OAK RIDGE National Laboratory

DOE Bioenergy Technologies Office (BETO) 2021 Project Peer Review

WBS 4.2.1.42

Attribution Analyses & Inter-Agency Collaborations

10 March 2020

Data, Modeling & Analysis Platform

Keith L. Kline (PI) and Rebecca Efroymson

ORNL Environmental Sciences Division

Project Overview

- **2-year project (new FY20-21) with two tasks**
  1. *Improve attributional and environmental analyses* for EPA report "Biofuels and the Environment: the Third Triennial Report to Congress" (TRtC or Report to Congress)
  2. Strengthen strategic collaborations to *expand benefits of BETO sustainability and attribution research* (e.g., IEA Bioenergy, role of biomass in the Circular Economy)
- **What are aims?**
  - Apply evidence-based methods to quantify effects attributable to biofuels
  - Amplify benefits of BETO analysis & sustainability investments

- **How is it done?**
  - Build partnerships & coauthor high-impact reports and peer-reviewed publications
  - Respond strategically to requests to address major analytical gaps
- **Why is it important?**
  - Sustainable biomass is essential to achieve climate and circular economy goals
  - Accurate attribution & measurement of effects is required to support decisions
  - *Wicked problems such as attribution for land-use change persist, but they benefit from collaboration to advance research and distribute findings*
  - Building consensus among agencies and other biofuel stakeholders will give the public more confidence in findings

1-Management & ORNL team

Management plans achieve goals defined with sponsors & collaborators while keeping parties informed. ORNL roles: research, reporting, coordination, outreach to stakeholders.

- *Weekly* check-ins with ORNL's Bioresource & Engineering Group
- *Monthly* BETO A&S calls & Monthly financial and progress reviews with sponsors & managers
- *Quarterly* progress reports, quarterly milestone reports, financial-vs-progress reviews & check-ins.

Keith Kline, PI
Sustainable development & evaluation involving renewable energy systems & natural resources management.

Rebecca Efroymson
Causal analysis, environmental effects; Lead author of Billion-Ton 2016-Enviro Impacts (Vol. 2)

Gbadebo Oladosu
30 years energy resource and environmental economist, policy analysis and modeling

Henriette Jager
Senior scientist & modeler specializing in ecosystem services provided by renewable energy systems

Mathew Langholtz
natural resource economist; lead for Billion Ton resource assessments

Nagendra Singh
Geospatial scientist; remote sensing, spatial-temporal analytics

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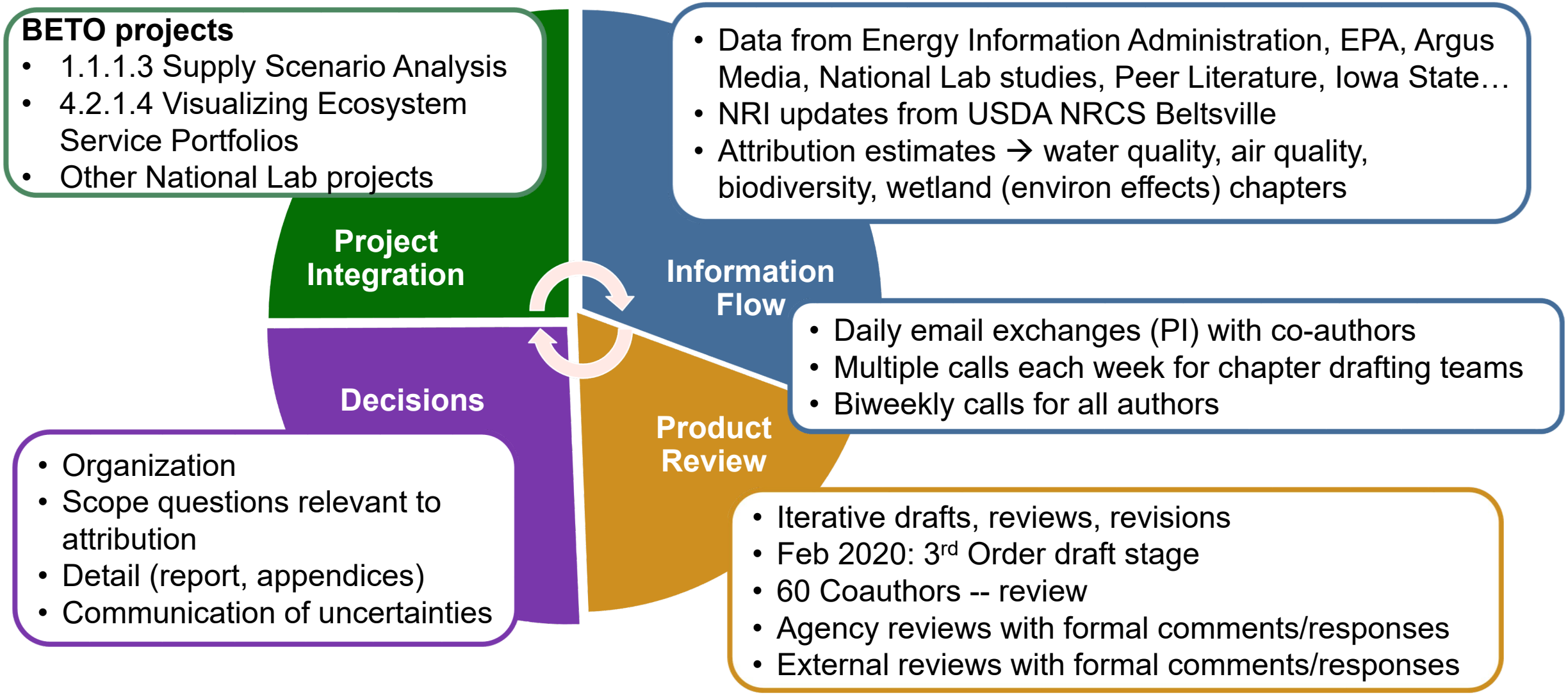
1-Management – strategic interventions to achieve goals
(Task 1)



1-Management - Collaborations expand benefits of research

Management strategy: engage to develop products with *shared ownership via appropriate lines of information exchange*

- IEA Bioenergy (Task 2)
  - U.S. team calls for all Tasks hosted by BETO Jim Spaeth (biweekly / monthly)
  - IEA Tasks 43 & 45 on sustainable supply chains:
    - Monthly Task calls
    - Participation in planning 3-year triennial work products
    - Coauthor and review reports and assessments
- Success Factors (both Tasks)
  - Catalyze evidence-based attributional analyses
  - Collaborate to improve baselines and selection of data & analyses
  - Employ methods that are transparent and replicable
  - Transfer knowledge & skills to others

IEA Bioenergy
Technology Collaboration Programme

1-Management – Risks and mitigations

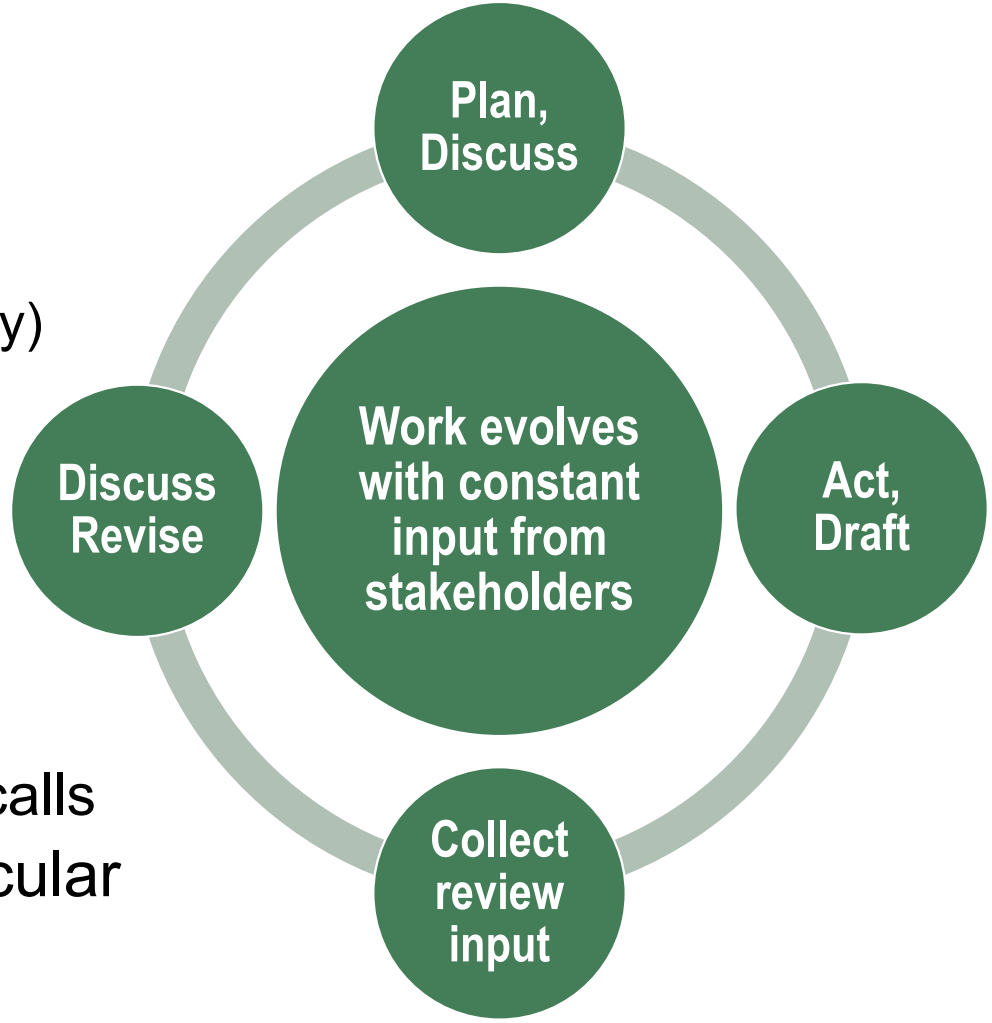
Risks	Mitigations
Delayed approval of Report to Congress[1] Extensive and conflicting comments or opposition to release	Engage agencies in drafting & reviews. Discuss and address concerns and comments. Develop materials to share findings via other, follow-on, publications.
Insufficient data to meet EPA goal of quantifying environmental effects of Renewable Fuel Standard	Acknowledge uncertainties and quantify ranges of potential effects. Identify areas for future joint research.
Lack of acceptance of innovative causal analysis methods by multidisciplinary authors	Recognize that paradigm shifts take time. Propose simplified approaches for using multiple lines of evidence.
Report and related publications require contributions after current project ends	Propose a 3rd year to complete revisions and responses to comments, and to submit publications with agency partners

1. The legislation creating Renewable Fuel Standards (RFS) (EISA 2007, Section 204) calls for EPA to report to Congress on the environmental and resource conservation impacts of the program, specifically air and water quality, water quantity, ecosystem health and biodiversity, soil quality, invasive species, and international impacts. EPA invited DOE and USDA to join in the development of this, the third report to Congress.

1-Management - Stakeholder communications to amplify impacts of BETO research

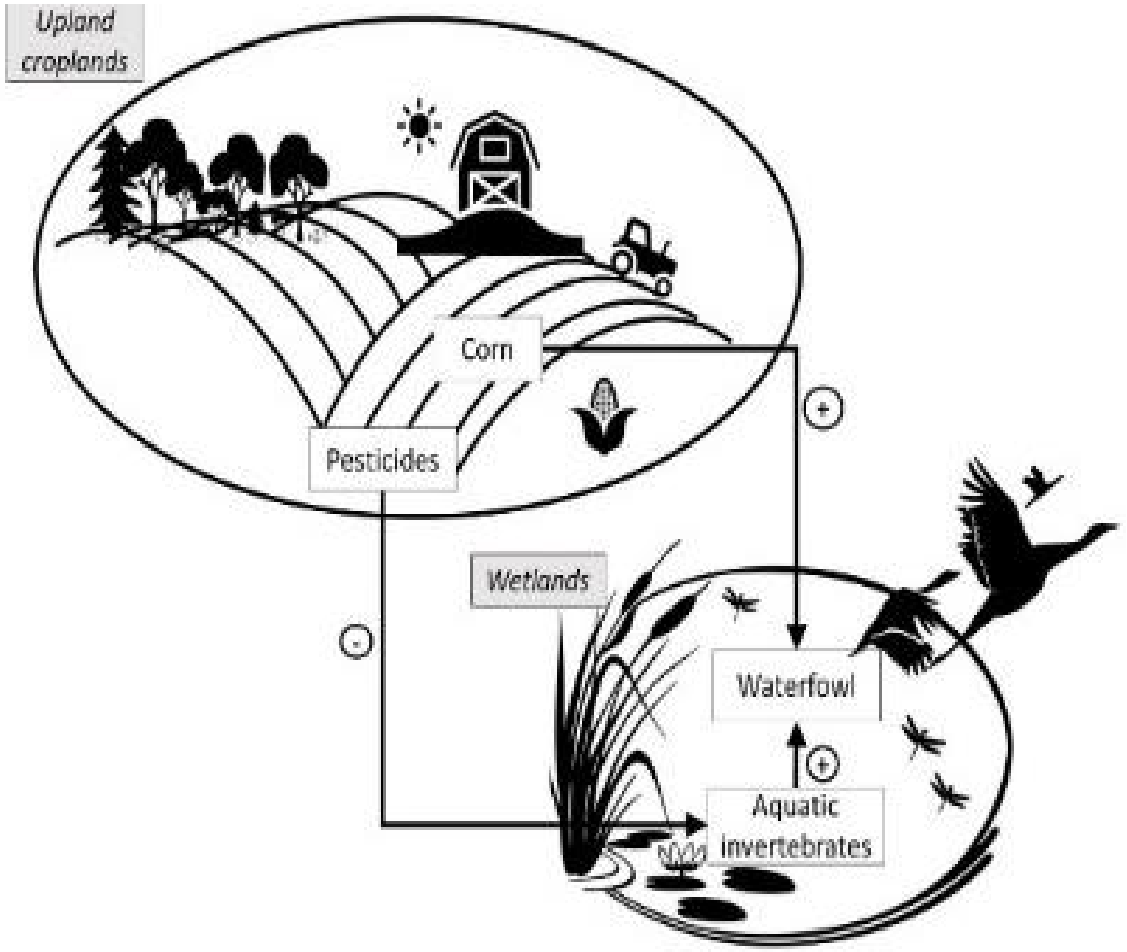
Management strategy: engage stakeholders to develop products with shared ownership. Examples (Task 2):

- Role of sustainable biomass in a ***Circular Economy***
  - Serve as expert on four drafting teams
    - Zoom calls/webinars (1-3 per week)
    - Shared working documents & email exchanges (daily)
  - ISO Technical Committee 323 Circular Economy
    - Weekly updates and monthly calls with U.S. Technical Advisory Group
    - Monthly updates to BETO, IEA, & managers
    - Quarterly reviews of progress → adjust future plans to increase efficiency and effectiveness
  - UL 3600 Circular Economy expert group: biweekly calls
- Private sector interest & representation in the circular economy work groups is high (>100 representatives)



2-Approach in Report to Congress** advances state-of-art

- Approach advances state-of-art by ***applying ORNL's causal analysis framework and recent work on economics, land-use, and ecosystem services to the TRtC.***
- Constructive collaborations between EPA, USDA, and national labs ***strengthen report's balance, analytical basis for estimating effects, and principal conclusions***.



*** High Impact Science Assessment, HISA Report**

Future work: responses to Agency and external reviews will require effort in FY22.

- Contribute to 9 Chapters of TRtC.
- *Approach reinforces links among BETO projects at ORNL and other labs.*

ORNL Projects

- Supply Scenario Analysis 1.1.1.3
- National Strategic Benefits 4.1.2.41
- Geospatial Analysis of Ecosystem Service Portfolios 4.2.1.40
- Science-based Reference Scenarios 3.1.4.001
- This project 4.2.1.42

2-Approach: Flexibility & innovation → effective contributions

- Identify, critically review & interpret emerging science, publications
- Make strategic contributions that address gaps and needs of collaborators
  - Task 1: Work as part of EPA-led team, responsive to their plan, deadlines, comments
  - Task 2: Work on teams with colleagues in IEA Bioenergy, international voluntary standards bodies, other research teams as co-contributors to priority deliverables and outcomes
- *If successful, the approach helps BETO achieve its goals to*:
  - Enhance economic and environmental sustainability of an expanding US bioeconomy
  - Provide consistent quantification of net effects attributable to bio-based fuel production chains

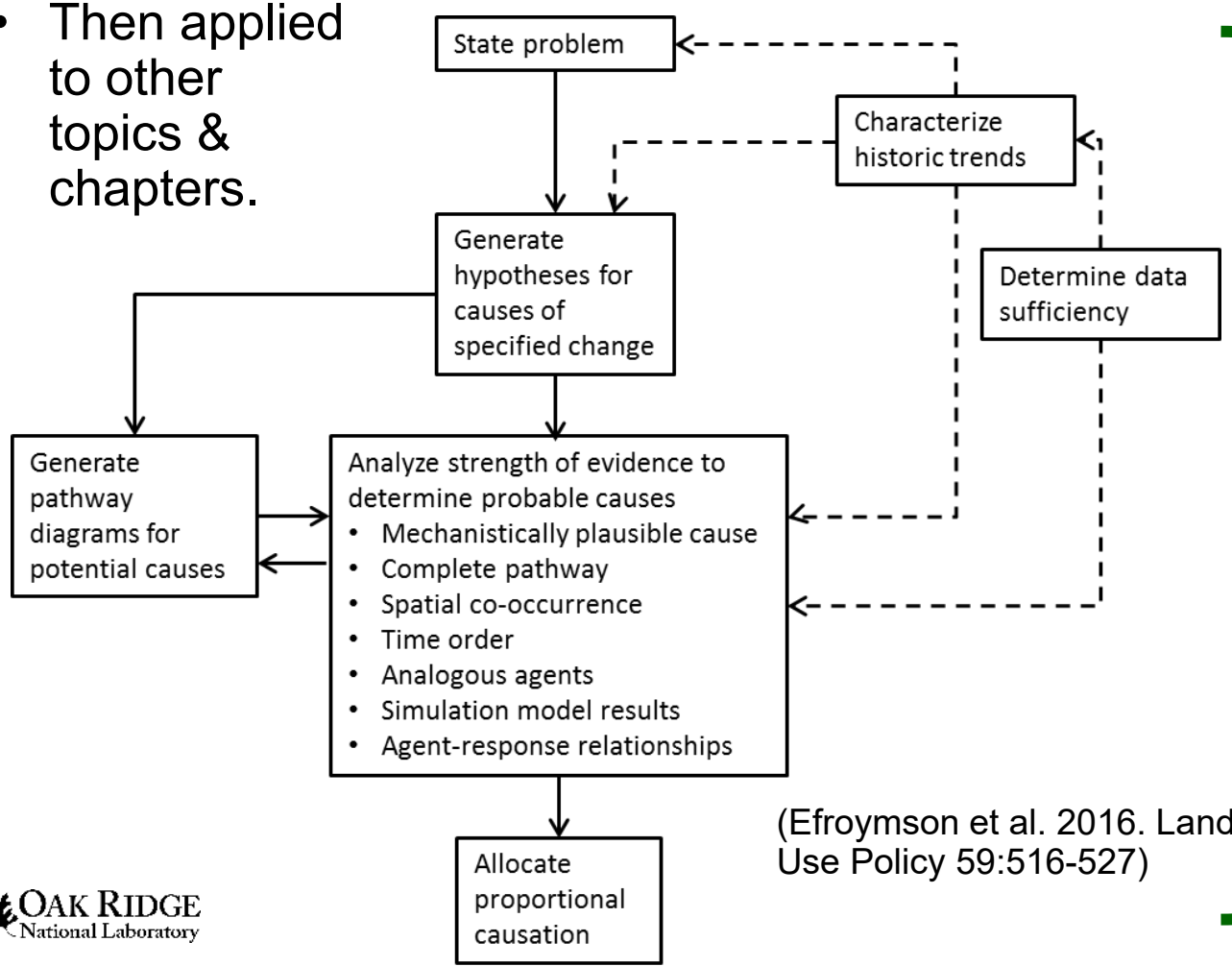
2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BIOENERGY TECHNOLOGIES OFFICE

Approach responds directly to 2019 Peer Review recommendations for BETO: increase coordination with other agencies & research on attribution.

2 – Causal Analysis: innovative approach to attribution

- Innovative causal analysis approach for bioenergy applied to develop First Order Draft of Report with EPA & USDA
- Causal analysis approach tested 1st on ethanol production, corn production, and land management attributable to RFS
- Then applied to other topics & chapters.



(Efroymson et al. 2016. Land Use Policy 59:516-527)

- Approach adjusted based on reviewer comments
- The revised causal analysis
  - retains focus on observed change (e.g., in ethanol output)
  - uses explicit lines of evidence
  - estimates quantitative ranges where possible

Causal analysis approach has *significant* bearing on the Report to Congress → share of attributable effects.

3 – Impacts & relevance: understanding cause and effects helps identify better supply chain designs & practices

Example, “Amplifying impacts of DOE research: enhancing sustainability of agricultural landscapes in developing nations (see publications)

Other Impacts: Scientific productivity *in addition to TRtC:*

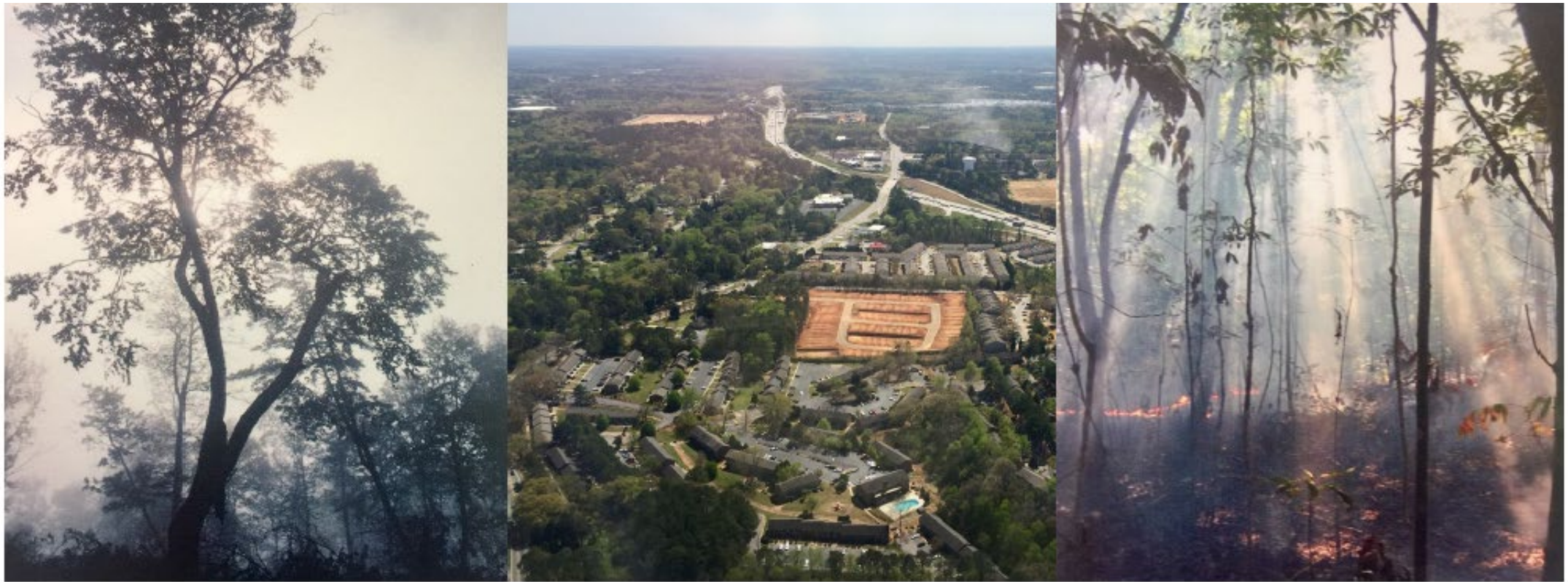
- **19 Publications**
- **11 Presentations**
- **Reports, reviews, & acknowledgements**

Causal analysis applied: a science-based, systematic method to consider weight of evidence by testing observations with sufficient documentation to facilitate replication

- ✓ Start with clear definition of problem
- ✓ Test hypotheses, links in causal chains
- ✓ Conduct critical analysis
- ✓ Document effects
- ✓ Test for potential causal agents
- ✓ Document results
- ✓ Ask the right questions

3 – Example: causal analysis helps frame science questions

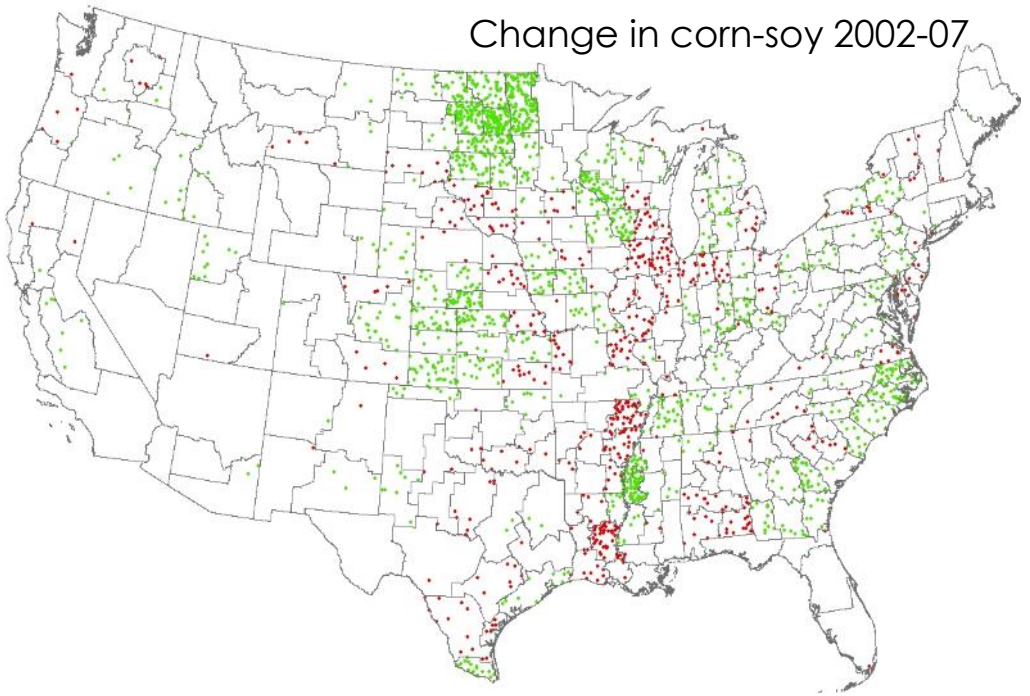
- First: When, where, what type, and how much “effect” is observed?
  - What share of observed increase in ethanol production is attributable to the RFS?
  - What share of US imports of biofuels are attributable to the RFS?
- What are plausible *causes* versus buffers and catalysts?
- What are reasonable alternatives, counterfactuals, or natural experiments?

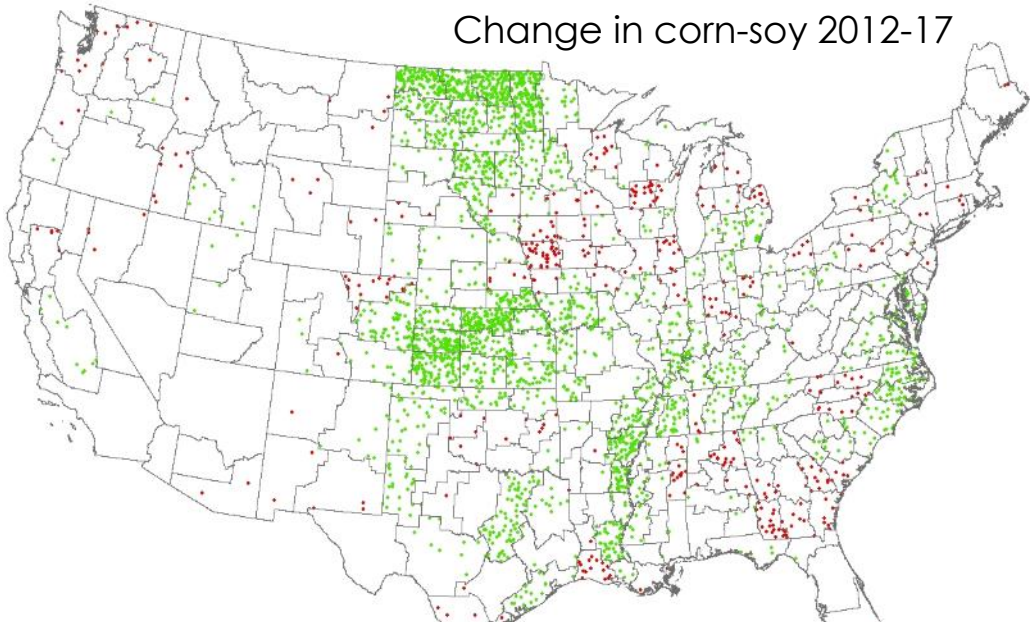


3 – Impacts (Report to Congress)

Substantive contributions to nine sections of the EPA-led "High-Impact Scientific Assessment" for the Triennial Report to Congress

- Clarified terminology: for example, "land cover and land management" replace "land use change"
- Used new approach for causal analysis and empirical evidence
- ***Increased understanding among 60 coauthors and capacities to conduct future assessments***
- Synthesized causal "lines of evidence" to identify priorities for future, joint research initiatives
- Improved visualization of change by providing maps and figures
  - Representation of USDA NRCS Natural Resource Inventory acreage data
  - Consistent measures for visualizing where and how much net change occurs (1 dot = 5000 acres (increase or decline) in each time step)





ORNL maps using USDA NRCS 2017 NRI data

3 – Impacts & significance: addressing key barriers to a sustainable bioeconomy

- Biomass recognized as essential to achieve climate, circular economy, and sustainable development goals but…
- *Bioeconomy cannot advance without public support which is limited by many concerns linked to attribution.*
- Accurate attribution and measurement of effects is required to support "continual improvement" & adaptive management (box)→
- Wicked problems benefit from collaborations to more quickly advance research, build consensus, and distribute findings
- Improved attribution reduces controversies & uncertainties associated with effects of bioenergy and related programs (RFS)
- Costs and benefits of an expanding US bio-based economy are more clearly and consistently quantified and communicated to Congress and stakeholders.

Attribution of past relationships offers guidance for how to get from the present to desired future conditions, including how to achieve BETO goals.

Task 2 partnerships build understanding and support for bioenergy integrated with landscape designs to provide multiple services & support Sustainable Development Goals (Kline et al. 2021; *Sustainability;* Dale et al. 2020 Lessons learned *Futures*).

4 – Linking project impacts & outcomes to DOE goals

supports

supports

Project

- Joint science-based research, EPA, USDA, Non-profits…
- Identifies ways to clarify and reduce risks
- Leverages resources via in-kind& SPP collaborations
- Responds to industry concerns about how attribution is calculated

BETO MYP

- Reduces uncertainties about sustainability measures and market access
- Increases understanding of science-based approaches for assessment
- Prepares and publishes high-quality, reproducible, analyses conducive to
  - Continual improvement
  - Adoption of better practices

DOE-EERE Goals

- Address barriers for market acceptance
- Accelerate deployment of domestic sources
  - Clean
  - Secure
  - Bioeconomy
- Lower transaction costs
- Reduce investment uncertainties
- Create value-added jobs

4 - Progress: Milestones met or exceeded, on time

FY20 Q1	Science-based inputs are proposed and accepted for consideration in development of analyses to support the 3rd Triennial Report to Congress (TRtC).	✓
Q2	Contributions to U.S. Technical Advisory Group and ISO Technical Committee 323 Circular Economy, clarify role of advanced biofuels and bioproducts in circular economy.	✓
Q3	The TRtC first order draft incorporates innovative analyses for land management and cover change attribution, and international effects (see Go/No-go in extra slide)	✓
Q4	Analyses are designed and completed to help clarify bioenergy-related attribution issues; at least two drafts papers are submitted to BETO for review. [3 submitted]	✓
FY21 Q1	Complete analysis of effects of a major U.S. bioenergy supply chain in support of joint DOE and IEA Bioenergy goals (2 deliverables in templates: Excel and Word document)	✓
Q2	Contribute to analyses and content in at least five Chapters of the Third Order Draft of the 3rd Triennial Report to Congress.	✓
Q3	Develop an Interagency Joint Research Plan and share for comment; AND complete revisions required per comments on the Internal Review Draft of TRtC	
Q4	Complete analyses and prepare manuscripts to clarify key bioenergy-related attribution issues.	
EOP	At least 2 manuscripts distributed to BETO for review and comment prior to subsequent publication steps, submissions to target high-impact journals.	

4 - Progress: Report to Congress: contributions by chapter

Part 1: Background, and Drivers

1. Introduction and Background
2. **Scope, Approach, Organization**
3. **Biofuel supply chain**
4. **Economics ***
5. **Land cover and land management ***

Part 2: Attribution (ORNL approach*)

6. **Ethanol and corn ***
7. **Other biofuels and feedstocks**

*** Lead or co-lead for chapter**

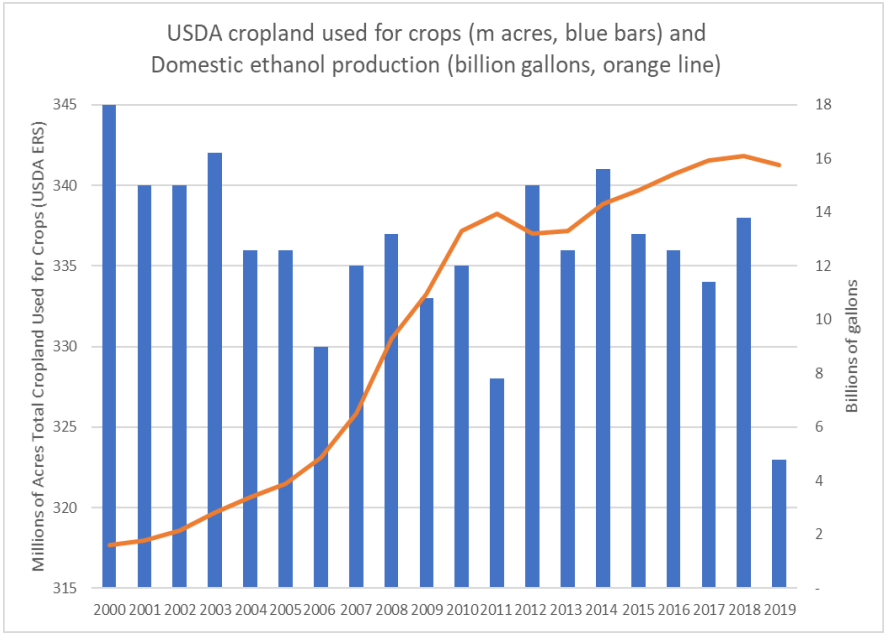
Part 3: Environmental and resource conservation effects

8. Air quality
9. Soil quality and conservation
10. Water quality (ANL, PNNL)
11. Water availability (ANL)
12. **Terrestrial ecosystems: grasslands, forests**
13. Aquatic ecosystems
14. **Wetlands**
15. Invasive species
16. **International effects ***
17. **Synthesis (all lead authors*)**

Part 4: Conclusions and Recommendations

- Overarching conclusions
- Specific conclusions
- Uncertainties & recommendations.

Part 5: Appendices



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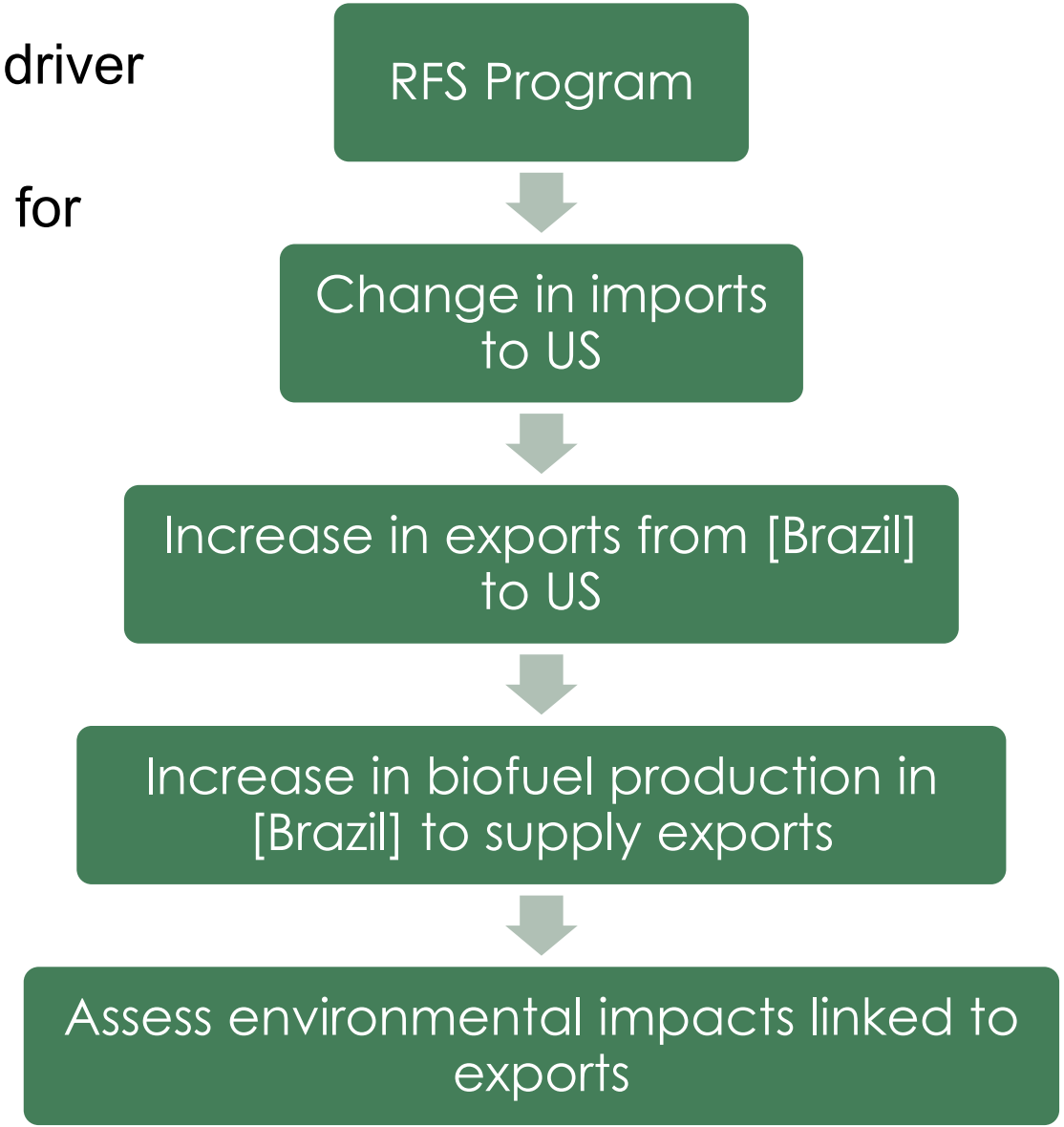
Example of outcomes – Applied attribution approach to causal chains relevant to international effects for Report to Congress

What observed effects (e.g., deforestation) are attributable to the Renewable Fuel Standard as a driver of US imports?

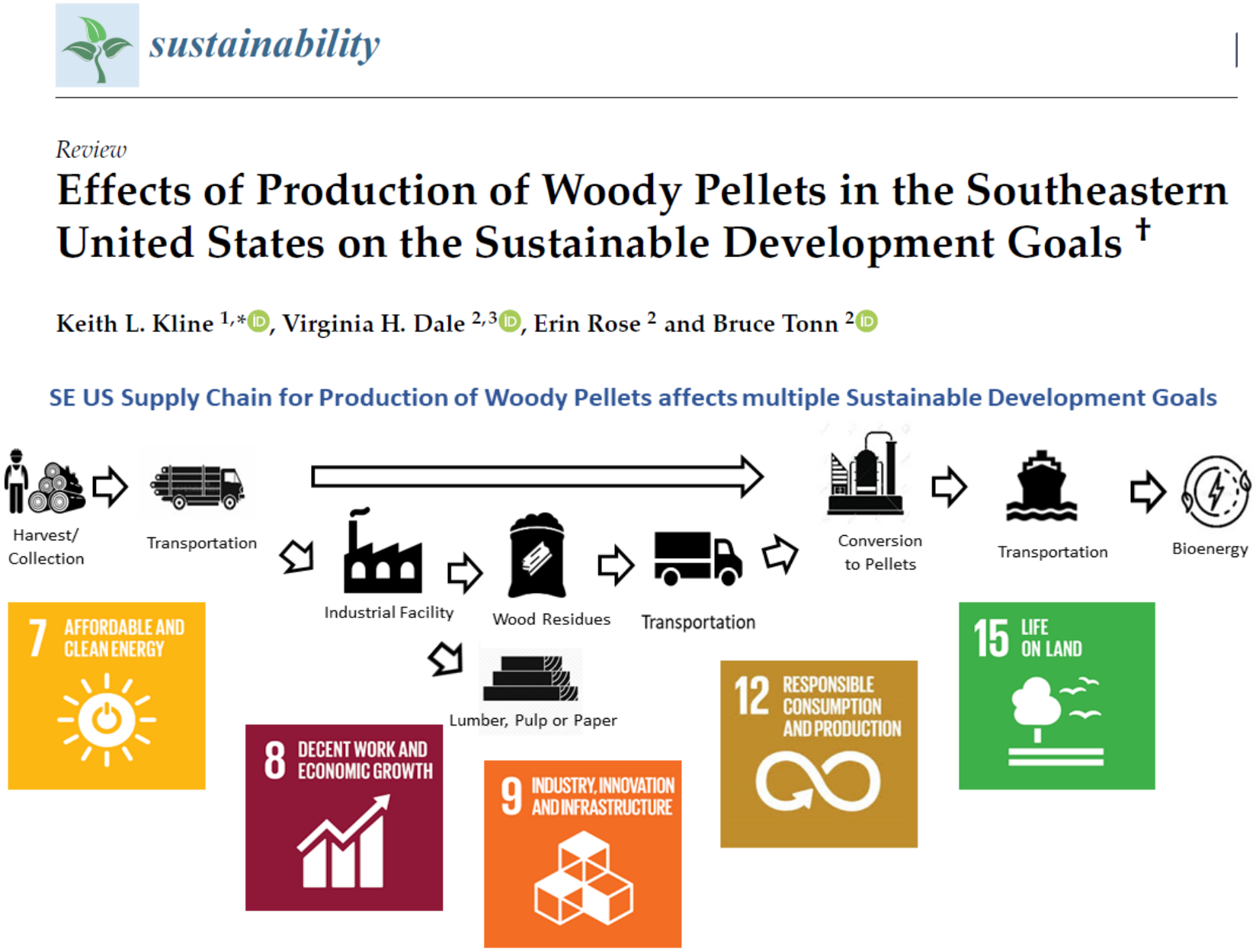
- Reviewed data for multiple lines of evidence for environmental effects in other nations.
- Hypotheses tested for each link in causal chains

***Brazil case analyzed in detail** -



4 – Progress: US case studies with IEA Bioenergy

- Case studies from around globe use comparable templates
- ***Identify options for bioenergy to help achieve United Nations Sustainable Development Goals & "world below 2-degree"*** increase
- Submitted 2 US cases
- Collaborations with USDA Forest Service, IEA Bioenergy, and private sector to assess southeast U.S. woody biomass supply chain



4 – Progress: collaborations with IEA Bioenergy and private sector generate useful lessons

- *Flex feedstocks – address concerns about food security*; opportunity to balance supply and demand, benefiting consumers and producers: https://www.agro-chemistry.com/news/variable-biofuel-production-improves-food-security/
- Analysis of supply chain resilience to unexpected disturbance (Pandemic)
- SE US pellet system surprisingly resilient. *Lessons learned*
  - *Essential workers, PPP & PPE*
  - *Long-term contracts*
  - *Proximity to ports and logistics*
  - *Culture of safety*
  - *Vertical integration…*

Perspective

Biofpr Biofuels Bioproducts & Biorefining

Variable demand as a means to more sustainable biofuels and biobased materials

Iris Vural Gursel, Wageningen Food & Biobased Research, Wageningen, The Netherlands
Foluke Quist-Wessel, AgriQuest, Heteren, The Netherlands
Hans Langeveld, Biomass Research, Wageningen, The Netherlands
Keith L. Kline†, Environmental Science Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA
Maja Slingerland, Plant Production Systems, Wageningen University and Research, Wageningen, The Netherlands
Patricio Grassini, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE, USA
Kees Kwant, Netherlands Enterprise Agency, Utrecht, The Netherlands
Wolter Elbersen, Wageningen Food & Biobased Research, Wageningen, The Netherlands

Received June 26 2020; Revised September 18 2020; Accepted October 07 2020;

CASE STUDY 20:

Southeast USA Pellets

Title: Woody Biomass from the Southeastern United States used for Bioenergy in Europe
Year of project: 2020
Location: Southeastern United States, North America
Status: Operational
Source: Various (see citations)
Author: Keith Kline, Virginia Dale, Erin Rose, and Bruce Tonn

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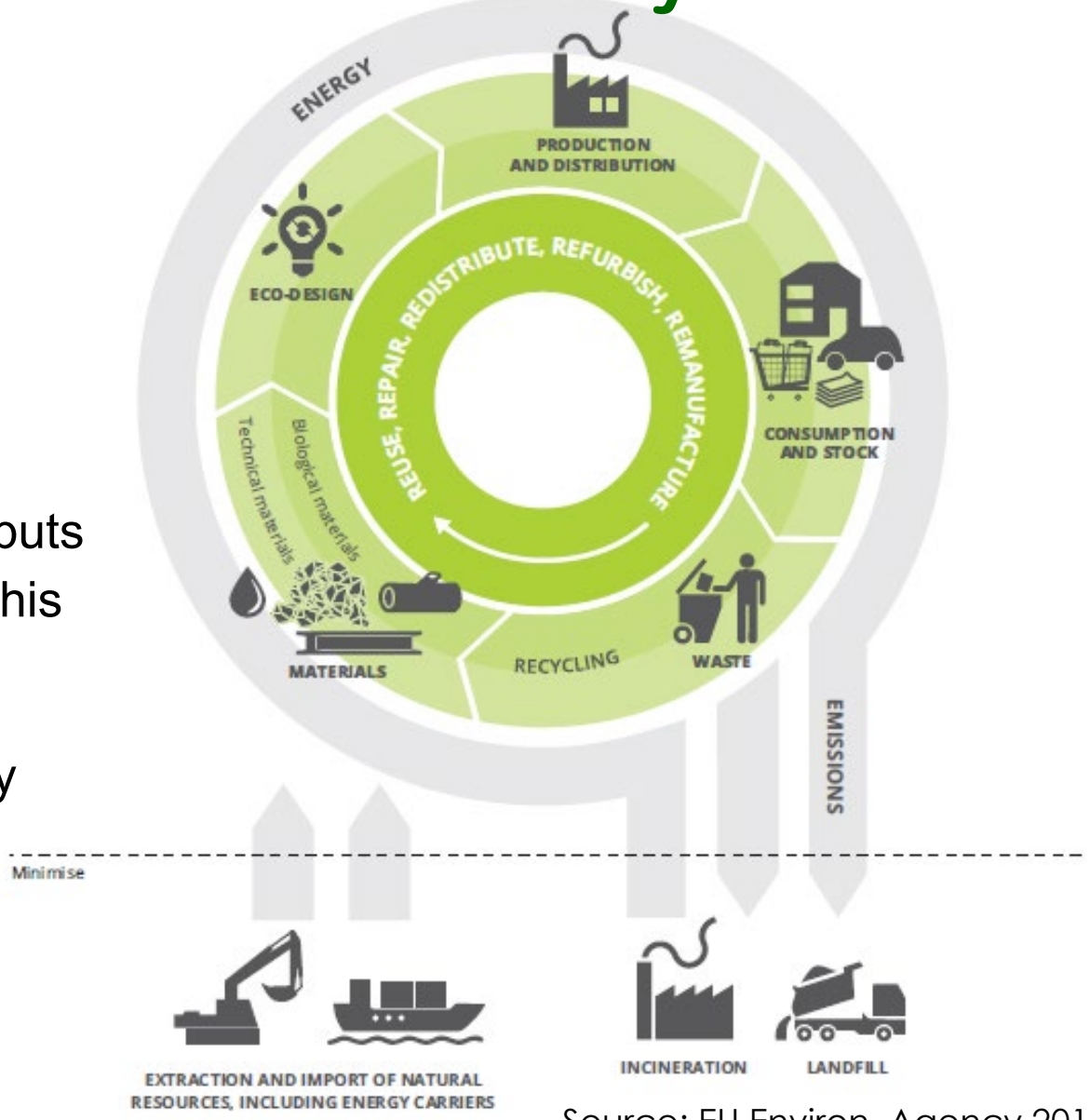
4 – Progress & outcomes: industry engagement succeeds in defining roles for biomass in the Circular Economy

- Led drafting team for measuring circular performance, coauthor of ISO working draft WD 59020 "*Circular economy -- measuring and assessing circularity*"
- Contributed to ISO working draft WD 59004 "*Circular economy concept and the related definitions, principles, and implementation frameworks*."
  - Terms, definitions, principles for bio-based inputs
  - Biomass eligible for circular economy under this proposed ISO international standard.
- External expert to UL 3600 Standard panel developing metrics for reporting circular economy
  - Challenge to verify & track "*sustainably sourced*" biogenic content through long life cycles and multiple (re)uses
  - Circularity values of reuse versus organic contributions to regrowth



Source: EU Environ. Agency 2016

4 – Progress & Outcomes amplify impacts of BETO research

- Impacts of BETO sustainability research can be amplified via collaborations, Special Partnership Projects, and scientific contributions to international standards.
- Lessons learned for sustainable agriculture and forest management (Dale et al. 2019) were documented for USAID & CIMMYT

  "***ORNL's contributions were absolutely valuable for our objectives and mission***" [sustainable intensification to improve rural livelihoods] --CIMMYT*
- Results from sustainability research continue to enhance collaborations with other agencies, IEA Bioenergy, voluntary standards bodies, and Food-Energy-Water nexus initiatives (see publications)

OAK RIDGE NATIONAL LABORATORY — FACT SHEET

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Amplifying impacts of DOE research: Enhancing the sustainability of agricultural landscapes in developing nations

* CIMMYT – International Research Center for Maize and Wheat Improvement (email to ORNL managers confirming successful project completion, Jan 2021)

USAID – U.S. Agency for International Development

4 – Progress & outcomes: Deliverables are useful and relevant per sponsor feedback

Dr. Chris Clark, EPA science lead for the Report to Congress

(09Feb 2021 email communication)

"ORNL's contributions were substantive in developing and co-leading multiple chapters and the insights on attribution strengthened the overall report.

ORNL's scientists have extensive research and experience in this area, and the collaboration between EPA and ORNL has helped to support the development of a robust Triennial Report to Congress."

Major Contributions:

- **Ch. 1-3** (inputs-terminology, data sources Kline)
- **Ch 4. Economics (Langholtz*, Oladosu)**
- **Ch 5: Land cover & land management (Kline, Singh)**
  - **Part 2: Attribution (Kline, Efroymson*)**
    Approach applied & influences subsequent chapters
- **Ch 6: Ethanol and Corn (Kline, Efroymson)**
- **Ch 7: Other Biofuels and Feedstocks (Kline)**
- **Ch 12 Terrestrial Ecosystems (Jager)**
- **Ch 14: Wetlands (Jager)**
- **Ch 16: International Effects (Kline*)**
- **Ch 17: Synthesis (lead authors*)**

Quad Chart Overview

- Start: Oct 2019
- End: Sept 2021
  (2 yr. unless extended)

	FY20	Project
DOE Funds	$**280,000** (10/2019 – 9/30/2020)	***$560,000*** *Life of project*

Partners

- USDA, EPA, BETO labs (Task 1)
- Private sector, IEA Bioenergy & other international centers (T2)

Barriers addressed

Need for consensus, data, and proactive strategies for improving land management.

Quantification of benefits and costs (attribution & related assumptions are key variables in biomass assessments.)

Goals

a) Demonstrate approaches that improve quantification and documentation of net effects attributable to bio-based fuels, products, and an expanding US bioeconomy.

b) Build productive research relationships among EPA, USDA, DOE, IEA Bioenergy, and other stakeholders.

End of Project Milestones

Complete causal analyses and consider weight of evidence to clarify bioenergy attribution issues required for modeling effects of bioenergy (input parameters and drivers e.g., price relationships, commodity or export displacement).

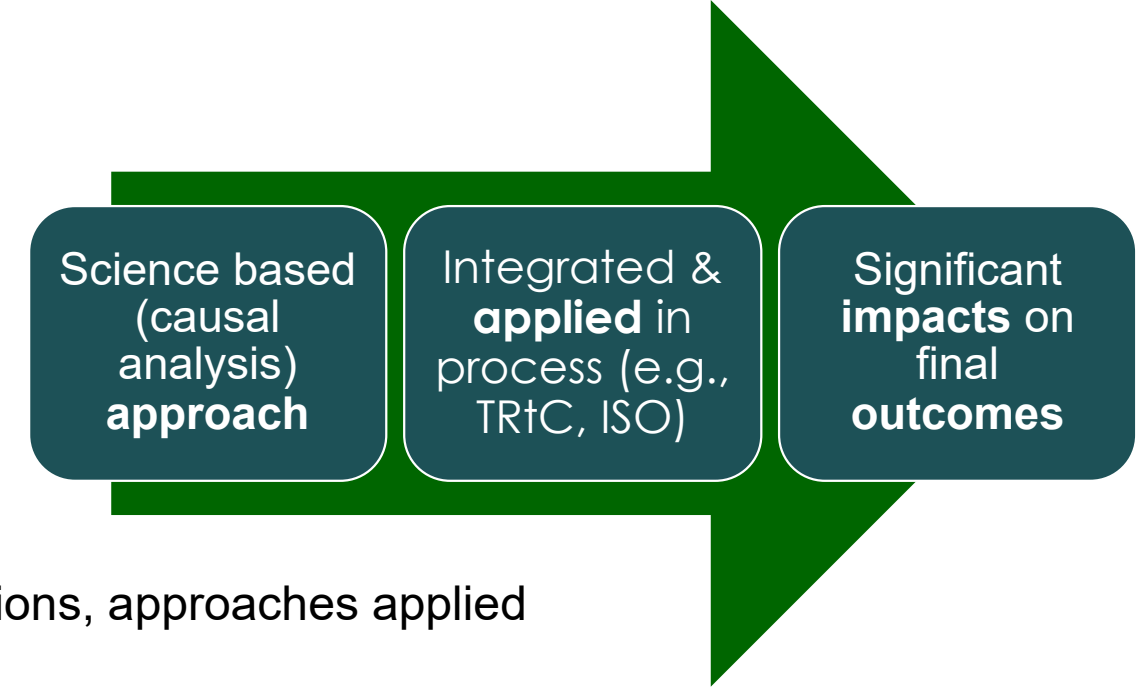
Joint inter-agency research plan developed to address priority issues identified in Triennial Report to Congress process.

Share results in reports and publications for research community to improve future simulations of effects of bioenergy and an expanding U.S. bioeconomy.

Funding Mechanism: AOP

Summary

- FY20-21 project, two tasks:
  1. **Improve analyses for Report to Congress**
  2. **Amplify benefits of sustainability & attribution research**
     - Shared & applied evidence-based approach
     - National & international impacts via partners
     - Beneficial outcomes documented in reports, publications, approaches applied



- ***Our strategy & risk mitigations succeeded in***
  - Building partnerships around high-impact reports & peer-reviewed publications
  - Assembling & sharing research via direct engagements with EPA, USDA, DOE, IEA Bioenergy, ISO, and other stakeholders
- ***This is important for BETO and other stakeholders because***
  - Sustainable biomass is essential to achieve climate and circular economy goals
  - Accurate attribution and measurement of effects is required to support decisions: a high priority to US forestry, agriculture & biofuel sectors
  - Project builds consensus and distributes findings to help BETO achieve goals to quantify effects of bioenergy and enhance beneficial outcomes

Additional Slides

Go / No-go review memo

- Approved as “go” by BETO Aug 4, 2020. Description: Project input on 1st draft Triennial Report to Congress (TRtC) is incorporated to improve science-based analyses of attribution to biofuels and understanding of international effects.
- Criteria: Decision = Go if draft TRtC includes inputs contributed by the project to improve analyses. If go, the team will continue collaborations with EPA and USDA on research to improve this and future attribution analyses.
  Decision = No-go if the first order draft TRtC repeats the same assumptions about international and induced effects of US biofuels as in the prior TRtC.
- Accomplishment: The First Order Draft of the Triennial Report to Congress (FOD TRtC) as distributed to BETO for review and comment, incorporated 7 chapters with significant ORNL contributions including 4 chapter titles unique to this TRtC (attribution approach; attribution for corn ethanol; attribution for international effects; and land cover and land management; plus economics, supply volumes, wetlands…)
- **Prior peer review**: New project FY20 (no prior comments) but the 2019 Peer Review recommendations to BETO included: assess attribution and strengthen collaborations with other agencies (EPA, USDA). This project responds to those two recommendations.

Publications (FY 20-present)

1. Kline KL, Dale VH, Rose E, Tonn B. 2021. Effects of Production of Woody Pellets in the Southeastern United States on the Sustainable Development Goals. Sustainability 13(2), 821; https://doi.org/10.3390/su13020821 [IEA Bioenergy WB2/SDG Inter-Task Project]
2. Vural-Gursel I, Quist-Wessel F, Langeveld J, Kline KL, Slingerland M, Grassini P, Kwant K, Elbersen W. Variable demand as a means to more sustainable biofuels and biobased materials. Biofuels, Bioproducts & Biorefining(1) 15-31. DOI: 10.1002/bbb.2164. https://onlinelibrary.wiley.com/doi/full/10.1002/bbb.2164 [IEA Bioenergy collaboration].
3. Kline and Efroymson 2021. ORNL Fact Sheet. *Assessing Effects of U.S. Corn Ethanol Production on land cover and management*. Center for Bioenergy Sustainability, https://cbes.ornl.gov
4. Englund O, Dale VH, Kline KL, McGrath, J, McDonnell K, Mola-Yudego B, Murphy F, English B, Negri MC, Parish ES, Cacho J, Zumph C, Quinn J, Mishra S, Dimitriou I. 2020. Multifunctional perennial production systems for bioenergy: performance and progress. (*Published on-line AND 'In press' as of May* 2020) WIREs Energy and Environment. https://doi.org/10.1002/wene.375
5. Kline KL 2021 (update) ORNL Fact Sheet, *Bioenergy and Food Security: development of renewable fuels can help feed the world while achieving other goals*. Center for Bioenergy Sustainability, accessible online: https://cbes.ornl.gov
6. Kline KL. 2020. Fact Sheet: *Amplifying impacts of DOE research: Enhancing the sustainability of agricultural landscapes in developing nations.* accessible online: https://cbes.ornl.gov
7. Dale VH, Kline KL, Lopez-Riadura S, Eichler SE, Ortiz-Monasterio I, Ramirez LF (2020). Towards more sustainable agricultural landscapes: Lessons from Northwestern Mexico and the Western Highlands of Guatemala. Futures Vol. 24, Dec 2020 (Special Issue 'Health, Climate Change, and Poverty') doi: 10.1016/j.futures.2020.102647 [Applies BETO research to SPP].
8. Kline KL, Ramirez LF, Sum C, Lopez-Riadura S, Dale VH. 2020. Enhancements to agriculture in Guatemala can reduce migration pressure. Nature-Sustainability 3(2), 74-76. doi.org/10.1038/s41893-020-0473-1. https://www.nature.com/articles/s41893-020-0473-1
9. Hodges DG, Chapagain B, Watcharaanantapong P, Poudyal NC, Kline KL, Dale VH. 2019. Opportunities and attitudes of private forest landowners in supplying woody biomass for renewable energy. Renewable and Sustainable Energy Reviews 113:10925 (Oct 2019)

Publications (FY 20-present)

10. Zhuang J, Sun H, Sayler G, Yu G, Kline KL, Dale VH, Jin M, Yu G, Fu B, Löffler FE. 2021. Food-energy-water crises in the United States and China: Commonalities and asynchronous experiences support the integration of global efforts. Environmental Science and Technology. Doi: https://dx.doi.org/10.1021/acs.est.0c06607
11. Kline KL, Dale VH. Protecting Biodiversity through Forest Management: Lessons Learned and Strategies for Success. Int J Environ Sci Nat Res. 2020; 26(4): 556194. DOI: 10.19080/IJESNR.2020.26.556194
12. Eichler SE, Kline KL, Ortiz-Monasterio I, López-Ridaura S, Dale VH. (2020). Rapid appraisal of landscape sustainability indicators for Yaqui Valley, Mexico. Env and Sust Indicators (INDIC-D-19-00140R) https://www.sciencedirect.com/science/article/pii/S2665972720300118
13. Englund O, Dale VH, Kline KL, McGrath, J, McDonnell K, Mola-Yudego B, Murphy F, English B, Negri MC, Parish ES, Cacho J, Zumph C, Quinn J, Mishra S, Dimitriou I. 2020. Multifunctional perennial production systems for bioenergy: performance and progress. (*Published on-line AND 'In press' as of May* 2020) WIREs Energy and Environment. https://doi.org/10.1002/wene.375
14. Kline KL. 2020. "What really works to conserve biodiversity and tropical forests?" *EURACTIV* Q&A *published* on 4 May 2020." https://www.euractiv.com/wp-content/uploads/sites/2/2020/05/Kline-Q-A-FINAL.docx and Simon F. 2020. US scientist: 'Roads and corruption' are big drivers of deforestation. EurACTIV Interview *published* May 2nd, 2020.
15. G.A. Oladosu, K.L. Kline, J.W.A Langeveld. Structural Break and Causality Analyses of U.S. Corn Supply, Use, Price and Trade Data. (submission to journal Agriculture https://www.mdpi.com/journal/agriculture Agriculture (Basel)
16. Efroymson RA, Parish ES, Kline KL, Dale VH, and Jager H. Setting targets for indicators of sustainable resource management. (*Submitted to* BioScience on May 26, 2020).
17. Dale VH, Kline KL, Hodges DG, Chapagain B, Watcharaanantapong P, Poudyal NC. 2019. Perspectives of Family Forest Owners Regarding Wood-Based Bioenergy. World Biomass 2019-2020 (Oct 2019), pages 42-47 http://www.dcm-productions.co.uk
18. Dale VH, Kline KL, Parish ES, Eichler SE. 2019. Engaging stakeholders to assess landscape sustainability. Landscape Ecology. DOI: 10.1007/s10980-019-00848-1. http://link.springer.com/article/10.1007/s10980-019-00848-1
19. (In press): Parish et al. 2021, "An Indicator-based Approach to Sustainable Management of Natural Resources" in 'Data Science Applied to Sustainability Analysis' 2020 [El Sevier book]

Presentations since last peer review

1. 13 Nov 2020–Kline gave invited talk+panel discussion; 4th annual Sustainability workshop for biofuels and bioenergy; D.Scott & S.Richman (RFA).
2. 06 Oct 2020--Kline presented, “Three big challenges to scaling up biomass feedstock production” for International Renewable Energy Agency (IRENA) Innovation Week 2020 (https://innovationweek.irena.org/). A summary report and recording of this and other presentations in the session “Growing the bio-economy: solutions for the sustainable supply of biomass & biofuels” can be accessed via the IRENA website
3. Presentation: “Collaborating & Communicating on Biomass & Sustainability” for the USIPA Annual Meeting and Conference (Oct 2019; Miami)
4. Presentation: “Approaches to Engage Stakeholders in Addressing Food-Energy-Water Systems Nexus Challenges,” for the NSF-UT sponsored FEWSTERN, US-China Symposium, Oct 25-27, 2019, Seattle.
5. Presentations: “Sustainability research: Common goals & stakeholder perspectives on priorities” and “Framing sustainability issues-introductory remarks, Conference Chair,” for the Bioenergy Sustainability Conference (Nashville, TN, Oct. 21-22, 2019), sponsored by American Institute of Chemical Engineers (AIChE) and NSF.
6. Presentations: “Challenges to measurement and attribution of changes in land cover & management” and “The role of land use and land use change in a dangerously warming planet” for the International 2050 Climate Calculator Conference, Windsor, UK. Sponsored by UK Government BEIS, CLIMACT, Mott MacDonald, Imperial College London (Nov 2019)
7. Ecological Society of America (ESA) Annual Meeting (virtual) “Harnessing the ecological data revolution” August 3-6, 2020. Keith Kline presented lessons learned applicable to more sustainable land management and responded to questions using the virtual platform. https://eco.confex.com/eco/2020/meetingapp.cgi/Paper/87347
8. PPT: Parish, Kline and Davis (presented by Parish) June 25 2020 PowerPoint Presentation to Antares Group and BETO Iowa Landscape Design Team monthly meeting, “Sustainability landing page on Bioenergy KDF” https://bioenergykdf.net/content/sustainability-and-standards-home (sustainability standards home page).
9. PPT: April 20: Overview for BETO and ORNL management on accomplishments to date on the Triennial Report to Congress (with Efroymson, Langholtz, Jager)
10. Presentation for 2019 Annual Meeting of the Landscape Design Team, Clive Iowa (Dec 2019), “Quantifying & Visualizing Progress Toward Sustainability –Standard Scenarios.”
11. Co-chaired and organized AIChE workshop on bioenergy sustainability, Nashville, TN, which included ORNL presentation on reference scenarios, inviting comments and stakeholder participation.

Other Reports since last peer review

1. GBEP Attribution Guidelines (contributions to incorporate appropriate reference scenario considerations; Jan 2020).
2. Junginger M, Fritsche U, Mai-Moulin T, Thrän D, Thiffault E, Kline KL, Dale VH. 2019. Measuring, governing and gaining support for sustainable bioenergy supply chains: Understanding positions and underlying motivations of stakeholder groups relative to their perceptions of bioenergy (21 pages). IEA Bioenergy Inter-Task Report. Published by IEA Bioenergy, IEA Energy Technology Network www.ieabioenergy.com