Beetlejuice

Researching Sustainable Biofuels from Beetle-Kill Wood in the Rockies

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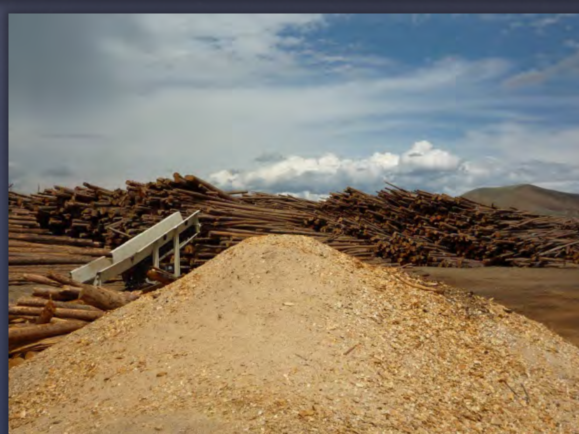
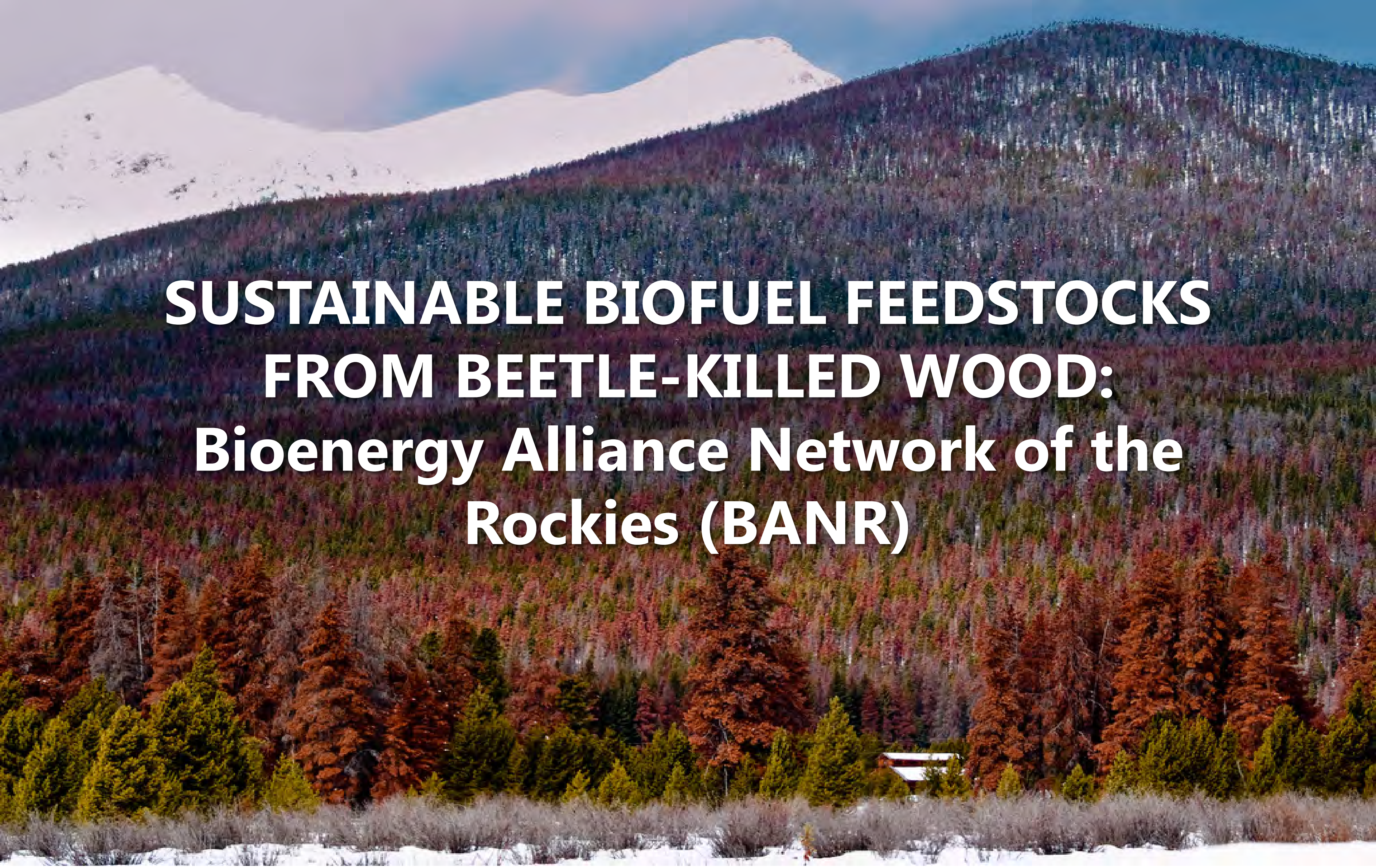
BANR

Bioenergy Alliance Network of the Rockies

Bark beetle-killed trees as biofuel feedstock?





SUSTAINABLE BIOFUEL FEEDSTOCKS FROM BEETLE-KILLED WOOD: Bioenergy Alliance Network of the Rockies (BANR)

University of Wyoming

Colorado State University

University of Montana

University of Idaho

Montana State University

Forest Service U.S. Department of Agriculture

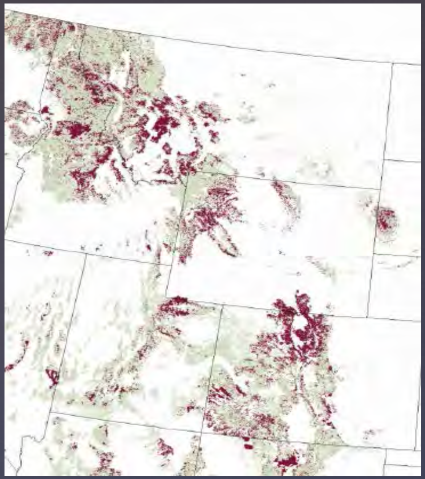
NREL National Renewable Energy Laboratory

coolplanet Energy Systems

Background

Beetle infestation is a major ecological and resource management issue in the Rocky Mountains

- 17 Mha (42 Ma) of forest in US impacted by bark beetles
  - 52% of total area is in CO, ID, MT & WY
- New infestations are occurring on millions of acres annually
- Several 100s of millions of tonnes of dead wood are a potential biofuel feedstock source



US Forest Service (2011)

Removal of beetle-kill wood and forest restoration have been proposed to meet various management objectives:

- Reduce risk of catastrophic wildfire
- Enhance safety for roads, trails, structures
- Enhance regeneration, diversity, habitat

Wood from thinning for fire control & forest restoration is currently a disposal problem

Can beetle-kill and other wood residues be a viable biofuel feedstock?

Opportunities

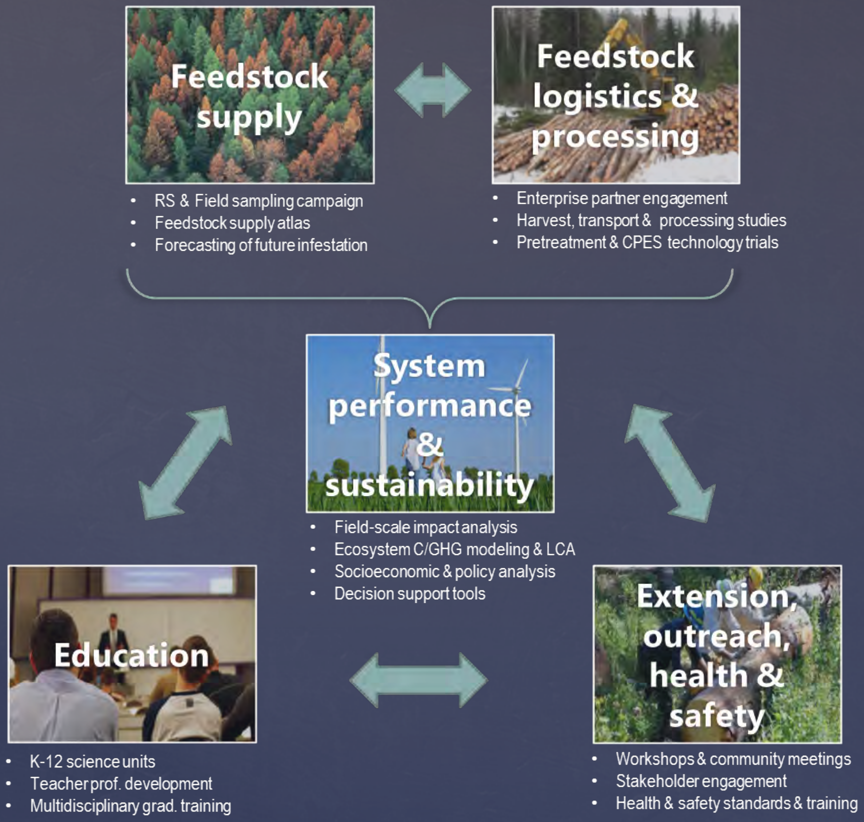
- Large quantities of wood potentially available as a feedstock
- **No** displacement of productive lands (no indirect land use change)
- Minimal competing uses for other wood products
- Synergisms with other land management objectives (e.g., fire mitigation, forest restoration)
- Existing forest infrastructure can be leveraged in many areas

Challenges

- Constrained accessibility in many areas (e.g., roads, topography)
- Large fraction of the area is Federal (and State) owned
  - Policy issues
  - Alternative use issues
- Feedstock 'creation' is unmanaged, episodic and patchy **(major constraint against large, fixed location biorefineries)**
- Potential adverse environmental impacts (e.g., erosion, water quality)

Overarching Objective

To provide the science-based underpinnings – through targeted research, education, training and extension – to support the development of sustainable biofuel production from beetle-killed and 'waste wood' feedstocks.



Overview of Biomass Conversion Technology

- Patented pyrolysis pathway to produce drop-in high octane fuel
- Flexible product pathway – use of biochar as a coproduct or as secondary stage feedstock
- Allows optimization between maximum fuel production and maximum greenhouse gas offset goals

- Fully-scalable modular technology
- Allows for distributed facilities (can exploit patchy, episodic feedstocks)
- Economies of scale achieved through mass production of standardized conversion modules

- Field-scale deployment and testing in CA
- Manufacturing facility to be built in CO
- Commercial-scale plants under construction in LA

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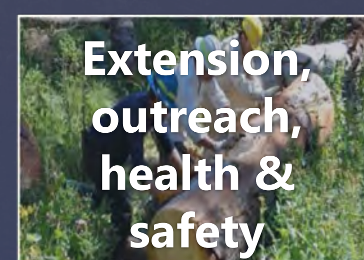
Project Task Overview

- RS & Field sampling campaign
- Feedstock supply atlas
- Forecasting of future infestation

- Enterprise partner engagement
- Harvest, transport & processing studies
- Pretreatment & CPES technology trials

- Field-scale impact analysis
- Ecosystem C/GHG modeling & LCA
- Socioeconomic & policy analysis
- Decision support tools

- K-12 science units
- Teacher prof. development
- Multidisciplinary grad. training



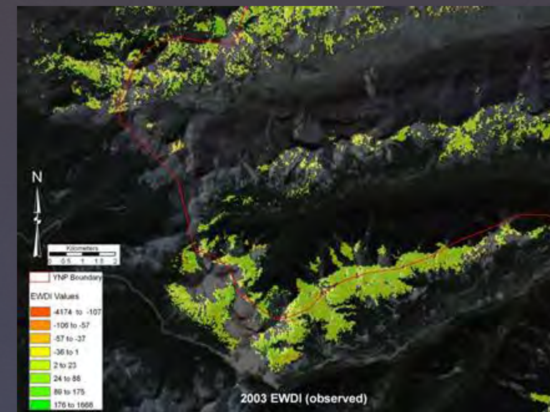
- Workshops & community meetings
- Stakeholder engagement
- Health & safety standards & training

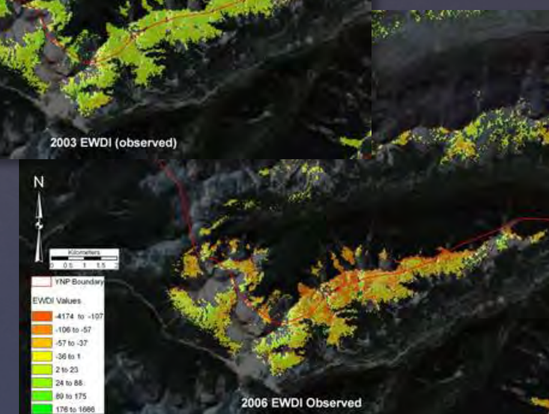
Task 1: Feedstock supply/availability

Team Leaders – Evangelista(CSU), Lawrence(MSU)

Objectives:

- Inventory beetle-killed biomass using remote sensing, ground surveys and spatial modeling
- Quantify and map relative to ecosystem, topographic and infrastructure constraints
- Develop procedures for forecasting new feedstock and rapid updating of feedstock inventory





Methods and Outcomes:

- *Integrate field plot data, remote sensing and geospatial layers (e.g. topography, climate) with a suite of correlative models to estimate feedstock supplies at multiple spatial and temporal scales.*
- *Produce digital feedstock atlas*

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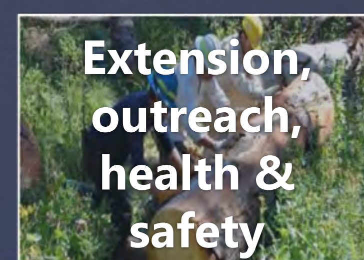

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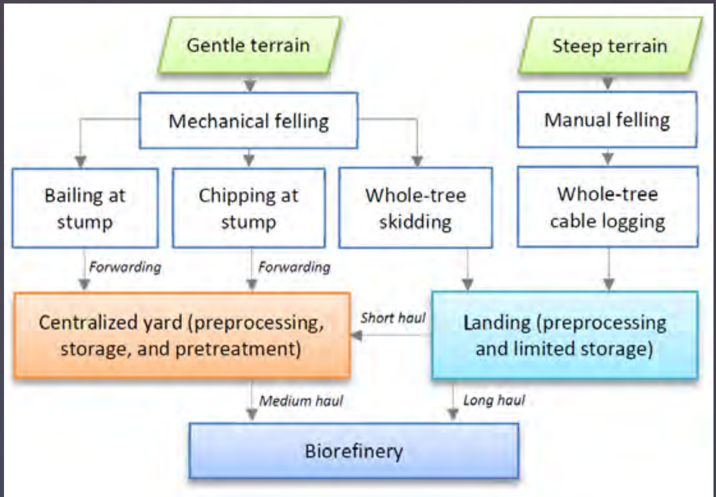
Task 2.1: Feedstock logistics

Harvest, preprocessing and transport

Team Leaders – Anderson(USFS), Chung(UM), Keefe(UI)

Objectives:

- Benchmark the performance of alternative operational configurations to harvest, preprocess and deliver feedstocks
- Optimize supply logistics as a function of site conditions, operational configurations, road infrastructure and silvicultural prescriptions
- Develop procedures for forecasting economic flows of feedstock and rapid, accurate estimates of delivered cost



Sample feedstock logistics

Methods and outcomes:

- *Use operations research methods to develop new cost and production models for biomass-only and integrated forest operations in beetle-killed stands*
- *Models will guide sustainable, economic harvest of forest biomass for bioenergy including site selection for harvest, concentration and conversion*

Collecting time study data for a biomass operation

Task 2.2: Feedstock processing

Team Leaders – Wilson(CPES)

Objectives:

- Establish feedstock guidelines that ensure the fractionator operates without plugging, fouling or coking
- Analyze impact of using varying wood quality (e.g., phase, bark, blue-stained), age and moisture content as components of the guidelines

Methods and Outcomes:

- *Prepare samples to various size specifications*
- *Characterize properties including composition, size distribution, crush strength, friability, and attrition*
- *Operate racetrack continuously while recording uptime and making operational observations*
- *Rank performance of tested biomass and sizes, and set guidelines for feedstock preparation and selection*

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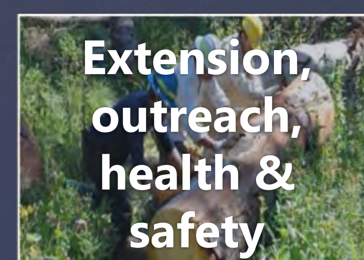

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Task 3.1: Field-scale environmental impacts

Team Leaders – Tinker(UW), Rocca(CSU), Rhoades(USFS), Paul(CSU)

Objective:

- Quantify the ecological impacts of harvesting beetle-killed trees in dominant forest types in the Rockies

Methods and Outcomes:

- *Paired study sites located in recently harvested and unharvested, post-outbreak forests*
- *Measurements will include:*
  - *Density of live and dead trees, including understory trees*
  - *Surface fuels*
  - *Aboveground NPP*
  - *Soil organic matter and nutrient dynamics*
  - *Plant species diversity*
- *Field studies and monitoring will help ensure that development of forest structural and functional characteristics are sustained or enhanced, and replanting will occur only if necessary*

Photo by Kellen Nelson

Photo by Jake Griffin

Task 3.2: Impacts of biochar use on biofuel sustainability

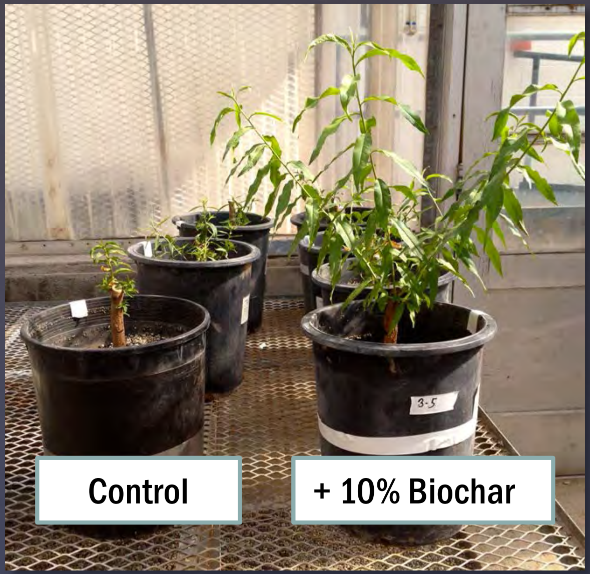
Team Leaders – Cotrufo(CSU), Coleman(UI), Hago(CP), Rhoades(USFS), Atucha(CSU)

Objectives:

- Determine physiochemical characteristics of biochar (BC) produced from different feedstocks
- Assess impacts of BC amendments on productivity and GHG balances in diverse managed ecosystems

Methods and Outcomes:

- *Biochar characterization and improvements*
- *Field trials on annual crops, orchards and forest reclamation sites*
- *Data for decision support tools*
- *Extension papers on recommended practices for biochar applications under different land-uses and managed practices*



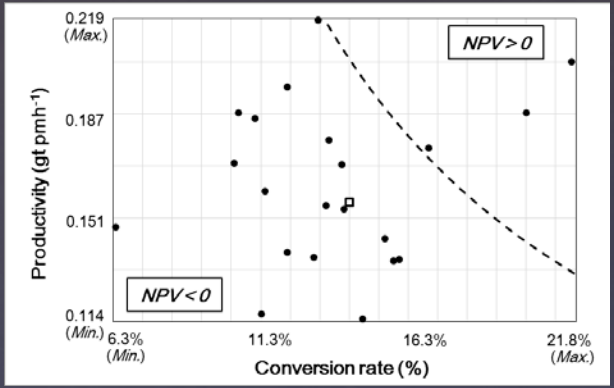
July 8, 2013: 24 Days after Tomato Transplant

Task 3.5: Financial analysis

Team Leaders – Anderson(USFS), Chung(UM), Wilson(CP)

Objectives:

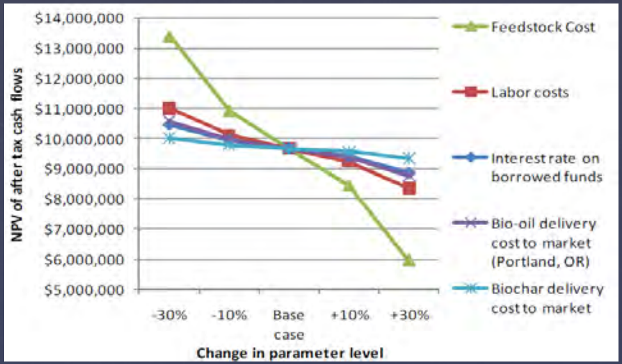
- Evaluate the financial feasibility of using CPES system to convert beetle-kill and waste wood to biofuel and coproducts
- Provide new knowledge to guide tech firms, investors and managers in evaluating cost-benefits of distributed thermochem processing systems



The effects of productivity and conversion rate on the NPV of a mobile pyrolysis system

Methods and Outcomes:

- *Use discounted cash flow analysis to compute the net present value of the CPES system deployed under different operational and economic conditions over a ten-year project period*
- *Financial models will guide deployment and investment by providing information about the conditions that are most likely to result in successful projects from a financial standpoint*



Sensitivity analysis of NPV for a $15 million facility over 10 years

Task 3.6: Socioeconomic and policy analysis

Team Leaders – O'Laughlin(UI), Cheng(CSU), Galvin(CSU), Strauss(UW)

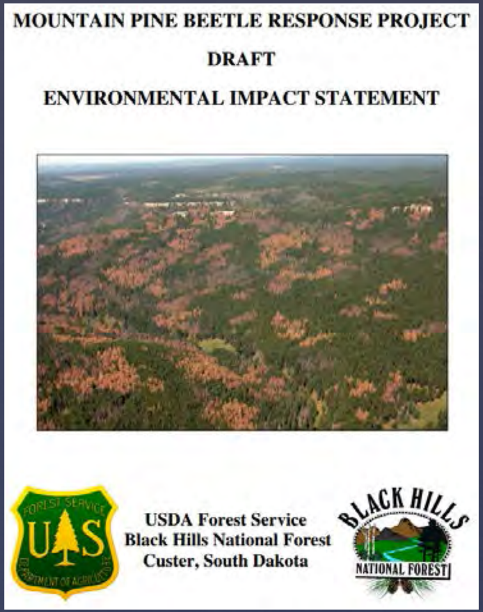
Objectives:

- Analyze economic, social and policy constraints for using beetle-killed and other wood resources as biofuels feedstocks.
- Develop policy options for improving problem situations related to socioeconomic and policy barriers; e.g.,
  - renewable biomass definition (EISA 2007)
  - public agency funding constraints
  - NEPA analysis (large-scale, e.g., Black Hills NF, 4-FRI in AZ)
  - litigation – reduced if "social license" exists

Source: National Report on Sustainable Forests – 2010 (USDA Forest Service 2011).

Methods and Outcomes:

- *Cost-benefit analysis of beetle-kill wood utilization, including other wood resources & products and benefits from avoided costs, e.g., wildfire suppression, post-fire rehabilitation*
- *Assess social acceptability of biomass removal at national, regional, and local levels using multiple methods (e.g., focus groups, survey questionnaires, and key informant interviews)*
- *Policy analysis: multi-scale assessment of policy factors & tools; identify problems, create & analyze options*



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Environmental Sustainability

“How much of USDA's $10 million will go to scientists finding forest ecosystems are capable of recycling their own carbon? How much will go to silence them as massive federal subsidies are created to grind those ecosystems up?”

Letter to the editor – Missoulian newspaper
January 8, 2014

“We are not industry dupes!”

Quote attributed to K. Paustian, Denver Post
November 6, 2014

Key sustainability issues

- **GHG mitigation – how effective?**

- Potential harvest site impacts
  - Soil disturbance, erosion, sediment yield
  - Runoff, water quality

- Releases from conversion facilities
  - Water quality
  - Criteria air emissions

- Ecosystem and landscape structure & function
  - Forest health
  - Wildlife habitat and biodiversity
  - Wildfire frequency and intensity

Task 3.3, 3.4: Modeling and life cycle assessment

Team Leaders – Paustian(CSU), Field(CSU), Bergman(USFS), Mann(NREL)

Objective:

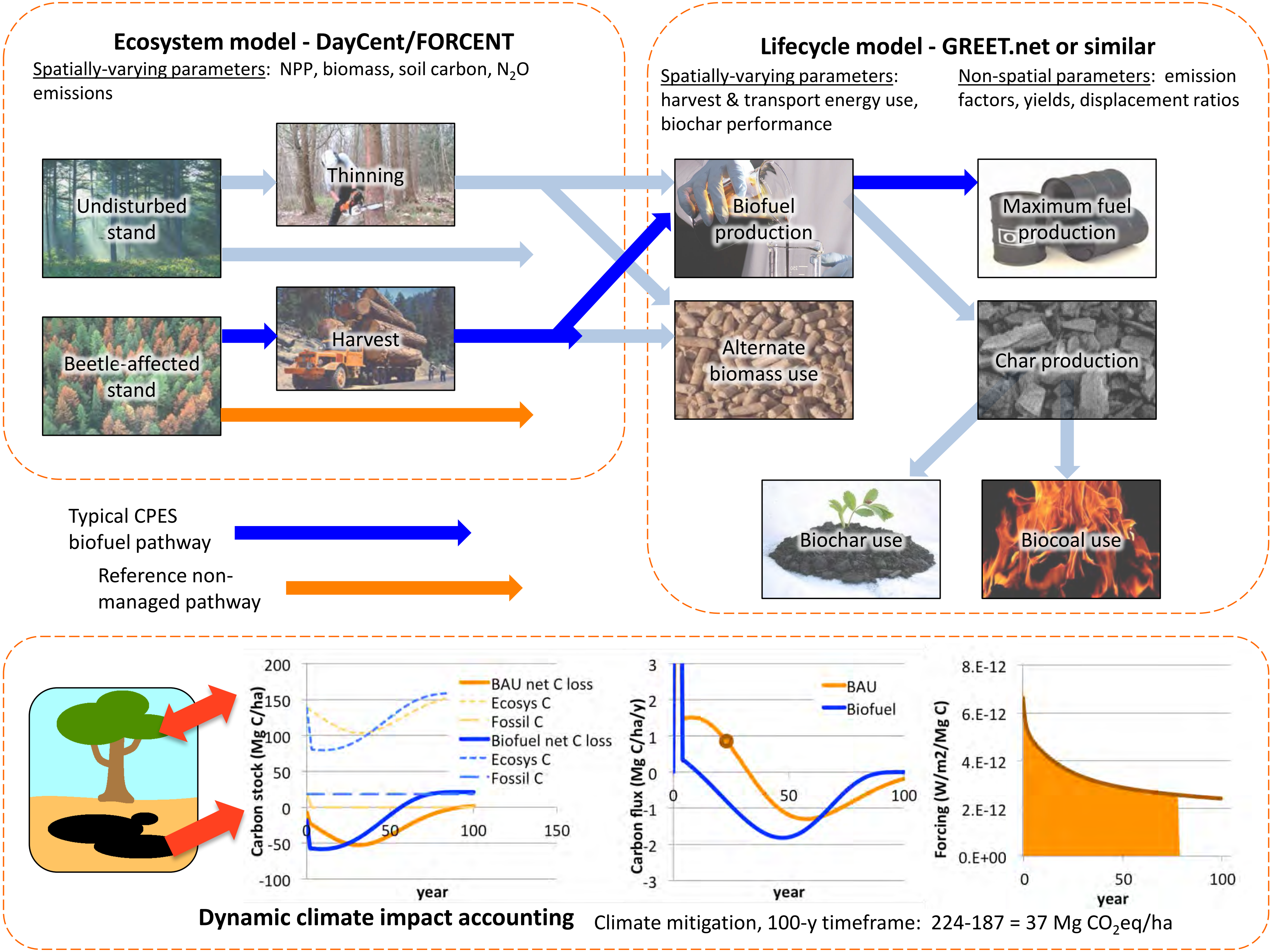
- Comprehensive analysis of environmental impacts of beetle-kill wood utilization

Methods:

- *Model forest C/GHG cycle impacts of beetle-kill wood utilization*
- *Life cycle assessments (LCA) that integrate:*
    - *Long-term forest C/GHG dynamics*
    - *Harvest and transport activities*
    - *Processing and conversion with CPES technology*
    - *Production of alternative fuel/biochar product ratios*
    - *Downstream emissions*
- *Implement time-dynamic accounting to assess climate impacts (i.e., radiative forcing)*

Outcomes:

- *Regionally representative, 'forest to pump' LCAs*
- *LCA methods and algorithms for deployment in web-accessible decision support tool*


Ecosystem model - DayCent/FORCENT
Spatially-varying parameters: NPP, biomass, soil carbon, N2O emissions
Undisturbed stand
Thinning
Beetle-affected stand
Harvest
Typical CPES biofuel pathway
Reference non-managed pathway
Lifecycle model - GREET.net or similar
Spatially-varying parameters: harvest & transport energy use, biochar performance
Non-spatial parameters: emission factors, yields, displacement ratios
Biofuel production
Maximum fuel production
Alternate biomass use
Char production
Biochar use
Biocoal use
BAU net C loss
Ecosys C
Fossil C
Biofuel net C loss
Ecosys C
Fossil C
Carbon stock (Mg C/ha)
year
Carbon flux (Mg C/ha/y)
BAU
Biofuel
Forcing (W/m2/Mg C)
Dynamic climate impact accounting
Climate mitigation, 100-y timeframe: 224-187 = 37 Mg CO2eq/ha

Task 3.7: Decision support tool

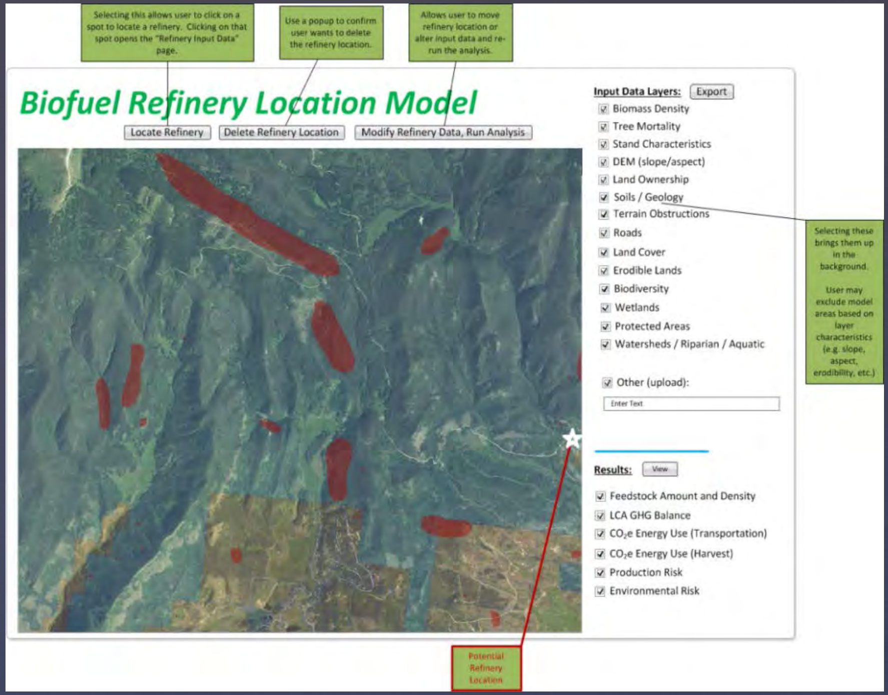
Team Leaders – Paustian(CSU), Evangelista(CSU)

Objective:

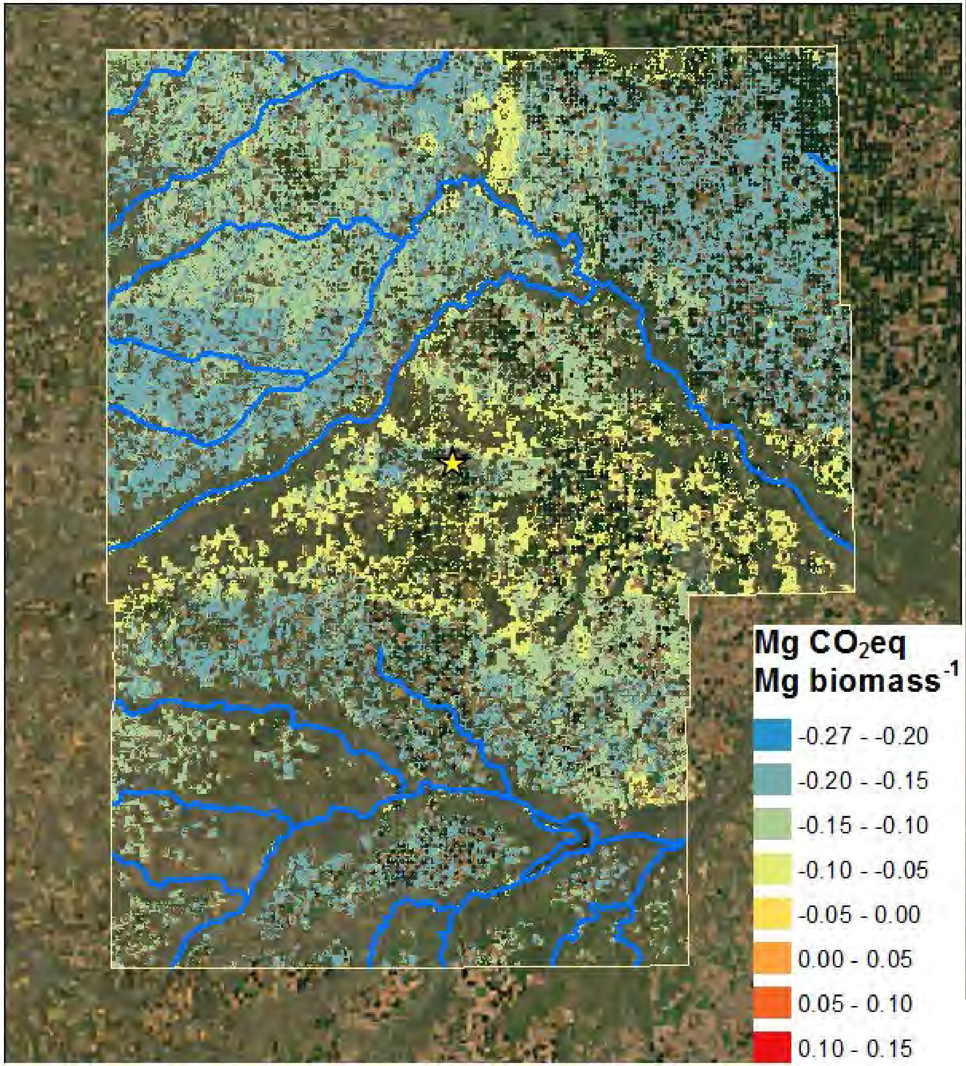
- Develop and deploy a user-friendly web-based system to assess feedstock availability and GHG emissions & environmental footprints for beetle-kill feedstocks

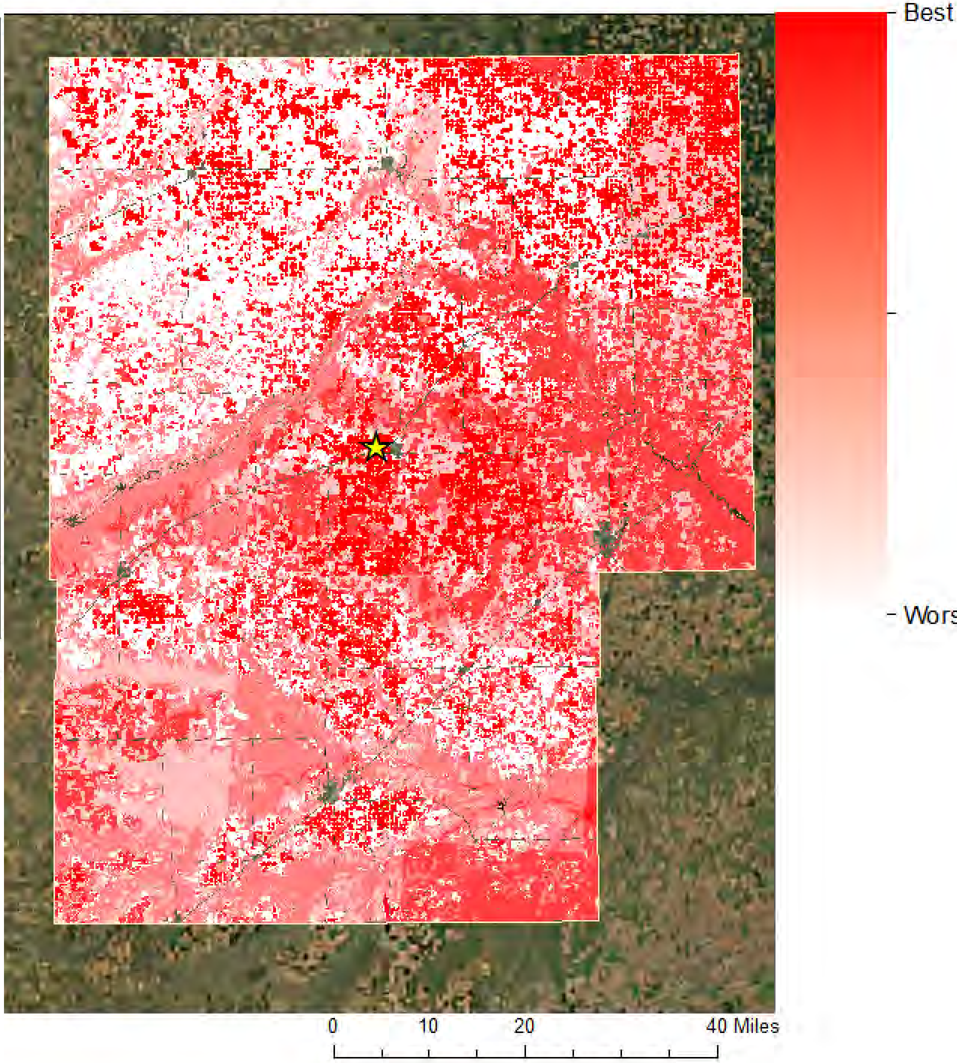
Methods and outcomes:

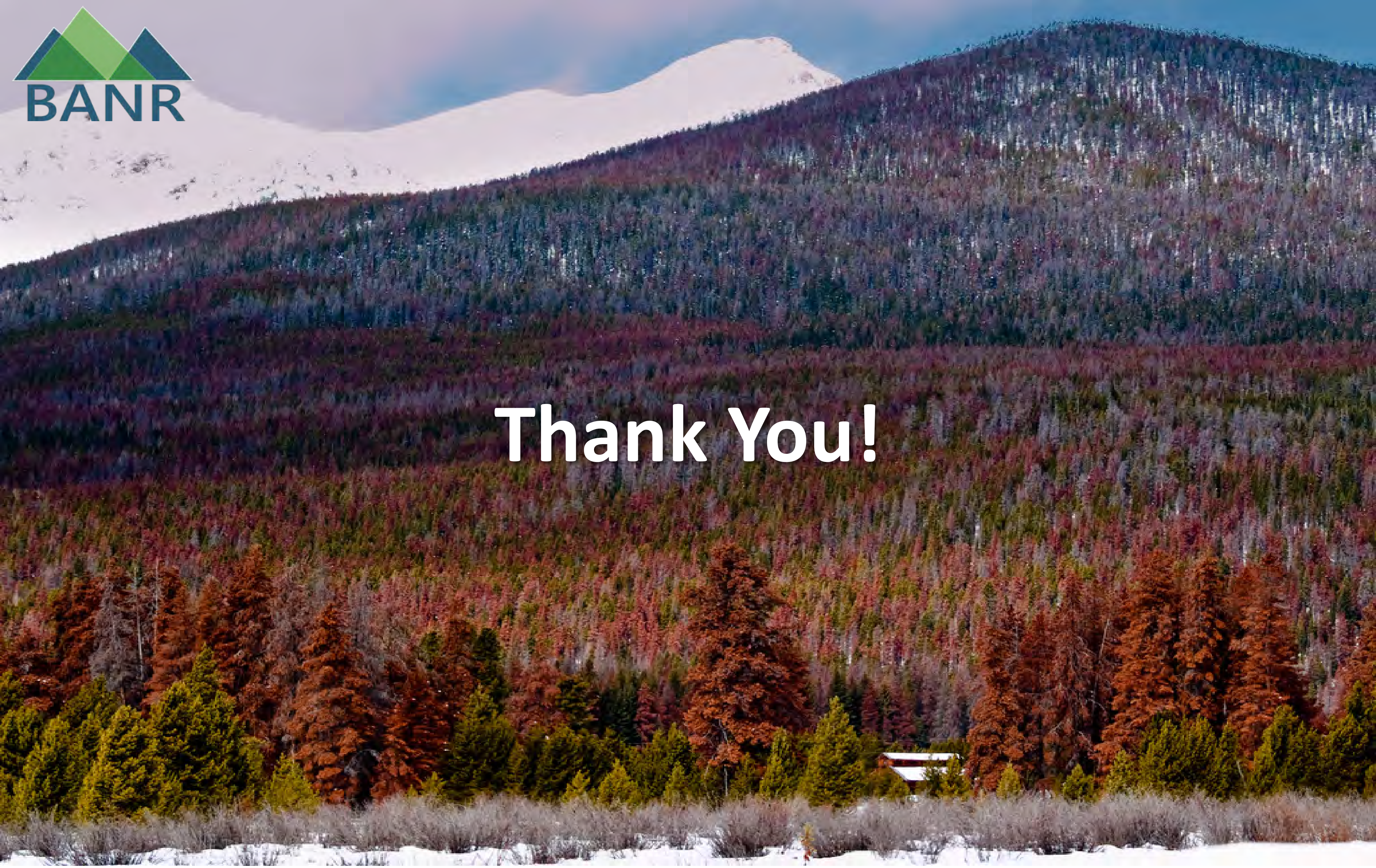
- *Incorporate spatial feedstock atlas (T1)*
- *Spatial graphics interface*
- *Optimization of conversion facility siting based on user-specified requirements*
- *Real-time simulation of forest C dynamics*
- *Incorporate other LCA components*
- *Leverages existing spatial web-tools for dynamic GHG accounting in LU systems (e.g., COMET-Farm, UNEP-CBP) and ongoing development of DSS tool for perennial grass biofuel feedstocks*



Example: Feedstock GHG footprint and optimal feedstock dispatching (including productivity, net GHGs (ecosystem & transport related) and cost for Hugoton KS cellulosic ethanol plant (John Field, unpubl.)







Thank You!

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