WCS-SCM: Advanced Supply Chain Engineering to Support Fuel Treatment and Forest Restoration

Harvesting woody biomass from forest restoration in Arizona to fuel a power plant.

The use of prescribed fire to maintain a fire resilient understory and stand structure.

A biomass power plant that uses biomass from forest restoration as fuel.

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Photos: Nate Anderson, Sharon Hood, Beth Dodson

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- New partners in 2023 and beyond
- USFS BIL Funding
- Previous funding provided by USDA-NIFA through NARA, BANR, MASBio, and others

What’s ahead?

- Background
  - The Wildfire Crisis
  - The Wildfire Crisis Strategy (WCS)
  - Research & Development Response
- The Integrated WCS-SCM Project
- Leverage Past and Ongoing Research
  - Forest operations research
  - Supply chain modeling
  - Regional supply chain analysis
- Questions and Discussion

Timber harvesting in Helena National Forest, Montana (left) and the Cetna pilot scale F-T hydrogen and biofuels plant in Brent, Alabama (above).

Photos: Anderson

Summary

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- Over $2 billion USD has been invested in land management activities
- Research & Development is a key component of WCS
- R&D Wood Innovation and Utilization is funding engineering research
- The WCS Supply Chain Management Project will address 5 areas:
  - Current operations assessment
  - Operations and logistics engineering
  - New supply chain models
  - Facility location and bio-hub design
  - Extension outreach and dissemination

Beaverhead-Deerlodge National Forest, Montana

Photo: Anderson

Current Ecological Conditions

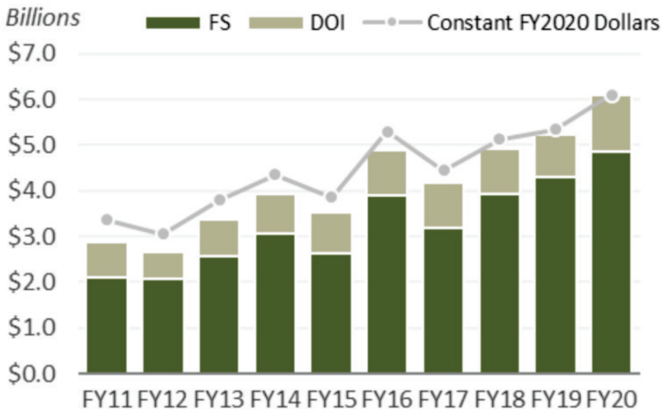
<u>Many millions of acres with:</u>

- Densely overstocked forests
- Increase in shade tolerant species
- Forest health problems
  - Drought stress
  - Insects
  - Disease
  - Damage
- High mortality
- Low vigor

A lodgepole pine (Pinus contorta) forest (left) in Montana, with high levels of tree mortality (80% to 90%) following infestation by the native mountain pine beetle, *Dendroctonus ponderosae* (inset). An overstocked mixed conifer forest in Colorado.

Photos: U.S. Forest Service (beetle) and Anderson

Current Management Conditions

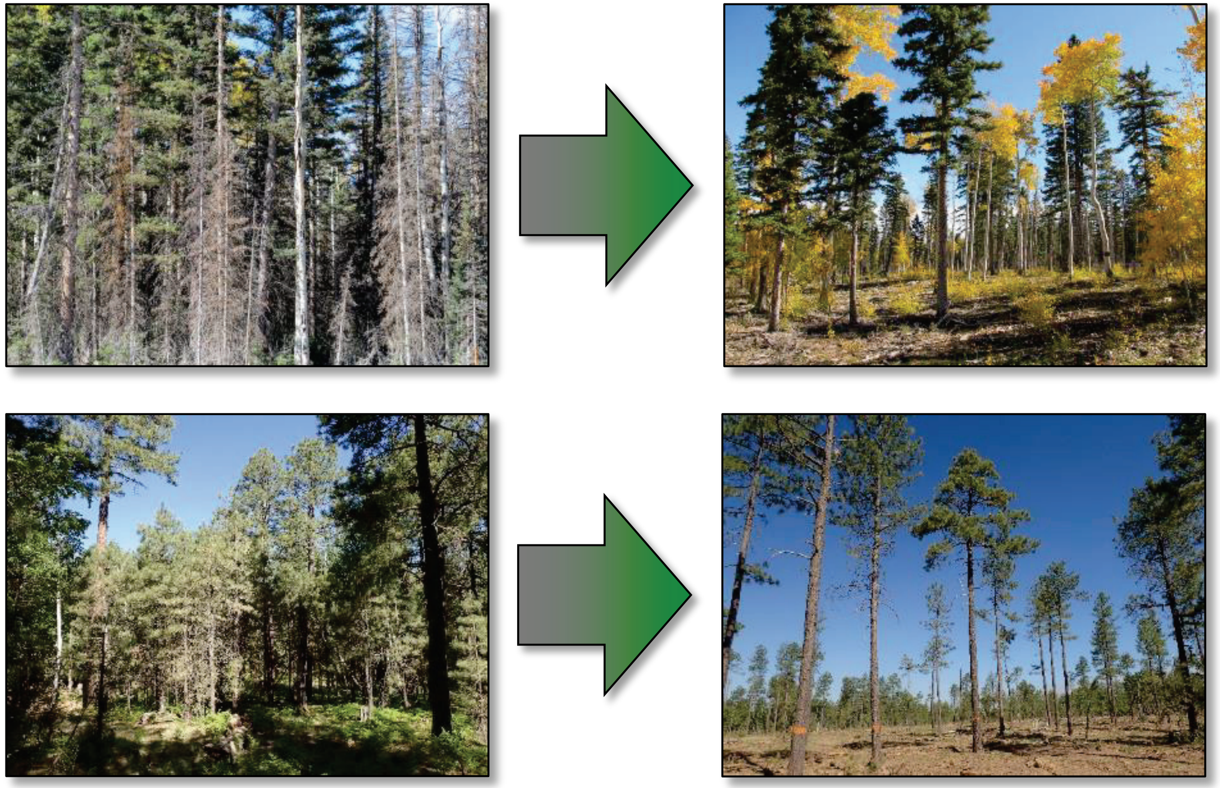


- Forests prone to large and severe wildfires
- Development in the wildland-urban interface (WUI)
- Climate change is making conditions worse
- Diverse values and ecosystem services at risk
- Escalating cost of wildfire management
- Fewer resources for all other management needs

Wildfire in the wildland-urban interface and combined USFS and DOI wildfire appropriations, FY2011-FY2020.

Photo: Stephen Lam/Reuters **Figure:** CRS 2020

Management Goals & Objectives



Examples of forest restoration in mixed conifer (top) and ponderosa pine forests (bottom) in Colorado and Arizona.

- Forest Landscape Restoration
  - Fire resilient forests
  - Drought resilience under climate change
  - More heterogeneity within range of variation
- Restore burned areas after fire
- Protect ecosystem function
  - Soil conservation and recovery
  - Watershed function and hydrology
  - Biodiversity
- Deliver ecosystem services
  - Timber, biomass, water, recreation, others
  - Carbon storage and climate change mitigation

Photos: Anderson

Big Operational Challenges with Fuel Treatment

Low value, small diameter timber and non-merchantable biomass from a fuel treatment (left) and ignitions of prescribed fire using a helicopter (below).

Compared to commercial timber operations:

- Difficult implementation
- Complex residual stand conditions
- Higher costs and lower product values
- Limited markets for products
- More risk to personnel and property
- Complex valuation
- Large volumes of non-saw biomass

Photos: Anderson and Sharon Hood

Wildfire Crisis Strategy

Over a 10-year period:

- Maintain current 2 to 3 million acres/year
- +20 million ac on National Forest
- +30 million ac on Fed, Tribal, State & private
- Long-term maintenance of treated areas

Bipartisan Infrastructure Law (BIL):

- > $2 billion USD to accomplish WCS
- And other land management goals

Use of prescribed fire in longleaf pine in the U.S. southeast and a restored ponderosa pine forest in Colorado.

Photos: Sharon Hood and Anderson

R&D Work Under WCS and BIL

- R&D Funding
  - $66 million in FY22 allocation to support 19 BIL provisions
  - SEC. 40803 WILDFIRE RISK REDUCTION - $35.6 million
  - SEC. 40804 ECOSYSTEM RESTORATION - $29.2 million
- Organization
  - Coordinated through Washington D.C. Office and Station Leadership
  - **Wood Innovation and Utilization** is one of 7 BIL R&D Core Teams
  - Projects developed through the Core Teams
- WCS Supply Chain Management (WCS-SCM) Project
  - $1.62 million BIL Funding plus additional resources
  - 3 years +
  - 8 primary research partners and growing

Biomass and biochar research in Flagstaff, Arizona.

Photo: Anderson

WCS-SCM Project Goals

- U.S. National Forests and other forest lands at risk:
  - More treatment and more removals
  - Better forest operations, logistics and supply chain management
  - Modern supply chain models and management techniques
- Industry and NGO partners:
  - Lower capital risk and higher capital investment
  - Construction, upgrades and expansion
  - Broader, complimentary portfolio of products
- Communities:
  - Jobs and rural economic development
  - Better social and environmental outcomes
  - Less smoke and better health outcomes
  - Enhanced ecosystem services

Logs from forest restoration on the Beaverhead-Deerlodge National Forest, Montana.

Project Objectives and Tasks

Task 1: Characterize current operations

Task 2: Improve operations and logistics

Taks 3: Develop new supply chain models for fuel treatment and restoration

Task 4: Optimize facility location and design new bio-hubs

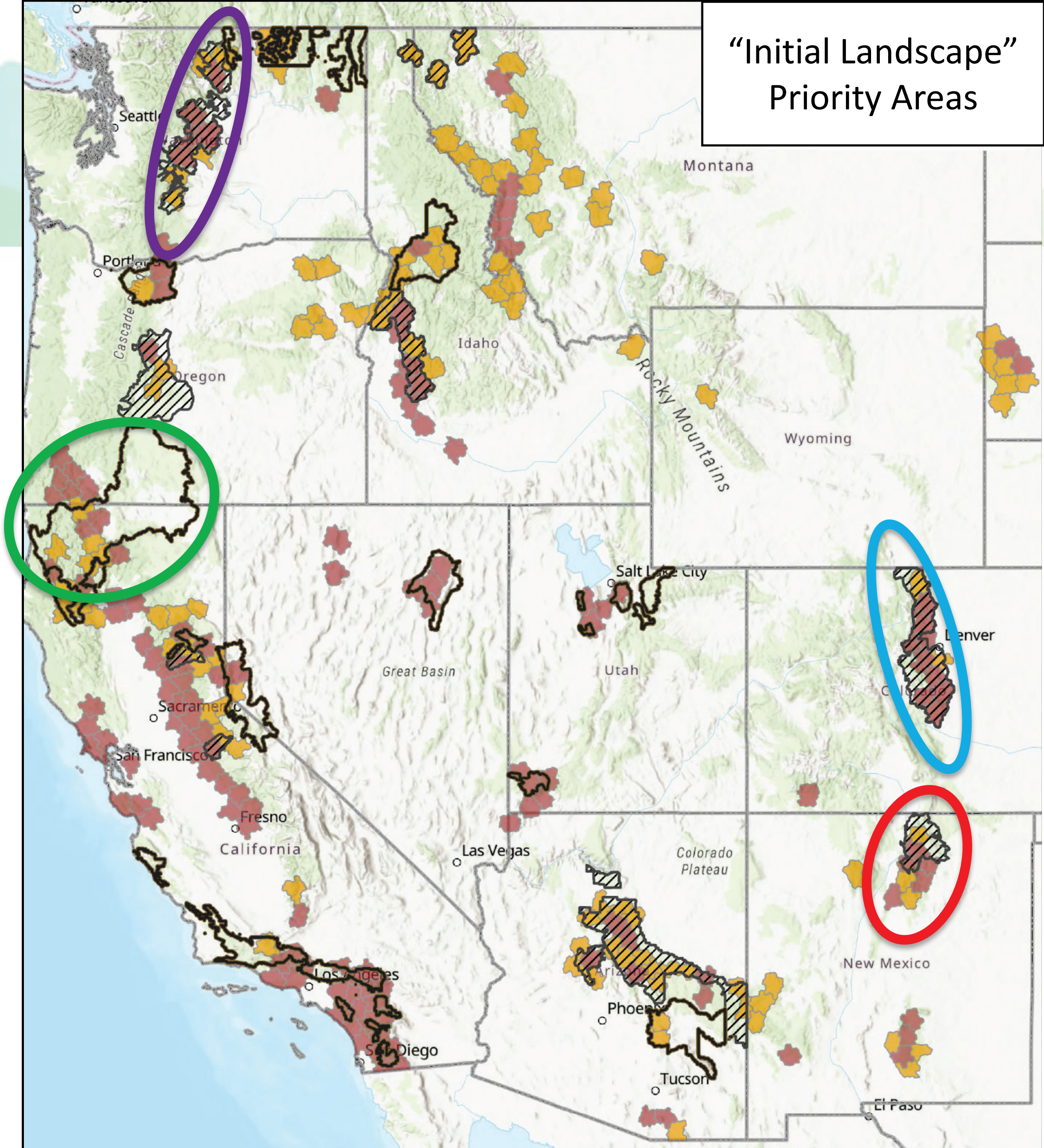
Taks 5: Disseminate results to practitioners and decision makers

LEVERAGE PAST AND ONGOING RESEARCH IN THESE FIELDS

Project Landscapes

- Central Washington Initiative
- Colorado Front Range
- New Mexico Enchanted Circle
- +Klamath River Basin

- Other ad hoc landscapes
- All landscapes for implementation

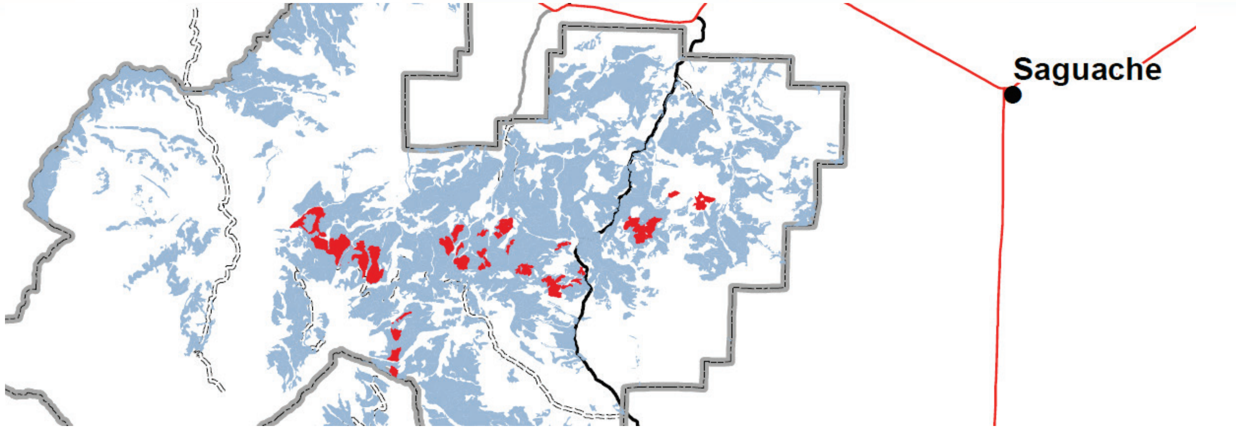


LANDSCAPES
NEW LANDSCAPES
EXISTING LANDSCAPES

HIGH-RISK FIRESHEDS
ALL LAND OWNERSHIPS
FOREST SERVICE LANDS

Task 1: Characterize Forest Operations

- Collect & analyze National Forest data
- Review past and ongoing operations
- Understand USFS
  - Appraisal systems
  - Product valuation
  - Contracting rules
  - Transaction costs



Potential Biomass										
Revision Date: Feb 2021	-									
Fiscal Year	102,663 102,663									
SALE NAME	ES	LP	DF		MIX	TOTAL CUT		Temp Road miles	Spec Road miles	Vol/Ac
	CCF					CCF VOL	treat acres			
	ST-d&d	ST	ST-live	ST-d&d	ST					
North Jacks Salvage (FT)	1,500					1,500	185.7			8.08
South Jacks Salvage (FT)	585					585	90.8			6.44
Full Tilt Units 3 & 4 (FT)	4,573					4,573	360.8			12.67
Moon Pass Dropped Units (LGH)	3,753					3,753	501.2			7.49
MOON PASS (LGH)	2,071					2,071	246.1			8.42
Easy Money Dropped Units (LGH)	9,350					9,350	1372			6.81
Golden State Dropped Units (LGH)	1,611					1,611	208.5			7.73
Franklin's Tower(LGH)	2,200		78			2,278	210	1.00		10.85
Spruce Lake (LGH)	4,749					4,749	648			7.33
Long Lost (LGH)	2,150					2,150	308			6.98
Miners Prong Dropped Units (LGH)	1,700					1,700	256			6.64
Lujan	500	2,300				2,800	350			8.00
Poncha					1,046	1,046	123			8.50
Ute Pass		1,500				1,500	250			6.00
Cave Creek (LGH)	2,000					2,000	300			6.67
Prong Creek (LGH)	3,000					3,000	300			10.00

Biomass availability estimates tied to unsold salvage timber sales on the Rio Grande National Forest, Colorado.

Task 1: Characterize Forest Operations

- Leverage previous forest operations research conducted with USFS partners
- Collect data and information from industry partners

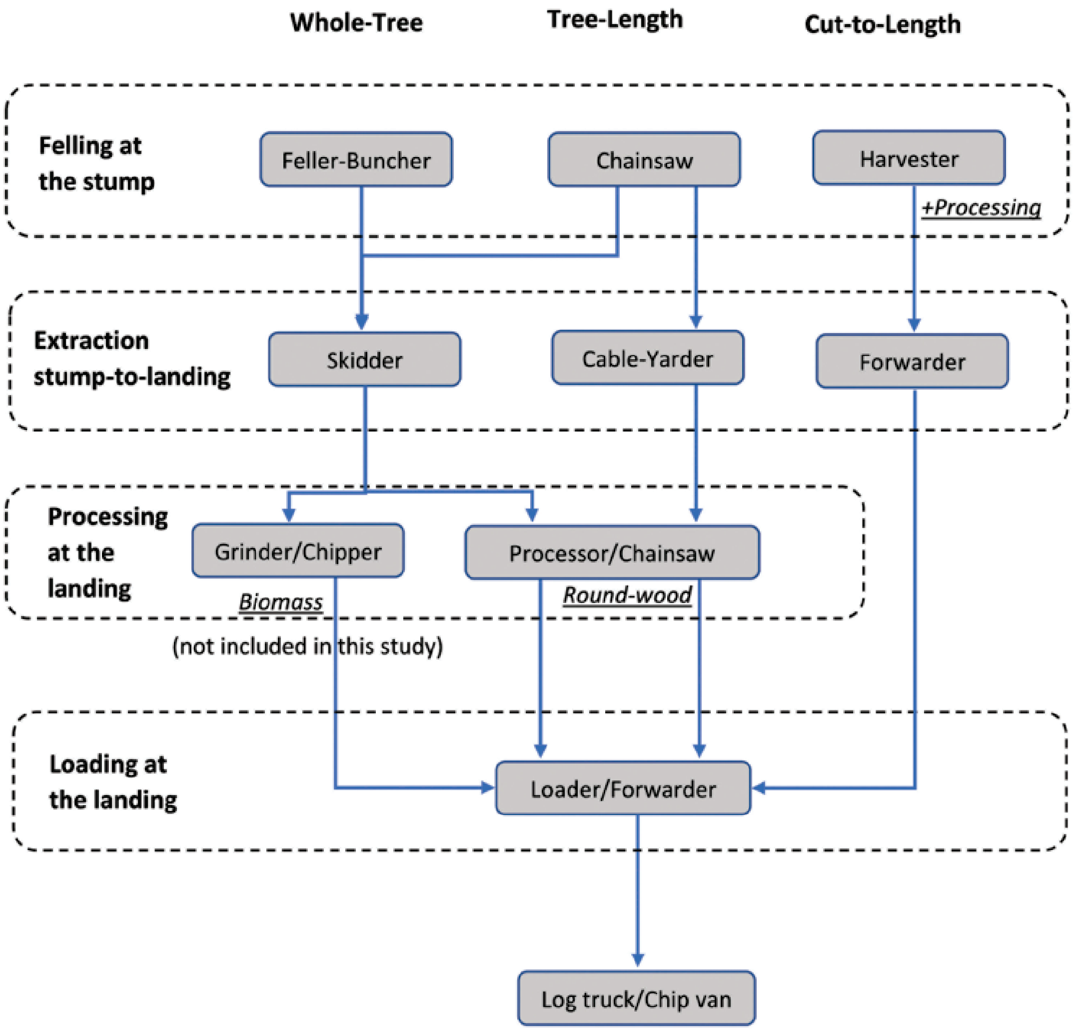
Table 13. Observed and modeled total stump-to-truck costs per tonne by operation in USD. Values may not perfectly sum because of rounding.

	Operation				
Function	1	2	3	4	5
Observed costs ($ per tonne)					
Felling	$4.54	$7.74	$13.17	$3.76	$16.06
Skidding	$8.13	$17.31	$11.37	$4.65	$12.47
Processing	$7.80	$7.38	NA	$5.89	$7.87
Loading	$3.86	$2.54	$9.38	$4.65	$3.42
Grinding	$9.02	$9.24	N/A	N/A	N/A
Round wood cost	$24.34	$34.97	$33.93	$18.94	$39.83
Round wood with biomass cost	$33.36	$44.21	N/A	N/A	N/A
Modeled costs ($ per tonne)					
Felling	$4.33	$4.54	$7.74	$4.84	$15.58
Skidding	$6.72	$9.38	$8.50	$9.59	$11.68
Processing	$7.51	$7.83	NA	$6.51	$7.87
Loading	$3.36	$3.27	$7.29	$4.65	$3.42
Grinding	$9.02	$9.24	N/A	N/A	N/A
Round wood cost	$21.92	$25.02	$23.53	$25.58	$38.55
Round wood with biomass cost	$30.94	$34.26	N/A	N/A	N/A

Townsend, L., Dodson, E., Anderson, N., Worley-Hood, G. and Goodburn, J., 2019. Harvesting forest biomass in the US southern Rocky Mountains: cost and production rates of five ground-based forest operations. *International Journal of Forest Engineering*, *30*(2), pp.163-172.

Task 2: Operations and Logistics R&D

- Identify gaps and areas for improvement
- Provide recommendations
- Assist in cost and productivity estimation
- Develop and deploy new resources and tools, like the NAU ThinCost model

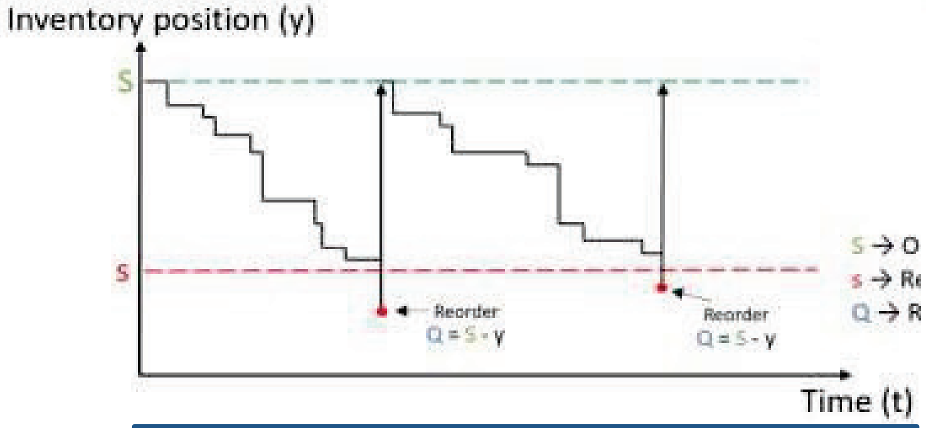


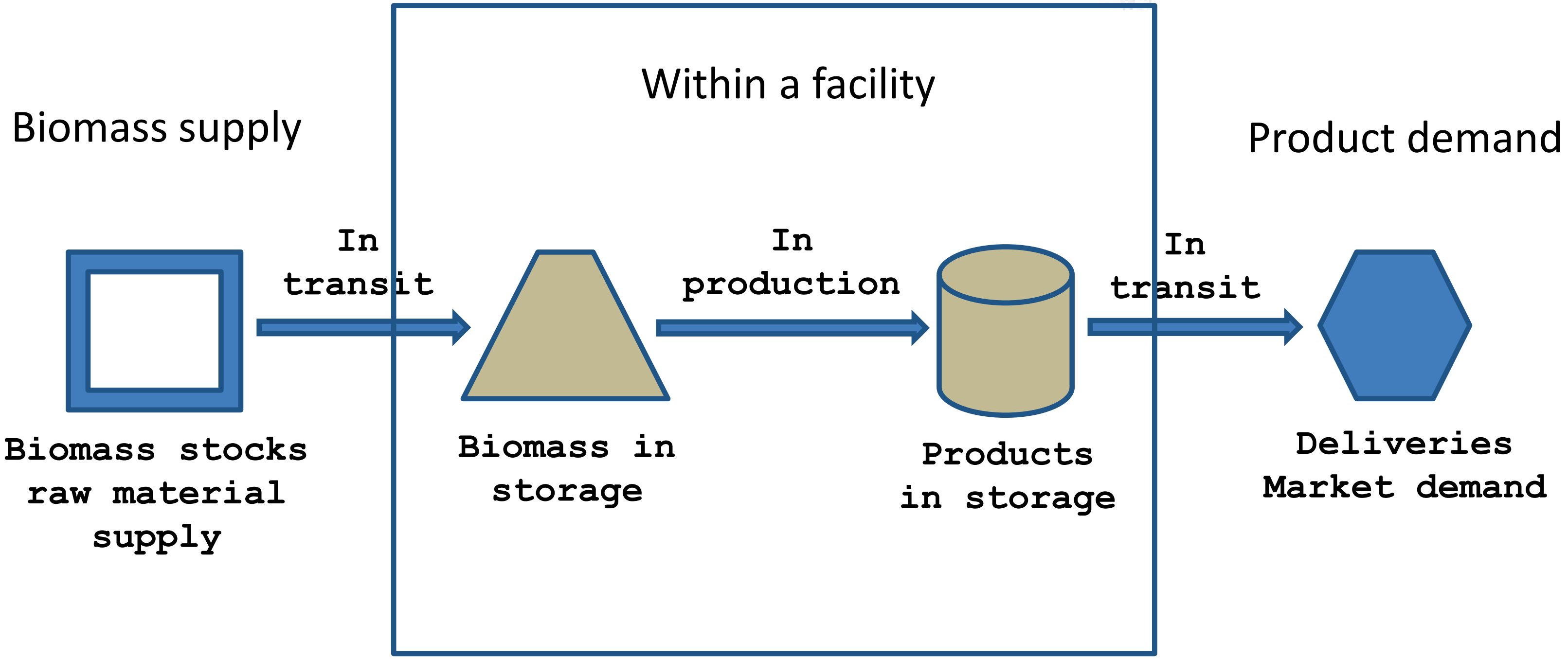
Chang, H., Han, H.S., Anderson, N., Kim, Y.S. and Han, S.K., 2023. The cost of forest thinning operations in the western United States: a systematic literature review and new thinning cost model. *Journal of Forestry*, *121*(2), pp.193-206.

Figure 8. Productivity and production cost of processor (left) and loader (right) depending on DBH from the ThinCost_1.0 for round-wood only.

Task 3: Supply Chain Modeling

- Operational models for log and biomass procurement
- Inventory control
- Facility-scale SCM





See: Wei, Y., Anderson, N., and Thompson, M. 2023. Developing inventory management models to study biomass supply chain resilience. COFE-FETEC 2023 Session 4-2.

Task 3: Supply Chain Modeling

- Continue to develop established modeling frameworks
- Include social and economic factors
- Adapt these frameworks to the WCS Initial Landscapes

Zhang, X., Wang, J. and Strager, M.P., 2022. Industrial Development and Economic Impacts of Forest Biomass for Bioenergy: A Data-Driven Holistic Analysis Framework. *Resources, Conservation and Recycling*, *182*, p.106296.

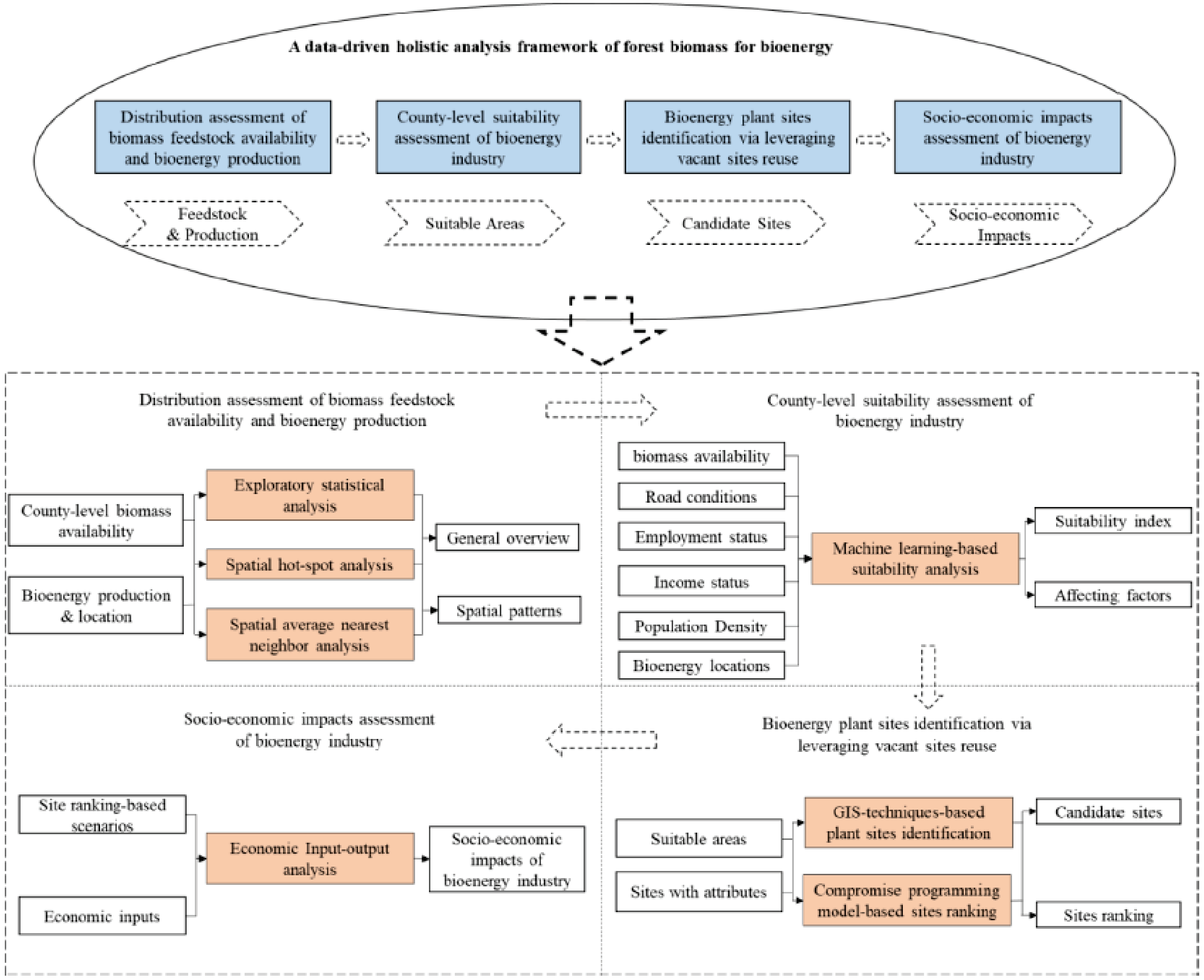


Figure 1. Schematic illustration of the holistic analysis framework and its components.

Task 4: Regional Analysis

- Conduct regional-scale analysis
  - For single WCS landscapes
  - Across multiple WCS landscapes
- Guide supply chain management
- Inform facility siting and investment

Ma, F., Lee, J.Y., Camenzind, D. and Wolcott, M., 2022. Probabilistic Wildfire risk assessment methodology and evaluation of a supply chain network. *International Journal of Disaster Risk Reduction*, *82*, p.103340.

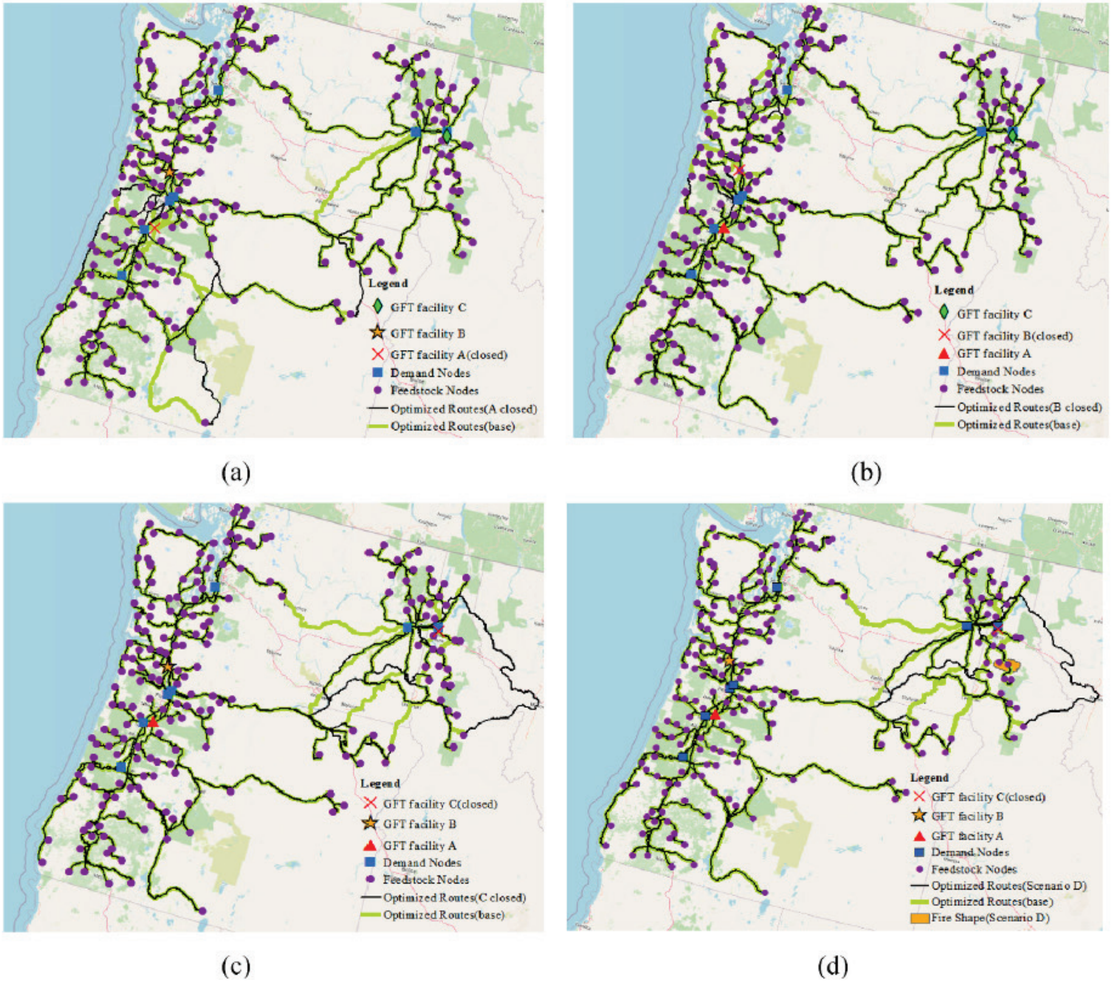


Fig. 9. Optimal routes for four scenarios, including (a) GFT Facility A closure; (b) GFT Facility B closure; (c) GFT Facility C closure; and (d) GFT Facility C closure and feedstock damages.

Task 4: Bio-hubs

- Understand the industrial ecology of forest restoration
- Design and develop regional bio-hubs to use biomass and logs from restoration

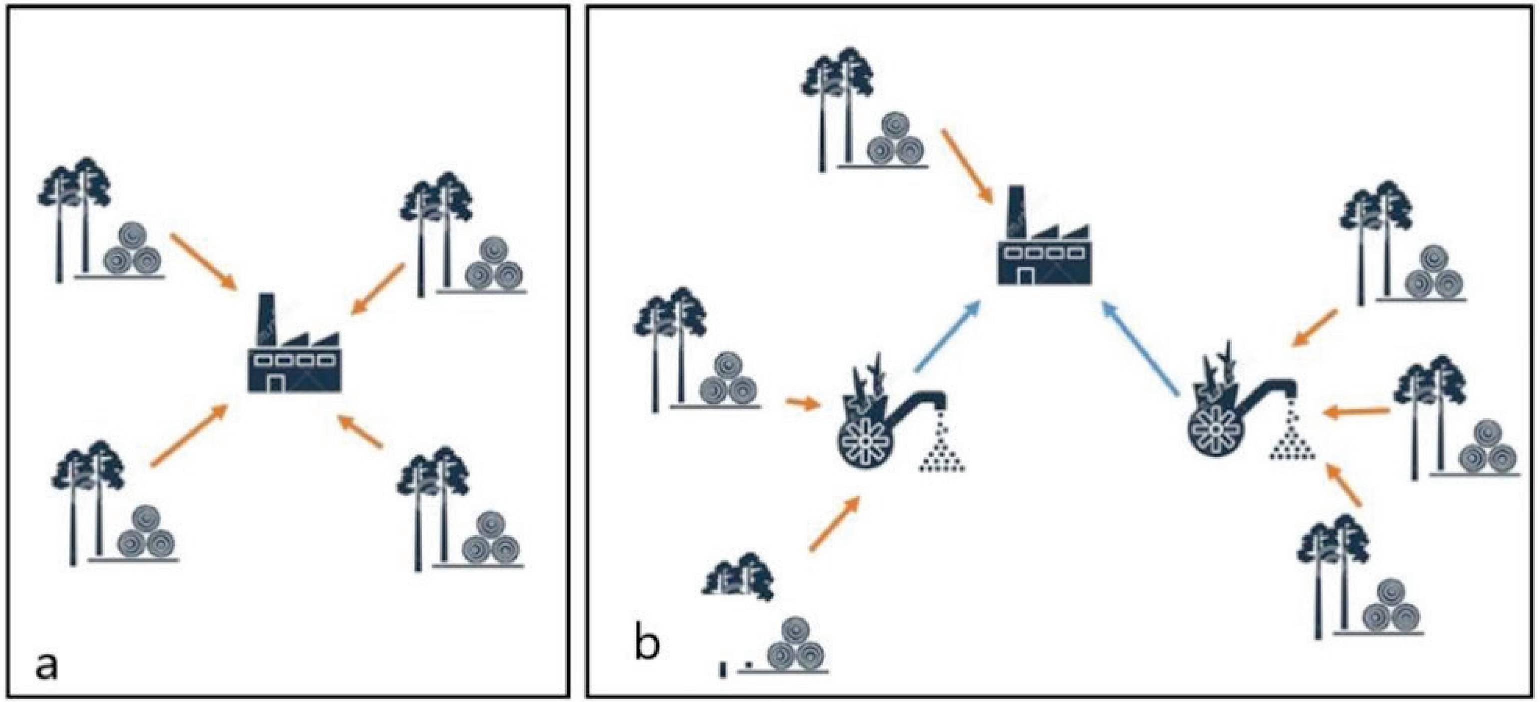


Figure 1. (**a**). traditional forest biomass supply chain, showing transportation from forest directly to central manufacturing facility; (**b**). bio-hub configuration, showing intermediate processing centers located between forest and central processing facility.

Nicholls, D., Vaughan, D., Mitchell, D., Han, H.S., Smidt, M. and Sessions, J., 2022. Forest Bio-Hubs to Enhance Forest Health While Supporting the Emerging Bioeconomy—A Comparison between Three US Regions. *Energies*, *15*(3), p.931.

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Beaverhead-Deerlodge National Forest, Montana

Photo: Anderson

Thanks!

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Basic American Foods in Rexburg, ID, which received biomass from the project below to fuel their biomass boiler.

Harvest of beetle-killed lodgepole pine sawlogs and biomass to reduce fire risk and protect a city water supply in Helena National Forest, Montana.

Photos: John Field, Google Earth and Anderson