



Project 001(D) Alternative Jet Fuel Supply Chain Analysis

The Pennsylvania State University

Project Lead Investigator

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University Participants

The Pennsylvania State University

- P.I.s: Lara Fowler, Professor of Teaching, Penn State Dickinson Law; Anne Menefee, Assistant Professor of Energy and Mineral Engineering (starting with funding period beginning June 14, 2022); Armen Kemanian, Professor of Production Systems and Modeling (starting with funding period beginning June 14, 2022; soil related activities transitioning to Project 104); and Seth Blumsack, Professor of Energy Policy and Economics and International Affairs
 - Researchers: Michael Helbing, Executive Director, Penn State Center for Energy Law and Policy; Ekrem Korkut, Legal Research Postdoctoral Associate (position ended June 30, 2024); Yuning Shi, Post Doc, Penn State College of Ag Sciences; Saurabh Bansal, Professor of Supply Chain Management (involvement ended in 2022); Thomas Chase Lam, Graduate Student, John and Willie Leone Family Department of Energy and Mineral Engineering; Emmy Wang, MS Candidate, Agricultural and Environmental Plant Science; Alicia Costello, MS Candidate, Ecology.
- FAA Award Number: 13-C-AJFE-PSU, RISK-INFORMED ALTERNATIVE JET FUEL (AJF)
- Periods of Performance: **Period A:** August 1, 2017, to January 31, 2022; **Period B:** June 14, 2022, to November 13, 2023; **Period C:** October 1, 2022, to September 30, 2023; and **Period D:** July 1, 2023, to September 30, 2026 (time period extended to 2026 through no-cost extension).
- Tasks:
 - Period A (August 1, 2017, to January 31, 2022)**
 1.
 - 1.3.1 Risk-reward profit-sharing modeling for first facilities
 - 1.3.2 Additional quantification of risk and uncertainties in supply chains (foundational part of Task 1.3.1)
 - 1.3.3 Supply chain risk analysis tools for farmer adoption
 - 1.4.1 National survey of current and proposed state and federal programs that monetize ecosystem services
 - 1.4.3 Support of stakeholder engagement efforts
 - Period B (June 14, 2022, to November 13, 2023)**
 1. Law and Policy Research
 - 1.1 Research existing federal law and policy drivers
 - 1.2 Research existing state and regional law and policy drivers
 - 1.3 Research proposed legislation (federal and state)
 - 1.4 Research other law/policy issues, as identified by the ASCENT Project 001 team
 2. Support Stakeholder Engagement Efforts
 - 2.1 Work with ASCENT Project 001 team to identify stakeholder engagement opportunities
 - 2.2 Develop a list of potential stakeholders critical to discussion
 - 2.3 Develop agenda/materials for critical discussions; meeting facilitation as needed
 3. Carbon Capture and Sequestration (CCS)
 - 3.1 Work with ASCENT Project 001 team members to identify critical questions, and refine the scope of work related to CCS



- 3.2 Conduct literature review regarding CCS and its potential use in conjunction with AJFs
- 3.3 Draft a review manuscript examining opportunities to integrate CCS and AJF
4. Organic Soil Carbon
 - 4.1 Work with ASCENT Project 001 team members to identify critical questions, and refine the scope of work related to soil organic carbon (SOC)
 - 4.2 Conduct literature review regarding SOC and its potential relation to AJF
 - 4.3 Draft review manuscript examining opportunities for SOC and AJF

Period C (October 1, 2022, to September 30, 2023)

1. Law and Policy Research
 - 1.1 Research existing and proposed federal law and policy drivers
 - 1.2 Research existing and proposed state and regional law and policy drivers
 - 1.3 Research other law/policy issues, as identified by the ASCENT Project 001 team
2. Support Stakeholder Engagement Efforts
 - 2.1 Work with ASCENT Project 001 team to identify stakeholder engagement opportunities
3. Carbon Capture and Sequestration
 - 3.1 Research integration of CCS
 - 3.2 Work with ASCENT Project 001 team to refine the scope of work and current needs
 - 3.3 Research and review paper on geologic carbon storage potential, with emphasis on permanence and risks (both technical and legal)
4. Organic Soil Carbon
 - 4.1 Refine global modeling systems using Level 3 Global Administrative Areas (GADM), soils from the International Soil Reference and Information Centre (ISRIC), and weather data from the North American Land Data Assimilation System (NLDAS)
 - 4.2 Use machine learning to generate SOC profiles for business as usual (BAU) conditions, or machine learning and combination of Cycles for automated SOC stock calculations; the initial geographic target is the continental United States (CONUS)
 - 4.3 Apply Cycles-A to the task of fitting sustainable aviation fuel (SAF) crops in the current agricultural matrix of the United States (U.S.), with focus on oil crops as an example
 - 4.4 Complete a SOC modeling manuscript with the goal of standardizing methods for SOC (and nitrous oxide) calculations in relation to the carbon intensity (CI) of BAU and SAF production scenarios

Period D. (July 1, 2023, to September 30, 2026)

1. Law and Policy Research
 - 1.1 Research existing and proposed federal law and policy drivers
 - 1.2 Research existing and proposed state and regional law and policy drivers
 - 1.3 Research other law/policy issues, as identified by the ASCENT Project 001 team.
2. Support Stakeholder Engagement Efforts
 - 2.1 Work with ASCENT Project 001 team to identify stakeholder engagement opportunities
3. Carbon Capture and Sequestration
 - 3.1 Research integration of CCS
 - 3.2 Work with ASCENT Project 001 team to refine the scope of work and current needs
 - 3.3 Research and review paper on geologic carbon storage potential, with emphasis on permanence and risks (both technical and legal)
4. Organic Soil Carbon
 - 4.1 Refine global modeling systems using Level 3 GADM, soils from the ISRIC, and weather data from the NLDAS
 - 4.2 Use machine learning to generate SOC profiles for BAU, or machine learning and combination of Cycles for automated SOC stock calculations; the initial geographic target is CONUS
 - 4.3 Apply Cycles-A to the task of fitting SAF crops in the current agricultural matrix of the U.S., with focus on oil crops as an example
 - 4.4 Complete a SOC modeling manuscript with the goal of standardizing methods for SOC (and nitrous oxide) calculations in relation to the CI of BAU and SAF production scenarios

Washington State University (WSU)

- Michael Wolcott, Regents Professor (for funding period from June 14, 2022, to November 13, 2023)
- Kristin Brandt, Staff Engineer (through funding period ending January 31, 2022)



University of Kentucky (UK)

- Burt English, Institute Professor (for work through April 2022); now retired.

Project Funding Level

FAA funding: \$150,000 (for Period D, July 1, 2023, to September 30, 2026)

Matching from Penn State: \$150,000

Total funding: \$300,000

Investigation Team

Period A (August 1, 2017, to January 31, 2022)

- Task 1.3.1 (Bansal; supported by Brandt and English): Risk-reward profit-sharing modeling for first facilities
- Task 1.3.2 (Bansal; supported by Brandt and English): Additional quantification of risk and uncertainties in supply chains (foundational part of Task 1.3.1)
- Task 1.3.3 (Bansal; supported by Brandt and English): Supply chain risk analysis tools for farmer adoption
- Task 1.4.1 (Fowler; supported by Korkut): National survey of current and proposed state and federal programs that monetize ecosystem services
- Task 1.4.3 (Fowler; supported by Korkut): Support of stakeholder engagement efforts

Period B (June 14, 2022, to November 13, 2023)

- Task 1.1 (Fowler, supported by Korkut): Research on existing federal law and policy drivers
- Task 1.2 (Fowler, supported by Korkut): Research on existing state and regional law and policy drivers
- Task 1.3 (Fowler, supported by Korkut): Research on proposed legislation (federal and state)
- Task 1.4 (Fowler, supported by Korkut): Research on other law/policy issues, as identified by the ASCENT Project 001 team
- Task 2.1 (Fowler, supported by Korkut): Work with the ASCENT Project 001 team to identify stakeholder engagement opportunities
- Task 2.2 (Fowler, supported by Korkut): Development of a list of potential stakeholders critical to discussion
- Task 2.3 (Fowler, supported by Korkut): Development of agenda/materials for critical discussions; meeting facilitation as needed
- Task 3.1 (Menefee): Work with ASCENT Project 001 team members to identify critical questions and refine the scope of work related to CCS
- Task 3.2 (Menefee): Conduct literature review regarding CCS and its potential use in conjunction with AJFs
- Task 3.3 (Menefee): Draft a review manuscript examining opportunities to integrate CCS and AJF
- Task 4.1 (Kemanian, supported by Wolcott): Work with ASCENT Project 001 team members to identify critical questions, and refine the scope of work related to SOC
- Task 4.2 (Kemanian, supported by Wolcott): Conduct literature review regarding SOC and its potential relation to AJF
- Task 4.3 (Kemanian, supported by Wolcott): Draft review manuscript examining opportunities for SOC and AJF.

Period C (October 1, 2022, to September 30, 2023)

- Task 1.1 (Fowler, supported by Helbing and Korkut): Research on existing and proposed federal law and policy drivers
- Task 1.2 (Fowler, supported by Helbing and Korkut): Research on existing and proposed state and regional law and policy drivers
- Task 1.3 (Fowler, supported by Helbing and Korkut): Research on other law/policy issues, as identified by the ASCENT Project 001 team
- Task 2.1: (Fowler, supported by Helbing and Korkut) Work with ASCENT Project 001 team to identify stakeholder engagement opportunities
- Task 3.1 (Menefee & Helbing): Research on integration of CCS
- Task 4.1 (Kemanian & Shi): Accounting for SOC and nitrous oxide emissions using agroecosystem models

Period D (July 1, 2023, to September 30, 2026):

- Task 1.1 (Fowler, supported by Helbing and Korkut [through June 30, 2024]): Research on existing and proposed federal law and policy drivers
- Task 1.2 (Fowler, supported by Helbing and Korkut [through June 30, 2024]): Research on existing and proposed state and regional law and policy drivers



- Task 1.3 (Fowler, supported by Helbing and Korkut [through June 30, 2024]): Research on other law/policy issues, as identified by the ASCENT Project 001 team
- Task 2.1: Work with ASCENT Project 001 team to identify stakeholder engagement opportunities
- Task 3.1 (Menefee, Helbing, & Lam): Research on integration of CCS
- Task 4.1 (Kemanian, Shi, Wang, & Costello; with Wang & Costello funded through Project 104): Accounting for SOC and nitrous oxide emissions using agroecosystem models

Project Overview

For the first period of performance (Period A), this project focused on developing a qualitative and quantitative understanding of factors to help establish biofuel supply chains for AJFs. Although efforts are being made to establish these supply chains, many face challenges because of a lack of clarity regarding the incentives that stakeholders would require to engage in these supply chains and devote their resources to investing in the facilities required for these supply chains. To this end, this project has two goals:

1. Develop pro forma cash flows that represent the financial status of various participants in biofuel supply chains for AJFs, to inform a transparent risk-sharing tool; and
2. Understand the policy landscape in various parts of the U.S. to encourage AJF supply chains and identify additional policy initiatives that may be needed.

During the second period of performance (Period B), this project continued to focus on understanding the law and policy drivers associated with AJF and expanded its focus to include two new areas—CCS and SOC—and their potential linkages to AJF.

During the third and fourth periods of performance (Periods C and D), this project continues to stay up to date on the law and policy changes associated with AJF and has also started to focus on important opportunities and knowledge gaps surrounding CCS and SOC. Two new PIs, Dr. Anne Menefee and Dr. Armen Kemanian, were on-boarded to focus on these emerging areas and provide relevant expertise across the ASCENT Project 001 team.

Periods A-B, Summary of All Tasks

The Pennsylvania State University

In this section, we briefly summarize the work done under all tasks in Periods A and B. Complete reports of activity during these periods can be found in annual reports for years 2024 and earlier.

During Periods A and B, research team members performed a number of research tasks designed to develop a qualitative and quantitative understanding of factors driving the establishment of biofuel supply chains for AJFs.

- The research team developed four Microsoft Excel® models using data from techno-economic analysis models developed by WSU to serve as a risk-sharing tool for better understanding of risks faced by supply chain members.
- Researchers developed a new econometric approach to quantify the probability distributions of uncertain quantities, such as yield or demand; that method was described in two manuscripts, which are listed among the publications below.
- The team performed a survey to better understand farmers' risk tolerance in certain situations. The results of this survey were presented in a manuscript that was submitted to the sponsor.
- An extensive effort was undertaken to survey and summarize current and proposed state and federal programs to monetize ecosystem services. That effort resulted in one peer-reviewed publication and four white papers, all of which are listed below.
- Throughout the project, we have worked to engage stakeholders and facilitate effective dialogue to help bridge gaps among producers, industry, government, and other affected stakeholders.
- In Period B, we initiated our work to study the integration of CCS into supply chains for AJF. We also began our research into critical questions regarding the effects of SOC on sustainability efforts related to AJF.

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Publications

Peer-reviewed journal publications

- Bansal, S., & Gutierrez, G. J. (2020). Estimating uncertainties using judgmental forecasts with expert heterogeneity. *Operations Research*, 68(2), 363-380. doi: 10.1287/opre.2019.1938
- Korkut, E. & Fowler, L. B. (2021). Regulatory and policy analysis of production, development and use of sustainable aviation fuels in the United States." *Frontiers in Energy Research*, 9, 750514. doi:10.3389/fenrg.2021.750514.

Written reports

- Bansal, S., & Wang, T. (2019). Using subjective probability distributions to support supply chain decisions for innovative agribusiness products. Report for the *Federal Aviation Administration*.
<https://s3.wp.wsu.edu/uploads/sites/2479/2021/05/ASCENT-Project-001D-attachment-1.pdf>
- Bansal, S., & Gutierrez, G. J. (2021). Optimal aggregation of individual judgmental forecasts to support decision making in an R&D program. Submitted to *Operations Research*.
<https://s3.wp.wsu.edu/uploads/sites/2479/2021/05/ASCENT-Project-001D-attachment-2.pdf>
- Korkut, E., & Fowler, L. (2021). *Regulatory and Policy Analysis of Productions, Development and Use of Sustainable Aviation Fuels in the United States* [White paper, draft]. Pennsylvania State University. [2021_01_08_SAF paper draft circulated for review_KCL_NB \(1\).docx](#)
- Western U.S. policy manuscript (with a focus on Washington State, last updated in 2019): [Southeast Bioenergy Law & PolicyDraft3.docx](#)
- Southeast policy manuscript (with a focus on Tennessee): [Southeast Bioenergy Law & PolicyDraft3.docx](#)
- Hawaii policy manuscript: [Hawaiian Biofuel Law & Policy_v5.docx](#)

Periods C-D, Task 1- Law and Policy Research

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Objectives

Stay up to date with existing and proposed federal law and policy drivers affecting SAF, including participation by the U.S. in international discussions and agreements (Task 1.1).

- Research existing and proposed state law and policy drivers (Task 1.2).
- Explore other issues identified by the ASCENT Project 001 team as needed (Task 1.3).

Research Approach

Following up on our previous law and policy research, the ASCENT Project 001 team stayed abreast of developments related to the One Big Beautiful Bill Act provisions related to SAF as well as broader legal developments that could have an impact on SAF. In addition, a 50-state survey of laws and policies impacting SAF development was completed and developed into presentations and a draft paper.

Milestone

At biweekly team meetings and semi-annual conferences, updates were provided on legal research topics. Email updates were sent as appropriate regarding significant legal developments.

Major Accomplishments

A presentation on the "50-State Survey" was presented in April 2025 at the SAF Spring Meeting in Knoxville, TN. Fifty-state survey research was also presented in poster form at the Penn State Climate Solutions Symposium in May 2025 and the ASCENT Fall Meeting in October 2025. In addition, Helbing led a team of ASCENT researchers exploring avenues of future research.

Publications

Peer-reviewed journal publications

- Korkut, E. & Fowler, L. B. (2021). "Regulatory and policy analysis of production, development and use of sustainable aviation fuels in the United States." *Frontiers in Energy Research*, 9, 750514. doi:10.3389/fenrg.2021.750514.



A manuscript presenting the 50-state survey research has been drafted and will be presented for FAA review early in the next cycle.

Outreach Efforts

Presentations

- Helbing, M. (2024, October). *Flying into the Future: Sustainable Aviation Fuel and the Policies Impacting its Development* [Oral presentation]. Penn State Earth and Environmental Systems Institute EarthTalks Series.
- Helbing, M. (2024, November). *Session 5: Discussion of other policy options that might merit review under the SAFGCR Action Area 4 - Policy Valuation and Analysis, Workstream PA.3 – Inform SAF Policy* [Panelist in oral presentation] Alternative Fuels & Chemicals Coalition’s SAF Workshop, Oxon Hill, MD.
- Johnson, M., & Helbing, M., (2025, April). *50-state Survey* [Oral presentation]. Spring 2025 ASCENT Sustainable Aviation Fuel Meeting, Knoxville, TN.

Poster

- Johnson, M., Helbing, M., & Fowler, L. (2025, May). *A 50-state Survey of Sustainable Aviation Fuel Policy*. [Poster]. Penn State Climate Solutions Symposium.

Awards

None.

Student Involvement

Third-year law student, Mary Johnson, researched policies affecting SAF development in all 50 states and presented her research at the ASCENT SAF Spring Meeting in Knoxville, TN, in April 2025.

Plans for Next Period

Our team will continue to work with the ASCENT Project 001 team to identify potential law and policy concerns and opportunities. Our team will also continue to explore how SAF and renewable natural gas might be developed in synergistic ways. We will complete the manuscript documenting the data from our 50-state survey and hope to publish it once it is approved by the FAA. We also plan to explore the possibility of creating and maintaining a website to make this information available to the public. Depending on available funding, we also hope to extend our research to include economic and logistical research into government programs such as low-carbon fuel standards and the One Big Beautiful Bill Act. Our team will continue to engage with other ASCENT Project 001 team members on evaluating areas for future research.

Periods C-D, Task 2 - Support Stakeholder Engagement Efforts

The Pennsylvania State University

Objective

Facilitate dialogue among producers, industry, government, and other affected stakeholders.

Research Approach

Our work under this objective has focused on stakeholder engagement and facilitation of effective dialogue to help bridge gaps among producers, industry, government, and other affected stakeholders. This role supports the needs of other team members.

Milestone

These efforts have supported stakeholder engagement efforts led by other teams, including but not limited to the regional partners identified in ASCENT Project 001.

Major Accomplishments

Our team has continued to participate in discussions and calls related to potential stakeholder engagement needs. Those discussions this year included conversations with Steve Csonka from the Commercial Aviation Alternative Fuels Initiative (CAAFI) and other members of the ASCENT research team. We have also held calls with officials from both the Pittsburgh



International Airport and the Philadelphia International Airport to discuss their SAF initiatives. Through networking at various events, we have also established relationships with representatives from Lanza Jet and Third Way, among others.

Publications

None.

Outreach Efforts

Michael Helbing attended the North American SAF Conference and Expo in Minneapolis, MN, in September 2025.

In June 2025, Fowler and Kemanian were part of a Pennsylvania delegation that traveled to Denmark to explore and understand the Danish biogas industry, which is significantly more advanced and integrated to the energy matrix and agricultural nutrient management than American biogas. This experience provided Fowler and Kemanian with an understanding of how the biogas industry in Denmark came to be so advanced as well as enhanced relationships with biogas stakeholders, including several Pennsylvania officials. This tour also highlighted opportunities for turning biogas co-products into sustainable aviation fuel.

Helbing has also had informal conversations about SAF at meetings not specifically dedicated to SAF, including the Penn State Climate Solutions Symposium and a project meeting of CO2-SMART: A National Science Foundation Industry/University Cooperative Research Center.

Awards

None.

Student Involvement

None.

Plans for Next Period

Work will continue with other ASCENT partners to facilitate work to support the U.S. delegation to the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) Working Group 5. Specifically, the aim is to deepen relationships with the Fueling Aviation's Sustainable Transition SAF grant recipients affiliated with the Philadelphia and Pittsburgh airports in Pennsylvania. We will also work with stakeholders to perform research into the impacts of government programs like low-carbon fuel standards and the One Big Beautiful Bill Act. As needed, support will be provided to working groups.

Periods C-D, Task 3 - Carbon Capture and Sequestration

The Pennsylvania State University

Objectives

- Work with ASCENT Project 001 team to identify critical questions and needs surrounding the potential for CCS in SAF/AJF supply chains and support other tasks looking to integrate aspects of CCS (e.g., carbon footprint, techno-economic, and feasibility analyses).
- Conduct literature review to understand the potential opportunities, challenges, research needs, etc.

Research Approach

The initial stages of the CCS task involved in-depth literature review to understand knowledge gaps and existing pathways to integrate CCS into SAF/AJF supply chains. Our approach and objectives were refined through discussions with the ASCENT Project 001 team to focus more on policy and risk related to CCS and to identify hurdles that need to be addressed to (1) enable integration into SAF/AJF supply chains and (2) achieve real and quantifiable emission reductions. As a result of those efforts, Dr. Anne Menefee and Michael Helbing finalized a white paper that has been distributed among ASCENT Project 001 team members and is now currently available on the Penn State Center for Energy Law and Policy website.





This project year, the work has expanded to developing regional U.S. case studies incorporating life cycle assessment to identify opportunities and challenges for CCS both on the side of fuel production and carbon dioxide (CO₂) transport/end use. We are developing the life-cycle assessment (LCA) framework in alignment with Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) guidance. This work is intended for a paper that will provide realistic assessments of SAF-CCS feasibility, based on realistic examples of AJF production facilities and the practical and logistical considerations of geologic CO₂ storage.

Milestone

PI Menefee along with researcher Helbing finalized a white paper discussing technical and policy research about CCS in SAF development. PI Menefee has also been involved in the CCS ad hoc group and sustainability working group.

Major Accomplishments

A white paper was drafted and circulated discussing the technical and policy research about CCS in SAF development. Menefee and Helbing also presented this paper at ASCENT Project 001 team meetings.

Publications

Menefee, A., Helbing, M. (2025). *Carbon Capture and Storage in Sustainable Aviation Fuel Supply Chains* [White paper]. PennState Center for Energy Law and Policy. <https://celp.psu.edu/wp-content/uploads/2025/01/SAF-CCS-white-paper-final-January-2025.pdf>

Outreach Efforts

None.

Awards

None.

Student Involvement

In this project year, Menefee has brought on a graduate student, Thomas Lam (M.S. in Chemical Engineering, University of Virginia). Lam is working with Menefee and Helbing on current research initiatives, developing case studies for incorporation of CCS into AJF supply chains with quantitative LCA analysis focused on how CCS impacts carbon intensity.

Plans for Next Period

Menefee and Helbing will continue to work with student Lam to develop an LCA model and accompanying paper discussing the feasibility of CCS in SAF production using realistic scenarios, alongside tradeoffs with respect to emission reductions and economic/logistical considerations.

Periods C-D, Task 4 - Organic Soil Carbon

The Pennsylvania State University

Objectives

Incorporate Penn State expertise on soil carbon and nitrogen cycling in the context of the calculation of the carbon intensity of SAF. This includes incorporating carbon cycling modeling and the inclusion of uncertainty bounds, methods for standardizing calculations that encompass baseline (or reference) scenarios and SAF production scenarios. These methods need to be applicable worldwide, but the initial focus is CONUS. In addition, it is expected that similar work accounting for the nitrogen cycle including the carbon footprint associated with the use of fertilizers and an accounting for the emissions of nitrous oxide, whose equivalent carbon footprint can surpass that of SOC both as a positive or negative climate forcing. These objectives will transition to ASCENT Project 104, now established.

Research Approach

The research approach for this task includes developing a standard method to account for land use and SAF production using Earth Stats and level three GADM to report calculations on a field basis but also on political units of relevance that are standardized around the world. This task also includes overlaying the NLDAS climate databases (reanalysis), and ISRIC soils, so that the model Cycles (developed in Dr. Kemanian's lab) can be operated through the cropland domain. Finally,



this task includes using machine learning combined with a standard initialization procedure to estimate steady state soil carbon stocks under BAU and alternative SAF production scenarios.

Milestone

The team established a stable database of land use, weather data, and soils, along with automated methods to run simulations with Cycles, and downloaded and curated the USDA-Natural Resources Conservation Service (NRCS) pedon database for machine learning analysis. This database has been augmented for soils, which enables adding the source of the soil data used in simulations to the uncertainty analysis. The proper allocation of biomass to rainfed and irrigated land, as well as carbon inputs from animal manure, has been resolved at the county level. We now aim at completing estimations of carbon inputs from crop residues. Only corn has been completed so far, with excellent results.

Major Accomplishments

Dr. Yuning Shi updated the global weather data from the Global Land Data Assimilation System (GLDAS) reanalysis database, to allow simulation of any crop rotation worldwide.

Dr. Yuning Shi and Dr. Armen Kemanian started developing a two-dimensional (2D) version of the model Cycles that will allow simulation of nitrous oxide fluxes in systems with banding of nitrogen fertilizer or manure. Banding is a common practice in crop production. Ignoring nitrogen banding can lead to gross underestimations of nitrogen uptake by crops and alter nitrous oxide emission estimates. The 2D version relies on the use of C-language Variable-coefficients ODE solver (CVODE), a solver for a system of ordinary differential equations maintained by the Lawrence Livermore National Laboratory. So far, water transport in 2D is still being tested, including infiltration that is resolved using a modification of the Green and Ampt method, and water redistribution using Richards equation.

Publications

Dr. Armen Kemanian co-authored a manuscript positing that the return to the soil of high-lignin fermentation byproducts, (i.e., the leftovers of fermenting cellulosic materials for ethanol or other products) can balance or overcome the otherwise expected SOC losses from the removal of corn residues. The manuscript was published in *Environmental Research Letters* on August 2, 2024 (Lynd et al., 2024).

Peer-Reviewed Journal Publication

Lynd, L., Kemanian, A., Smith, J., Richard, T. L., Arifi, A., Bozzetto, S., Fabbri, C., Field, J., Pries, C. H., Kubis, M. (2024). Soil application of high-lignin fermentation byproduct to increase the sustainability of liquid biofuel production from crop residues, *Environmental Research Letters*, 19(8). doi: 10.1088/1748-9326/ad601a

Outreach Efforts

Presentations

Kemanian, A. (2024, October). *Risk-Informed Alternative Jet Fuel (AJF) Supply Chain Analysis: Top-Down Modeling of Soil Organic Carbon in Cropland* [Oral presentation]. Fall 2024 ASCENT Advisory Committee Meeting.

Posters

Posters from students have been added to the corresponding section of the report for ASCENT Project 104.

Awards

None.

Student Involvement

P.I. Armen Kemanian hired Emmy Wang, MS Candidate, Agricultural and Environmental Plant Science, and Alicia Costello, MS Candidate, Ecology, to contribute to this research. Both presented posters at the ASCENT 2025 Fall Meeting in Alexandria, VA.

Plans for Next Period

As a joint-effort by the Penn State team working on ASCENT Projects 001 and 104, the top-down modeling of the SOC balance at the county level presented in the ASCENT meeting in Alexandria, VA, in October 2024 is being refined. The



results will be summarized in a draft article for publication. Specifically, the analysis to date used SOC from the STATSGO (U.S. General Soil Map) database; it will be replaced (or duplicated) with the global Soil Grids database from the ISRIC. Carbon input, which was estimated using only grain yield and forage yield, will be updated with a longer statistical time series from the National Agricultural Statistical Service and parsed for rainfed and irrigated land, although the analysis will only focus on rainfed soils. As reported before, the analysis has been completed for corn, and we are proceeding with estimates of carbon inputs from other crops. The target journals are *Global Change Biology - Bioenergy* (Oxford) and *Energy Advances* (Royal Society of Chemistry). This manuscript will complete the transition of SOC and nitrogen work from ASECENT Project 001 to ASCENT Project 104.