DOE Bioenergy Technologies Office (BETO) 2019 Project Peer Review

Pacific Northwest NATIONAL LABORATORY

Sustainable Biomass through Forest Restoration (WBS 4.1.1.52)

6th March 2019

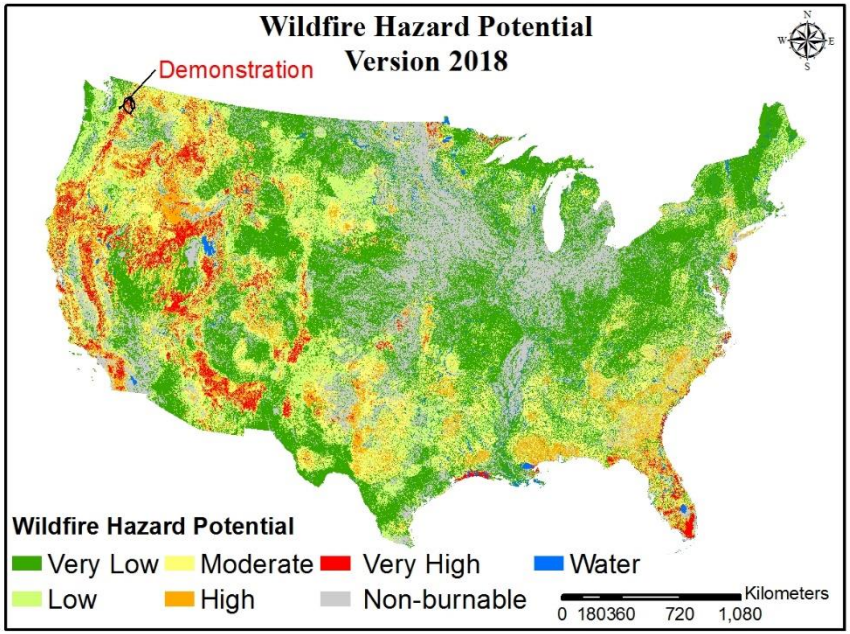
Analysis & Sustainability

Principal Investigator

Mark Wigmosta

Goal Statement

Challenge: Forest restoration is being used to reduce wildfire risk and has been identified as a potentially significant source of bioenergy – however, additional planning and decision support tools are needed to access economic and environmental sustainability.



- **Goal:** This project is developing and demonstrating an analysis framework **to prioritize how and where to target forest restoration (timber harvest and thinning) and fuels reduction to have the greatest benefit for bioenergy, reduce severe wildfire risk, increase water yield, and improve ecosystem services.**
  - Multi-agency collaboration between DOE-BETO (PNNL, ORNL) and USFS R&D
  - Demonstration basin with very high wildfire hazard potential

- Capabilities developed under this project will provide an analysis framework for the bioenergy industry to increase forest derived biomass in a publicly and ecologically acceptable manner.

Quad Chart Overview

Timeline

- Project start date: October 1, 2016
- Project end date: September 30, 2019
- Percent complete: 75%

	Total Costs Pre FY17**	FY 17 Costs	FY 18 Costs	Total Planned Funding (FY 19 - Project End Date)
DOE Funded		$240K	$200K	$250K
Project Cost Share*				

Partners: USFS (40%); ORNL (funded under WBS 4.2.140)

Collaborators: The Nature Conservancy and the Upper Columbia Salmon Recovery

Barriers addressed

- At-E. Quantification of Economic, Environmental, and Other Benefits and Costs
- At-F. Science-Based Methods for Improving Sustainability
- At-H. Consensus, Data, and Proactive Strategies for Improving Land-Use Management

Objective

Develop and demonstrate an analysis framework to prioritize how and where to target forest restoration (timber harvest and thinning) to have the greatest benefit for bioenergy, reduce severe wildfire risk, increase water yield, and improve ecosystem services.

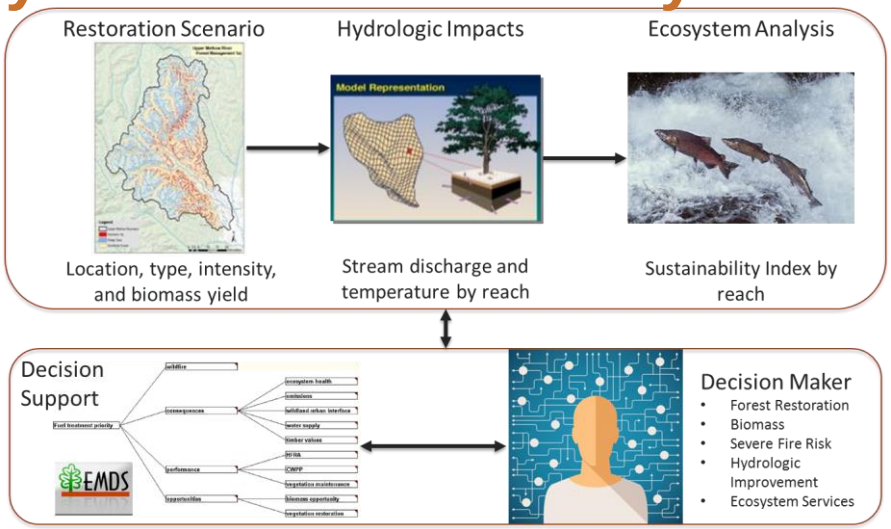
End of Project Goal

To provide a foundation for the bioenergy industry to increase forest derived biomass in a publicly and ecologically acceptable manner.

1 - Project Overview

- Fire suppression and land management have resulted in greatly increased forest density which increases mega-fire frequency, and alters multiple hydrologic processes including streamflow patterns, and reduced water availability.
- USFS/DOI/States response: implement strategic thinning and prescribed burning across the U.S.
  - Air quality standards, forest economic sustainability and budgets limit amount of annual restoration
- Excess biomass material has the potential to make large volumes of forest residues and small-diameter trees available for bioenergy
  - 0.2 to 0.6 billion dry tons in 5 western states (USDOE, 2011; USFS, 2005)
  - Red Rock Biofuels in southern Oregon, will utilize residue from forest and saw mill operations, and is under contract with FedEx and Southwest Airlines to supply aviation-grade biofuel
- This project is using a linked set of spatial, biophysical models coupled with existing USFS decision support software to develop and demonstrate an analysis framework to prioritize how and where to target forest restoration to address multiple objectives.

Project Directly Addresses Key BETO Analysis and Sustainability Goals



- Advance scientific methods and models for measuring and understanding bioenergy sustainability.
- Disseminate practical tools that support analysis, decision making, and technological development.
- Identify, develop, and promote practices that enhance sustainable bioenergy outcomes.
- Develop landscape design approaches that increase bioenergy production while maintaining or enhancing ecosystem and social benefits.
- Develop and maintain analytical tools, models, methods, and datasets to advance understanding of bioenergy and related impacts.
- Convey results of analytical activities to a wide audience.

2 – Approach (Management)

- Following BETO project management protocols
  - Annual Operating Plan (AOP)
  - Quarterly Progress Reports to BETO
- Project Communications
  - Weekly planning with PNNL staff
  - PNNL/ORNL/USFS conference calls as needed
  - USFS subcontract reporting
  - Quarterly calls with BETO Analysis and Sustainability
- Use of Microsoft Project to track tasks, milestones, staffing, and budget
- Potential Challenges
  - State of the Science – limited datasets for model validation
  - Adequate datasets for application for other regions in U.S.
  - Communication and feedback from industry and stakeholders

PI/PM Wigmosta
Project Coordinator: Lilly Burns-Pearson

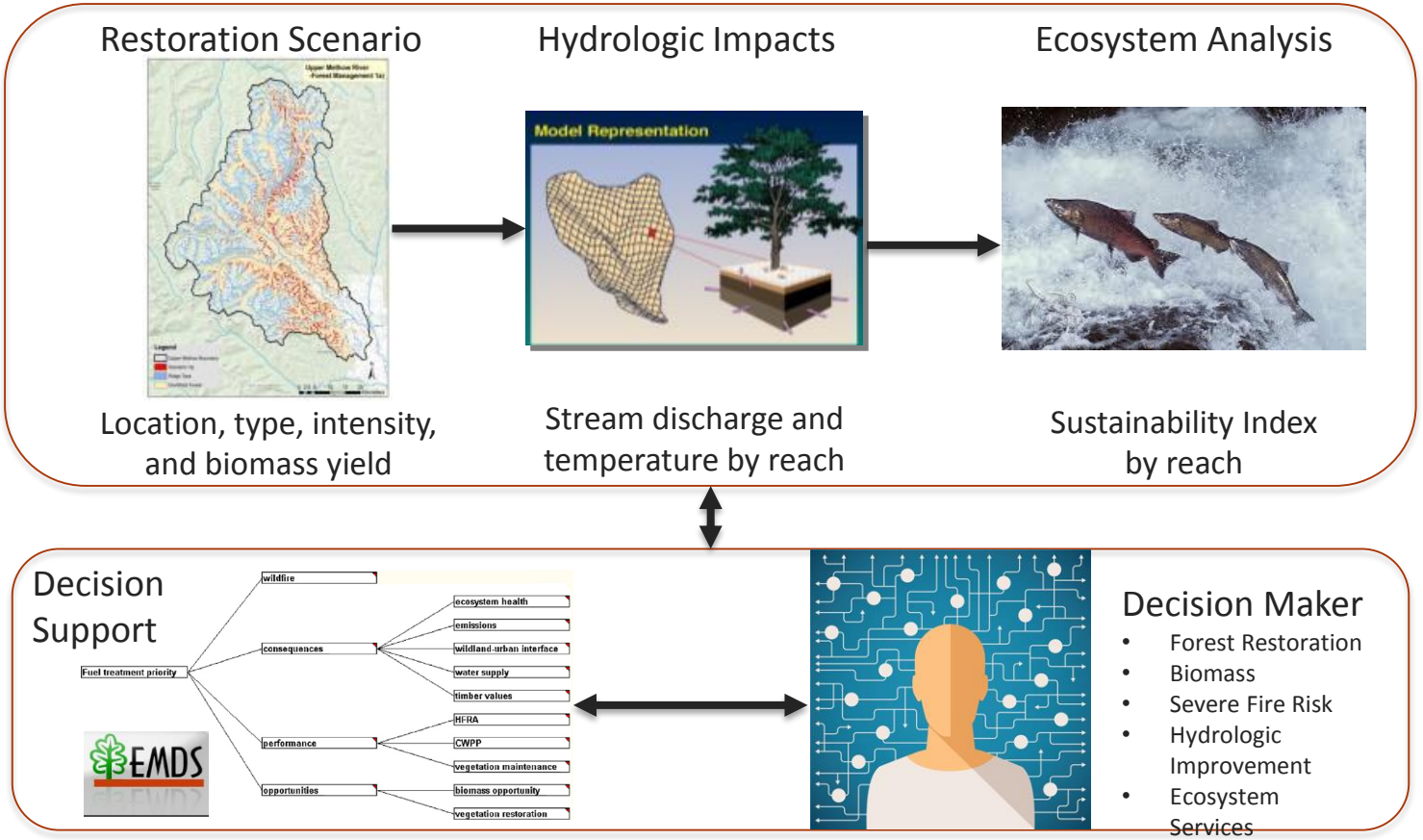
Task	Lead
Forest Restoration Planning and Biomass Yield	Hessburg (USFS)
Hydrologic Analysis	Wigmosta (PNNL)
Ecosystem Analysis and Sustainability	Jager (ORNL)
Decision Support	Reynolds (USFS)

2 – Approach (Technical)

- Fine resolution (30-m) vegetation data are being used to accurately estimate sustainable forest biomass and support distributed hydrological, ecological, and wildfire risk modeling to assess priority restoration to reduce high fuel loads, increase biomass yield, streamflow and ecosystem services.
  - Initial focus on high-risk areas in the Pacific Northwest at watershed to regional scale using data, models, and analysis techniques that can be applied nationally.
  - USFS planning a 70,000 acre forest restoration project in our study basin
- **Technical Success**: Analysis framework prioritizing how/where to target restoration
- **Market Success**:
  - Dissemination of study results through peer-reviewed publications, conferences and workshops, and dissemination to Bioenergy KDF
  - Tech transfer through USFS EMDS decision support software
  - Leverage existing PNNL/UCSRB/Ecotrust “Snow2Flow” modeling and decision support system
    - Technical Advisory Group: National, State, and Local agencies, Forest Products Industry, Tribes, and NGO’s (e.g., TNC)
    - Web-based Interface
- **Key challenges**:
  - State of the Science: Limited, but increasing, observational data to support model parameterization and validation
  - Appropriate datasets for ultimate national application
  - Integration in bioenergy feedstock mix (e.g., Billion Ton)

2 – Approach (Technical)

Integrate Detailed Spatiotemporal Data with Biophysical Models for Multi-Scale Tradeoff Analysis



EMDS is the USFS corporate software solution for decision support used by the USFS and USDI since 2006 to evaluate wildfire potential across all administrative units in the continental US, and establish priorities for allocating fuel-treatment budgets.

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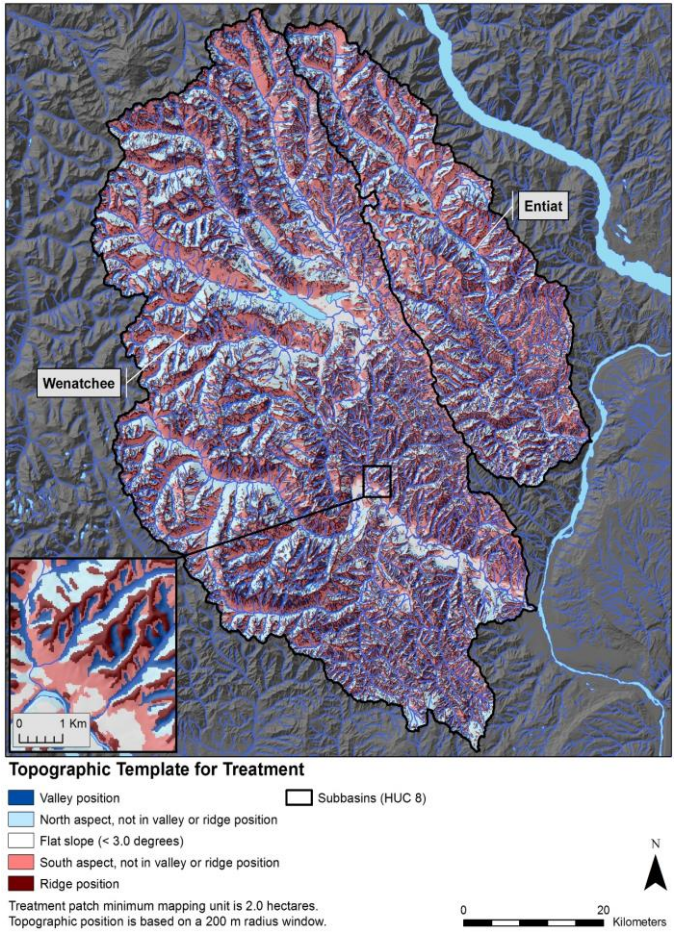
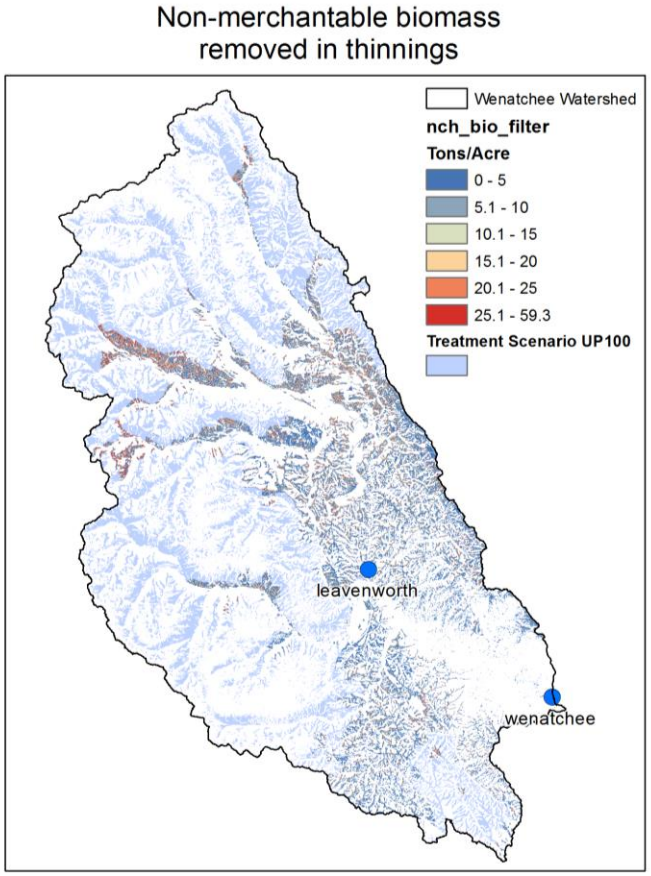
3 – Results:
Forest Treatment Scenarios and Associated Biomass Available for Energy



Treatment on South-Facing Slopes and Ridgetops for Fuel Reduction



Harvest Residue Available for Bioenergy (via FVS) close to existing roads

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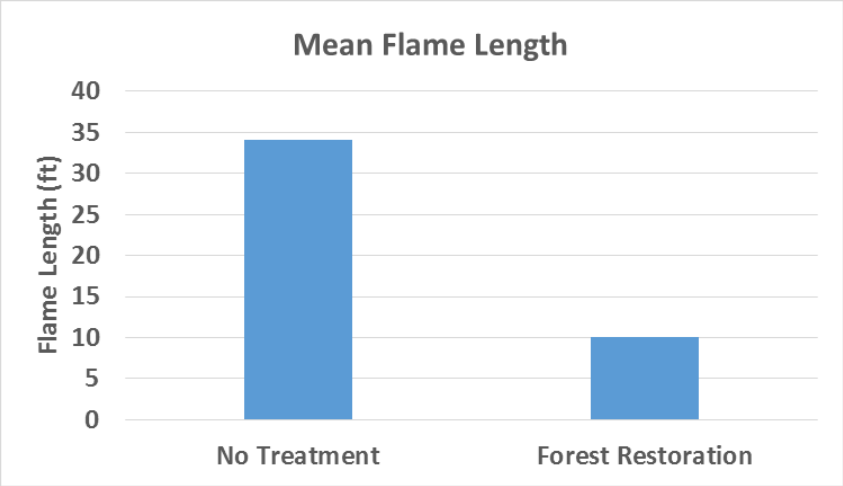
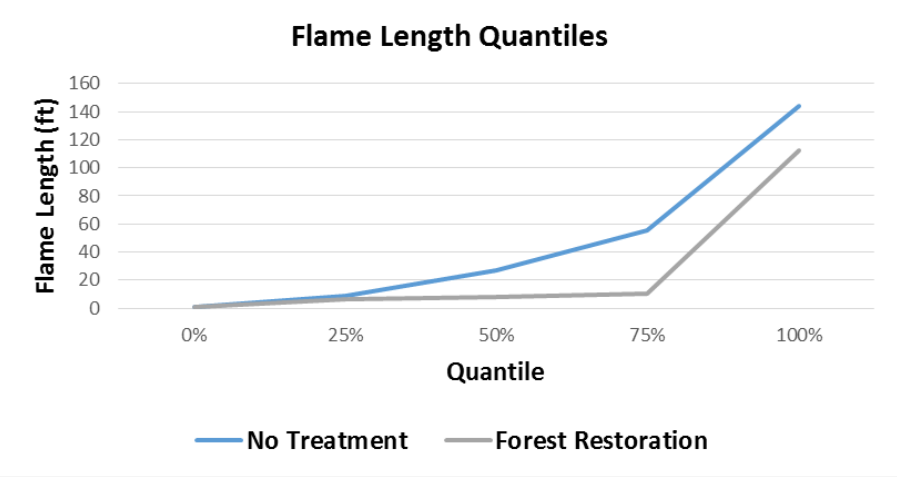
3 – Results

Reduction in Wildfire Risk Through Forest Restoration

- **Flame length** under severe weather conditions, which can describe potential risk of torching and indicate the likelihood that direct attack fire suppression would be viable.
  - Initial evaluation is only for locations with forest restoration and does not currently consider spread between treated and untreated locations.





- Significant reduction in flame length on treated pixels
- More detailed analysis of wildfire spread is underway

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3 – Results

Costs to Collect, Process, and Deliver Wood Chips to Selected Mill Locations

Approach:

We used the fixed and transportation costs of Martinkus et al. (2017)*.

Fixed collection and processing costs are:

- transporting residues to a forest landing ($16.5/BDmT)
- grinding the residue ($22.4/BDmT)
- loading ground material onto a waiting chip van ($3.9/BDmT)

Round trip transport costs for (loaded/unloaded) chip van:

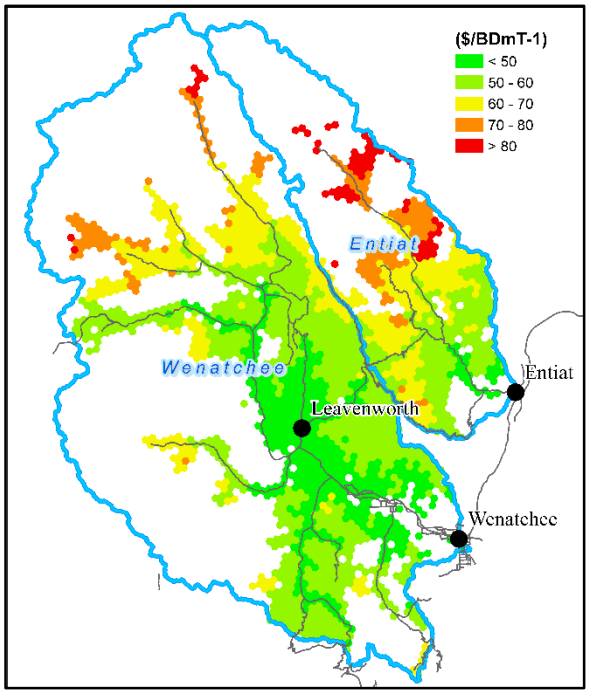
- $0.344 per mile paved road (one-way)
- $0.766 per mile gravel road (one-way)
- $1.100 per mile dirt road (one-way)

Least-cost road network analysis to three potential mill locations

Delivered cost target

- for wood chips: $50-60 BdT (WSU)
- for Biorefinery: $84 BdT (2016 Billion Ton Update)

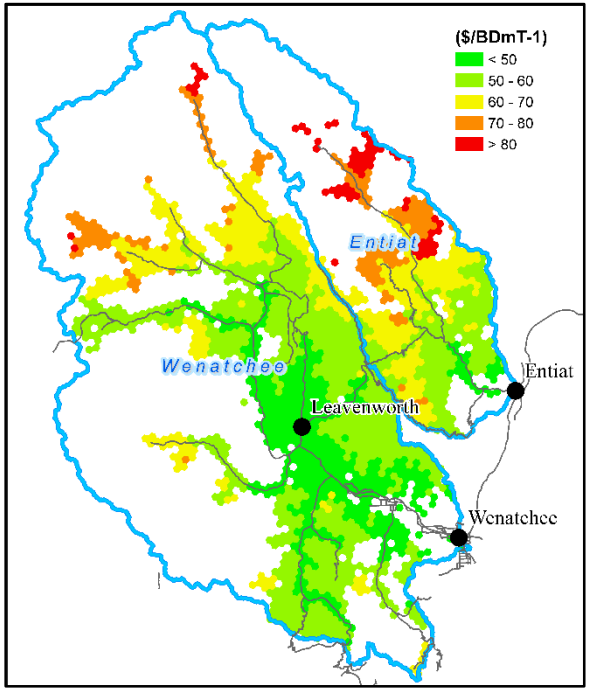
Relatively easy to apply, peer-reviewed methodology developed for the Pacific Northwest.

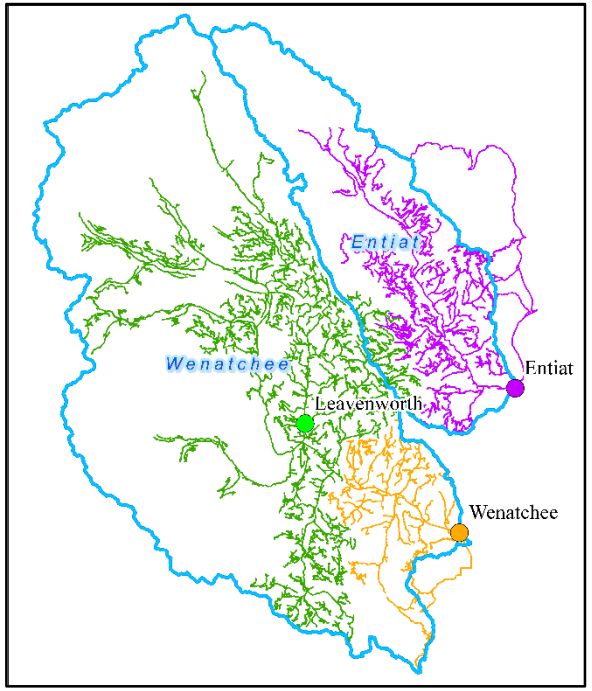


* We also include a $4/BDmT credit for avoided disposal costs

3 – Results

1.4 Million Tons of Economically Viable Biomass Available for Energy





- A total of 373,233 to 394,821 tons of wood chips are delivered at $60 per ton or less depending on the mill location scenario
  - 373,233 for Leavenworth only
  - 394,821 with all three mills
- Additional 1,019,000 tons of mill residue
  - Assuming a sawmill residue weight factor of 0.5 (Yang and Jenkins, 2008)

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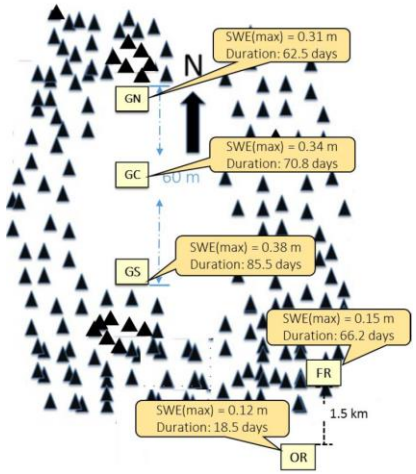
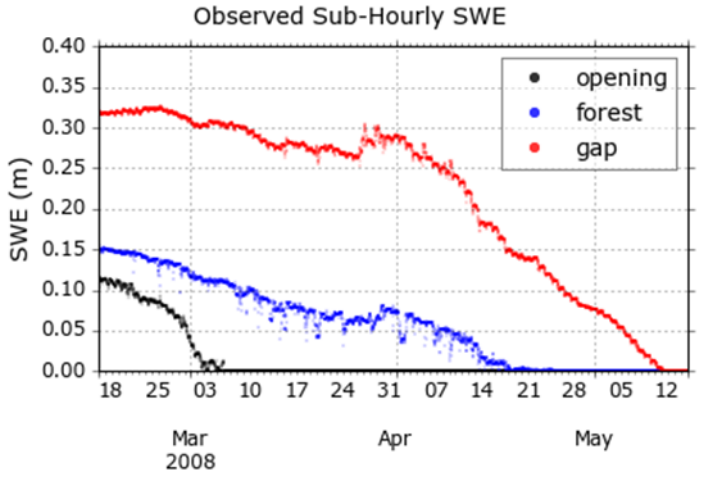
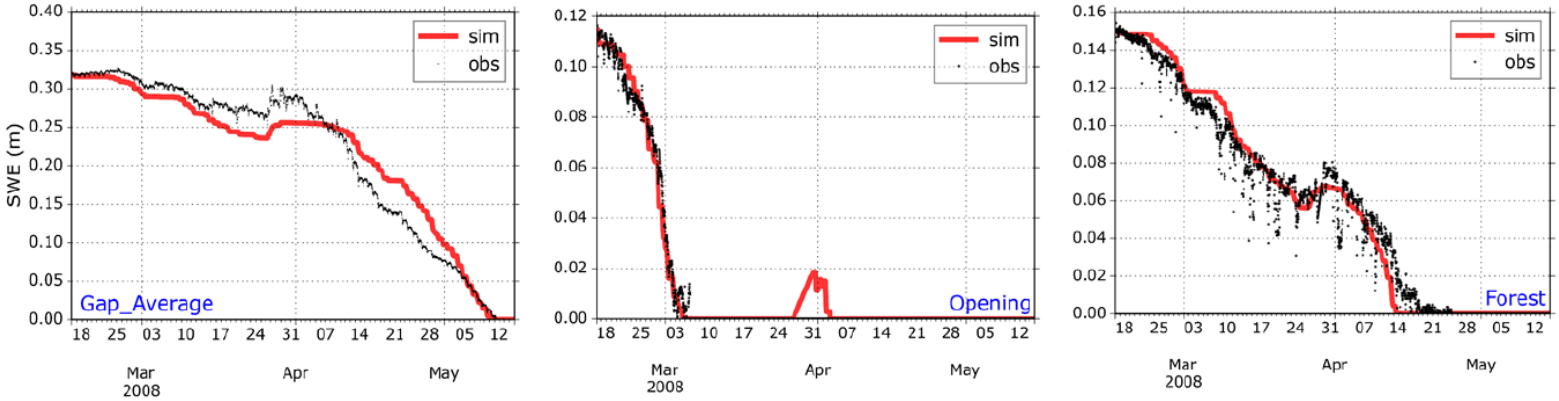
3 – Results

Validation of DHSVM Enhanced Forest Canopy-Snow Process Representation





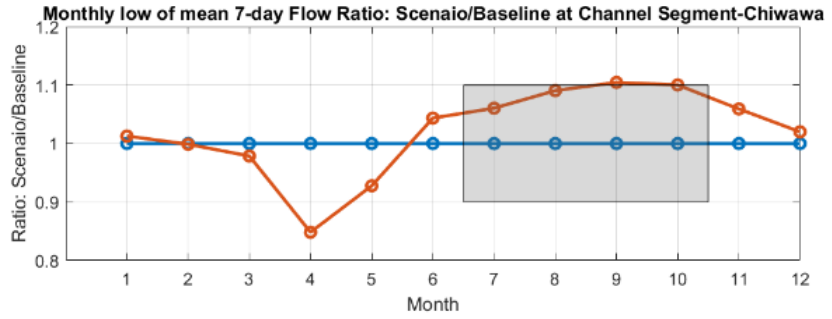
U. of Idaho Experimental Forest

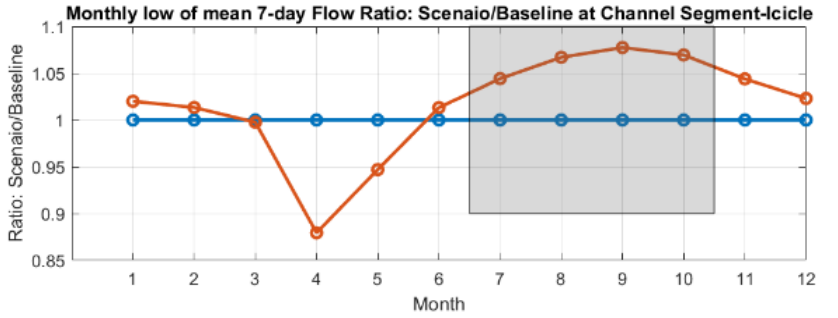


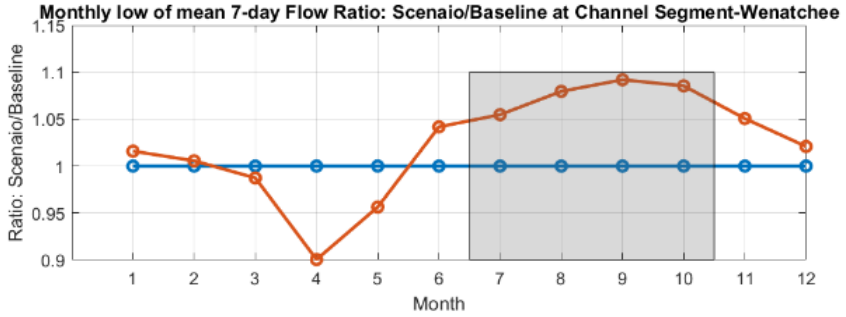
Excellent DHSVM simulation results for a range of forest conditions: gap in the forest, in the open, and under the forest canopy

3 – Results

Forest Restoration Produces an Important Increase in 7-day Low Flow During the Critical Summer Salmon Rearing Season







In areas where snowpack supplies late season flows, forest restoration can help increase critical summer low flows

4 – Relevance:
Capabilities Developed under this Project will Provide a Foundation for the Bioenergy Industry to Increase Forest Derived Biomass in a Publicly and Ecologically Acceptable Manner

- Integration of biophysical models and existing decision support software to identify biomass available through forest restoration directly supports BETO Strategic Analysis Program goals to
  - Develop and maintain analytical tools, models, methods, and datasets to advance the understanding of bioenergy and its related impacts
  - Develop landscape design approaches that increase bioenergy production while maintaining or enhancing ecosystem and social benefits
  - Analyses that integrate economic and environmental dimensions to understand trends, synergies, and trade-offs

- Technology transfer though dissemination to Bioenergy KDF, EMDS, Snow2Flow, publications, and stakeholders to addresses Strategic Analysis Program goal to "convey results to a wide audience…"
  - USDA Forest Service PNW Research Station
  - Okanogan-Wenatchee National Forest
  - NGO's: The Nature Conservancy, Upper Columbia Salmon Recovery Board
  - State and local government
  - Forest products industry

5 – Future Work (FY19):
Fully Demonstrate Decision Support for Multi-Objective Tradeoff Analysis Considering Biomass Yield, Cost, Reduction in Wildfire Risk, and Improved Streamflow/Ecosystem services

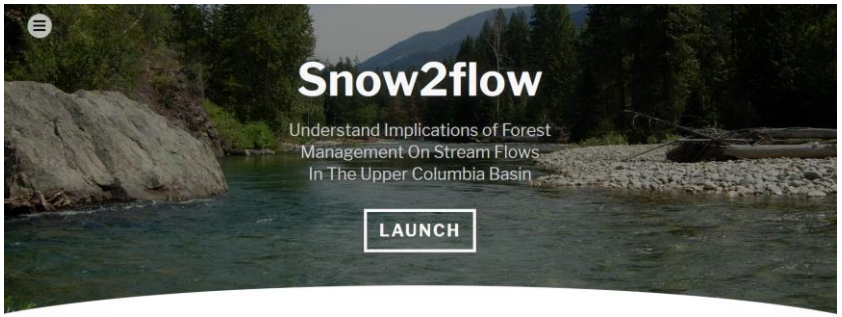
- Prior to linkage with EMDS
  - Complete final forest restoration scenarios and determine biomass yield
  - Complete wildfire risk reduction
  - Complete DHSVM simulations to determine impacts to streamflow and temperature
  - Estimate stream-reach specific salmon sustainability indicators
- Complete linkage with EMDS to demonstrate the resource assessment framework in the Wenatchee and Entiat demonstration basins with full decision support to assess sustainable forest biomass potential for energy considering, cost, reduction in wildfire potential, improved streamflow, and ecosystem services.
- Continued coordination with The Nature Conservancy field studies for DHSVM parameterization and the Upper Columbia Salmon Recovery Board Snow2Flow (Phase 3)
- Engage with OWNF planning for 70,000 acre restoration project
- Submit manuscript for journal publication

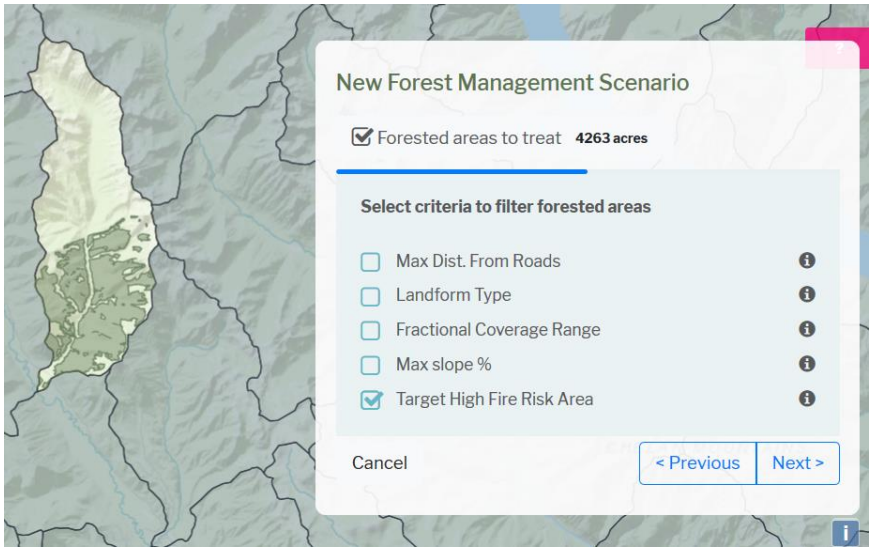
5 – Future Work (FY20):
Consider Forest Regrowth, Uncertainty, and Conduct Aggressive Outreach via EMDS and Snow2Flow

- Simulate vegetation regrowth to better estimate long-term, sustainable biomass supply and changes in streamflow
  - Periodic restoration may be required to maintain reduced wildfire risk
- Capture uncertainty in forest restoration impacts to streamflow and water temperature
  - Ensemble based approach to propagate errors in model forcing data and parameters
- Integrate biomass for energy in “Snow2Flow” web-based decision support tool (next slide)
  - Snow2flow is built on previous DHSVM model simulations by PNNL and allows the user to easily evaluate the impact of various forest restoration strategies on snowmelt and streamflow.
- Aggressive outreach through EMDS and Snow2Flow
  - Extensive stakeholder engagement

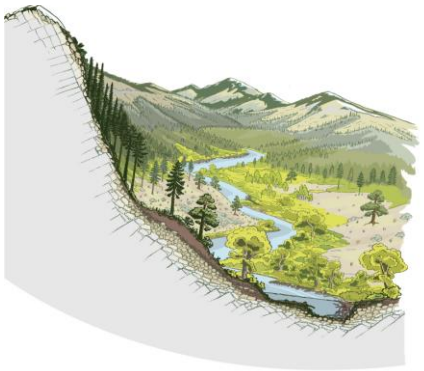
5 – Future Work

Integrate Bioenergy in Snow2Flow as a Practical Tool to Support Stakeholder Analysis and Decision making



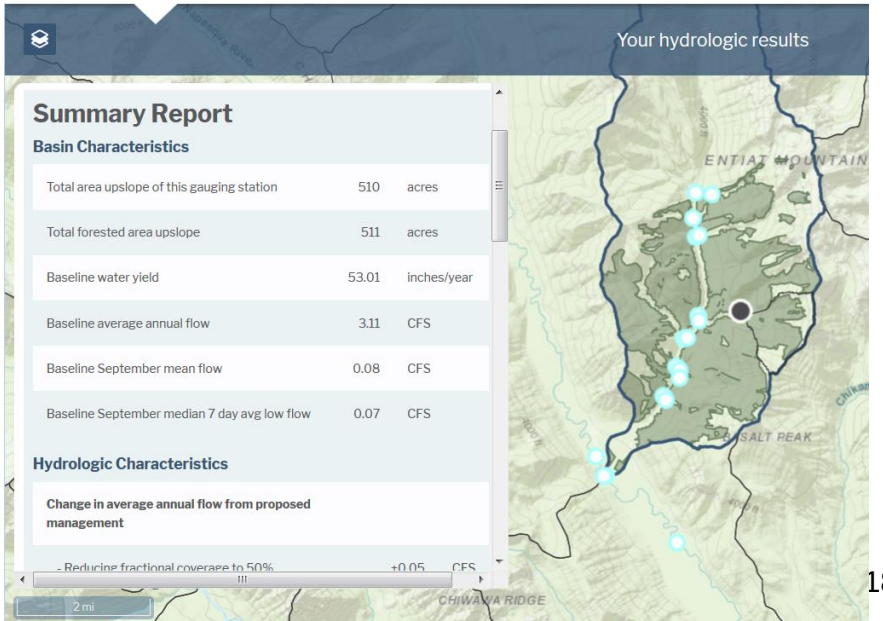


restoration practitioners support salmon recovery across North Central Washington. The easy-to-use website informs salmon recovery by assessing the effects of forest restoration activity on snowpack retention and subsequent water supply and timing.



About the App

Water availability, especially during the late summer, affects salmon populations in the Upper Columbia. One of several approaches to increasing the amount of water available for instream flow in the late summer is by increasing the capture and duration of storage of mountain snowpack. This tool builds on Pacific Northwest National Laboratory's Distributed Hydrology Soil Vegetation model (DHSVM) to identify both how forest restoration activity affects downstream flows, and where to target upstream restoration activities to benefit specific in-stream locations.



http://s2fdemo.ecotrust.org/app

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Summary:
Capitalize on Forest Restoration as a Sustainable Source of Bioenergy while Reducing Fire Risk and Improving Ecosystem Services

- Ongoing/future forest restoration has the potential to make available significant quantities of biomass
  - Air quality standards, forest economic sustainability and budgets limit amount of annual restoration
- Initial application in the Wenatchee demonstration basin demonstrates the potential of forest restoration to provide sustainable biomass for energy considering cost, wildfire mitigation, and improved streamflow.
- Direct benefit to bioenergy industry by increasing forest derived biomass in a publicly and ecologically acceptable manner
- Technology Transfer through EMDS and Snow2Flow

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Additional Slides

Responses to Previous Reviewers' Comments

Review Comment: It will be important to engage outside stakeholders to determine what forest restoration scenarios would be viable. It may be necessary to look at road access, for example, or slope conditions. Whatever forest restoration scenario is proposed, it must be economical and sustainable. In some cases, it may make sense to burn the biomass in place etc. since harvesting it would not be cost effective. I would urge working with the forest service on this.

Response: We used the fixed and transportation costs of Martinkus et al. (2017) to determine economic sustainability. Fixed collection and processing costs included transporting residues to a forest landing, grinding the residue, and loading ground material onto a waiting chip van. Round trip transport costs for a (loaded/unloaded) chip van where also computed for paved, gravel, and dirt roads. A least-cost road network analysis was conducted to two potential mill locations identified in The Nature Conservancy Study. As the reviewer suggested, when collection and transport was not cost effective, the biomass was assumed to be burned in place.

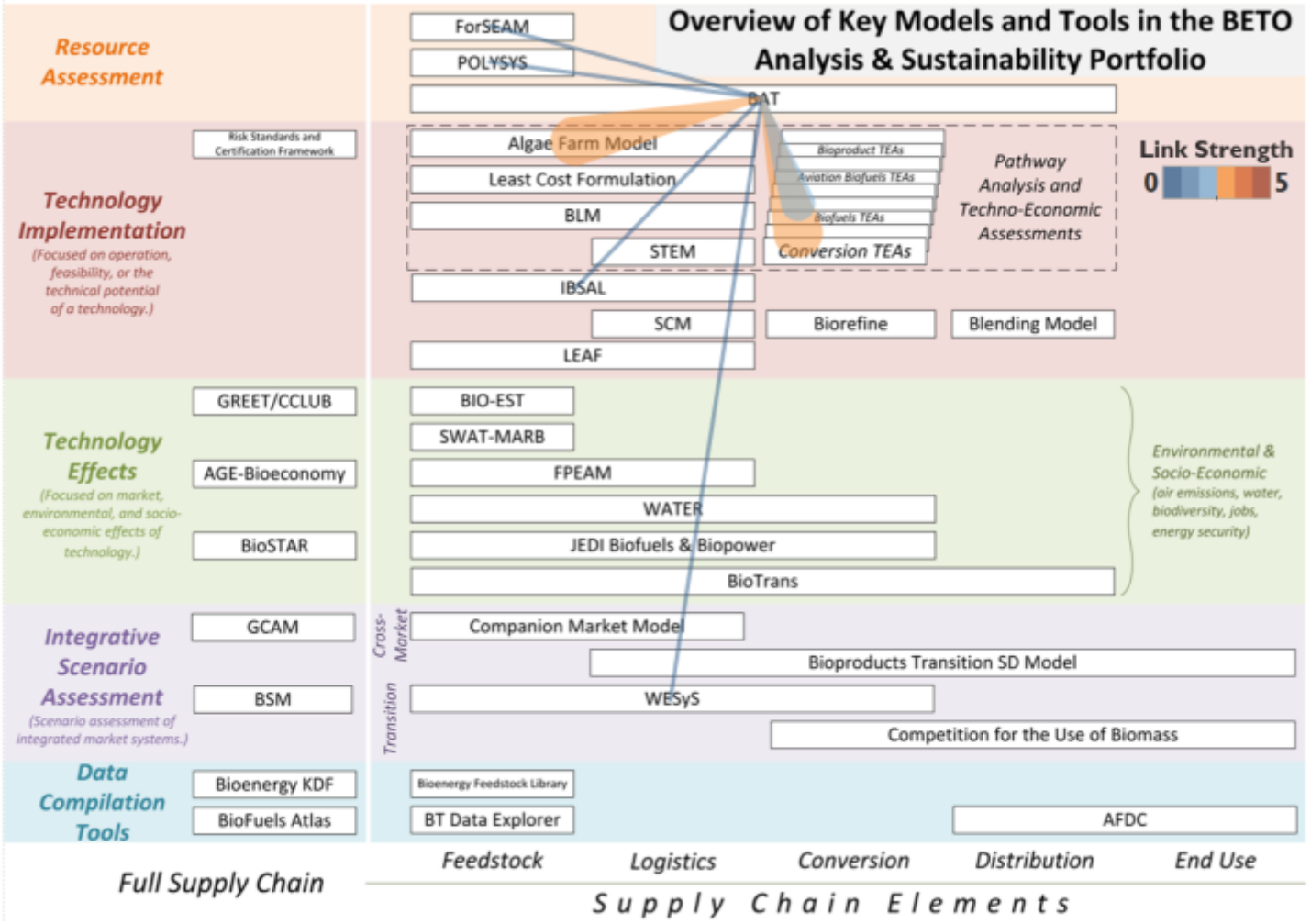
Publications, Patents, Presentations, Awards, and Commercialization

- Sun N, Wigmosta M, Zhou T, Lundquist J, Dickerson-Lange S, Cristea N. 2018. Evaluating the functionality and streamflow impacts of explicitly modelling forest–snow interactions and canopy gaps in a distributed hydrologic model. Hydrological Processes;1–13. https://doi.org/10.1002/hyp.13150

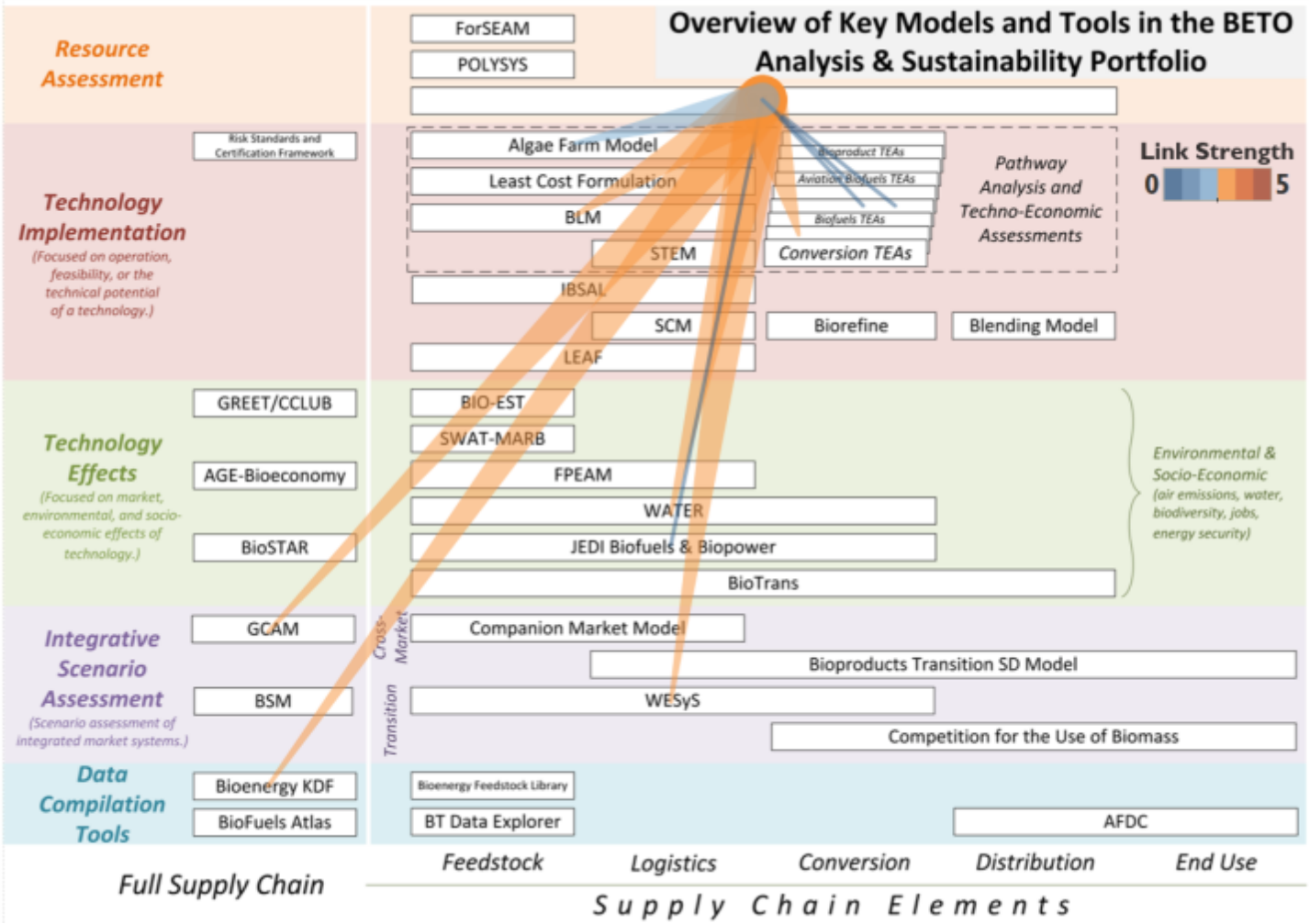
Model Mapping

- The analysis framework developed under this project links tightly with the PNNL Biomass Assessment Tool (BAT), which provides a key resource assessment capability for BETO and Analysis and Sustainability (next two slides)
  - Ability to utilize input from selected key models
  - Provides output for use by selected key models
- This linkage will allow rapid dissemination of project results across the Analysis and Sustainability portfolio

BAT - Inputs


Overview of Key Models and Tools in the BETO Analysis & Sustainability Portfolio
Resource Assessment
ForSEAM
POLYSYS
BAT
Technology Implementation
(Focused on operation, feasibility, or the technical potential of a technology.)
Risk Standards and Certification Framework
Algae Farm Model
Least Cost Formulation
BLM
STEM
IBSAL
SCM
LEAF
Bioproduct TEAs
Aviation Biofuels TEAs
Biofuels TEAs
Conversion TEAs
Pathway Analysis and Techno-Economic Assessments
Biorefine
Blending Model
Link Strength
0
5
Technology Effects
(Focused on market, environmental, and socio-economic effects of technology.)
GREET/CCLUB
AGE-Bioeconomy
BioSTAR
BIO-EST
SWAT-MARB
FPEAM
WATER
JEDI Biofuels & Biopower
BioTrans
Environmental & Socio-Economic
(air emissions, water, biodiversity, jobs, energy security)
Integrative Scenario Assessment
(Scenario assessment of integrated market systems.)
GCAM
BSM
Cross-Market
Transition
Companion Market Model
Bioproducts Transition SD Model
WESyS
Competition for the Use of Biomass
Data Compilation Tools
Bioenergy KDF
BioFuels Atlas
Bioenergy Feedstock Library
BT Data Explorer
AFDC
Full Supply Chain
Feedstock
Logistics
Conversion
Distribution
End Use
Supply Chain Elements

BAT - Outputs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Technology Effects
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GREET/CCLUB
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BIO-EST
SWAT-MARB
FPEAM
WATER
JEDI Biofuels & Biopower
BioTrans
Environmental & Socio-Economic
(air emissions, water, biodiversity, jobs, energy security)
Integrative Scenario Assessment
(Scenario assessment of integrated market systems.)
GCAM
BSM
Cross-Market
Transition
Companion Market Model
Bioproducts Transition SD Model
WESyS
Competition for the Use of Biomass
Data Compilation Tools
Bioenergy KDF
BioFuels Atlas
Bioenergy Feedstock Library
BT Data Explorer
AFDC
Full Supply Chain
Feedstock
Logistics
Conversion
Distribution
End Use
Supply Chain Elements