DOE Bioenergy Technologies Office (BETO) 2023 Project Peer Review

Geospatial Analysis of Ecosystem Service Portfolios from Biomass Production (4.2.1.40)

April 4, 2023

Data Modeling and Analysis

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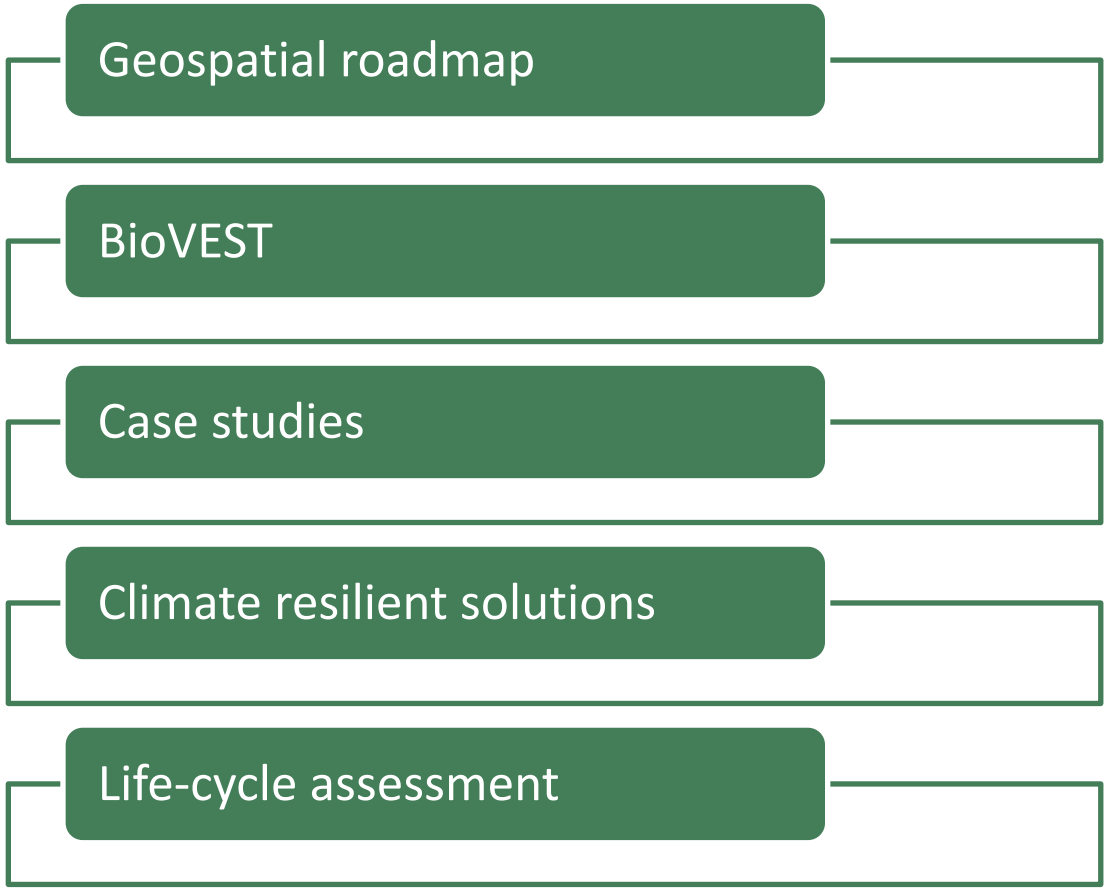
ORNL is managed by UT-Battelle LLC for the US Department of Energy

Project Overview

- **Why?** Lack of demand and profitability are barriers to adoption of sustainable bioenergy production from perennial and waste feedstocks.
- **What?** Push advanced feedstocks over the profitability threshold by generating carbon and nutrient credits in the Mid-Atlantic region.
- **Goal:** Demonstrate where payments for ecosystem services can offset 25% of biomass production cost and 10% of fuel cost.
- **Risks?** There could be insufficient overlap between watersheds with environmental credits and markets for cellulosic feedstocks.
- **How?** Develop tools and conduct analyses of advanced feedstocks with high potential for providing ecosystem services as well as fuel (See next slide for details). Quantify ecosystem services at the feedstock production and fuel production phases. Tools include BioVEST, GREET, and BILT (see definitions, Slide 21, Acronyms).

Project Goals, Milestones, Task structure

- **Goal:** This project seeks to find where the costs of biomass fuels can be reduced through payments for ecosystem services. Assess overlap between incentives (demand) and sustainable supply.
- This project is in its 3rd year. We passed our Go/No-Go milestone last year.
  - Can payments for ecosystem services from perennial feedstocks planted in riparian buffers offset at least 25% of production cost? (Go-No/Go)
  - Can these offset 10% of the cost of fuel? (End of project)
- We have five tasks, each with metrics of success.



Relevance to BETO decarbonization pillars, EERE emphasis areas

Contribute to meeting BETO's goal of understanding and quantifying environmental and economic effects associated with emerging biofuel and bioproduct technology pathways.

Decarbonization

- **Agriculture**: Quantify where and how much carbon sequestration can be achieved through placement and harvesting of perennial riparian buffers for the Mid-Atlantic.
- **Transportation sector**: Conduct LCA to evaluate cellulosic and animal waste pathways to reduce GHGs. Demonstrate bio-based pathways with lower life cycle GHGs in comparison to petroleum.

Environmental justice

- Refinery siting to avoid areas where air pollution is a concern. (completed)

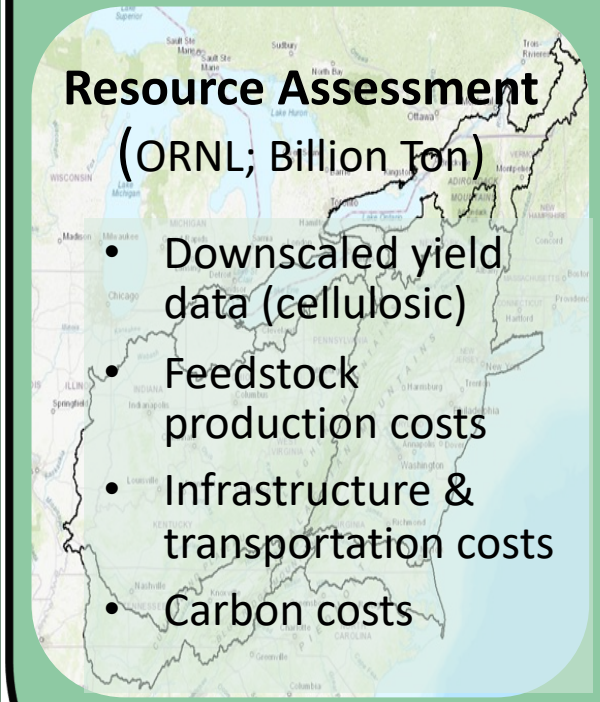
<u>Develop data needed to:</u>

- Evaluate potential for partially harvested riparian buffers to mitigate the effects of increased flooding under future climate conditions in rural areas.
- Examine trade-offs associated with producing renewable natural gas from animal wastes.

FY21-23 Project workflow and collaborations

Feedstock production phase

Resource Assessment
(ORNL; Billion Ton)



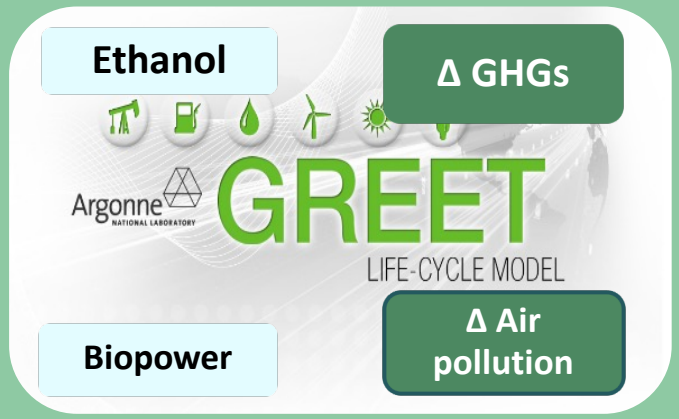
- Downscaled yield data (cellulosic)
- Feedstock production costs
- Infrastructure & transportation costs
- Carbon costs

Ecosystem Service Assessment
(ORNL; BioVEST)

Biophysical modeling	Monetization
Feedstock biomass*	$$ Production Cost*
Water quality	$$ Water purification
Soil carbon	$$ Climate regulation
GHG emissions	$$ Climate regulation
Avoided flood damage	$$ Climate regulation

Fuel production phase

Life Cycle Assessment
(Argonne; GREET)



Biorefinery siting
(ORNL; BILT)

- Uses riparian biomass, ΔCarbon crop production,
- Offset farmgate cost
- Siting considers environ-mental justice

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FY21-23 AOP Task descriptions & Collaborators

Task	Description	Primary collaborators
1. Geospatial Roadmap	Umbrella task; demand-side spatial data and regional screening analysis for the Mid-Atlantic - Biomass from riparian buffers; Animal wastes	A) Forest Service (Spencer) B) Ohio Restoration Workgroup members (watershed organizations)
2. Valuation with BioVEST	BioVEST development (Modeling of changes in water quality soil carbon, GHGs (N_2O) compared to annuals and value thereof)	A) ORNL Supply Scenario Analysis (Langholtz)
3. Case Studies	Biodiversity modeling: A) Iowa agricultural fuelshed B) Wenatchee basin, WA, Wildfire-wildlife review, Western North America	A) Antares (Comer, Belden), ORNL (Parish), Pheasants Forever, USDA (Karlin) B) PNNL (Wigmosta); Forest Service (Hessberg);
4. Climate Resilience	FY21: Supported Global Change Analysis Modeling, IEA Task 45 FY22: Inundation modeling task to assess insurance savings	A) Leverages Report to Congress on Hydropower risk, NASA-funded research, & BETO high-performance computing B) USDA-ERS (Maguire)
5. Life Cycle Assessment	Quantify pathways (FY23: Ethanol) Future: RNG, biopower	A) Argonne GREET project (Hawkins) B) Resource assessment project (Langholtz)

Challenges

Task	Challenges	Mitigations
1. Geospatial Roadmap	Lack of information about where incentives for growing feedstocks along rivers and/or collecting animal wastes exists.	Identified datasets to enable watershed groups to identify where opportunities do exist for different feedstocks based on their priorities and where incentives are most needed
2. Valuation with BioVEST	Deployment of Shiny application to allow stakeholders to use it exceeds the size allowed for free hosting services.	Delayed, but recently purchased support from Posit web-hosting platform
3. Case Studies	NA (task completed)	NA
4. Climate Resilience	1) Computationally intensive regional-scale flood-inundation modeling 2) Limited expertise in crop insurance	1) Engaged ORNL supercomputing capabilities, parallelized code in C++ 2) Engaged USDA ERS collaborators
5. Life Cycle Assessment	Delays in data exchange from ORNL, since this task is at the end of the pipeline.	Finalized supply data and provided refinery locations from BILT analysis

Metrics of success

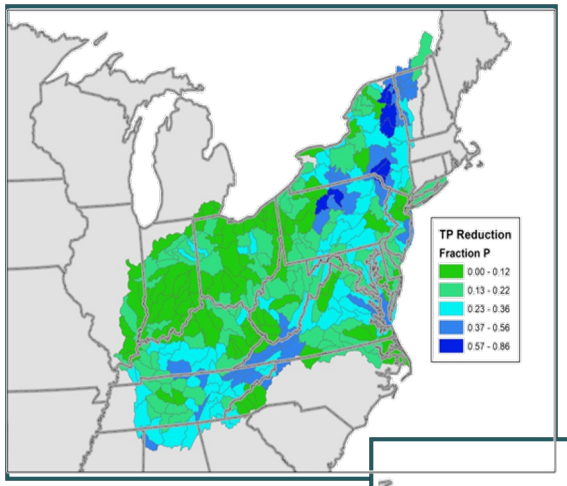
Task / % completion	Metrics of success
1. Geospatial Roadmap (50%)	A) Evaluate spatial overlap between ecosystem services & credits B) Determine magnitude of water quality improvements from animal waste collection
2. Valuation with BioVEST (90%)	A) See Go/No go criterion B) Provide inputs to GREET and BILT C) Identify stakeholders and deploy Shiny application
3. Case Studies (100%) *Task completed in FY21*	A) ANTARES project report chapter B) Publish results quantifying improvements to avian habitat from planting switchgrass in less-profitable areas.
4. Climate Resilience (80%)	A) Develop an approach to quantify avoided insurance benefits. B) Publish quantified benefits.
5. Life Cycle Assessment (10%) *-Initiated late-FY22*	A) See end-of-project milestone B) Incorporate environmental justice, air quality and valuation

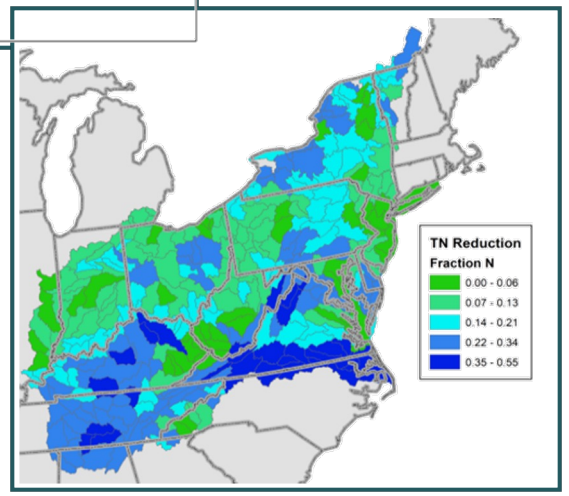
Task 1. Geospatial roadmap – Renewable natural gas from manure has high potential for water quality impact

- Used RSPARROW to assess potential for nutrient reductions by collecting animal wastes (manure) in the Mid-Atlantic.
- Analysis showed significant water quality benefits (maps).
- BILT refineries for anaerobic digestion were sited by Ojadeyi et al. (Resource Assessment project).

<u>Next steps:</u>

- Combine LCA, Siting, Environmental analysis in Geospatial Roadmap tool (FY23)
- Future considerations:
  - Environmental justice (avoid air quality issues in selected census tracts per EPA guidance, where are water quality improvements are most needed?)
  - Proximity to a refinery and CAFO density (collection)





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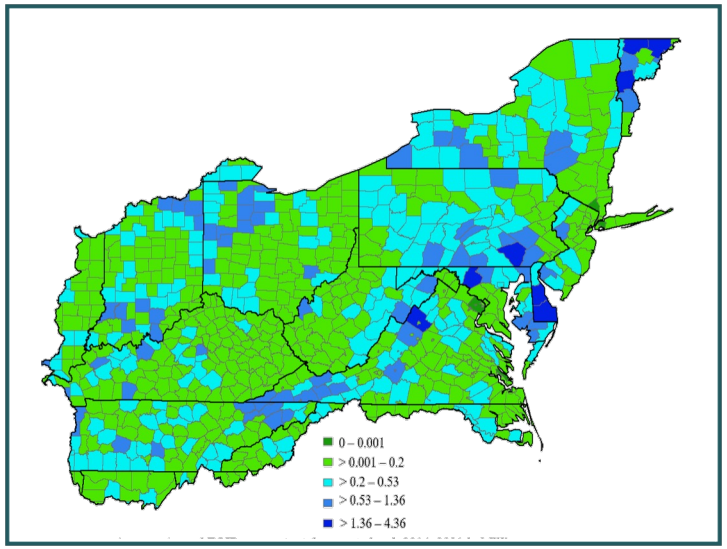
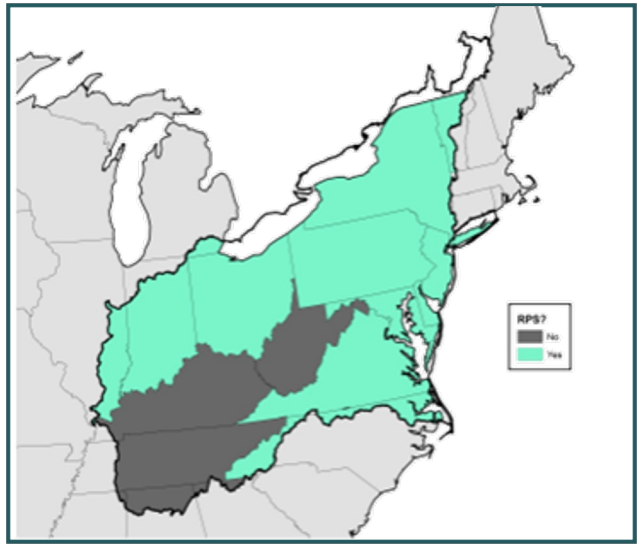
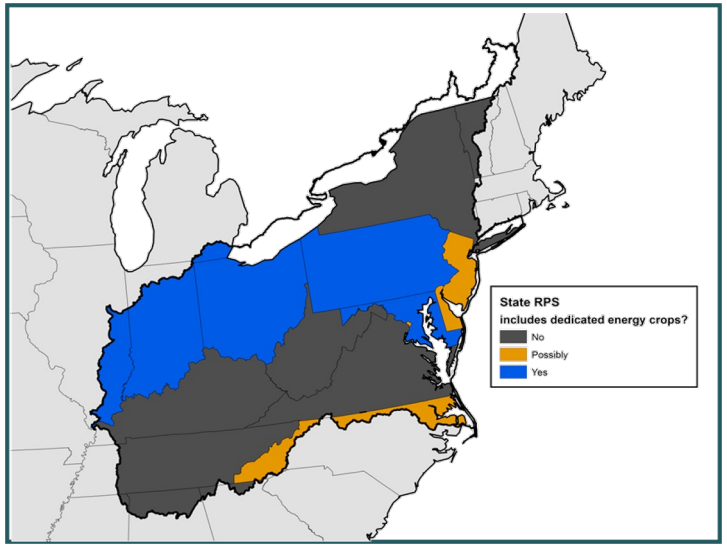
Task 1. Environmental credits (demand for ecosystem services)

Where are the best opportunities for growing or collecting biomass feedstocks that can generate ecosystem services and are eligible for payments?



USDA Environmental Quality Incentives Program (EQIP) program permits harvesting. Average annual EQIP payments (million $), 2014–2021





Mid-Atlantic States with current Renewable Portfolio Standards (right) that support the use of dedicated bioenergy crops as a potential resource (left). These maps were developed with information from the Database of State Incentives for Renewables & Efficiency (DSIRE) supplemented by State websites and rule notices.

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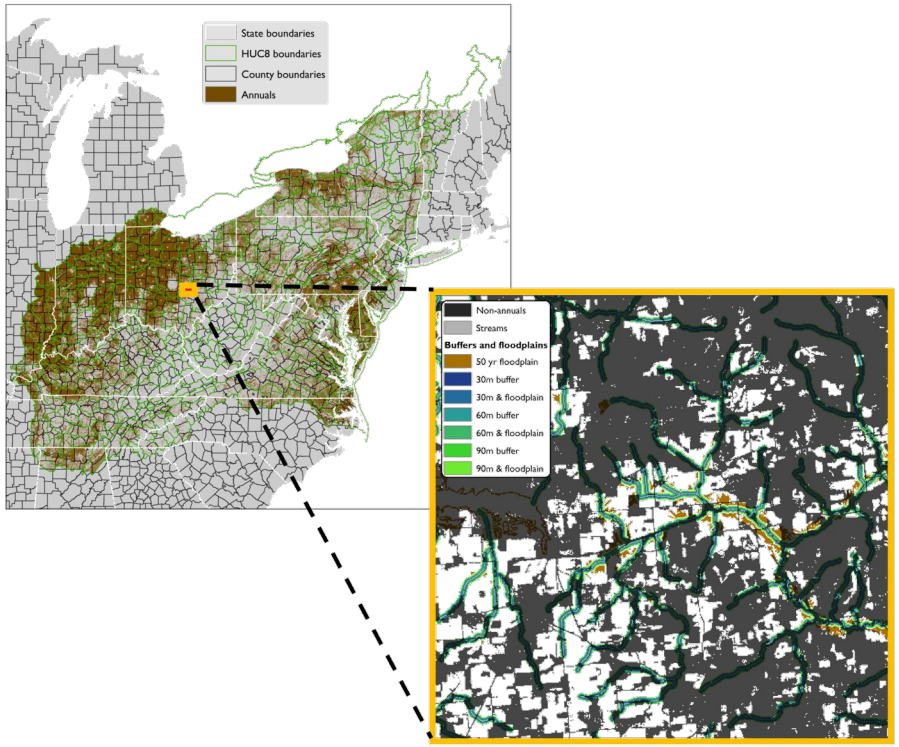
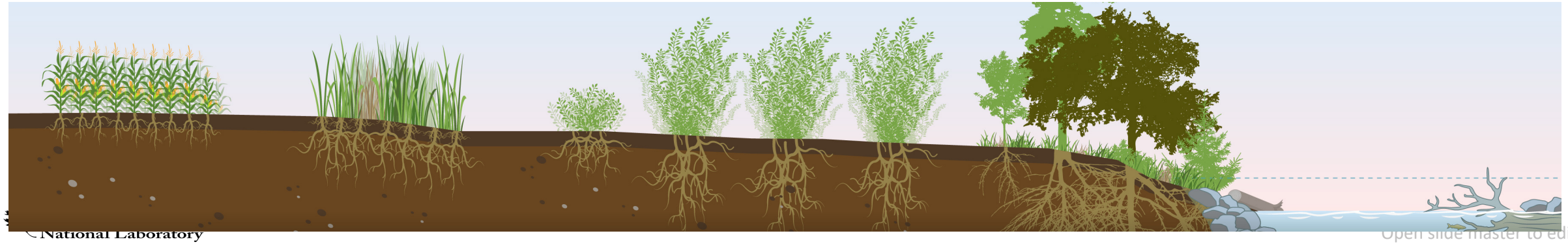
Task 2. BioVEST development:
Nature-based solutions: multi-functional riparian buffers

Riparian buffers planted in deep-rooted perennial plants provide multiple ecosystem services

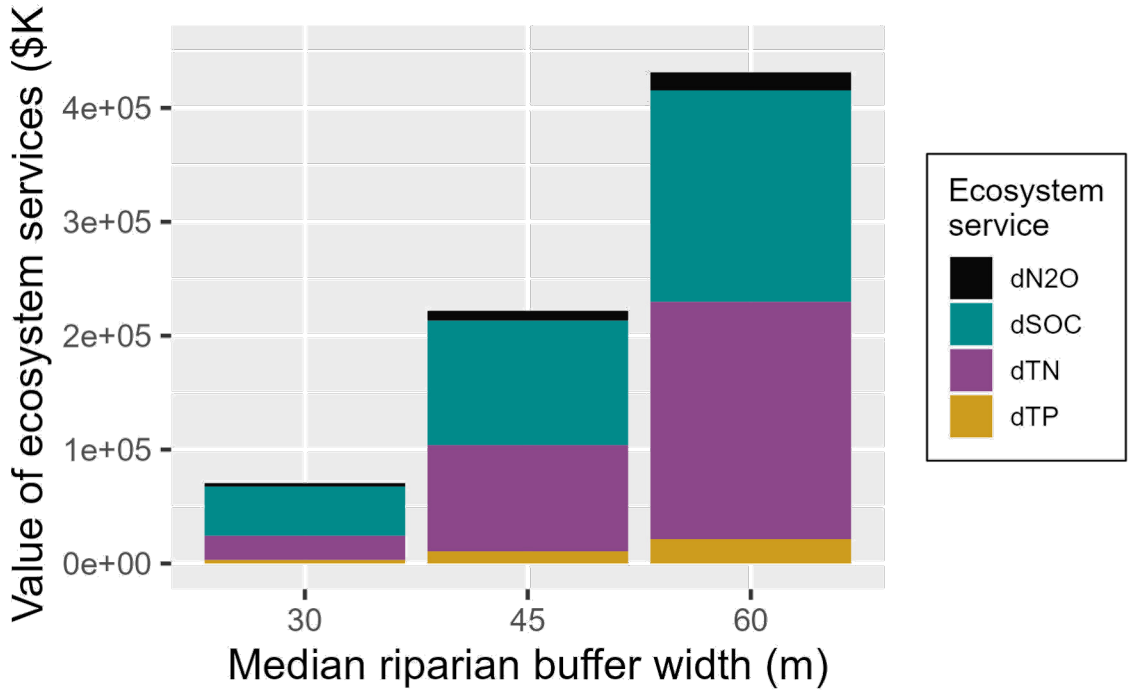
- Hold soil and prevent erosion, importantly better adapted to withstand extreme weather events
- Remove nutrients and contaminants, especially if harvested.
- Shade streams, improving aquatic habitat.
- Sequester carbon, especially in floodplains
- Provide feedstocks for bioenergy and bioproducts.

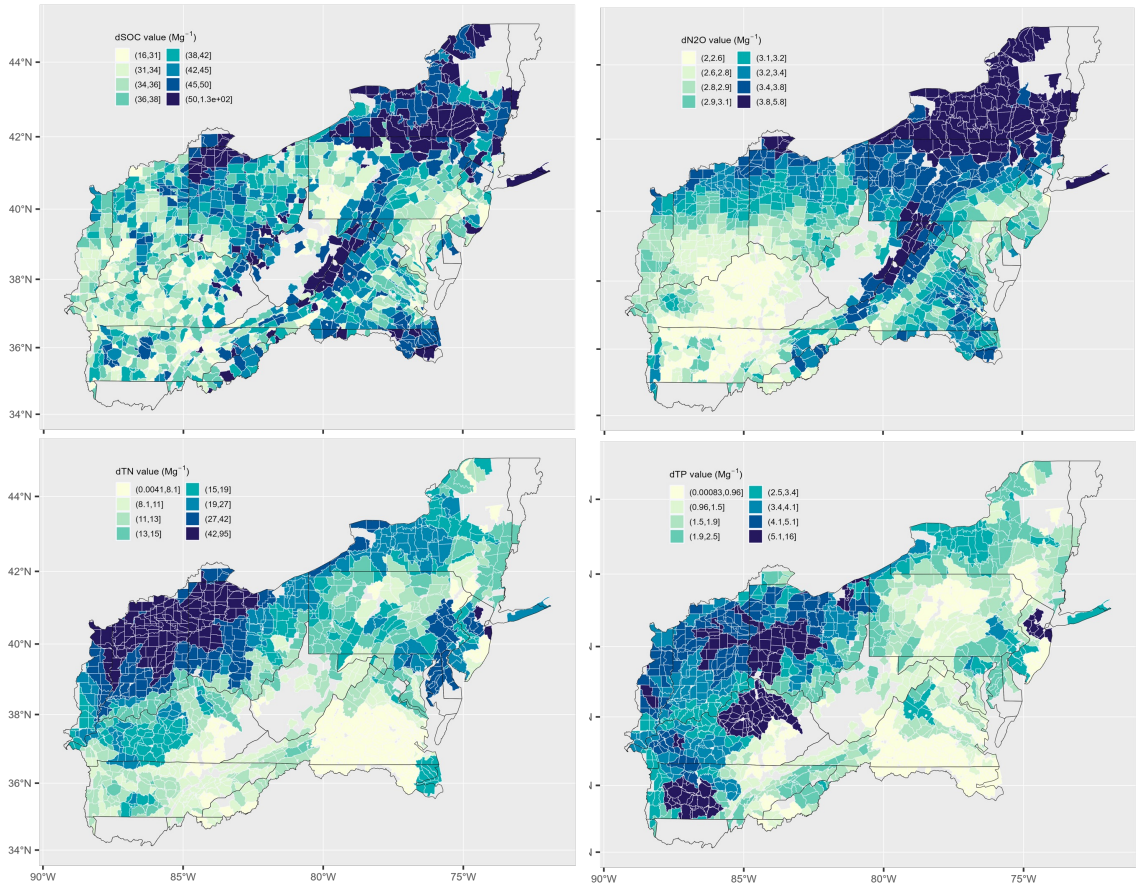




Go / No-Go passed in FY22

Payments for ecosystem services from perennial feedstocks planted in riparian buffers could offset at least 25% of fixed and variable production cost. (median ~40%)





The main ecosystem services responsible for high value were soil organic carbon and reduced total nitrogen in runoff.

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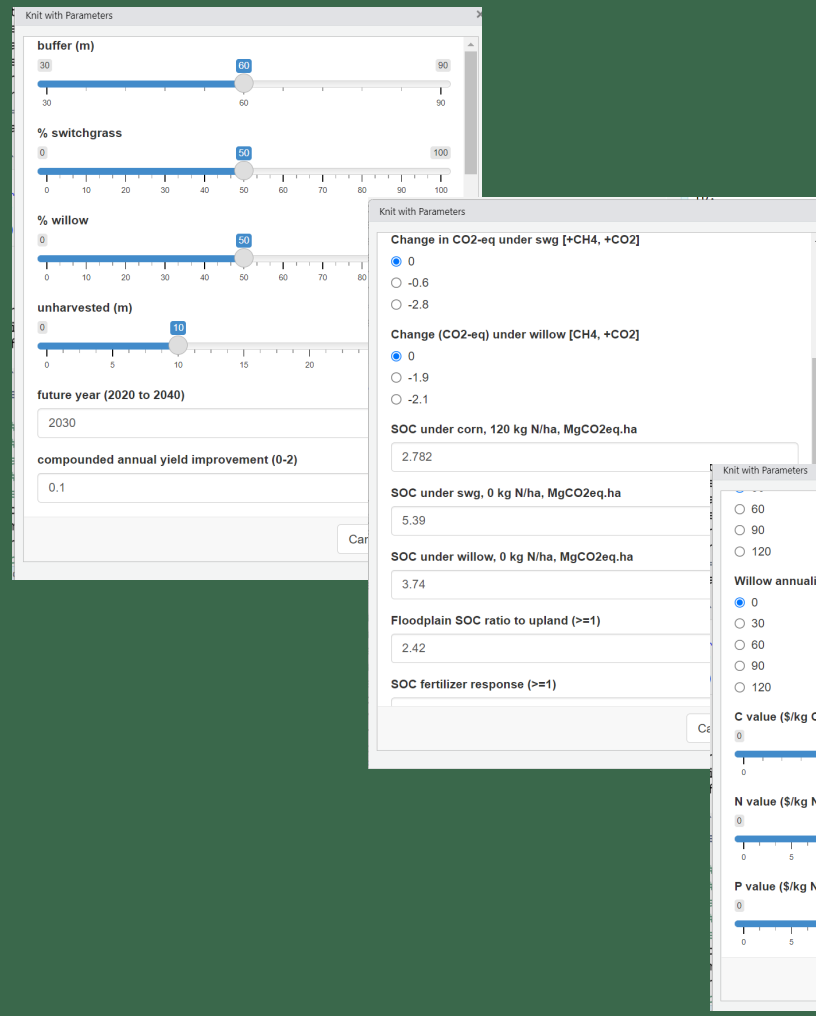
Task 2. BioVEST development

Key products – Software

New version of BioVEST allows stakeholders to design partially harvested riparian buffers and quantifies changes in SOC, N_2O and nutrient runoff.

Next steps:

Public testing & deployment to watershed and land conservancy organizations, biofuel industry



Menu interface allows users to design buffers

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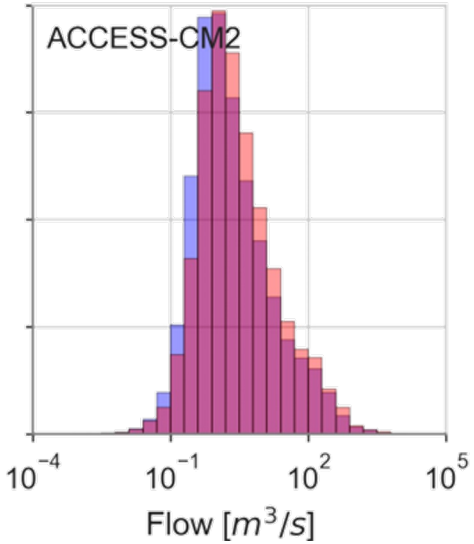
Task 2. BioVEST development

Key products: Publications

- Jager et al. 2022. 'Visualizing a sustainable bioenergy future: Mapping ecosystem service supply and value' that describes the water quality valuation. Science of the Total Environment. 834 155255. https://www.sciencedirect.com/science/article/abs/pii/S0048969722023488
  In the Arkansas-White-Red river basin, the value of water quality improvements exceeded the cost of production for nearly half of supply. This offset over 20% of the 3-billion-gallon target for sustainable aviation fuels.
- Jager, HI, S. Nair, C. DeRolph, RA Efroymson, E Parish, G. Ghimire, S. Gangrade, Y. Liu. Dec. 2023. 'Ecosystem Services from Partially-harvested Riparian Buffers'. Session: Innovation: Carbon Monitoring Systems Research and Applications. American Geophysical Union 2023 meeting. Virtual attendance of annual meeting in Chicago, IL.
- Jager, HI, S. Nair, C. DeRolph, RA Efroymson, E Parish, G. Wang. Submitted. 'Ecosystem services from partially harvested riparian buffers can offset biomass production costs'. Science of the Total Environment.

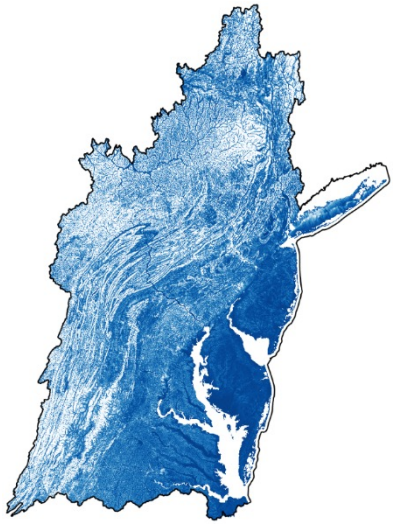
Task 3. Climate resilience – innovative flood risk modeling

Flood frequency analysis → NOAA NWC FIM3 workflow (full resolution mode) → Inundation Mapping → Insurance Modeling



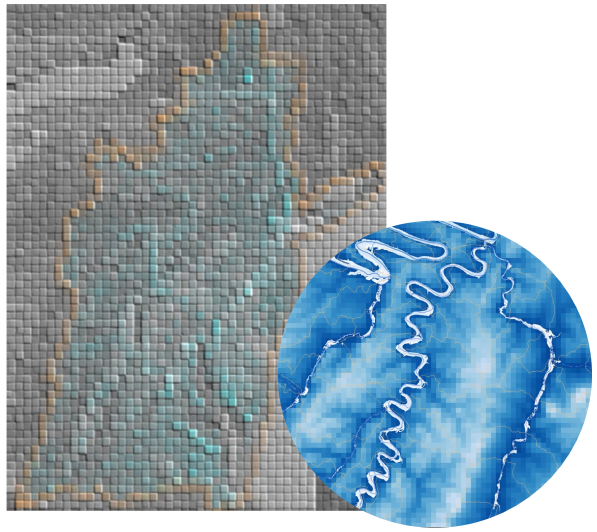
Climate Drivers

- Past (1980-2019, blue) future (2020-2059, red) period
- 6 Climate models downscaled & routed runoff
- 4 Return periods (25, 50, 100, 200 y)



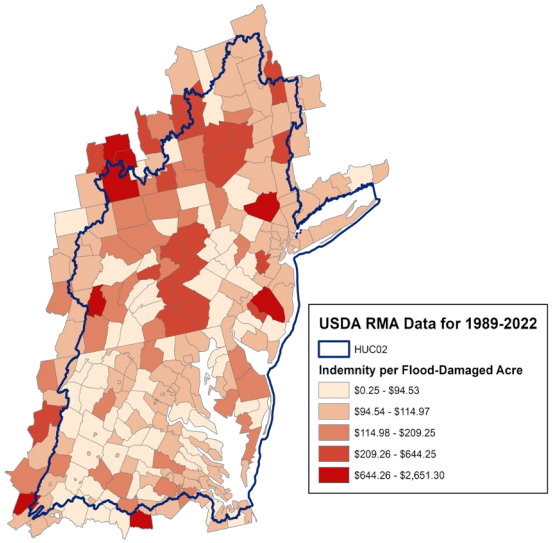
Elevation modeling

- 3M Digital Elevation
- Healed HAND raster
- Network of 166,245 streams & synthetic rating curves



Flood inundation maps

- Used BETO high performance computing Resources
- Completed Shenandoah valley test case (circle inset)
- Completed 48 subbasins in USGS Region 2 in <12 h



Crop insurance modeling

- Quantified the avoided crop insurance cost for farmers and society from growing perennial biomass crops.

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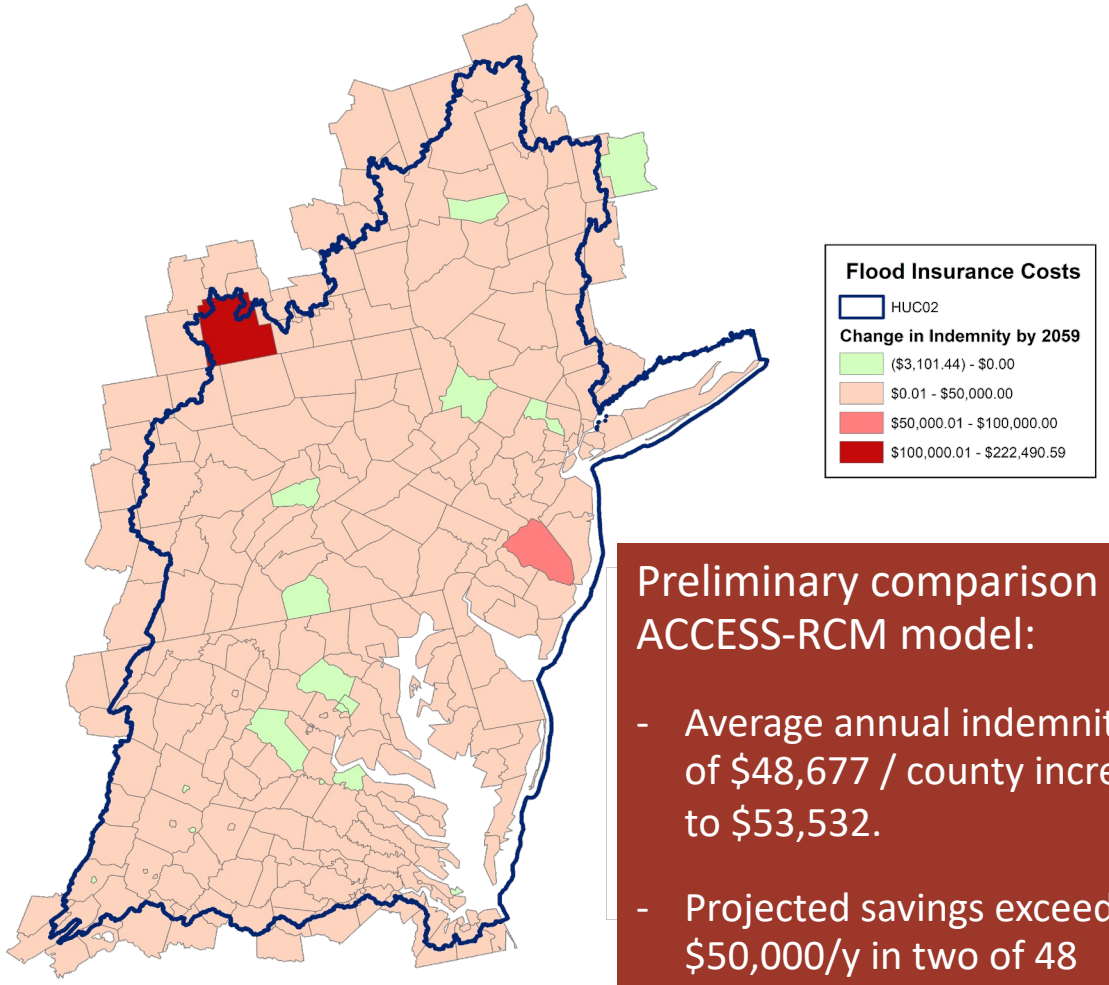
Task 3. Climate resilience: Estimated value of avoided indemnities reaped by planting partially harvested buffers, ~ 50K/county

Key products: Flood-insurance modeling team is on track to submit two papers in FY23.

- Milestone report demonstrated the approach to modeling avoided insurance cost (FY22 Q2).
- G. Ghimire, S. Gangrade, Y. Liu, DeRolph, E Parish, HI Jager, 2023. Perennial Riparian Buffers for Bioenergy: A Flood-Resilient Climate Adaptation for Agricultural Landscapes. 3/29/2023. Innovations in Climate Resilience Conference. March 28-30, Columbus, Ohio.
- G. Ghimire et al. in prep. 50% Perennial Riparian Buffers for Bioenergy: A Flood-Resilient Climate Adaptation for Agricultural Landscapes.
- Liu, Y. et al. In prep. 80% Scalable high-resolution flood inundation mapping for real-time inundation forecast and climate resilience studies. Frontiers in Big Data. May submission



Preliminary comparison using ACCESS-RCM model:

- Average annual indemnity cost of $48,677 / county increased to $53,532.
- Projected savings exceeded $50,000/y in two of 48 counties; $1.253 million/y across the region

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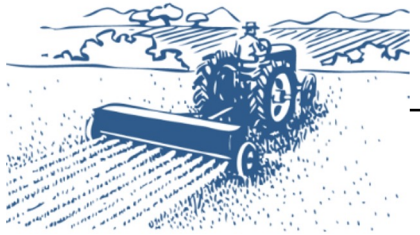
Task 4. GREET LCA System boundaries: producing ethanol from switchgrass, willow

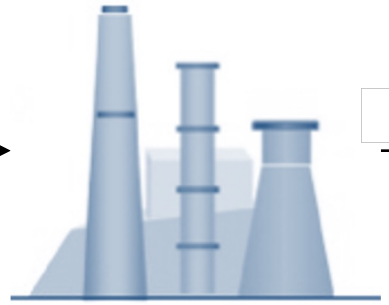
Fertilizer
Herbicide
Diesel

Input for ethanol production via fermentation, e.g., Sulfuric acid, Ammonia, Corn steep liquor

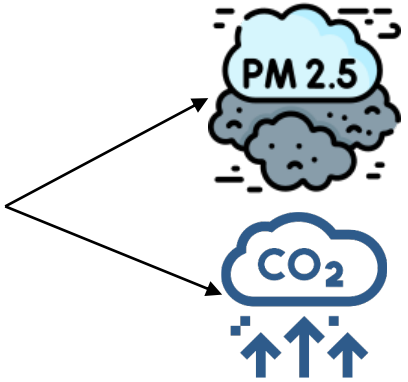


switchgrass

willow



ethanol



Feedstock Production

CO_2/N_2O sequestration

Refinery

Electricity (coproduct)

Fuel pump

Combustion

Biomass Production	T&D to Refinery	Ethanol Conversion	T&D to Pump	Use Phase

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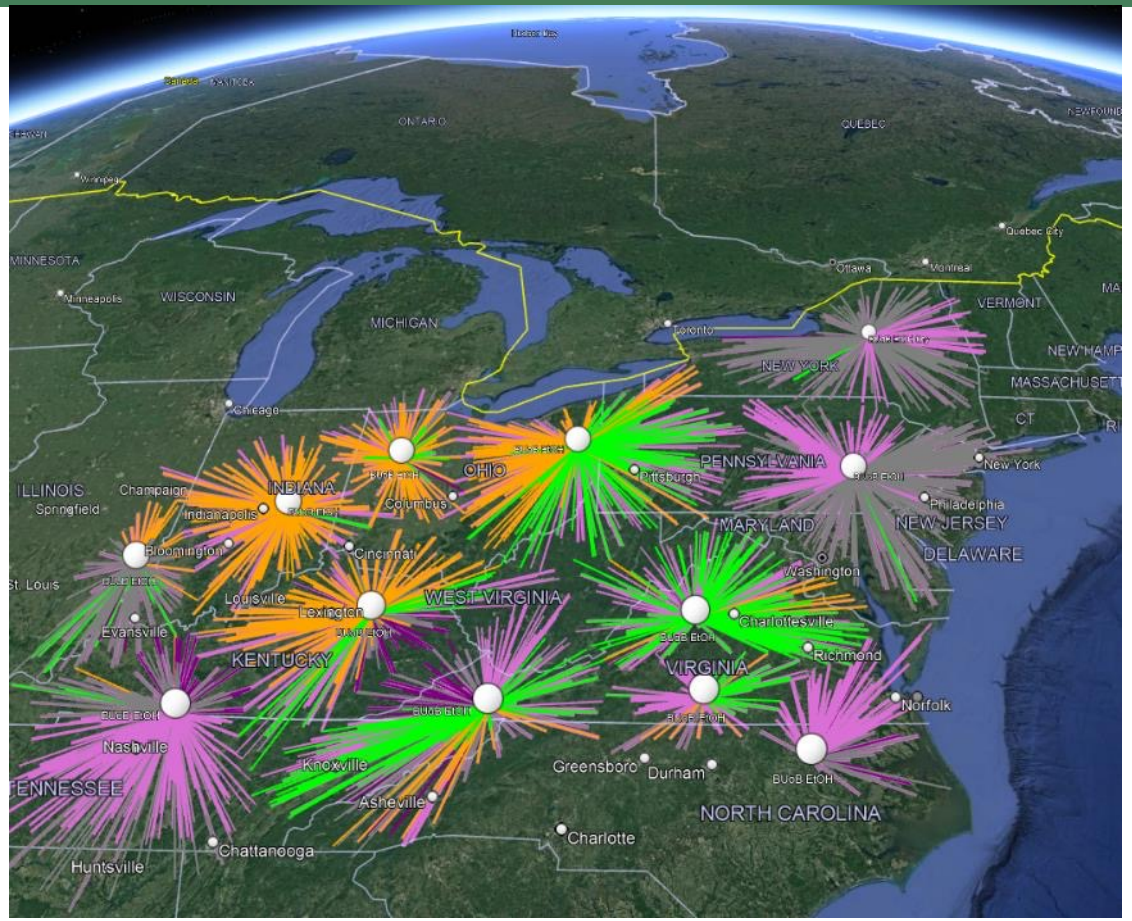
Task 4. LCA – BILT refinery siting to promote environmental justice and ecosystem services



BILT solution w/ 90% of carbon avoided (19.4 Mt CO2) sited 11 refineries (2,000 Mt biomass/d) and one 1,000-Mt refinery in upstate NY (green=switchgrass, orange=willow, grey/purple=forestry wastes).

- Candidate sites screened by excluding census tracts with a high score for any of six indicators related to air pollution from EPA's Environ. Justice Screening Tool.
- Biomass from partially harvested riparian buffers and forest residues feeding refineries of 1,000, 1,500 or 2,000 Mt/day biomass producing ethanol, electricity, gasoline).
- Included carbon sequestration from crop production phase (SOC, N_2O) from BioVEST.
- Overall, avoiding carbon increased the number of refineries. Higher carbon removal targets increased the amount of willow feedstock used.
- Next step:
  - Reduce farmgate price by payments for ecosystem services where available, driving BILT to select cheapest (most-environmentally friendly) feedstocks first.

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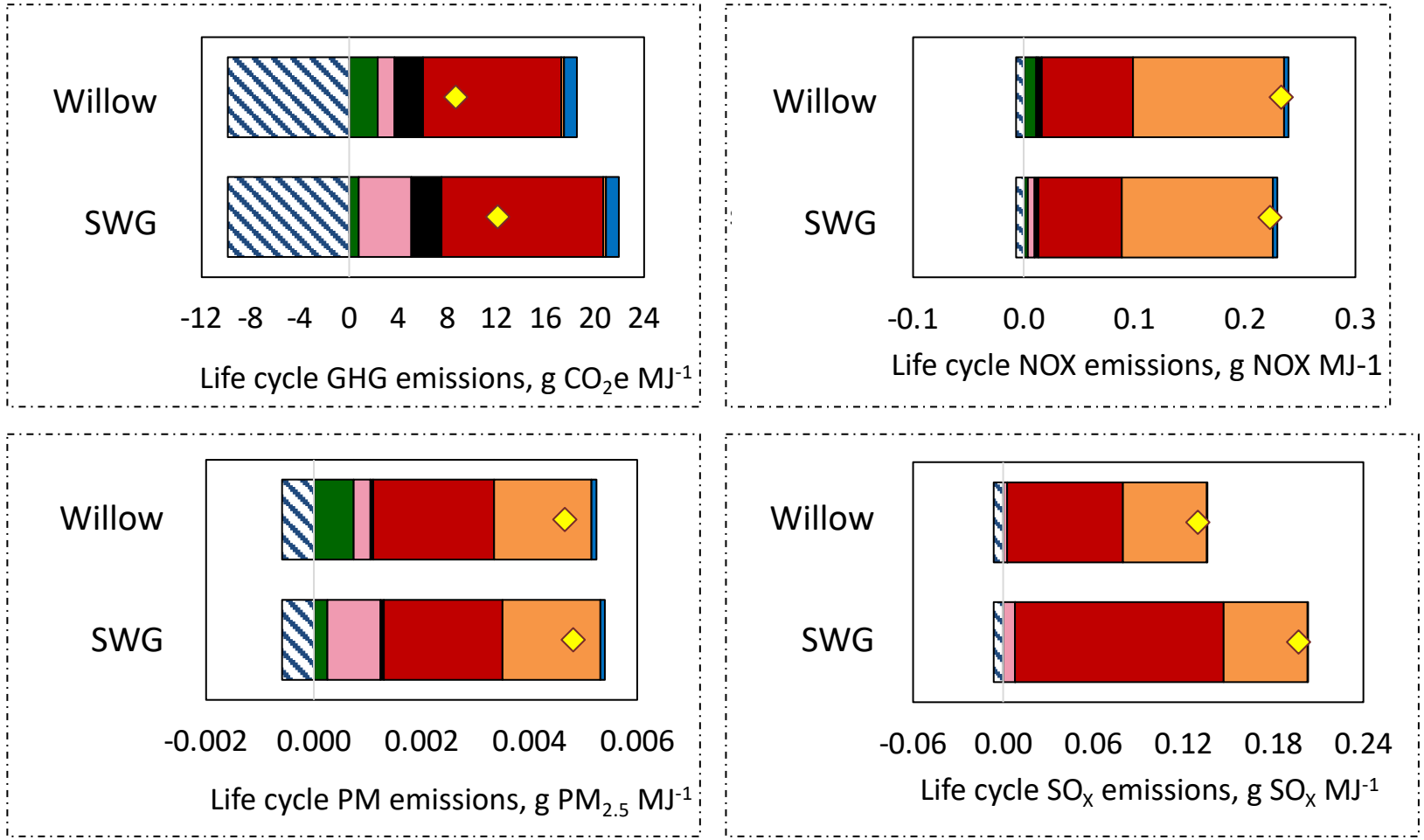
Task 4. LCA for ethanol produced from riparian buffer biomass shows promising GHG results and provides inputs for air quality analysis

Ethanol from buffer biomass achieves 82%+ GHG reduction over gasoline.



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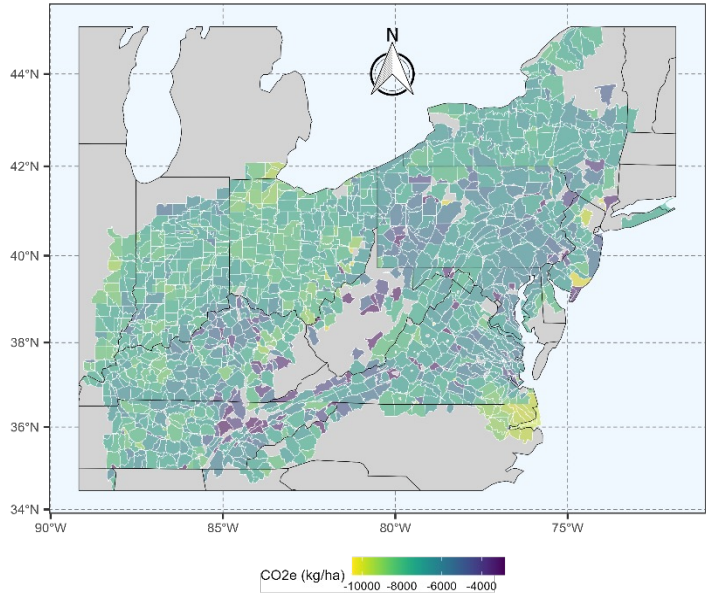
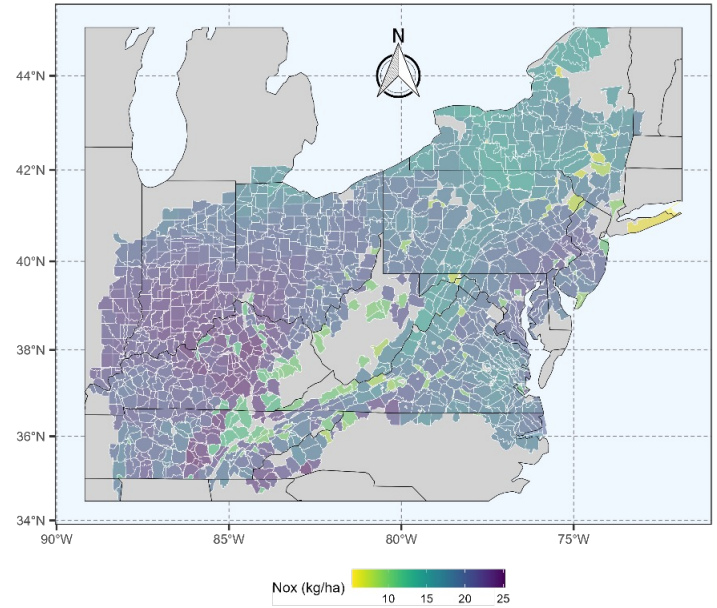
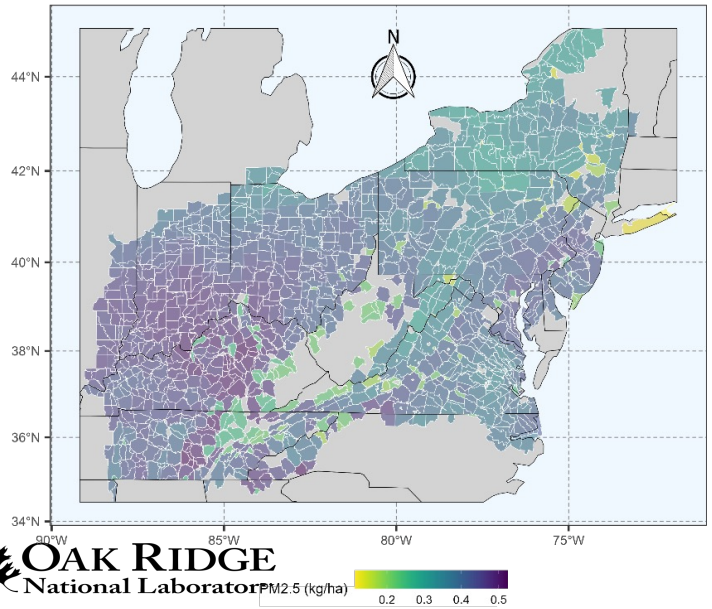
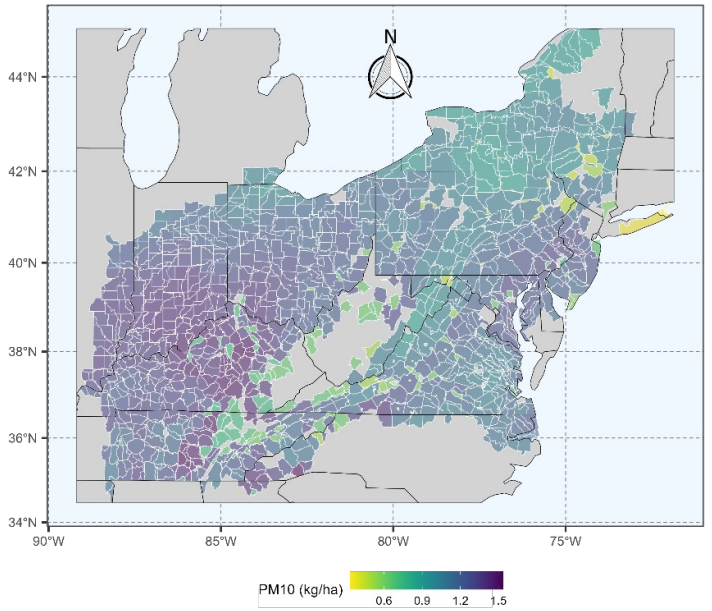
Task 4. LCA – preliminary GREET air-pollution results

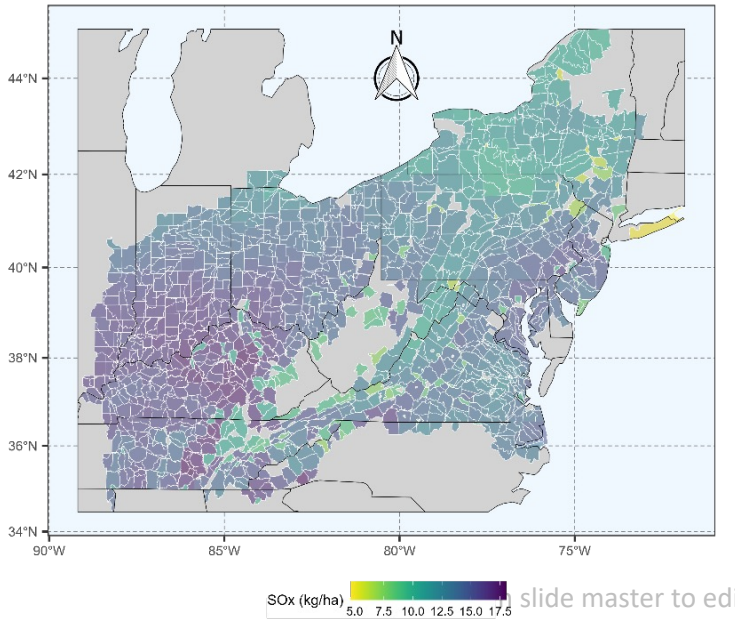


- Previous GREET results showed that emissions from production of cellulosic feedstocks are of lower concern than gasoline.
- GREET simulates eight criteria air pollutants and VOCs.
- Future: Valuation of benefits relative to gasoline.









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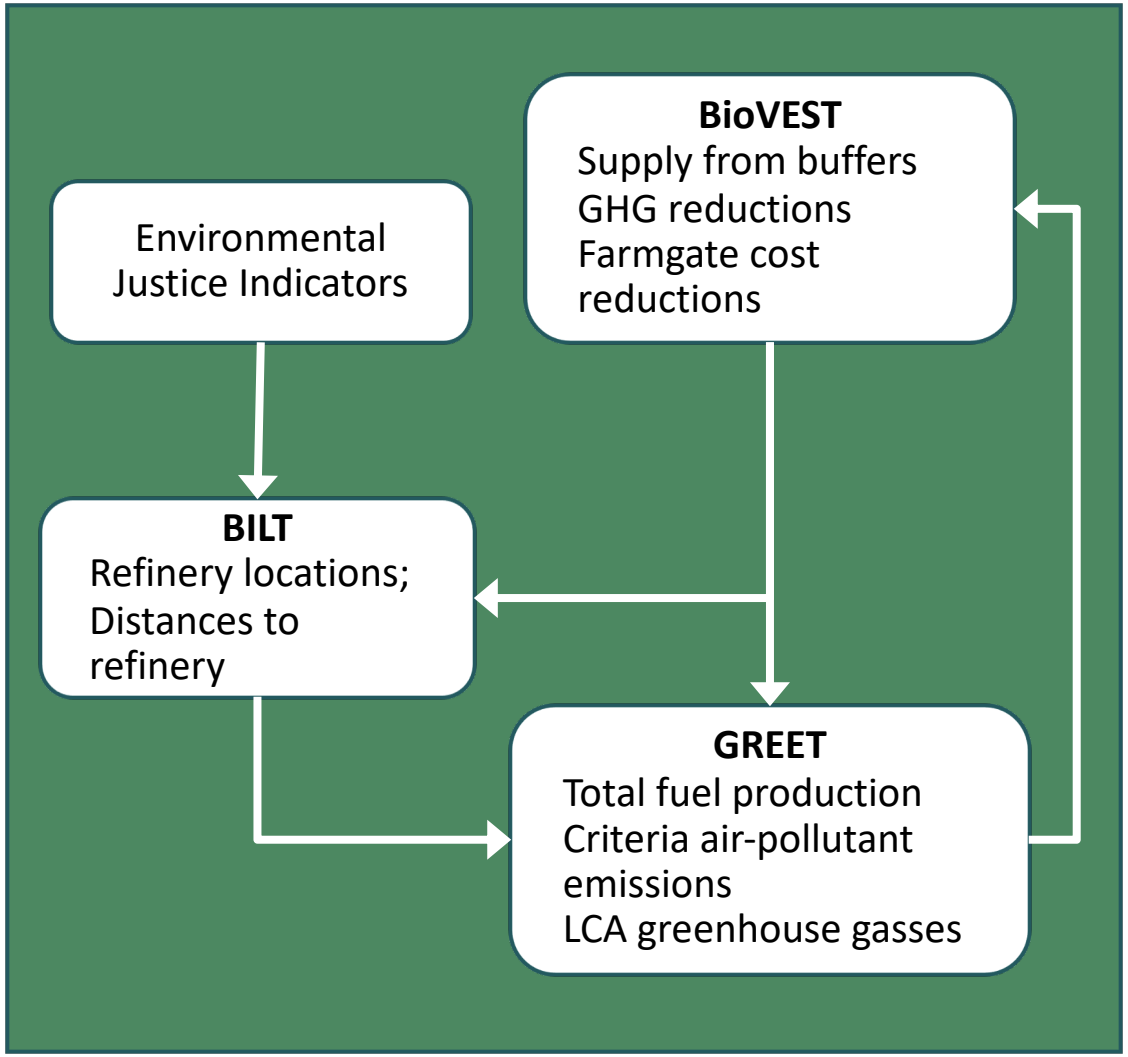
Stakeholder outreach

- USEPA (Authored Wetland and Terrestrial Biodiversity chapters of the Triennial report)
- ANTARES Group, Inc. (Contributed Biodiversity chapter to final report, sharing of biodiversity results with collaborators including USDA, growers, Pheasants Forever)
- 2022 Short Rotation Woody Crops International Conference. (Operations Working Group)
- Ohio Restoration Working Group (Plan for federal funding for restoration projects in the Ohio River Basin); includes watershed stakeholder organizations to be included in outreach efforts.
- Land Trust Alliance, Southeastern Land Conservation Trust (April 26-29 workshops on carbon credits, decision tools and other relevant topic). Joined Energy Working Group
- Scientific forums (e.g., AGU: Innovation: Carbon Monitoring Systems Research and Applications, Battelle Conference on Innovations in Climate Resilience)
- Next steps:
  - Publish webtool on the KDF. Stakeholders invited will include watershed groups and conservation trusts.
  - Appalachian Carbon Forum (invited to provide materials)
  - EPRI Climate-READI Regional Workshops (member utilities, users of biopower), invited to host in 2024

Key project impacts disseminated through tools, publications & collaborations

- Spatially explicit modeling of the value from ecosystem services associated with partially-harvested riparian buffers are being disseminated through tools (to be hosted on-line), peer-reviewed publications, and presentations.
- BioVEST feeds biomass supply, changes in SOC, N_2O into BILT to obtain refinery locations.
- BILT provides distances (between feedstock sources and refineries) to GREET.
- BioVEST feeds biomass supply, changes in SOC, N_2O into GREET to assess GHG emissions, air pollution, and the cost of fuel production.
- LCA research using GREET is showing significant reductions in GHGs in the ethanol production phase compared to gasoline.
- Next: Evaluate whether the magnitude of environmental credits and insurance savings represents ~10% of fuel cost.



Key project impacts disseminated through tools, publications and collaborations

- Demand-side research identified where value of ecosystem services is highest and where opportunities for payments or incentives for ecosystem services exist.
- Work with USDA-ERS to assess climate-resilient solutions and benefits related to avoided crop insurance benefits, building on ORNL high-performance computing and climate projections.
- Publish LCA research using GREET to quantify reductions in GHGs in the ethanol production phase compared to gasoline and reduction in cost where incentives are available.
- Dissemination and outreach: EPA (Triennial report), ANTARES, Watershed associations, USDA-Economic research service, the Ohio Restoration Working Group, Land Trust Alliance, Short Rotation Woody Crops Operations Workgroup.

Summary

1-Approach	• Develop and provide a user-friendly open-source tool to assess spatial opportunities for monetizing ecosystem services provided by biomass production from the most environmentally friendly feedstock systems (riparian buffers and animal wastes) • Link eco-economic models to evaluate and visualize the value of ecosystem services spatially for both the crop production and fuel production phases (full life cycle). • Well-defined metrics for project success.
2-Progress & Outcomes	• Identified systems to improve species habitat in an agricultural and a forested case study-FY21 • Produced two publications demonstrating that a high percentage of biomass production costs can be offset by focusing on feedstock systems rich in ecosystem services, where incentives exist. • Developed software allowing stakeholders to visualize ecosystem service values. • Quantified avoided crop insurance costs under current & future climate by planting biocrops. • Demonstrated high potential for water quality benefits from manure-> RNG in the Mid-Atlantic
3-Impact	• Sharing online decision tools with groups that disseminate or use incentives (Short-rotation Watershed groups, Land Trust Alliance, Ohio Restoration Working Group, ANTARES, Appalachian Carbon Forum) to highlight the win-win of harvested riparian buffers. • Publications highlighting benefits of perennial feedstocks for climate resilience in high-impact journals. • Outreach to partners: EPA, USDA-ERS, Forest Service to highlight win-win benefits.

Quad Chart Overview

Timeline

- Project start date: 10/01/2021
- Project end date: 9/30/2023

	FY22 Costed	Total Award
DOE Funding	$340.12K	1,200K (400K/y ORNL) $150K (100K/y ANL)
Project Cost Share	100%	

Funding Mechanism: Lab Call FY21, *DMA*

Project Goal

Assess the potential for lowering the cost of biomass fuels through payments for ecosystem services. Provide tools to find spatial overlap between environmental incentives (demand) and sustainable supply for specific biomass production systems with a focus on watershed-based decisions now and under future climate conditions. A full-life-cycle spatial valuation will include relevant ecosystem services (e.g., water purification, carbon regulation) for feedstocks (ORNL) and carbon cost associated with fuel production (ANL).

This project addresses BETO's 2025 goal: to understand and quantify environmental and economic effects associated with emerging biofuel and bioproduct technology pathways.

End of Project Milestone

Demonstrate where and how the cost of biomass production can be offset through payments for ecosystem services resulting in a 10% decrease in fuel cost.

Project Partners

- Year 1: Biodiversity modeling to support the ANTARES FOA project & PNNL Forest Thinning project (Wigmosta), Forest Service
- Years 2-3: 4.1.1.10 GREET project, Argonne National Laboratory (Troy Hawkins)
- Years 1-3: 1.1.1.3 ORNL Supply Scenario Analysis (Langholtz) (separately-funded)

Additional Slides

Acronyms

Acronym	Definition
BioVEST	Model that estimates the supply of feedstocks from partially harvested riparian buffers, the change in nutrient runoff, soil carbon, and N2O emissions, and the monetary value generated by these changes compared to the status quo.
BILT	Biofuel Infrastructure, Logistics and Transportation Model for siting biorefineries of different sizes
GREET	Full Life cycle Greenhouse Gas Regulated Emissions and Energy Use in Transportation
HUCx	USGS Hydrologic Unit Code, delineated river basins, where x is the spatial resolution (e.g., 8-digit)
LCA	Life-cycle assessment
Rmarkdown	R Markdown documents are 'fully reproducible. Use a productive notebook interface to weave together narrative text and code to produce elegantly formatted output.'
RSPARROW	Spatially Referenced Regression on Watershed (w/ R-interface)
Shiny	Shiny is an R package that makes it easy to build interactive web apps straight from R. You can host standalone apps on a webpage or embed them in R markdown documents
SOC	Soil organic carbon
TN, TP	Total nitrogen, total phosphorus

GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies)

- Tracks life cycle performance of fuels and transportation technologies

- Over 50,000 registered users
  - Distributed globally and across industry and research organizations

- Used to support regulatory measures
  - U.S. Environmental Protection Agency Renewable Fuels Standard
  - California Low Carbon Fuel Standard
  - International Civil Aviation Organization (ICAO)
  - Oregon Clean Fuels Program

- Developed since 1995 with annual updates and expansions
  - Long-term support from U.S. Dept. of Energy
  - Bioenergy Technology Office
  - Vehicle Technologies Office
  - Hydrogen Fuel-Cell Technology Office

https://greet.es.anl.gov/

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2021-23 Peer-reviewed publications (6 total, *4 impact > 5)

- *Jager et al. 2022. Visualizing a sustainable bioenergy future: Mapping ecosystem service supply and value' that describes the water quality valuation. Science of the Total Environment. 834 155255. www.sciencedirect.com/science/article/abs/pii/S0048969722023488

- *Vera, IC,…HI Jager, Parish, et al. 2022. Land use for bioenergy: synergies and trade-offs between Sustainable Development Goals (SDGs), Renewable and Sustainable Energy Reviews 161 www.sciencedirect.com/science/article/pii/S1364032122003173

- *Jager, HI, RA Efroymson, & RA McManamay. 2021. Renewable Energy and Biological Conservation in a Changing World. Biological Conservation 263, 109354. Special Issue.

- Jager, HI, JW Long, RL Malison, BP Murphy, A Rust, LGM Silva, R Sollmann, ZL Steel, MD Bowen, JB Dunham, JL Ebersole, & RL Flitcroft. 2021. Resilience of terrestrial and aquatic fauna to historical and future wildfire regimes in western North America. Ecology and Evolution, 11(18), 12259-12284, doi.org/10.1002/ece3.8026.

- *Kreig, JAF, E Parish, & HI Jager. 2021. Growing grasses in unprofitable areas of US Midwest croplands could increase species richness. Biological Conservation 260, 109289, doi.org/10.1016/j.biocon.2021.109289

- Parish E, Dale V, Davis M, Efroymson R, Hilliard M, Kline K, Jager H, Xie F. 2021. An Indicator-based Approach to Sustainable Management of Natural Resources. Chapter 14 of "Data Science Applied to Sustainability Analysis 2020". Co-edited by Jennifer Dunn and Prasanna Balaprakash for Elsevier.

Publications in progress (submit, in review, or revised, FY23)

Submitted or accepted before the end of FY23

- *Jager, HI, S. Nair, C. DeRolph, RA Efroymson, E Parish, G. Wang. Submitted. Ecosystem services from partially harvested riparian buffers can offset biomass production costs. Science of the Total Environment.
- *Efroymson, RA, E Parish, K Kline, V Dale, HI Jager. Resubmitted. Setting targets for indicators of sustainable resource management. BioScience. (funded by this project and 4.2.2.40)
- Kreig, JAF, E. HI Jager, E. Ponce and S. Lenhart. In prep. A spatially explicit individual-based modeling approach to evaluate temporal harvesting strategies on ring-necked pheasant (*Phasianus colchicus*) populations. Ecological Modeling.
- Ghimire, G., Y. Liu, S. Gangrade, S-C Kao, C. DeRolph, E. Parish, & HI Jager. In prep, 50%. Perennial riparian buffers for bioenergy: a flood-resilient climate adaptation for agricultural landscapes. Journal TBD. 50% done.
- Liu, Y. et al. In prep. 80% Scalable high-resolution flood inundation mapping for real-time inundation forecast and climate resilience studies. Frontiers in Big Data. (Will submit in April.)

FY24 plans

- Farhad, M. et al. Life-cycle assessment of ecosystem services from riparian buffers in the Mid-Atlantic region. (LCA results)
- Parish, E., I. Busch, et al. Siting biorefineries to promote environmental justice and generate ecosystem services.
- Jager, HI, et al. Where are the win-win opportunities for enhancing ecosystem services by producing or collecting biomass feedstocks in the Mid-Atlantic region? (Geospatial roadmap results, both animal wastes and riparian buffers).

Awards & professional service, 2021-2023

HI Jager

- Elected to the 2022 class of fellows of the American Fisheries Society. https://ornl.sharepoint.com/Pages/Article.aspx?articleId=42526 .
- Joined the Leadership Team for the ORNL Climate Change Science Institute.
- Served on the organizing committee for the 2022 Joint Aquatic Sciences Meeting on a subcommittee tasked with selecting plenary speakers with diversity and equity among considerations.
- Joined the Editorial board of the journal Water Security & Biology.
- Nominated for election to the steering committee of the Ohio River Basin Alliance (ORBA), which is seeking to establish programs to incentivize water quality improvements in the basin. Contributed to Climate Change chapter of the Ohio River Restoration plan.

JAF Kreig

- Awarded Director's Fellow at Los Alamos National Laboratory, 2023 based in part on her BETO-funded research at ORNL.
- Awarded the 2021 Graduate Student Policy Award by the Ecological Society of America for her presentation on 'Biomass and Birds'. www.esa.org/blog/2021/03/15/esa-selects-2021-graduate-student-policy-award-recipients.
- Earned her doctoral degree from the University of Tennessee, July 2021.

Scientific presentations and posters, 2021-2023

- Ghimire, G., S. Gangrade, Y. Liu, DeRolph, E Parish, HI Jager, 2023. Perennial Riparian Buffers for Bioenergy: A Flood-Resilient Climate Adaptation for Agricultural Landscapes. 3/29/2023. Battelle Conference on Innovations in Climate Resilience. March 28-30, Columbus, Ohio.
- Jager, HI, S. Nair, C. DeRolph, RA Efroymson, E Parish, G. Ghimire, S. Gangrade, Y. Liu. Dec. 2023. 'Ecosystem Services from Partially-harvested Riparian Buffers'. Session: Innovation: Carbon Monitoring Systems Research and Applications. American Geophysical Union 2023 meeting. Virtual attendance of annual meeting in Chicago, IL.
- Efroymson, R. et al. 2022. 'Ecosystem service benefits of shrub willow grown in riparian zones of annual croplands' to the Short Rotation Woody Crops meeting in Asheville, May 2-4, 2022. https://woodycrops.wixsite.com/srwc2022/program.
- COVID, 2021-2022

Responses to reviewer comments

- In general, reviewers found the work up to FY21 (the 1st year of this cycle) to be extremely valuable. The main concerns are listed below:

  (1) The project had too many moving parts and was difficult to understand in terms of overarching project goals.

  – This happened because new opportunities for collaborations developed and we chose to use them as Case Studies (forest thinning in the Wenatchee Valley, WA and adding biodiversity modeling to the ANTARES-led FOA project in Iowa). To address this concern, we finished the Case Studies in FY21 and then focused completely on the proposed milestones related to offsetting production costs by producing ecosystem services. We have not added new case studies to reduce project complexity.

  (2) Our biodiversity research was found to be valuable, but the reviewers were interested in understanding how biodiversity assessment could be consistently applied alongside other metrics.

  – We responded that future work would have less emphasis on biodiversity. However, we would like to develop general approaches in the context of climate mitigation (e.g., shading from riparian buffers and potential gains in coldwater habitat) that could be incorporated into BioVEST.

  (3) A reviewer highlighted the collaboration with the BioSTAR project to conduct stakeholder engagement but was disappointed not to hear more about it.

  – The BioSTAR project was not funded and COVID limited our outreach efforts. Now that we have developed the interactive BioVEST tool, we are focusing on stakeholder outreach to watershed groups, land conservancy organizations, industry (e.g., short-rotation woody crop organization) and federal collaborators.

2018-2020 Publications (*impact > 5)

1. *Jager, Parish, Langholtz, and King. 2020. Perennials in flood-prone areas of agricultural landscapes: a climate-adaptation strategy. BioScience 10.1093/biosci/biaa006
2. *Langholtz, Jager, et al. 2021 Increased nitrogen use efficiency in crop production can provide economic and environmental benefits. Science of the Total Environment. *https://doi.org/10.1016/j.scitotenv.2020.143602*.
3. *Jager, HI and CC Coutant. 2020. Knitting while Australia burns. Nature Climate Change 170: 10.1038/s41558-020-0710-7 2.
4. *Gorelick, D, LM Baskaran & HI Jager. 2019. Visualizing feedstock siting in biomass production: tradeoffs between economic and water quality objectives. Land Use Policy 104201.
5. *Kreig, JFA, I Chaubey, H Ssesane, CM Negri & HI Jager. 2019. Designing bioenergy landscapes to protect water quality. Biomass & Bioenergy 128 105327. https://doi.org/10.1016/j.biombioe.2019.105327
6. *Chen, H, Z Daib, HI Jager, SD Wullschleger, X Jianming & CW Schadt. 2019. Influences of nitrogen fertilization and climate regime on the above-ground biomass yields of miscanthus and switchgrass: A meta-analysis. Renewable and Sustainable Energy Reviews 108: 303-311. 10.1371/journal.pone.0211310
7. Jager, HI & JFA Kreig. 2018. Designing landscapes for biomass production and wildlife. Global Ecology & Conservation 16 https://doi.org/10.1016/j.gecco.2018.e00490
8. *Jager, HI & RA Efroymson. 2018. Can biomass production increase the flow of downstream ecosystem goods and services? Special Issue. Biomass and Bioenergy 114: 125-131. https://doi.org/10.1016/j.biombioe.2017.08.027
9. *Wang G, Jager HI, Baskaran LM, & Brandt CC. 2018. Hydrologic and water quality responses to biomass production in the Tennessee river basin. Global Change Biology: Bioenergy 10: 877-893.
10. *Dale, VD, HI Jager, AK Wolfe, & RA Efroymson. 2018. Risk and resilience in an uncertain world. Frontiers in Ecology and the Environment (Guest editorial). 16(1): 3-3. https://doi.org/10.1002/fee.1759