the team with Theme 1.3
2. Assist in modeling of risk-reward profit sharing by providing information from past work on cellulosic supply chains to Pennsylvania State University (PSU)
3. Assist PSU in the National Survey of current and proposed programs that incentivize ecosystem services
4. Finish environmental impact analysis for the aforementioned crops, examining soil, water, greenhouse gas (GHG) emissions and sequestration, and direct land-use change

Research Approach

1. Using an existing model, POLYSYS, the price for a commodity or annual demand for feedstock was exogenously determined and placed into the model. For this year, no analysis was conducted for a model cover crop. Instead, additional work was pursued on last year's model runs by using carinata as a feedstock. The camelina work captured in a thesis will be further developed as a journal article on the findings of the POLYSYS camelina feedstock analysis.
2. The carinata budget developed last year was revisited by using new information received from Florida.
3. The cover crop carinata was added to the list of potential feedstock candidates; we are in the process of developing a fact sheet for this crop.
4. Logging residues in the Southeast United States were examined. ForSEAM output generated for the Billion Ton Study was downscaled to BioFLAME hexagon-shaped supply regions of 5 square miles, and these hardwood and softwood potential feedstock availability streams are being readied for placement in ASCENT 1's Database. Note: These were initially developed at the POLYSYS region level and downscaled with Cropscape.
5. Using internal funds, trial plots were established for the oilseed cover crops pennycress, camelina, carinata, and canola. This procedure was performed to validate the yield estimates that we are using for Tennessee cropping systems.

New Findings

- Carinata has the potential to supply both oil and biomass to the biofuel market in the southern United States. We currently do not know how far north carinata could be grown.

Milestone(s)

- We generated data that have been passed on to the ASCENT 01 database for camelina feedstock.
- The camelina pathway analysis was completed, and an article is being written.

Major Accomplishments

- We provided information to Purdue regarding the pennycress potential (yield and costs) around northeast Indiana and Sioux City, Iowa.
- We ensured that the crushing facility spreadsheet matched ASCENT's current financial assumptions.

Publications
None.

Outreach Efforts
The results have been disseminated to academia through professional conferences. A poster was presented at the Southern Agricultural Economics Association annual meeting. A selected paper was presented at the 2019 Southern Agricultural Economics Association Annual Meeting in Alabama, in February, 2019, which was based mainly on the pro forma financial analysis of the crushing facility for pennycress. A manuscript based on this presentation was submitted to a journal for peer review during the spring/summer of 2019.

English, B.C., Menard, J. R., Trejo-Pech, C., Rahmann, U., & Edward Yu, T. (2018). Initial steps to laying the groundwork for a renewable aviation fuel industry in Tennessee: Economic feasibility and economic impact analysis. Poster presented at the CAAFI annual meeting, Washington, D.C.

English, B.C. & Rials, T. (2018). Feedstock viability and potential economic impacts. Paper presented at the CAAFI annual meeting, Washington, D.C.

Sharma, B. P., Edward Yu, T., English, B.C., & Boyer, C.N. (2018). Welfare analysis of carbon credits to the sustainable aviation fuel sector: A game-theoretic perspective. Poster presented at the CAAFI annual meeting, Washington, D.C.

Trejo-Pech, C.O., Larson, J., English, B., & Yu, T.E. (2019). Return and risk profile of a potential Pennycress processing facility for the aviation industry. Southern Agricultural Economics Association, 51st Annual Meeting Program, Birmingham, AL.

Awards
None.

Student Involvement
In the near future, the pro forma financial analysis spreadsheet will be used either for teaching purposes in a graduate class in agribusiness finance at the University of Tennessee or as a guide or template for graduate students completing capital budgeting analysis for similar crops.

A Master's degree student, Alan Robertson, is working on this project. He has gathered information on carinata and developed an analysis examining this crop as a cover crop feedstock. He will be conducting a feasibility analysis using carinata as a potential feedstock for SAF needs at the Memphis airport. A previous PhD student, Bijay Sharma, currently working at the University of Illinois as a postdoctoral student, worked on completing journal articles reflecting risk.

Plans for Next Period
- Complete cover crop analysis for feedstock costs and yields.
- Develop POLYSYS analysis for camelina, carinata, and winter rye.
- The information gained is available online[1].

[1] https://app.box.com/folder/2689605965

Task 1.2 - Delineate the Sustainability Impacts Associated with Various Feedstock Choices, Including Land-Use Effects

University of Tennessee

Objective(s)

Environmental Sustainability – Regarding environmental sustainability, the impacts associated with LCB feedstock production, such as GHG flux and soil erosion, are estimated on the basis of local geographic characteristics. The GHG flux related to land-use change and LCB feedstock production is analyzed with the POLYSYS model. Different agricultural land-use systems have varying effects on soil erosion or soil loss. The effect of different LCB feedstock production on soil erosion is simulated with the Universal Soil Loss Equation and the 1997 National Resources Inventory database.

Economic/Social Sustainability – The input-output analysis provides estimates of output, employment, and income multipliers, which measure the response of the economy to changes in demand or production. The economic multipliers measure the indirect and induced effects of a change in final demand (direct effects) for a particular industry (for example, the introduction of biorefineries and preprocessing facilities in a region). The indirect effects are the secondary effects or production changes when input demands change because of the effects of the directly affected industry (for example, the construction sector, agriculture producers, and transportation sectors). The induced effects represent the response by all local industries caused by changes in expenditures by households and interinstitutional transfers generated from the direct and indirect effects of the change in final demand. Projections of changes in jobs (job creation), economic activity, taxes, and gross regional domestic product are estimated, providing information on what might be expected if an industry developed within the region. The FT-SPK and ATJ-SPK multipliers have been estimated for the entire 48 contiguous states, and maps have been developed that will allow for estimation of the economic impacts of the direct investment and operating transactions to be reflected in the economic impacts of a given area within the country. The model regions are the 187 Bureau of Economic Analysis regions in the country. This process was completed, and information is available for total industry output, value added, and employment.

Research Approach

Develop impact analysis for economic and environmental parameters

Input-output analysis

By using the revised ASCENT techno-economic analyses (TEAs) developed by Washington State University (WSU), the economic impact information is being revised. We received seven ASCENT conversion technologies and have placed investment and operating costs into IMPLAN industries by using NACS conversion tables. We have completed a crush facility spreadsheet and used it in an oilseed cover crop analysis.

Environmental parameters

We have not made additional progress, but we have made presentations and have two journal articles in review examining welfare analysis linked to carbon credits, by using feedstock locations in Tennessee and airport SAF potential demands. The work is not completed yet.

Consumer preferences

Marketing coproducts could significantly improve the cost effectiveness of biofuel production. We conducted two surveys that examined potential coproducts of a biofuel pathway including biochar and cellulose. We administered a survey through Qualtrics to Tennessee respondents 18 years of age or older in late August 2018. The survey contained several sections, including questions about the level of influence of environmental attributes on purchase decisions for disposable dinnerware; expenditure patterns for disposable dinnerware; demographics including age, education, gender, and household income; and attitudes toward the environment. The purposes of this study are to provide estimates of consumers' preferences for environmental attributes in disposable dinnerware; the probabilities of preferring particular attributes; and the influence of demographics, expenditure patterns, and environmental attitudes on these preferences for environmental attributes in disposable dinnerware.

- The results from this study suggest that consumers are interested in disposable dinnerware with environmental attributes. In particular "no plastic" and "recyclable" are the two attributes most often selected. Results from this study also suggest that consumers view products made from cellulose from crop byproducts similarly to those made from dedicated crops. Interestingly, "no trees" was least often selected, despite its use in labels on some alternative fiber products in the marketplace. This result may suggest that consumers believe that trees can be grown in a sustainable manner for their cellulose and/or may suggest that consumers might potentially be willing to purchase disposable dinnerware that is blended from tree cellulose along with other cellulose sources (for example, bamboo, bagasse, or wheat straw). However, determining the motivations underlying the responses with regard to how people view growing or harvesting trees for cellulose in disposable dinnerware is beyond the scope of this study.

- Certain market segments have stronger views about environmental attributes in disposable dinnerware (e.g., those with males, in urban areas, with children in the household, with higher income, and with stronger environmental concerns). In addition, prior purchase of alternative fiber products had a positive effect on the environment as well as the probability of choosing a greater number of environmental attributes. This result suggests that consumers who have tried these products before may be repeat customers.
- This study region was limited to Tennessee. To effectively market these emerging products, a national study should be conducted. Furthermore, the study did not include price effects. Additional research might integrate prices along with attributes in a conjoint analysis for a disposable dinnerware product.

Another coproduct, biochar, can serve as an effective soil amendment. Markets for soil amendments with biochar are emerging, but consumer willingness to pay (WTP) is uncertain. This study uses results from a survey of 577 Tennessee home gardeners to estimate the WTP for a potting mix consisting of 25% biochar. The estimated WTP for an 8-quart bag was $8.52, compared with $4.99 for a bag with no biochar. Consumer demographics and attitudes toward both the environment and biofuel production were associated with WTP for the biochar-supplemented potting mix. The results also suggested that the Tennessee gardeners most likely to purchase the biochar mix are younger, spend a higher percentage of their income (up to 2.44%) on gardening supplies, purchase greater amounts of potting mix in a year, and usually purchase this potting mix at garden centers. The results suggest the following:

- Garden centers appear to be a prime retail outlet for biochar-supplemented potting mix.
- Positive correlations between WTP for the biochar mix and the use of organic gardening practices, as well as respondents' views on the importance of biofuels for meeting our nation's future energy needs and the need to take action to combat climate change, suggest that more environmentally concerned gardeners are likely to constitute a target market for biochar-blended potting mix.
- The most common reason for unwillingness to pay a premium for biochar-supplemented potting mix was an inability to afford the biochar mix.
- However, the second most commonly cited reason was that the respondents did not pay much attention to labels on potting mix bags. Thus, differentiating potting mixes supplemented with biochar from conventional potting mixes may pose a hurdle to marketing biochar mixes at higher prices.
- Hence, coupling labeling measures with media messaging (such as on gardening-related television shows and in gardening magazines) highlighting the performance and environmental benefits of blending biochar with potting mix might help to market biochar potting mix blends.

Major Accomplishments

- Completed biochar analysis and estimated demand in Tennessee for biochar-supplemented potting mix
- Obtained ASCENT TEAs and determined the linkage between input and equipment requirements and IMPLAN industrial sectors
- Submitted two journal articles examining the impacts of carbon emissions and credits and the effects on industry feasibility

Publications

Peer-Reviewed Journal Publications

Sharma, B. P., Yu, T.E., English, B.C., Boyer, C., & Larson, J.A. (2019). Impact of government subsidies on a cellulosic biofuel sector with diverse risk preferences toward feedstock uncertainty. (In review). Submitted to Energy Policy.

Sharma, B. P., Yu, T.E., English, B.C., Boyer, C., & Larson, J.A. (2019). Stochastic optimization of cellulosic biofuel supply chain under feedstock yield uncertainty. Energy Procedia, 158: 1009-1014.

Yu, E., Sharma, B.P., English, B.C., & Boyer, C.N. (2019). Economic and environmental analysis of a sustainable jet fuel sector: A game-theoretic perspective. (In review). Submitted to Energy Economics.

Outreach Efforts

Gill, M., Jensen, M., Upendram, S., Labbe, N., & English, B.C. Consumers' willingness to pay for disposable dinnerware molded from wheat straw. Western Agricultural Economics Association Annual Meeting, Coeur d'Alene, Idaho

Gill, M., Jensen, M., Upendram, S., English, B., Labbe, N., Jackson, S., & Lambert, D. (2019). Consumer preferences for environmental attributes in disposable dinnerware. Applied and Agricultural Economics Association, poster presentation, Atlanta, Georgia

Sharma, Bijay P., Yu, T.E., English, B.C., & Boyer, C.N. (2018). Welfare analysis of carbon credits to the sustainable aviation fuel sector: a game-theoretic perspective. CAAFI annual meeting, poster presentation, Washington, DC.

Thomas, M., Jensen, K.L., Clark, C.D., Lambert, D., English, B.C., & Walker, F.R. (2019). Tennessee home gardener preferences for environmental attributes in gardening supplies: a multiple indicators multiple causation analysis. SNA

Yejun, C., Lambert, D., Jensen, K., Clark, C., English, B., & Thomas, M. (2019). Consumer preferences for potting mix product with biochar under the IIA assumption. Western Agricultural Economics Association Annual Meeting, Coeur d'Alene, Idaho

Awards

None.

Student Involvement

Gill MacKenzie, MS student at University of Tennessee
McKenzie Thomas, MS student at University of Tennessee
BiJay Sharma, PhD, postdoctoral associate at University of Illinois

Plans for Next Period

N/A

Task 2 - Support the Lipid-Focused Comprehensive Analyses in ASCENT Project 1 Strategy

University of Tennessee

Objectives

Task 2.1 – Provide national analysis for lipid-based feedstocks

Task 2.2 - Complete supply potential analysis for each lipid fuel pathway, incorporating supply chain costs, preprocessing and conversion facility costs for selected fuel pathways, including social capital and environmental tradeoff components (WSU, PSU)

Task 2.3 - Continue to conduct analysis on new lipid feedstocks, and achieve a one-month turnaround on national analysis, with documentation to follow (this also contributes to Task 2.2)

Research Approach

Same as in Task 1, focused on oilseed analysis.

1. The carinata budget developed last year was revisited by using new information received from Florida.
2. The cover crop carinata was added to the list of potential feedstock candidates; we are in the process of developing a fact sheet for this crop.

Milestone

Initiated a thesis with a chapter focused on carinata.

Major Accomplishments

- The carinata budget has been revised and is under review.

- The Southeast Partnership for Advanced Renewables from Carinata and oilseed U.S. Department of Agriculture projects have been contacted; information has been transferred and compared to our assumptions.

Publications
N/A

Outreach Efforts
N/A

Awards
None.

Student Involvement
None.

Plans for Next Period
Incorporate camelina study, national pennycress study, and carinata analysis into POLYSYS.

Task 3 - Lay the Groundwork for Regional Deployment and Production of Lipids and/or Biomass in Tennessee and the Southeast United States
University of Tennessee

Objective(s)
The University of Tennessee will lead the process of laying the groundwork for supply chain analysis of lipids and/or biomass in Tennessee and the Southeast United States in the following:

- Identifying two potentially viable supply chains to support a specific airport and end user in the Southeast United States, and providing a proposal for a specific (tactical) deployment project
- Delineating sustainability impacts associated with different feedstock choices
- Assessing viable conversion technologies
- Identifying stakeholders and partners
- Convening a workshop for southeastern stakeholders
- Initiating a stochastic analysis of the system
- Evaluating markets for potential coproducts for Task 3 groundwork and deployment projects
- Assisting in the development of social capital spatial analysis to be incorporated in regional analysis

Research Approach
We used similar techniques to those in in Task 1 but focused on the Southeast. We will develop a budget or use information from the modeling efforts in the 2016 Billion Ton Study analysis. We will use BioFLAME, a geographic information system model that has 5-square-mile hexagons defined as supply regions. Information supplied by ForSEAM will be used on logging residue locations through downscaling its estimates from agricultural statistical districts to the supply regions by using the National Agricultural Statistics Service crop supply layer as a means to achieve this goal. The analysis will be run to find where a sufficient supply might be available to provide a sustainable logging residue feedstock.

In examining potential coproduct markets, the research seeks to use the contingent valuation method to determine whether home gardeners would pay a premium for potting mix containing 25% biochar. The method used follows a random utility framework (McFadden, 1974). Responses are structured as a binary variable: respondents choosing the base product being are counted as zeros, and those who choose the 25% biochar product are counted as ones. Respondents are also given the option to select neither product. In the contingent valuation approach used, the prices of the base and biochar-potting mix products are provided to respondents, who may select either or neither product (Hanemann, 1984). The probability of choosing the biochar product is then a function of price, demographics, expenditure patterns, and attitudes. The model is estimated as a logit model, and WTP is calculated by using the estimates.

Additionally, The University of Tennessee Institute of Agriculture convened a workshop in Knoxville, Tennessee on April 24–25, 2019 to address approaches to making SAFs widely available in the Southeast. The invited participants were led through a facilitated brainstorming session to identify barriers restricting progress toward this goal. The group brought to the discussion extensive experience from different operations in the supply chain (from agriculture to airlines), as well as different perspectives from government, academia, and industry. After reviewing the workshop materials, it was decided that analysis was needed on two feedstocks: oilseed cover crop (such as pennycress, camelina, or carinata) and logging or forest residues.

1. Forest and logging residue:
    - From a different project, logging residues were explored, and facility locations were developed for Alabama.
    - The pathway selected for analysis was logging residues delivered directly to ASCENT's fast pyrolysis biorefinery in chipped form.
    - Last year, we found that biorefineries requiring 545,000–720,000 dry tons cannot be located in the Southeast, on the basis of the assumption of a maximum feedstock transportation distance of 70 miles, which was increased to 200 miles; at 150 miles, a capacity of 720,000 dry tons could be located. In a project funded by the Bioenergy Technologies Office, larger facilities were found to be able to be located within less distance if a blended feedstock was used.
    - If collection points were added where preprocessing could be achieved, then five biorefineries could be established at 720,000 dry tons of logging residues/year, if the maximum driving distance was increased to 150 miles.
    - Transportation costs could be reduced if logging residues were blended with a dedicated energy crop such as switchgrass (Figure 1).
2. Completed conversion facility economic feasibility analysis for pennycress/hydroprocessed ester and fatty acid (HEFA) pathway for Nashville airport.
3. Delivered pennycress and crush facility spreadsheets to WSU, Purdue, and PSU for use in other projects and for posting on the ASCENT website.

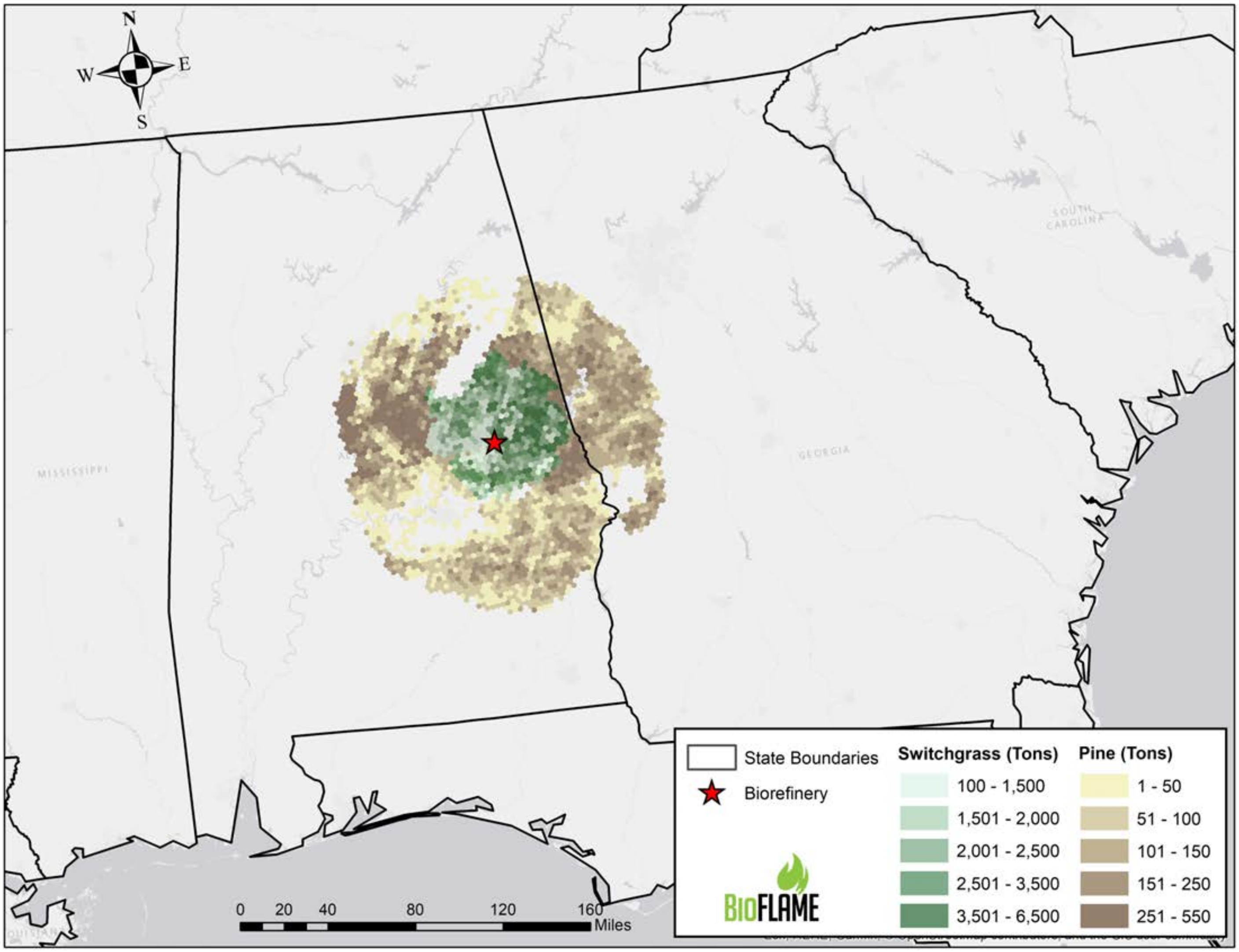

Figure 1. Using a 50–50% blend of pine logging residues with switchgrass a biorefinery reduces transportation needs.

4. Published a Nashville/pennycress article:
   - Use of ASCENT HEFA technology, the crushing facility cash flow spreadsheet, and pennycress as a cover crop feedstock yielded the following findings:
     - Three crush facilities would be required to supply the ASCENT HEFA TEA-based biorefinery.
     - Two of the three would be located in west Tennessee, and one would be located northwest of Nashville.
     - The biorefinery would be located near Nashville, transporting SAF (36 million gallons or 40% of current aviation fuel use) to the airport fuel depot via truck and transporting alternative coproducts to a blending facility (Figure 2).
     - Farmers can produce pennycress within a corn/soybean rotation as a cover crop following corn at a break-even cost of 8.1 cents/pound delivered; the crushing facility, under the assumption of a 12.5% return on investment, can afford to pay 10.5 cents/pound of pennycress seed. If 10.5 cents/pound is paid, the delivery cost to the biorefinery is estimated at $1.09/gallon of unrefined oil, and if

break-even costs are covered, the cost of producing and transporting the oil to the biorefinery is estimated to be $0.80 per gallon.

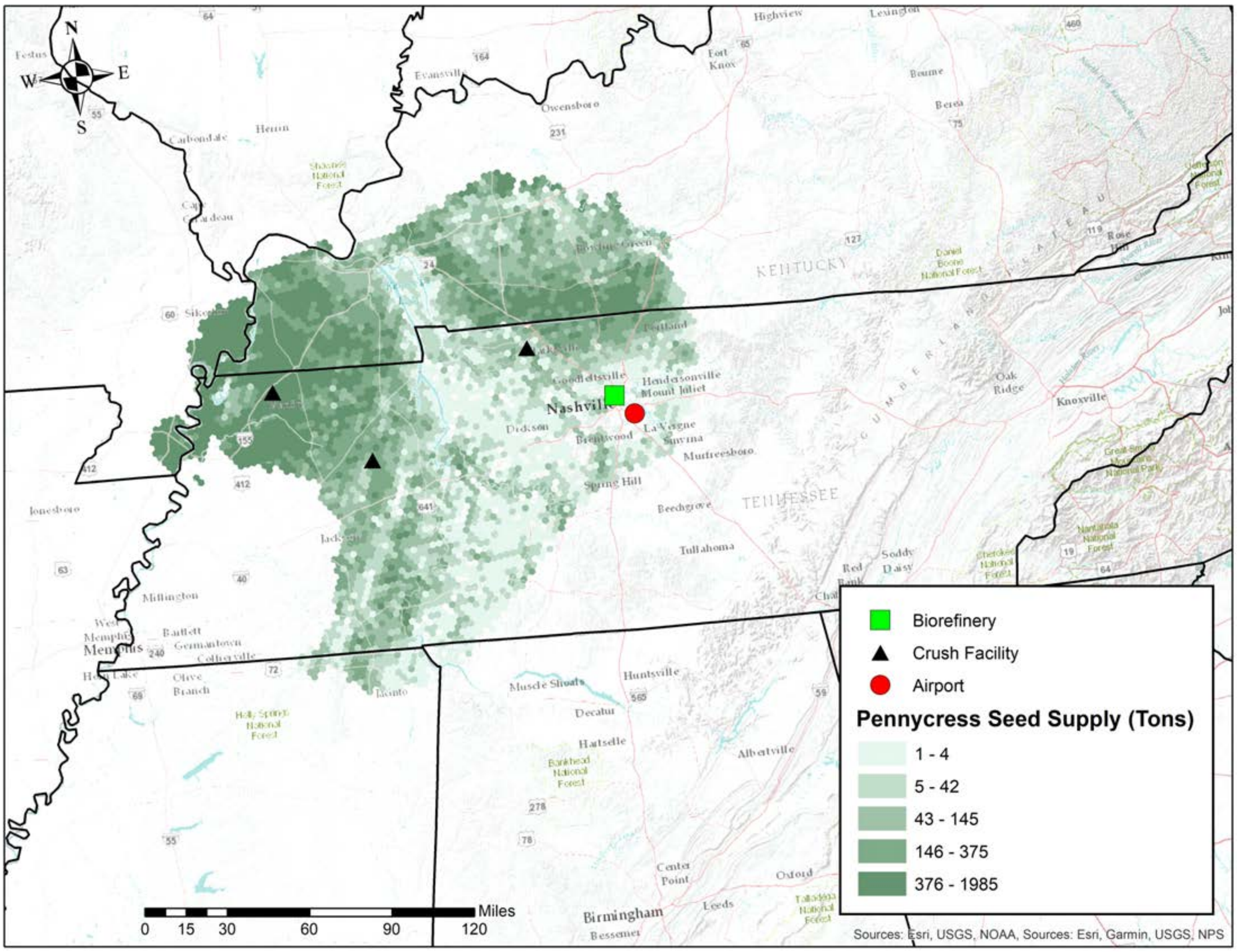

Figure 2. Locations of biorefineries and crush plants to supply nearly 40 million gallons of renewable aviation fuel to the Nashville Airport fuel depot.

5. Identified a number of challenges during the "Sustainable Aviation in the Southeast: Moving from Strategic to Tactical" workshop; pinpointed the following six initial areas hindering broader development of the region's SAF capacity:
    - Create a favorable policy environment: The average carbon intensity of fuels sold in California has declined almost 5% since 2010, thus resulting in a reduction of more than 38 million tons of carbon. A direct result of the low-carbon fuel standard, this finding highlights the potential for well-crafted policy to accelerate regional development.
    - Define sustainability criteria: The fundamental premise of biofuel systems is sustainable production; however, uncertainty exists in the methods and tools available to fully assess specific pathways. Progress is

needed to foster confidence in perceived benefits and to facilitate monetization of ecosystem services (e.g., water quality and carbon sequestration).

- Establish feedstock standards: The Southeast is characterized by a highly fragmented landscape, thus increasing the likelihood of feedstock being produced with an array of crops and biomass sources. This scenario reduces risk and introduces the strategic advantage of blended formulations; however, guidelines are needed to establish required feedstock properties to meet performance targets.
- Increase feedstock readiness level: One opportunity for our rural economy to benefit includes the demand for new, purpose-grown crops on the landscape. Improved management, innovative equipment, and intermediate processing facilities are necessary to advance the feedstock readiness level.
- Expand education programs: The state of the art of SAFs is rapidly progressing. Acceptance of innovative fuel products will require versatile new outreach programs to inform individuals involved in different supply chain operations, as well the flying public.
- Design coproduct strategies: Less than 50 percent of crop biomass is currently used in fuel production. Integrated conversion technologies are needed that fully utilize the individual components of the different biomass sources. Introduction of these new processes will require guidance to identify markets that align demand with potential supply.

Milestone(s)

1. Completed conversion facility economic impact analysis for the HEFA pathway
2. Convened a southeastern stakeholder workshop to collect supply chain input

Major Accomplishments

Completed cover crop analysis for Nashville airport.

Publications

Markel, E., English, B.C., Hellwinckel, C.M., & Menard, J.R. (2019). Potential for Pennycress to support a renewable jet fuel industry. Ecology, Pollution and Environmental Science, SciEnvironm 1:121.

Sharma, B. P., Yu, T.E., English, B.C., Boyer, C., & Larson, J.A. (2019). Stochastic optimization of cellulosic biofuel supply chain under feedstock yield uncertainty. Energy Procedia, 158: 1009-1014.

Trejo-Pech, C., Larson, J.A., English, B.C., & Yu, T.E. (2019). Cost and profitability analysis of a prospective Pennycress to sustainable aviation fuel supply chain in southern USA. Energies, 12, no. 16: 3055.

Outreach Efforts

N/A

Awards

None.

Student Involvement

None.

Plans for Next Period

- Continue to work on logging residues and their potential for meeting SAF needs in the Southeast
- Work on carinata and its potential in meeting the SAF needs at Memphis
- Work on feedstock sustainability issues

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 barriers, along with individuals who expressed interest in supporting the effort, are summarized below. The individual teams will work to better define the barriers and develop strategic approaches to reduce the challenges that they present. Regular web meetings will be hosted to facilitate the discussion.

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

Task 4 - Support Biorefinery Infrastructure and Siting

Washington State University

Objective(s)

The University of Tennessee team will play a supporting role in this task. Several models are available to contribute to the effort, including BioSAT (which is currently available for the 33 eastern states) and BioFLAME (whose geographic scope we hope to expand from its current Southeast U.S. regional focus to the contiguous 48 states).

Research Approach

- Provide feedstock information (location, price, and quantity) to the ASCENT Database
- Contact WSU for ASCENT conversion technologies
- Provide pennycress feedstock information to VOLPE and save it to shared folders available to all ASCENT Project 001 researchers
- Work with WSU on developing a TEA for the crush facility

Milestone(s)

- WSU provided additional TEAs for economic indicator development.
- Economic indicators were developed for those additional technologies, and existing indicators are being updated with the latest IMPLAN data.

Major Accomplishments

We reviewed current financial assumptions developed by Purdue and WSU and used them in our ASCENT analyses.

Publications

N/A

Outreach Efforts

N/A

Awards

None.

Student Involvement

None.

Plans for Next Period

- Complete the TEA for the crush facility and compare solvent-based and mechanical-based crush facilities
- Develop risk analysis around the oilseed pathway for Nashville
- Survey producers in a seven-state area regarding willingness to grow oilseed cover crops
- Explore oilseed/cover crop potential around the Memphis airport
- In June, collect information on oilseed plots and confirm current yield estimates used in the analysis