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DOE Bioenergy Technologies Office 2021 Project Peer Review

Geospatial Analysis of Ecosystem Service Portfolios from Biomass Production

3/10/2021 (1:20 pm)
Data, Modeling & Analysis
Henriette Jager (ORNL)

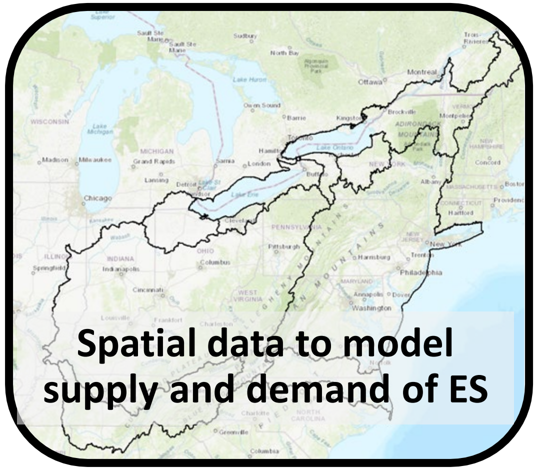
U.S. DEPARTMENT OF ENERGY

Project Overview

- **Why?** Lack of demand and profitability are barriers to adoption of sustainable bioenergy production from perennial and waste feedstocks
- **What?** Can we push advanced feedstocks over the profitability threshold by generating carbon and nutrient credits and/or providing ancillary services in the Mid-Atlantic?
- **End of project goal:** Demonstrate where payments for ecosystem services can offset 10% of fuel cost using LCA / BioVEST. Our **Go/NoGo** is to demonstrate the ability to offset 25% of production cost.
- **How?** Conduct demand-side research (geodata, eco-economic tools) that considers D3/D5 RINS, carbon (e.g., NE/Mid-Atlantic LCFS), and water quality credits. Use BioVEST for assessment of biomass production and valuation of ecosystem services. Use GREET LCA for fuel production.
- **Risks?** There could be insufficient overlap between watersheds with environmental credits and markets for cellulosic feedstocks. If so, shift focus to renewable natural gas (e.g., waste/cellulosic co-digestion) pathways.

FY21-23 Project workflow and collaborations

Geospatial Roadmap (Jager, Parish – ORNL Spencer - FS)



***Langholtz - ORNL**
- Production costs
- Downscaled yield data (cellulosic)

Feedstock Production (Jager - ORNL)

Feedstock Scenarios

Biophysical modeling (SWAT+, BioEST)

Monetization (BioVEST)

- Feedstock biomass* → $$ Production Cost*
- Water quality → $$ Water purification
- Species biodiversity → $$ Fishing hunting Spp. recovery
- **Soil carbon** → $$ Climate regulation

Fuel Production (Hawkins – ANL)

Biophysical modeling (GREET)

Monetization (LCA)

- **Biopower**
- **Renewable Natural Gas**

- **$$ Cost**
- **$$GHGs**

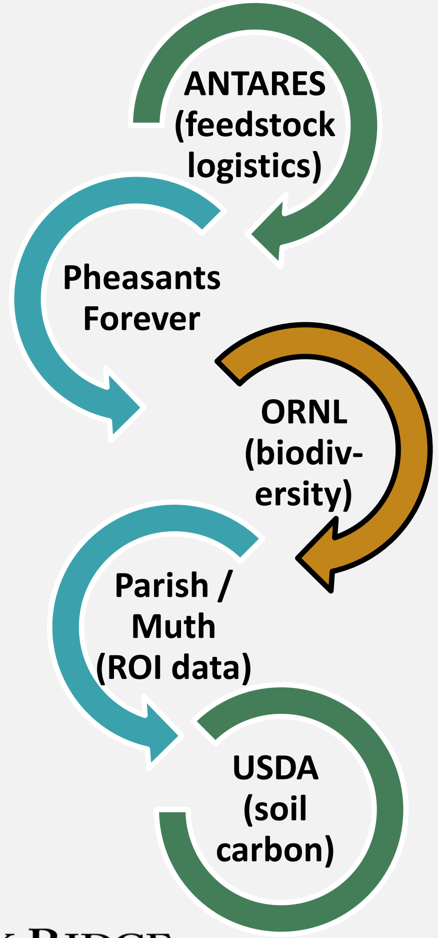
BioSTAR (Parish – ORNL)

Stakeholder engagement
- **Case study focus groups**
- **Industry relevance**
- **Elicit priorities, feedback**

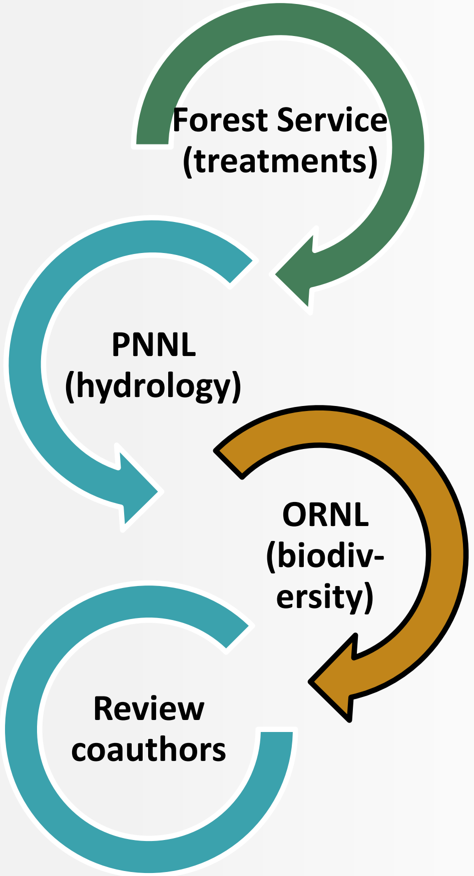
Web-based visualizations

Collaborations, current and future

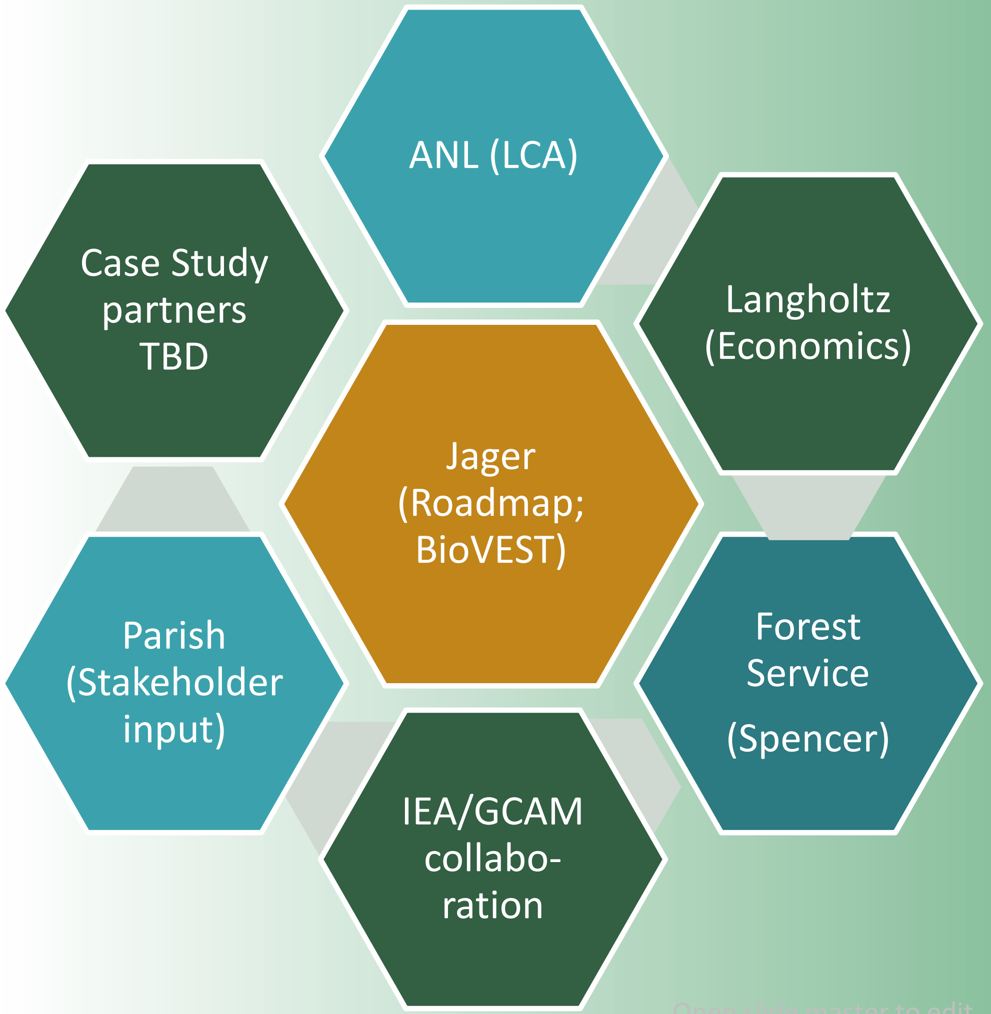
Midwest Case study Landscape design FY18-FY21



Western Case study Forest treatment FY19-FY21



BioVEST modeling -FY23



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Project team and collaborating ORNL projects

- **Dr. Henriette Jager, ORNL PI**
  - Project management
  - Ecosystem services valuation, BioVEST development
  - Salmon modeling
  - Editor, Special Issue
- **Chris DeRolph**
  - Geospatial roadmap
  - Riparian buffer analysis
  - River/watershed data
- **Jasmine Kreig (PhD student)**
  - Biodiversity modeling for Agricultural case study (ANTARES, Iowa)
- **Dr. Rebecca Efroymson**
  - Geospatial roadmap planning
  - Review of pesticide use on perennials versus annual crops.
  - Soil carbon estimation / valuation
  - Editor, Special Issue
- **Dr. Sujith Nair**
  - Crop modeling, climate effects
  - BioVEST development
  - Watershed (SWAT, water quality and soil carbon) modeling
  - Water quality trading and valuation

Project Coordination
- Bi-weekly project meetings
- Quarterly reporting, monthly BETO A&S PI call
- Monthly coordination meetings with Parish (BioSTAR project)
- ANTARES project monthly calls and annual meetings
- Regular EPA Triennial Report calls
- Bi-annual coordination meetings with partners, Forest Service, ANL

Dr. Esther Parish
(PI collaborating project)

Dr. Matt Langholtz
(PI collaborating project)

Project success factors, risks, & mitigations

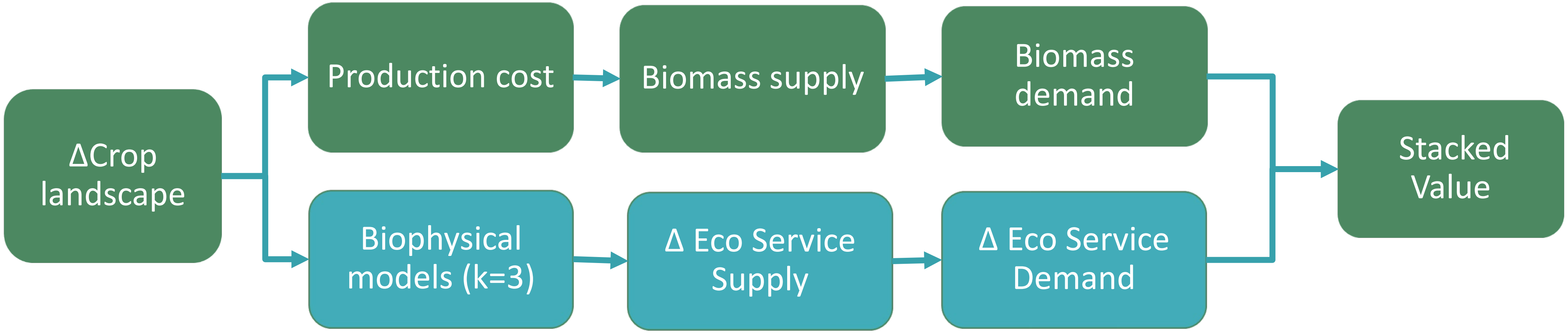
Success factors	• Collaborations • Tools for assessment of ecosystem services and valuation • Production cost data and crop projections, economics • Demand-side and environmental geospatial data • Access to computing resources
Risk #1	Go/No go: Possibility of insufficient opportunity to identify overlap between watersheds with environmental credits and markets for cellulosic feedstocks.
Mitigation	Emphasize renewable natural gas (e.g., waste/cellulosic co-digestion) pathways.
Risk #2	Project complexity
Mitigation	• Wrap-up Biodiversity Case Studies and publish outcomes • Focus on one region, Mid-Atlantic in FY22-23

FY21 AOP Task descriptions

Task	Description	Primary collaborators
1. Geospatial Roadmap Development	Mid-Atlantic region, demand-side spatial data and screening analysis	A) Spencer (Forest Service) B) Biogas representative, TBD C) Watersheds, recreation associations
2. Valuation with BioVEST	Watershed-scale case study Add carbon to BioVEST	
3. Case Study Implementation FY21 – complete A & B, identify new watershed collaboration	Biodiversity response modeling: A) Iowa agricultural fuelshed B) Wenatchee basin, WA, Wildfire-wildlife review, Western North America	A) Antares (Comer, Belden), ORNL (Parish), Pheasants Forever, USDA B) PNNL (Wigmosta); Forest Service (Hessberg, Long), EPA…
4. Bioenergy enhances Climate Resilience	Support GCAM modeling, IEA Task 45 publication – Mid-Atlantic case study, Other opportunities to highlight how growing biomass adds climate resilience in publications.	NREL (Schwab, Lammers), PNNL (Wise), ORNL (Jager, Parish), INL (Griffel), ANL (Quinn)
5. Life Cycle Assessment– FY22-FY23	Quantify pathways (e.g., Ethanol, RNG, biopower)	Argonne (GREET project, Troy Hawkins & Michael Wang)

Ecosystem services from biomass

Valuation of ecosystem services associated with biofuel production



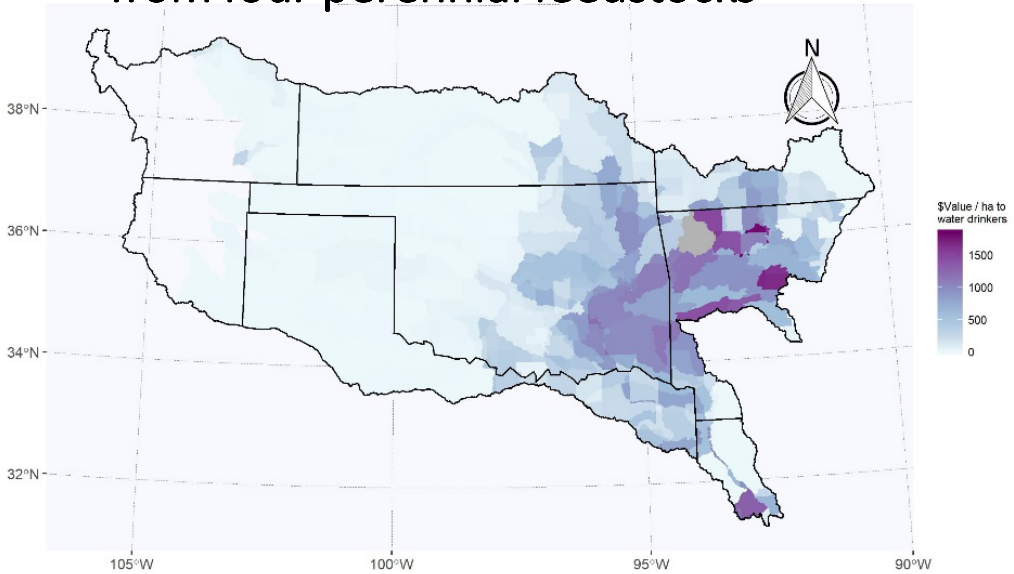
- Produced tools to monetize water quality improvements, quantify sustainable supply, and evaluate the potential for pushing cellulosic feedstocks across profitability thresholds (with Langholtz 1.1.1.10).
- SWAT (biophysical model for water quality) was implemented for a large HUC2 region, the Arkansas-White-Red basin
- Compared a baseline and downscaled future landscape (BT16 BC1 scenario) with four perennial feedstocks.
- Valued changes in water quality for different beneficiaries using EPA's approach.
- BioVEST valuation of improved drinking water, and recreation; assumed farmgate price $60/dt (BETO goal is $83/dt)

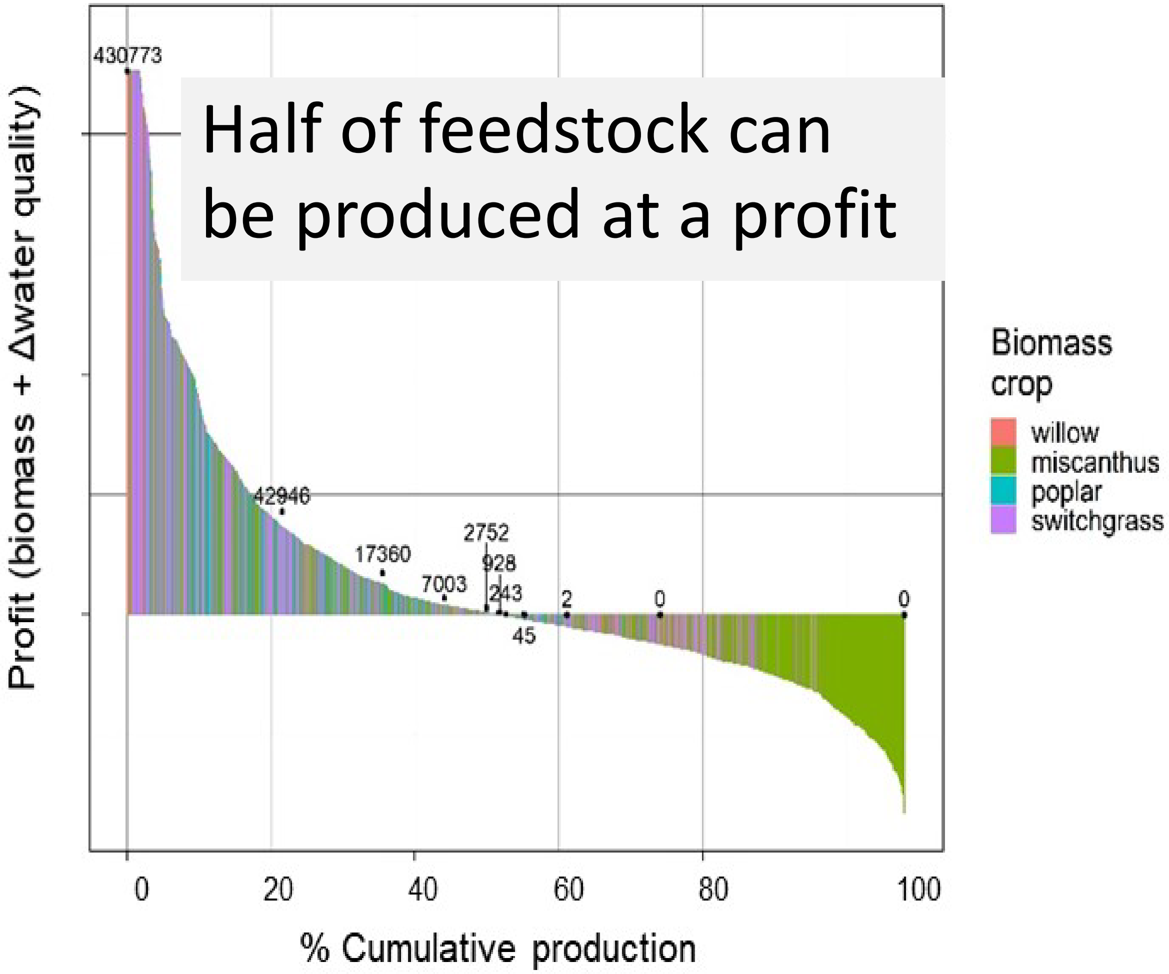
Valuation of ecosystem services associated with biofuel production

Key Outcomes:

- Environmental supply curves show sustainable supply
- Total value curves show an increase in profitable supply
- Mapped opportunities for environmentally-mediated profitability
- BioVEST publications #2, plus Q3 milestone manuscript #18.

Spatial assessment of added value from four perennial feedstocks

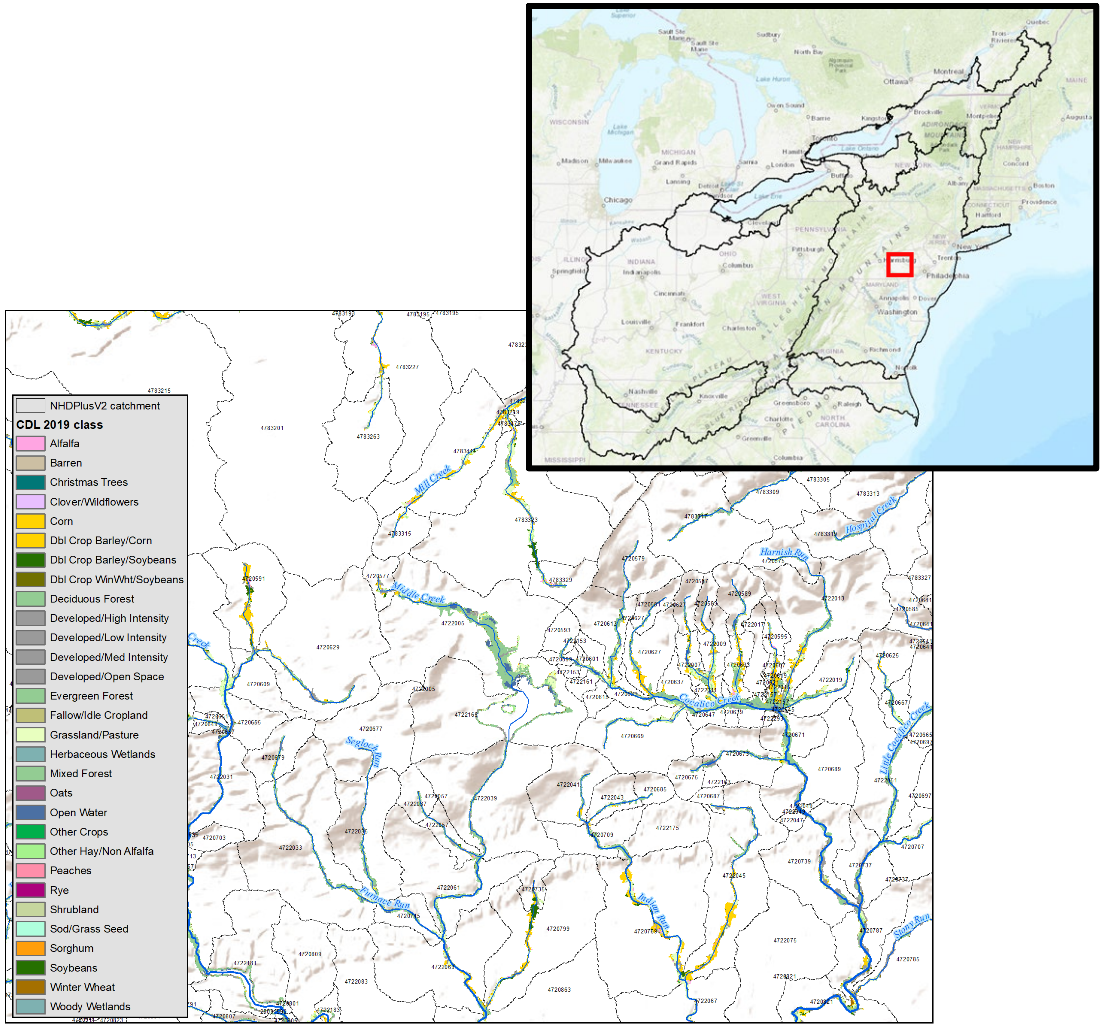




Half of feedstock can be produced at a profit

Watershed-based screening assessment of ecosystem services

- Next milestone: a plan for the Geospatial Roadmap including geospatial data to assess opportunities.
- Watersheds differ in potential for feedstock supply and demand.
  - Perennial feedstocks: Address how land are selected based on current crop cover, potential for carbon sequestration, available credits for carbon and water quality improvements, and access to markets.
  - Waste feedstocks: Identify supply and demand.
- **IEA Task 45 Case Study.** This analysis will be a case study to quantify carbon sequestration in riparian buffers of the Mid-Atlantic region and feed into PNNL's GCAM modeling effort. This is an FY21 milestone.
- Thus far, In collaboration with the Forest Service, we have determined that 20% of area along Mid-Atlantic streams is currently planted in row crops or small grains.



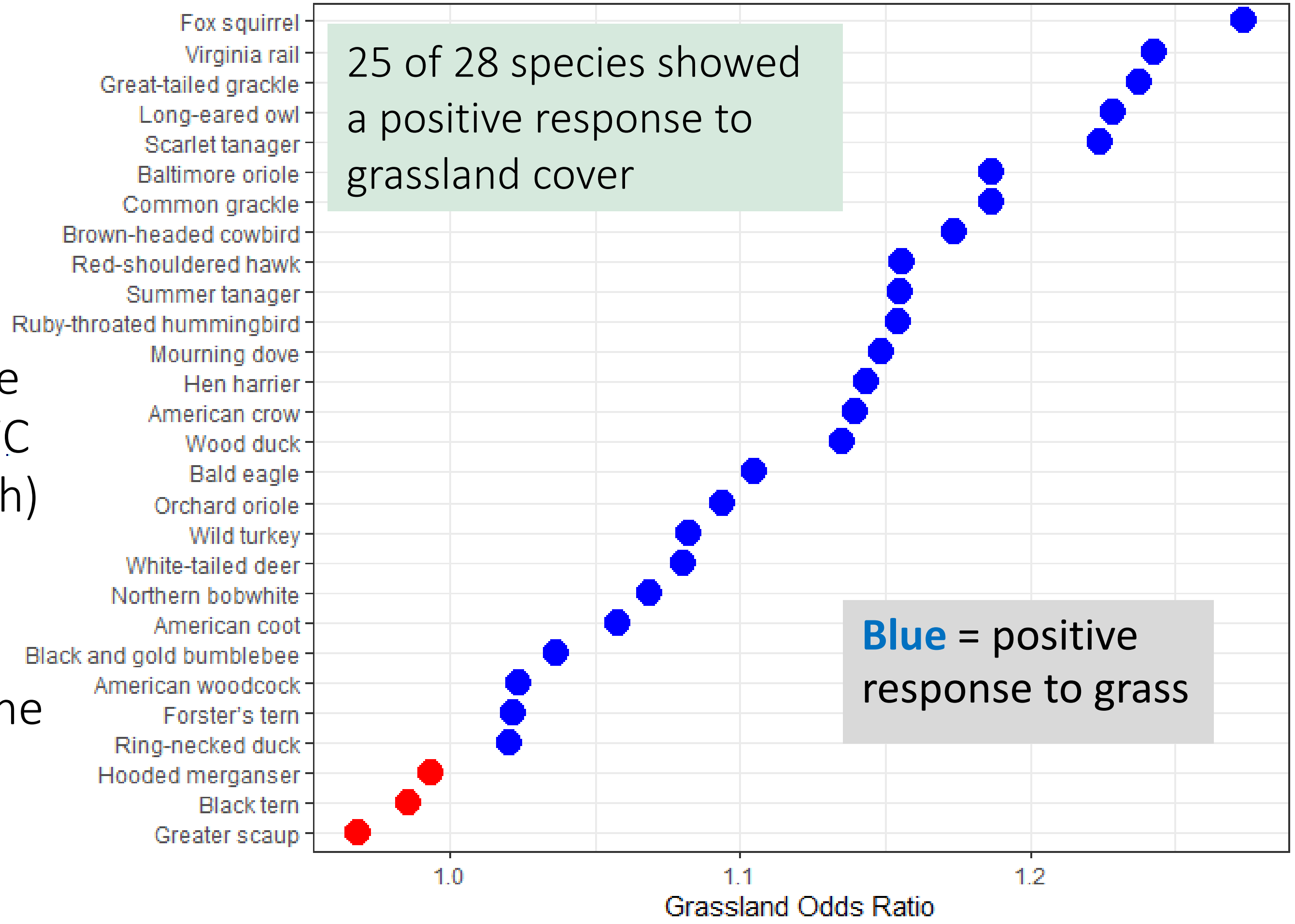
Land cover in riparian buffers from a small area in several PA watersheds of the Mid Atlantic region

Agricultural Iowa Landscape Design

- Biomass landscapes that benefit multiple species
- Harvest strategies for biomass and pheasants

Can planting a perennial grass in less-profitable fields increase species richness?

- We modeled the presence of species in Iowa from predictors including land/crop cover, climate data, soils, proximity to water, forest at 1-km resolution
- Model accuracy > 0.7 was satisfied for 28 species, mostly birds but a few other taxa.
- Areas with low return on investment (ROI) were identified using Profit-zone Manager (Muth, EFC Systems) in collaboration between ORNL (Parish) & the ANTARES-led Landscape Design project (Comer).
- We simulated changes in species richness for the current and future landscape with grass replacing corn/soy in low-ROI areas.



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ANTARES-ORNL collaboration

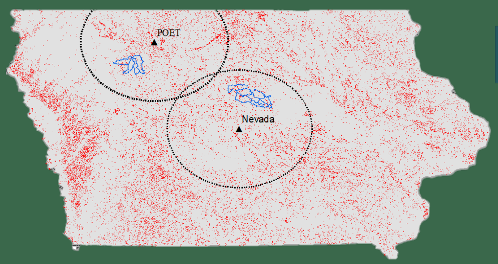
ANTARES & EFC Systems

1 AgSolver crop management scenarios

2 Profit Zone Manager

ORNL Parish

3 Cluster analysis to find large-enough low-ROI subfields for switchgrass

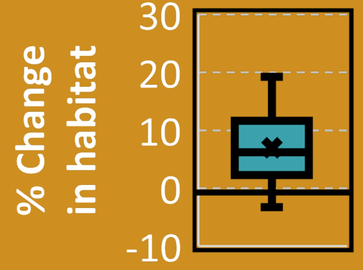


ORNL Jager

4 BioEST – species response modeling*

Climate and other predictors

Comparison showing increased richness

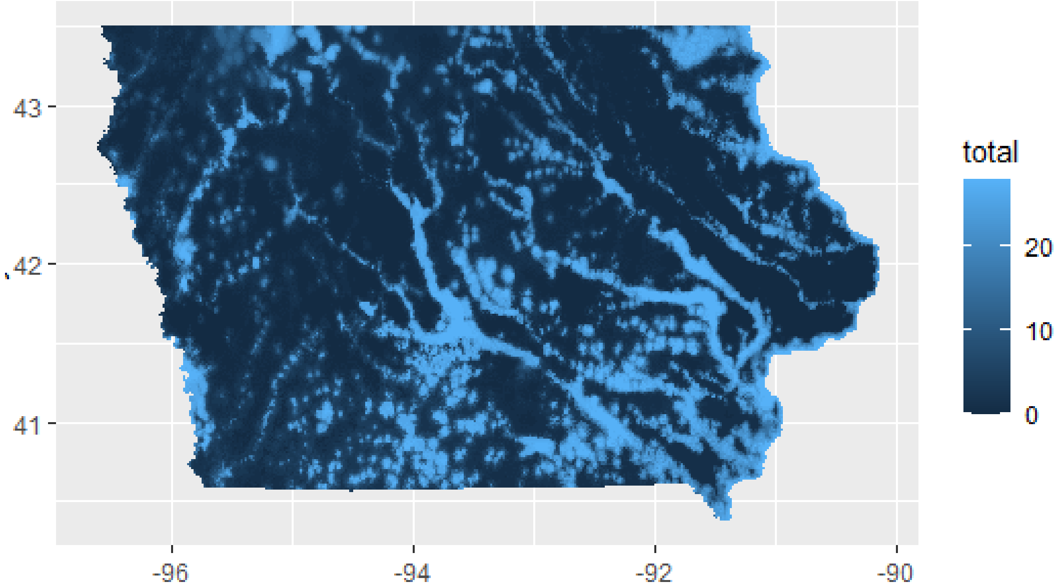


*Kreig, J, ES Parish, HI Jager. Submitted. Adding perennial grasses to unprofitable fields in Iowa increases biodiversity. Special Issue on Renewable Energy in Biological Conservation

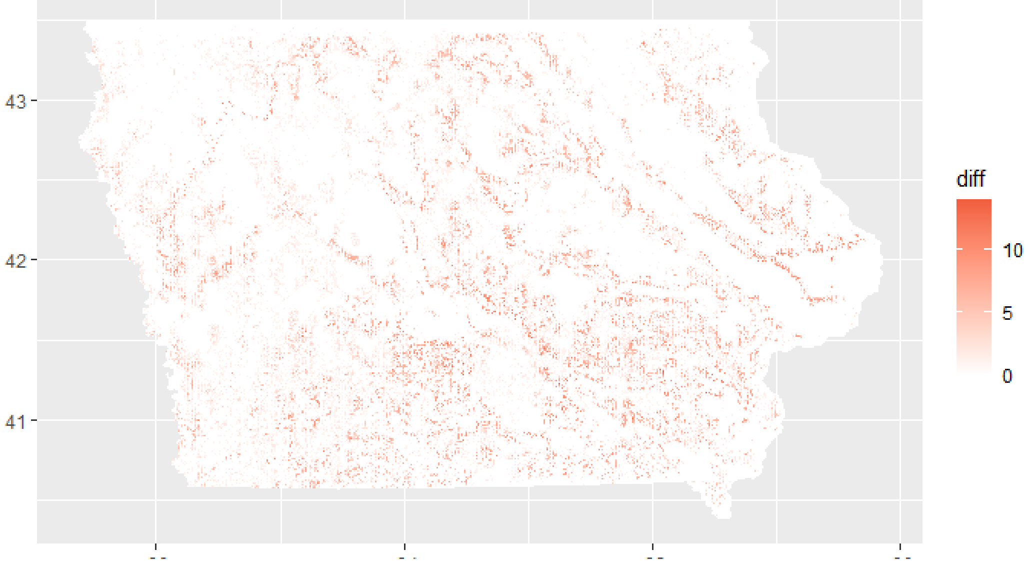
Planting a perennial grass in less-profitable fields increase predicted species richness

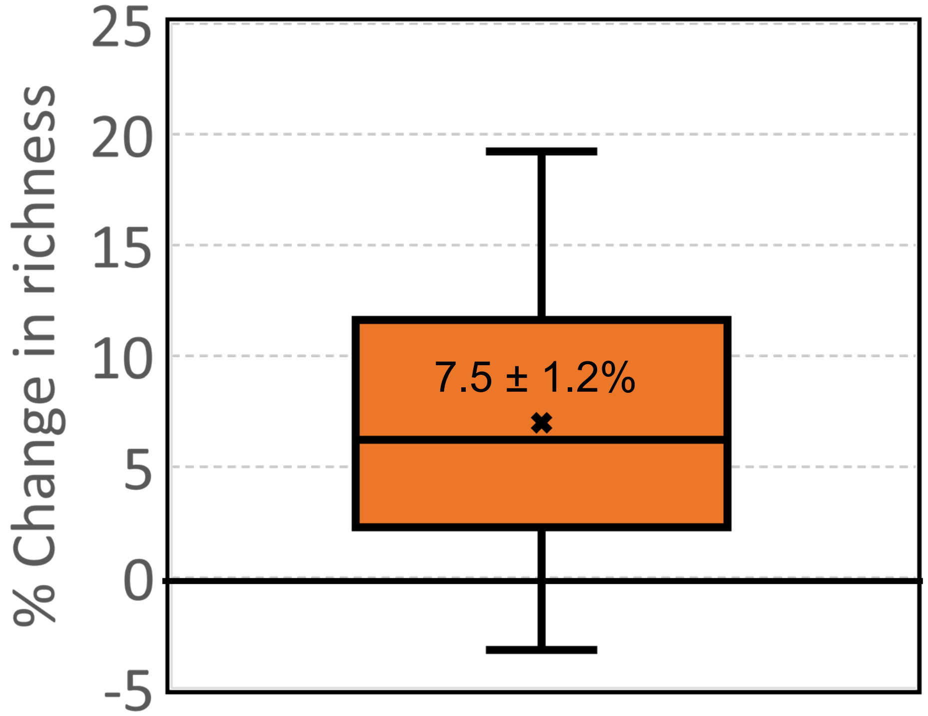
4-Progress & Outcomes

Baseline species richness



Predicted change in species richness





- Biodiversity Chapter, ANTARES final report
- Will submit manuscript #14 by Feb 28
- May add future climate

Wildfire & western forests

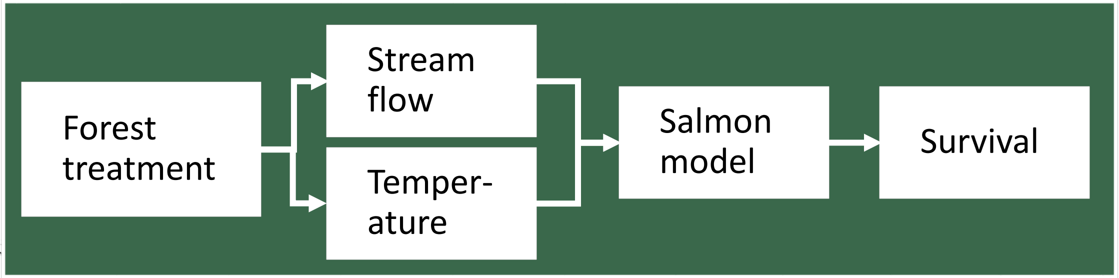
- Demonstrate benefits of forest restoration: triple-win salmon modeling
- Climate-wildfire-wildlife review

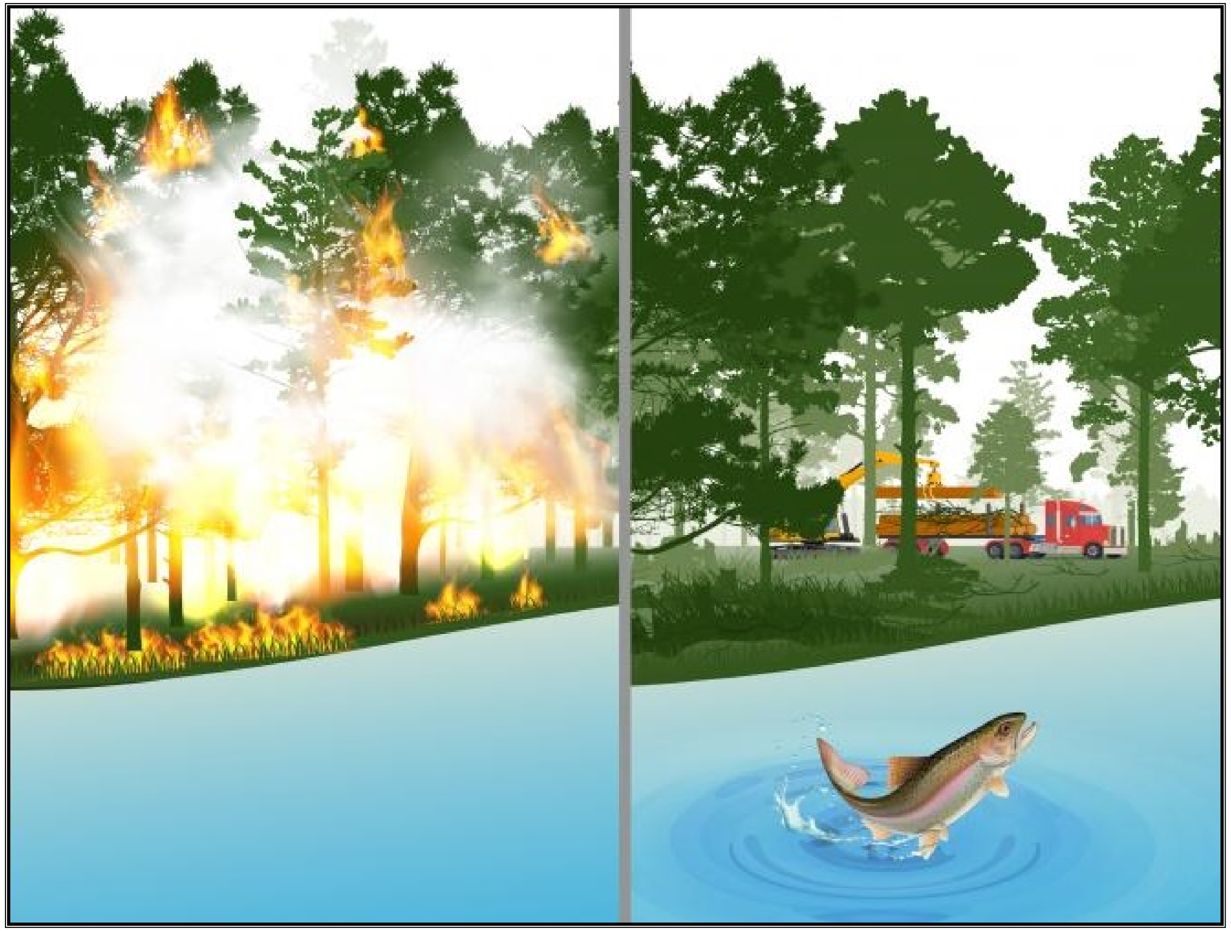
Can forest thinning treatments provide a triple win?

↑biomass, ↓wildfire, ↑ salmon

Proposition: Low thinning of western forests can provide biomass, reduce risk of high-intensity wildfires, and improve habitat for federally-endangered salmon that are very important in the western US.

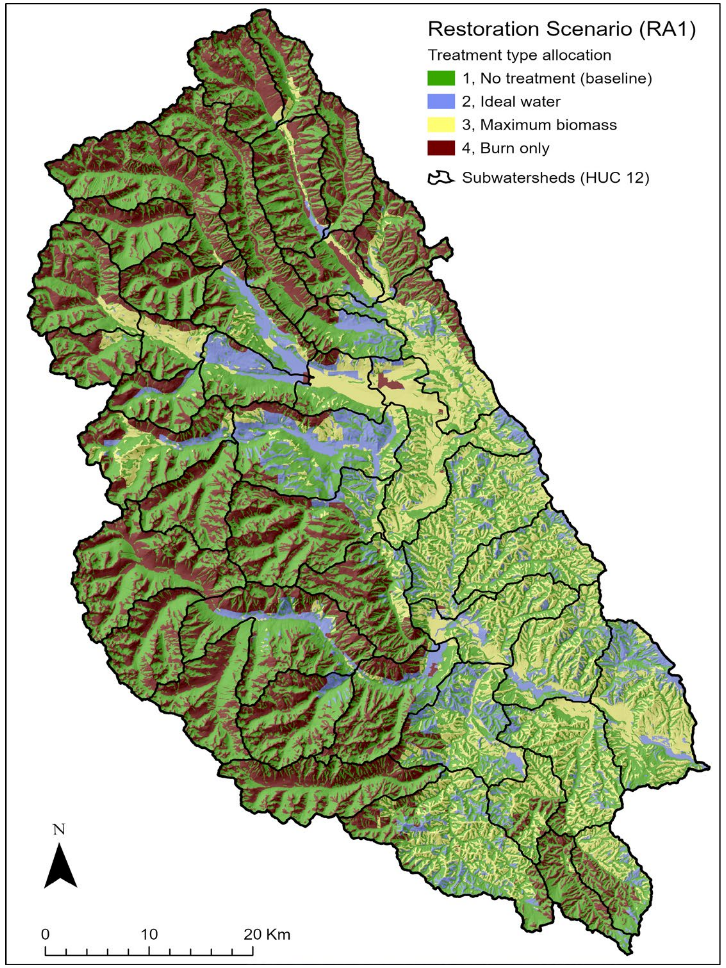
- Adapted, tested QUANTUS, a model of early salmon development, growth, and survival.
- Simulated four forest treatment scenarios in ORNL cloud-computing environment for a large number (>1,000) river reaches
- Valuation to quantify benefits potential restoration funding and potentially climate simulations.



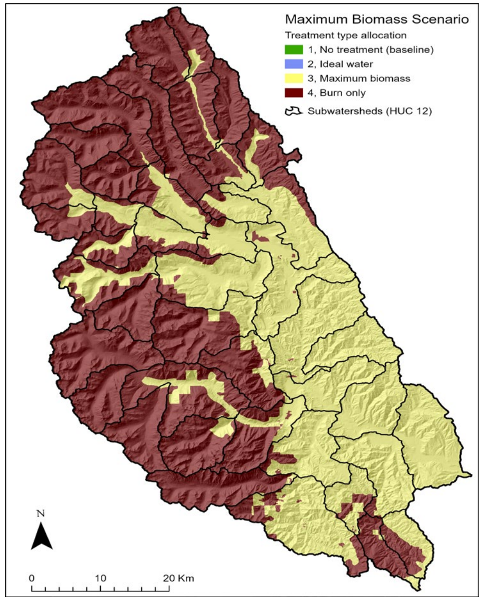


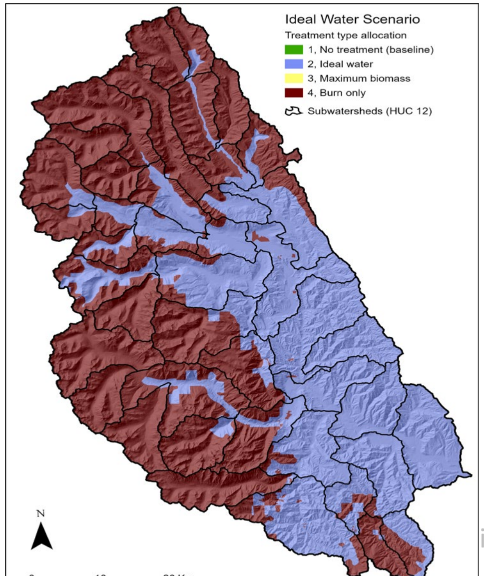
Compared simulated restoration scenarios

- PNNL validated DHSVM flow predictions in the Chiwawa basin within the larger Wenatchee from 1993-2003 for 1002 reaches. NS=0.78 in validation.
- ORNL simulated survival of endangered spring Chinook as a function of stream temperature and flow and compared to fish observations.
- True accuracy in predicting occupancy of reaches in the Wenatchee basin = 0.8224.
- PNNL and Forest Service produced four treatment scenarios, including a burn-only (everywhere), maximum treatment, ideal water (snow stored in forest gaps), and 'principles-based' treatment (RA1).



4th is all-burn scenario





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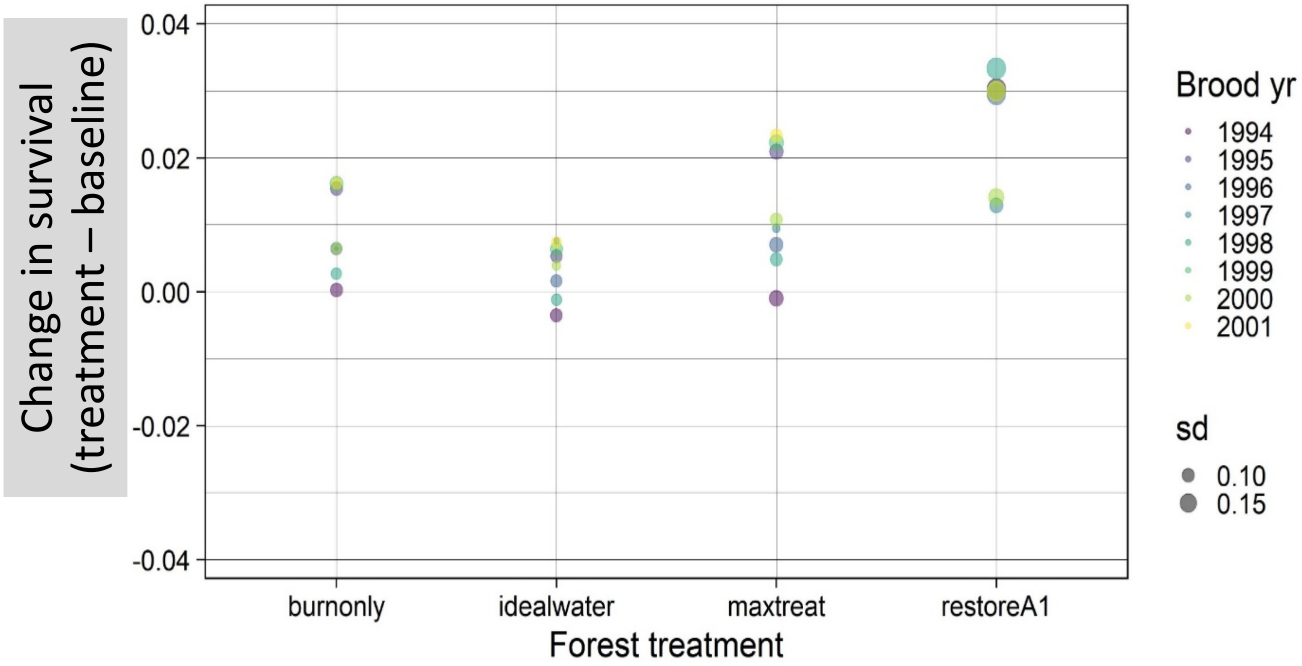
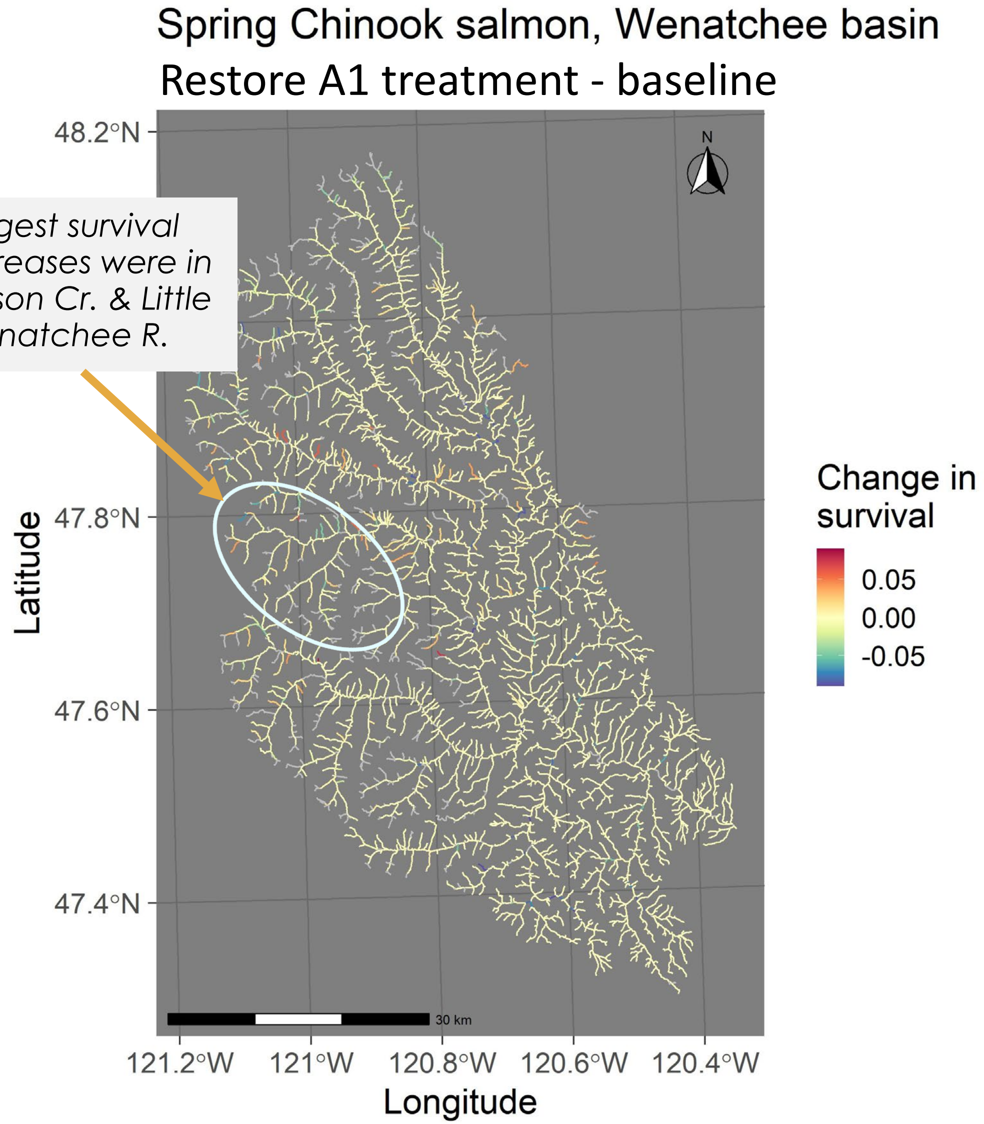
Restoration scenario that combined biomass, water, and wildfire objectives best for spring-run Chinook Salmon



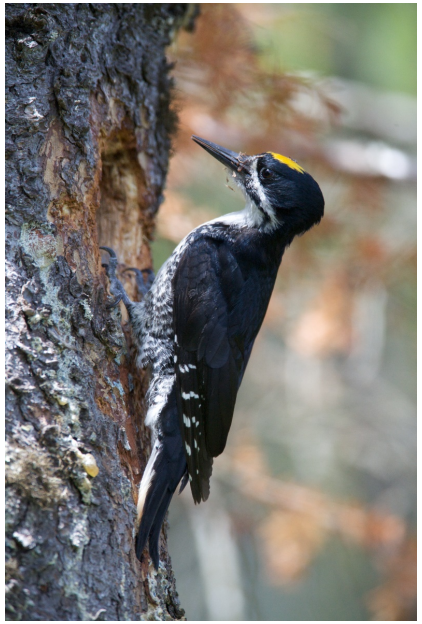


Next steps:

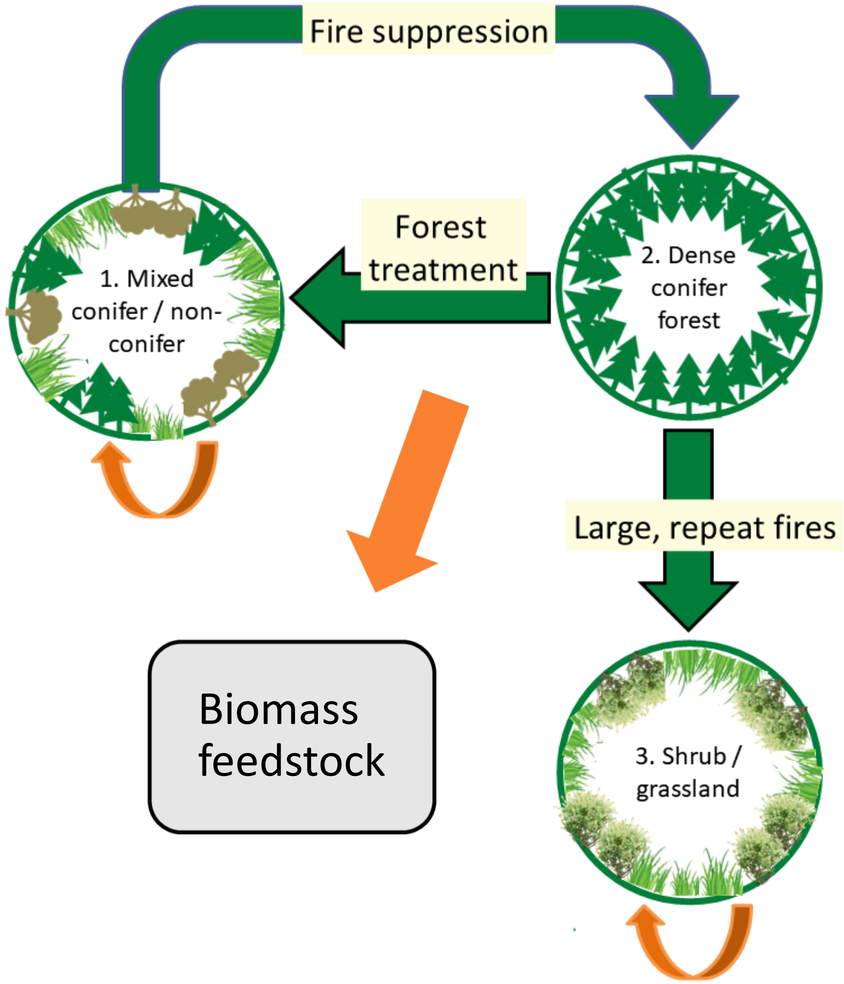
- Conduct habitat valuation (funds are available to improve salmon habitat)
- Submit manuscript #16

Review: Resilience of terrestrial and aquatic fauna to historical and future wildfire regimes in western North America

4-Progress & Outcomes



- Wildfires in many western North American forests are becoming more frequent, larger, and more severe due to changes in climate and past fire suppression. Dominant vegetation in some areas will continue to shift from conifers to non-conifers.
- Co-organized largest Symposium at a joint meeting of the American Fisheries Society and The Wildlife Society in Reno on 'Wildfire and Wildlife' - Increased wildfire under climate warming / drying and impacts on fish and wildlife.
- Produced a multi-author review paper including 10+ authors (Forest Service, EPA and academia).
- **Authors came to agreement on proposed forest treatments to reduce risk of large, high-severity fires.**



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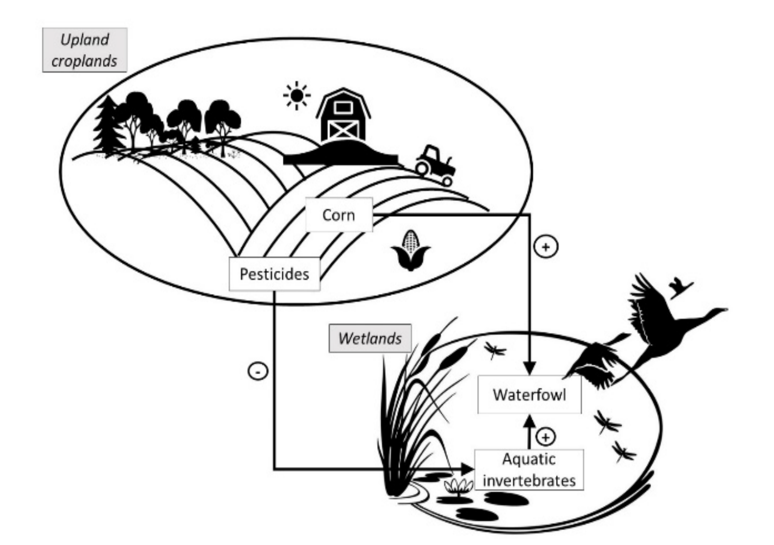
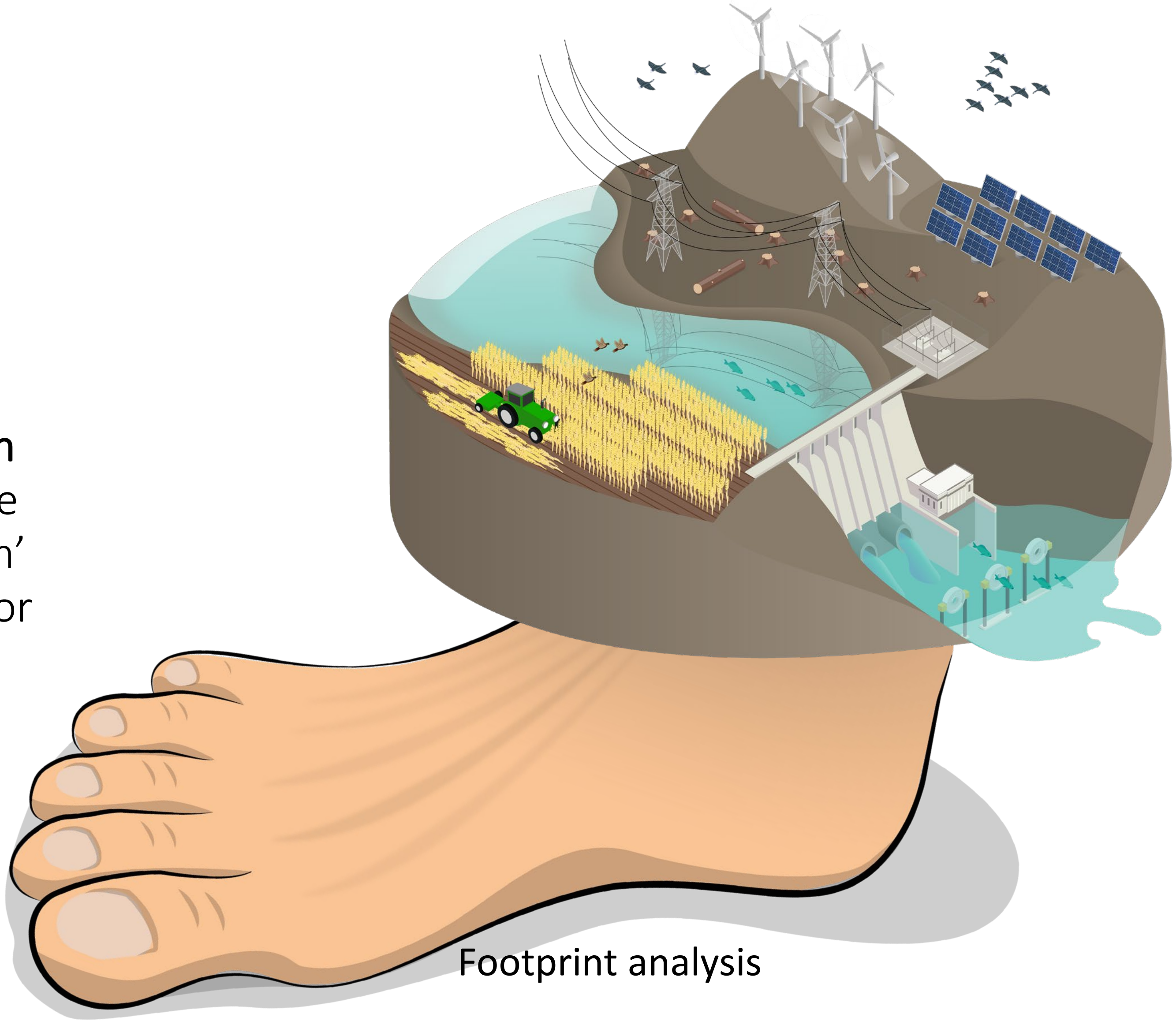
Impact & Summary



Impact through publications and key reports

- Coauthored two chapters of the **EPA Triennial Report to Congress** (Terrestrial Biodiversity and Wetlands and reviewed Aquatic Biodiversity Chapter)
- Highlighted biodiversity research (ours and by other groups) by **Guest editing a Special Issue in Biological Conservation** (IF=4.7). It examines the trade-off between avoiding the 'sixth extinction' associated with climate change and the need for renewables that can help integrate variable renewable sources by providing storage and dispatchability.



Footprint analysis

Highlighted climate resilience associated with perennial feedstocks planted in riparian zones

- Disseminated results through high-impact (e.g., BioScience IF=8.3, Renewable & Sustainable Energy Reviews IF=12.1) and medium-impact journals (complete list at end).
- Biomass production as a strategy for climate resilience:
  - Perennial biomass crops as a solution to increased flood frequency in the Midwest, #1
  - Selective forest thinning as a strategy for wildfire management in western North America, #14.
  - See also, publications #4, 11 at end of presentation
  - IEA and GCAM modeling efforts: Case study to quantify carbon sequestration in riparian buffers of the Mid-Atlantic region.

Viewpoint

Perennials in Flood-Prone Areas of Agricultural Landscapes: A Climate Adaptation Strategy

HENRIETTE I. JAGER, ESTHER S. PARISH, MATTHEW H. LANGHOLTZ, AND ANTHONY W. KING

"Floods are 'acts of God,' but flood losses are largely acts of man."

—Gilbert White (1942)

Extreme precipitation events will become more frequent in the future for large areas of the United States. Meanwhile, agricultural landscapes have lost resilience to flooding because we have drained wetlands and constrained rivers. US farmers have frequently experienced catastrophic ... flooded croplands over the agricultural productivity back to levels of the 1980s (US Global Change Research Program 2018), with annual row crop yields decreasing by up to 46% (Araya et al. 2017).

Future risk to croplands is exacerbated by the fact that we have reduced the water-storage capacity of US landscapes. In many areas, wetlands were drained to increase row-crop yields, whereas rivers were straightened to improve navigation and reclaim land. More than half of US wetlan... been drained and ... area is ... of Agriculture's Risk Management Agency, indemnities for US acreages eligible for prevented planting compensation exceeded $1 billion in 2019 and in each of five previous major flood events. These severe floods also washed away significant quantities of topsoil, which could have long-term effects on productivity.

In a future characterized by more frequent and extr...

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Summary

1-Management	• Bi-weekly project meetings; Quarterly reporting; EPA, Case study, and IEA Task 45 meetings • Multi-lab / project collaboration to monetize fuel production (LCA)
2-Approach	• Developing open-source tools and publishing research in high-impact outlets. • Linked eco-economic models to evaluate and visualize the value of ecosystem services provided by biomass production • Metrics of success: a) %Cost (feedstock and fuel) offset by environmental credits. b) Supply of feedstock at break-even point with and without credits. c) Monetized changes in ecosystem services (soil carbon, GHGs, species habitat, & water quality
3-Impact	• Project has developed tools to quantify and communicate sustainability results • Demonstrated improved salmon habitat as part of a triple-win for thinning western forests • Predicted increased species richness in a landscape planted with switchgrass in low-ROI areas. • Highlighted benefits of perennial feedstocks to climate resilience in high-impact journals • Authored EPA Triennial Report to Congress (biodiversity)
4-Progress & Outcomes	• Special Issue includes papers 1) comparing pesticide use in perennial biomass crops (#12); 2) reporting Iowa biodiversity modeling; and 3) an Overview LCA/footprint paper that highlights tradeoffs 6th- extinction v renewable integration, electrification. • Developed valued stacked supply curves and other tools for quantifying benefits. • Demonstrated benefits to biodiversity in an agricultural and a forested case study.

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Summary

Collaborations	1. EPA Triennial Report 2. Multi-institution co-authored publications 3. Forest Service, PNNL 4. ANL, Forest Service 5. IEA / C with BETO, PNNL, NREL, INL, ORNL (Parish)
Stakeholder input	1. Engage stakeholders through collaboration with Parish 4.1.1.20. Use BioSTAR as a tool for presenting results and soliciting feedback. 2. Formalize stakeholder engagement to include low-carbon energy industry representatives, NY/Mid-Atlantic, after year 1.
Risk & mitigation	1. Diverse project with multiple case studies. Mitigation: Finalize two case studies focused on biodiversity in FY21. 2. Opportunities for cellulosic to offset production cost may be rare. Mitigation: 1) Survey using demand-focused regional tools; 2) Include waste feedstocks for RNG and possibly ancillary services

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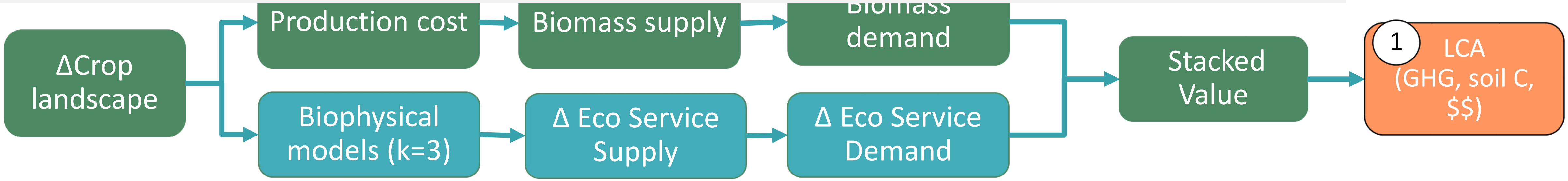
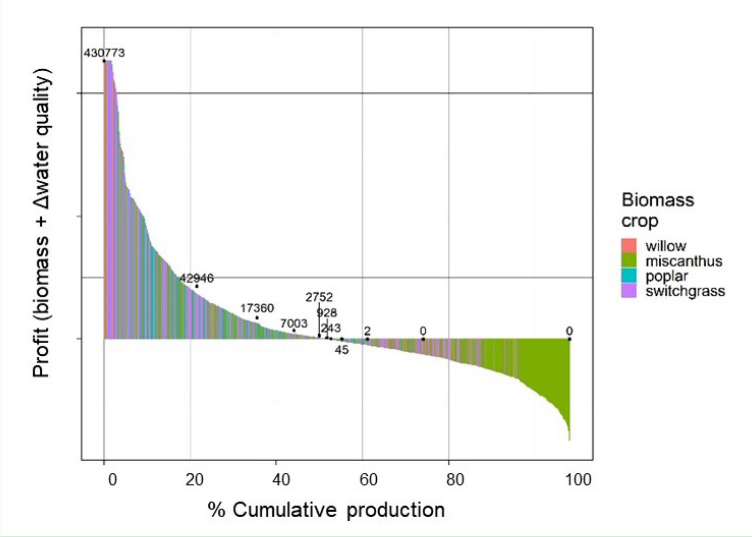
Future Plans

Future: Valuation of ecosystem services associated with biofuel production



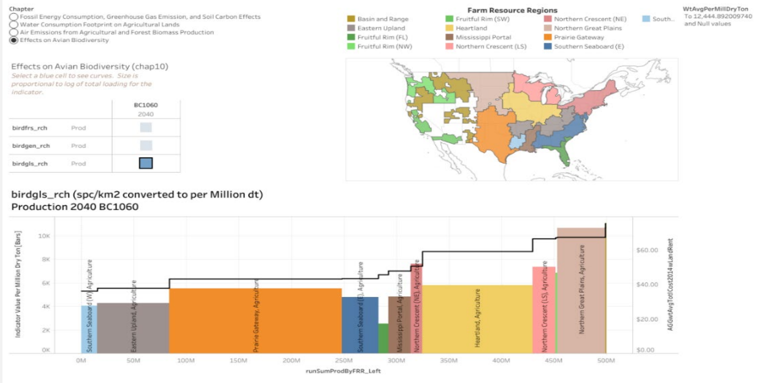
Water Purification

- SWAT-simulated changes in water quality for baseline, BC1 landscape
- BT16 production costs



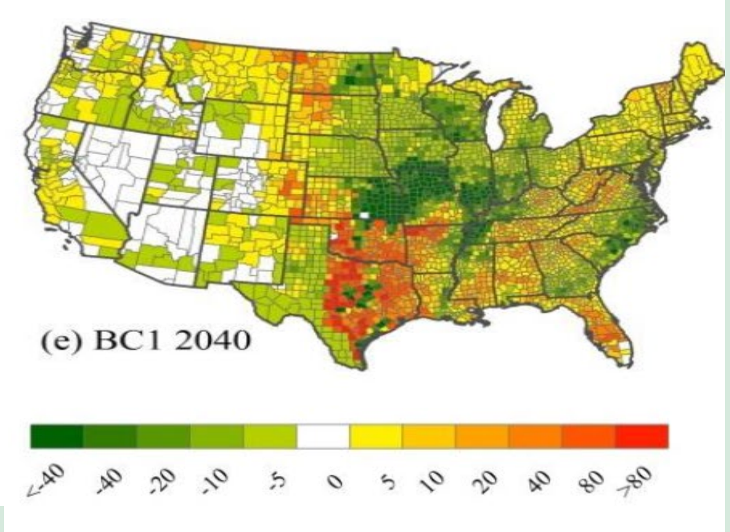
Biodiversity

- Valuation of species habitat improvements or biodiversity

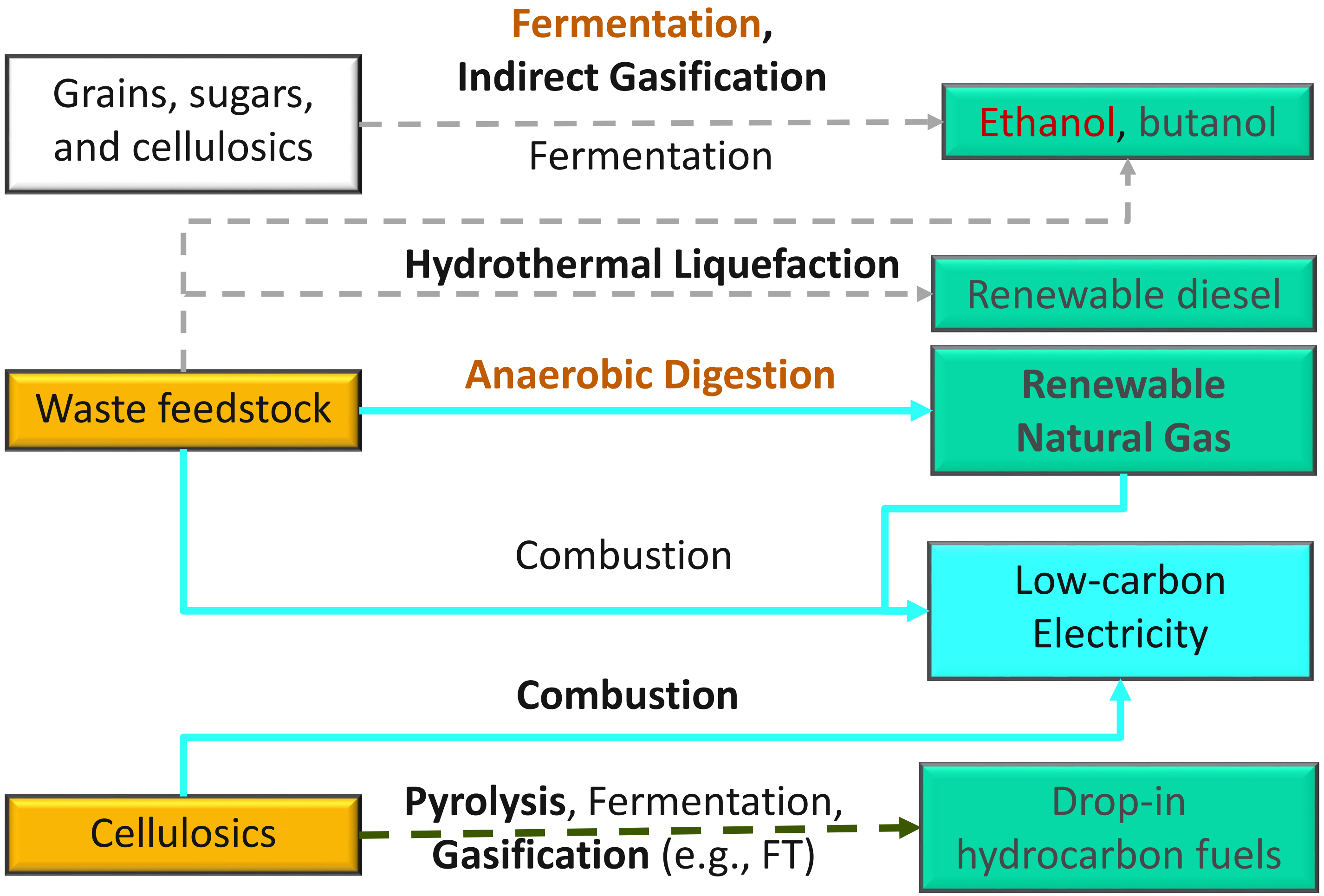


2 Carbon Regulation

- Biophysical modeling of soil carbon sequestration, GHGs
- Valuation of carbon credits

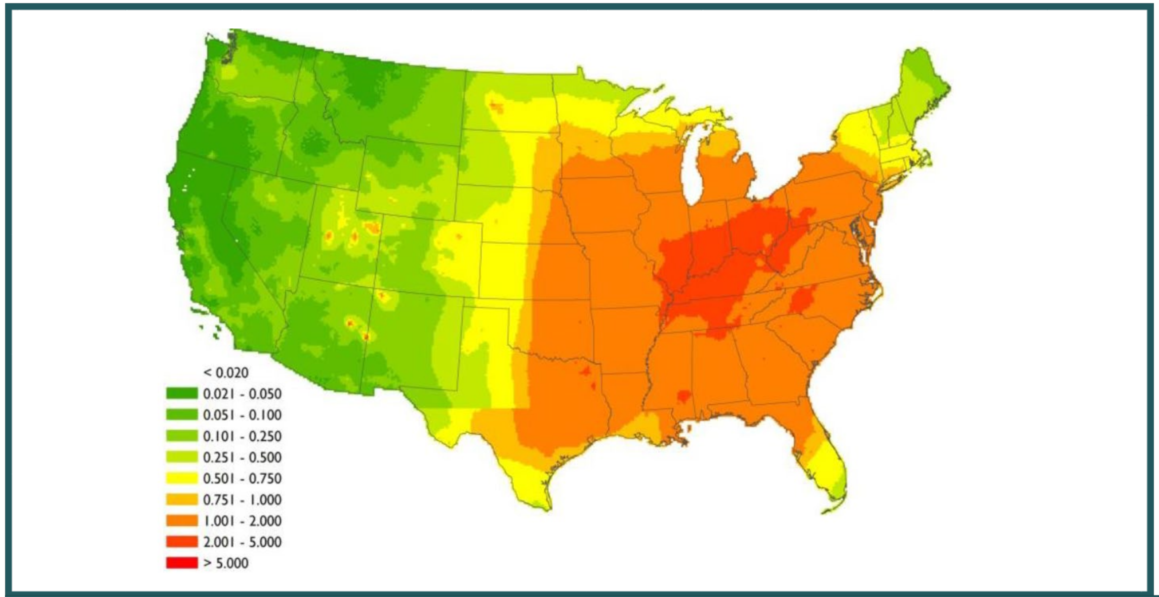


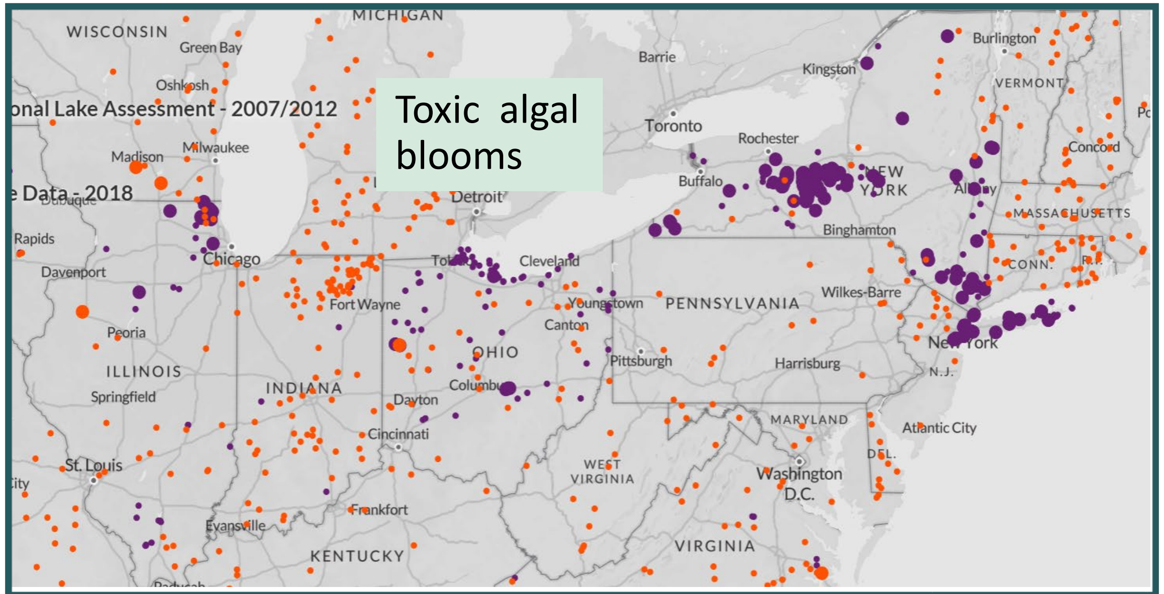
LCA: Argonne's GREET includes environmentally-relevant biofuel technology pathways for terrestrial and waste feedstocks



- Consistent comparison across all relevant technologies key to providing actionable insights.
- Highlighted options have significant volumes in low-carbon fuel standard (LCFS) and RFS.
- We will focus on perennial cellulosic (e.g., riparian buffers, SRWC, grasses) and CAFO, dairy wastes as feedstocks, and fuel pathways shown as solid cyan lines.

Mid-Atlantic region





- Hotspot for particulate emissions from fossil fuels (top graph)
- Growing toxic algae and other water quality issues (bottom graph)
- Opportunities for RINS, carbon credits, LCFS, and other environmental markets
- Opportunities to support wind penetration and low-carbon electrification

Additional Slides for Reviewers

Project Overview: Quad Chart

Timeline

Project start date: FY21
Project end date: FY23
Percent complete: 8%

Budget

	FY20	Active Project
DOE Funding	$400K	$400K (FY21-23) + $25 (FY22), $75 (FY23) for ANL

Project Partners – FY21-FY23
- ANL -- Troy Hawkins
- Forest Service – Linda Spencer (DC)
- Univ. Tennessee Bredesen Center
- ORNL-Parish – stakeholder engagement
- ORNL-Langholtz-feedstock production cost
- TBD – pending Geospatial Roadmap outcome

Project Partners – FY19-FY21
- ANTARES – Kevin Comer (FY19-21)
- PNNL – Mark Wigmosta (FY19-21)
- Forest Service – Paul Hessburg (Wenatchee)

Project Goal

Demonstrate where payments for ecosystem services can offset production costs and promote low-carbon electricity. Develop demand-side geodata and analysis tools at regional and watershed scales.

Go/NoGo: Crop production represents only 1/3 of fuel cost but has high potential for offsetting carbon emissions and generating other ES. We will demonstrate potential for ecosystem services to defray 25% of the cost of feedstock production based on Roadmap screening assessment in the Mid-Atlantic region.

End of Project Milestone

Demonstrate where and how the cost of production can be offset through payments for ecosystem services resulting in a 10% decrease in fuel cost. Produce a full-life-cycle spatial valuation for a selected Case study watershed including relevant ecosystem services (e.g., water purification, carbon regulation, habitat) for feedstock (ORNL) and carbon cost associated with fuel production (LCA, ANL). This will contribute to BETO's 2025 goal: to understand and quantify environmental and economic effects associated with emerging biofuel and bioproduct technology pathways.

MYPP-19 Barriers addressed

At-C. Data Availability across the Supply Chain. …Filling data gaps and improving data accessibility would improve efforts to understand all relevant dimensions of bioenergy and bioproduct production and use and inform model development.

At-E Quantification of Economic, Environmental, and other Benefits and Costs. Synergies can be enhanced, and tradeoffs minimized when costs and benefits are well-quantified

At-H. Consensus, Data, and Proactive Strategies for Improving Land-use Management. Science-based multi-stakeholder strategies to integrate bioenergy with agricultural and forestry systems in a way that reduces wastes, maintains crop yields, enhances resiliency and supports multiple ecosystem services.

Project adjustments to 2019 review comments

- Comment: This project offers an interesting eco-economic modeling for ecosystem services via biomass feedstock production using an ecosystem service valuation approach. In particular, it focuses on biodiversity impacts as indicated by two case study species. Important to push on biodiversity impacts, but is there a way to do a more generalized analysis that doesn't hinge on a highly detailed approach to a couple of key species?
  Response: We have developed a general tool for evaluating responses to land use management and applied it for ~30 species in the Iowa Case Study. Our new AOP does not focus on specific species. However, ~~note that~~ valuation requires knowing the species' identity.

- Comment: In order for ecosystem services to contribute to project revenue/breakeven point, presumably someone has to be willing to pay for the purification. Need to clarify whether there is already a policy or program that would do this currently …in a way that would accrue to the farmer.
  Response: To address this, we are shifting to the Eastern US (Mid-Atlantic states, e.g., NY, DE, MD), where there are carbon markets and, in some places, water quality credits ~~available~~.

- Comment: Further coordination with other projects in the portfolio to test and refine would be a good addition. In particular, with …Quantifying & Visualizing Sustainability (NL002601), and Integrated Life Cycle Sustainability Analysis (NL0027693).
  Response: To address this, we are now working with NL002601 to engage stakeholders through BioSTAR. Secondly, our new AOP includes collaborating with ANL (Troy Hawkins/Michael Wang) to conduct an LCA in years 2.5-3.

2018-2021 Publications (*High impact)

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. *This paper used BioVEST to value water quality improvements associated with increased NUE.*
3. Parish E, Dale V, Davis M, Efroymson R, Hilliard M, Kline K, Jager H, Xie F. In press. 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.
4. *Jager, HI and CC Coutant. 2020. Knitting while Australia burns. Nature Climate Change 170: 10.1038/s41558-020-0710-7 2.
5. Gorelick, D, LM Baskaran & HI Jager. 2019. Visualizing feedstock siting in biomass production: tradeoffs between economic and water quality objectives. Land Use Policy 104201.
6. 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
7. *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
8. 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
9. 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
10. 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.
11. 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

Publications in progress, review, or revision 2021

Special Issue: Renewable Energy and Biological Conservation in a Changing World. Biological Conservation

12. Jager, HI, RA Efroymson, and RA McManamay. Submitted. Renewable Energy and Biological Conservation in a Changing World. *Overview paper includes review of LCA crosscutting renewables and fossil*

13. Efroymson, RA, JAF Kreig, and HI Jager. In review. Perennial energy crops provide net positive ecosystem services to beneficial insects in an agricultural landscape.

14. Kreig, J, ES Parish, HI Jager. Submitted. Adding perennial grasses to unprofitable fields in Iowa, USA increases biodiversity. *(Iowa case study)*

15. McManamay, RA, CR Vernon, and HI Jager. In review. Global biodiversity implications of land requirements for alternative electrification strategies under shared socioeconomic pathways. (*crosscutting renewables using GCAM*).

Wildfire, wildlife, and forest thinning

16. Jager, HI[1], P Hessburg[2], R Novello[3], Z Duan[4], Mark Wigmosta[4], R Efroymson[1], R Flitcroft[5], Gordie Reeves. Can adaptive treatments in the Wenatchee River subbasin, USA increase the climate and wildfire resilience of forests and habitats of ESA-listed salmon? Draft, in progress, waiting for FS and PNNL to submit their methods papers.

17. Jager and 11 coauthors. Resubmitted, 'Resilience of terrestrial and aquatic fauna to historical and future wildfire regimes in western North America' to a Special Issue on Resilience Ecology in Journal of Animal Ecology. Co-authors include speakers at our 2-day symposium Fire Resilience: Can Fish, Wildlife, and Humans Adapt to Shifts in Wildfire Disturbance? Who represent academia, the Forest Service, EPA, and USGS. *Includes management solutions that addresses forest treatments including thinning as adaptations needed under future climate.*

Valuing ecosystem services (BioVEST)

18. Jager et al. 2019. Visualizing a sustainable bioenergy future: Mapping ecosystem service supply and value. Target PNAS. Submit by Q3/4 (milestone). *Focused on water quality. Submitting and publishing this is a near-term priority.*

Publications in progress 2021 and published related non-A&S

In progress

19. 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)

20. Kreig, JAF, E. HI Jager, E. Ponce and S. Lenhart. A spatially explicit individual-based modeling approach to evaluate temporal harvesting strategies on ring-necked pheasant (*Phasianus colchicus*) populations. Target journal: Ecol. Modeling. In progress.

21. Kreig, JAF, E. Ponce, S. Lenhart, and HI Jager. A spatially explicit individual-based modeling approach to evaluate spatial planting, harvesting and hunting strategies on ring-necked pheasant (*Phasianus colchicus*) populations. In progress.

Sustainable Algae Production (BETO)

22. Efroymson, RA, HI Jager, S Mandal, ES Parish, TJ Mathews. In press. Better management practices for environmentally sustainable production of microalgae and algal biofuels. Journal of Cleaner Production.

23. Jager, HI, RA Efroymson & LM Baskaran. 2019. Avoiding conflicts between future freshwater algae production and water scarcity in the United States at the energy-water nexus. Special Issue: Energy-Water Nexus, Water 11(4): 836-851.

Ecosystem Services Valuation (non-BETO, NSF)

24. Galic, N, CJ Salice, B Birnir, RJF Bruins, V Ducrot, HI Jager, A Kanarek, R Pastorok, R Rebarber, P Thorbek & VE Forbes. 2019. Predicting impacts of chemicals from organisms to ecosystem service delivery: A case study of insecticide impacts on a freshwater lake Science and the Total Environment 682: 426-436. 9.

25. Forbes, V, S Railsback, C Accolla, B Birnir, R Bruins, V Ducrot, N Galic, K Garber, B. Harvey, H Jager, A Kanarek, R Pastorok, R Rebarber, P Thorbek & C Salice. 2019. Predicting impacts of chemicals from organisms to ecosystem service delivery: A case study of endocrine disruptor effects on trout. Science and the Total Environment 649: 949-959

Publications, reports and presentations

Reports, Webinars, Theses

1. EPA Triennial report (in progress, two chapters)
2. ANTARES final report, biodiversity chapter (draft submitted)
3. Kreig thesis '*Evaluating scenarios using an agent-based model for pheasant populations and biomass harvest strategies*'
4. Gulf Hypoxia Workshop report
5. Jager & Wu, Mississippi River Water Quality modeling webinar

Presentations:

Feb, 2020. H. Jager. How will Pacific Northwest salmon respond to forest thinning and hydropower under future climate? Meeting of the AAAS. Seattle, WA.

Mar, 2020. K. Johnson, Lamers, Griffel, Jager, Negri, Parish, Wigmosta, Lindauer. Ecosystem services through terrestrial biomass production: An overview of research efforts funded by the US Department of Energy. 4th Brazilian Bioenergy Science & Technology Conference- BBEST 2020, San Paolo, Brazil.

Oct 21-22, 2019, Nashville, TN, Efroymson, Langholtz, Jager, Hilliard. Environmental supply curves highlight relationship between environmental indicators, cost, and biomass for energy in national-scale assessment, AIChE Bioenergy Sustainability Conference.

Aug, 2019. Kreig, Jager, Lenhart. Management strategies that promote pheasant populations and production of biomass are not mutually exclusive. Joint meeting of the Ecological Society of America and the US Society of Ecological Economics. Louisville, KY

Dec, 2019. Mark S Wigmosta, Zhuoran Duan, Miles Lefevre, Brion Salter, Golam Arif Rabbani, Nicholas Povak, Paul F Hessburg, Henriette Jager, Ning Sun. Assessment of Sustainable Biomass through Forest Restoration AGU Fall Meeting. Attended by Mark Wigmosta

Co-organized Symposium entitled Fire Resilience: Can fish, wildlife, and humans adapt to shifts in wildfire disturbance? American Fisheries Society/The Wildlife Society 2019 Annual Joint Meeting, Reno, NV, USA (Jager)

Oct 1, 2019. Jager. Agent-based modeling to design wildlife-friendly renewable energy projects. American Fisheries Society/The Wildlife Society 2019 Annual Joint Meeting, Reno, NV, USA

Oct 1, 2019. Jager, Wigmosta, Hessburg, Duan, Salter, Povak, LeFevre. Modeling Chinook salmon response to forest thinning.. Fire Resilience: Can fish, wildlife, and humans adapt to shifts in wildfire disturbance?

Awards and professional activities

- H. Jager was elected as a fellow of the American Association for the Advancement of Science for "distinction in ecological modeling that meets conservation needs and promotes sustainable, renewable energy." February, 2020.
- June 27, 2019. Kreig, J. Travel Award from the National Institute of Mathematical and Biological Sciences to present BETO research to the annual meeting of the International Society of Mathematical Biologists held in Toronto. See video: https://youtu.be/TYipd6hbKN8
- H Jager is serving a two-year term as President of the Water Quality Section, American Fisheries Society
- HI Jager is serving on the organizing committee for the 2022 Joint Aquatic Sciences Meeting.
- HI Jager has been nominated for election to the steering committee of the Ohio River Basin Alliance, which is seeking to establish programs to incentivize water quality improvements in the basin.
- J Kreig received her Masters degree from the University of Tennessee (Summer, 2019). She passed her Comprehensive Exam (March, 2020) and is now a doctoral candidate. J Kreig was awarded the Service award by the UTK Bredesen Center. 2019.

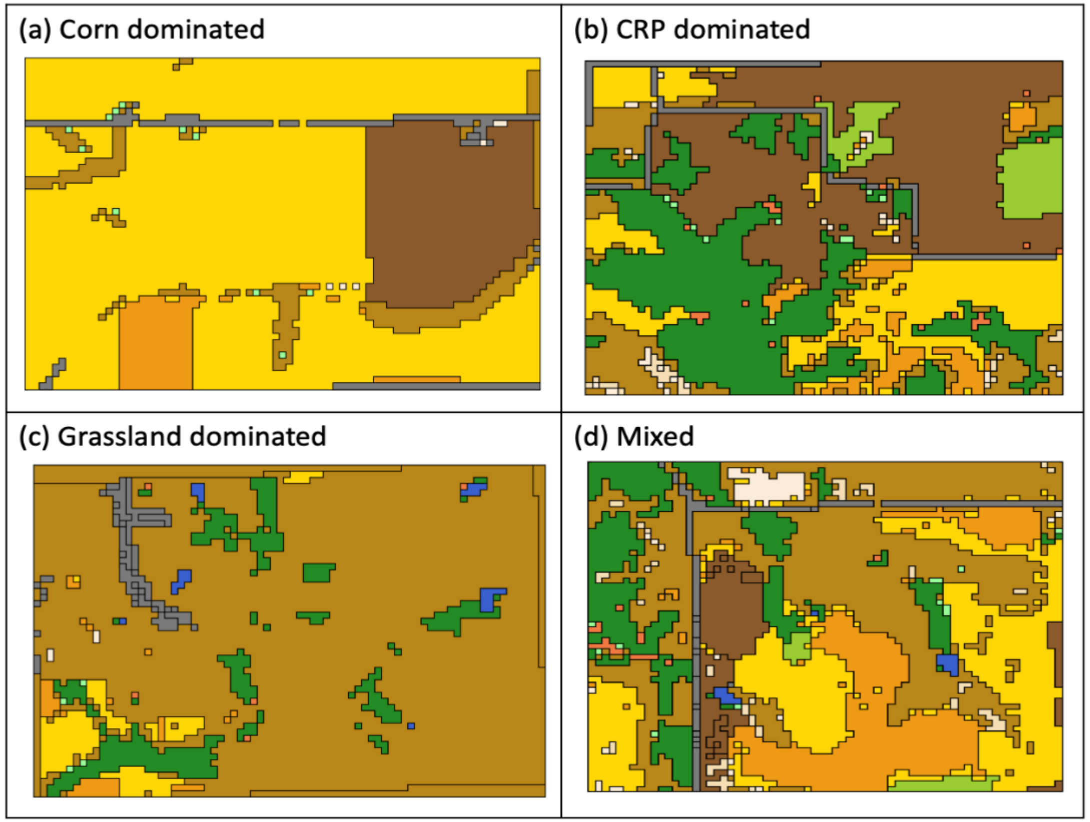
Optimize biomass harvest for pheasants and feedstock

- Agent-based model to guide management represents tractors, hunters, and pheasants as agents at the scale of multiple fields.
- Model simulates pheasant population size, harvest, and biomass yield for different biomass harvest and four landscapes.
- Implementing the Portable Lightweight & Generic Framework for Parallel Parameter Studies (PaPaS) to facilitate running more (100) replicates.
- Conducted preliminary valuation of each landscape scenario (*EV*):

$$EV = \beta h_b + \rho(r - d) + \gamma(h_c)$$

where, β = price (in dollars) per dry ton for biomass feedstock, h = harvested feedstock (dry ton), b for biomass and c for corn, ρ = "worth" of one pheasant, r = number of roosters bagged, d = # accidental pheasant deaths from tractors.

Four landscapes



OAK RIDGE National Laboratory

Agent-based modeling to optimize timing harvest of switchgrass for biomass and ring-necked pheasants

- Simulated pheasant harvests were within the range of reported data over 17 years.
- In test runs (10 replicates), we observed a trade-off between biomass value and value to hunters.
- A better time for harvest was once later in the fall.
- Publications planned separate the temporal and spatial problems (strategies) #21, 22 and PhD thesis.

OAK RIDGE
National Laboratory