Producing Biochar as an Alternative to Open Burning: LCA, Logistical and Economic Considerations

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Western Forest Economists, Olympia WA

Consortium for Research on Renewable Industrial Materials

A non-profit corporation formed by 20 research institutions to conduct cradle to grave environmental studies of wood products

Data Integration from "Waste to Wisdom"

- **Funding**
  - **Humboldt State University under a sub-award from the Office of Energy Efficiency and Renewable Energy (EERE), United States Department of Energy, Biomass Research and Development Initiative (BRDI) project number DE-EE0006297.**
- **Contributors:**
  - **Luke Rogers and Jeff Comnick, University of Washington, Seattle, WA (supply)**
  - **Maureen Puettmann, Woodlife Consulting, Corvallis, OR (LCA of biochar production)**
  - **Ted Bilek and Kamalakanta Sahoo, USDA FS Forest Products Laboratory, Madison WI (economics)**

Waste to Wisdom project goals

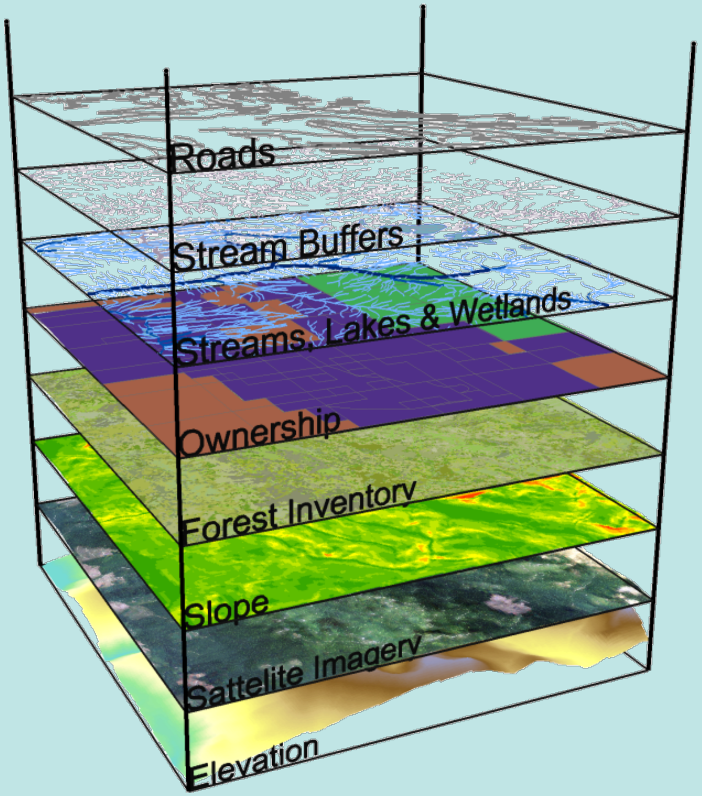
- assess the viability of developing mobile biomass conversion technologies
- optimize biomass operations logistics
- Use field data to conduct techno-economic and life cycle assessment analyses
- Find the ‘sweet spot’ that could lead to improved rural economic opportunities, environmental benefits associated with reduced smoke from wildfires, and produce bio-based products with a lower greenhouse gas footprint than comparable fossil energy products.

Feedstock Supply

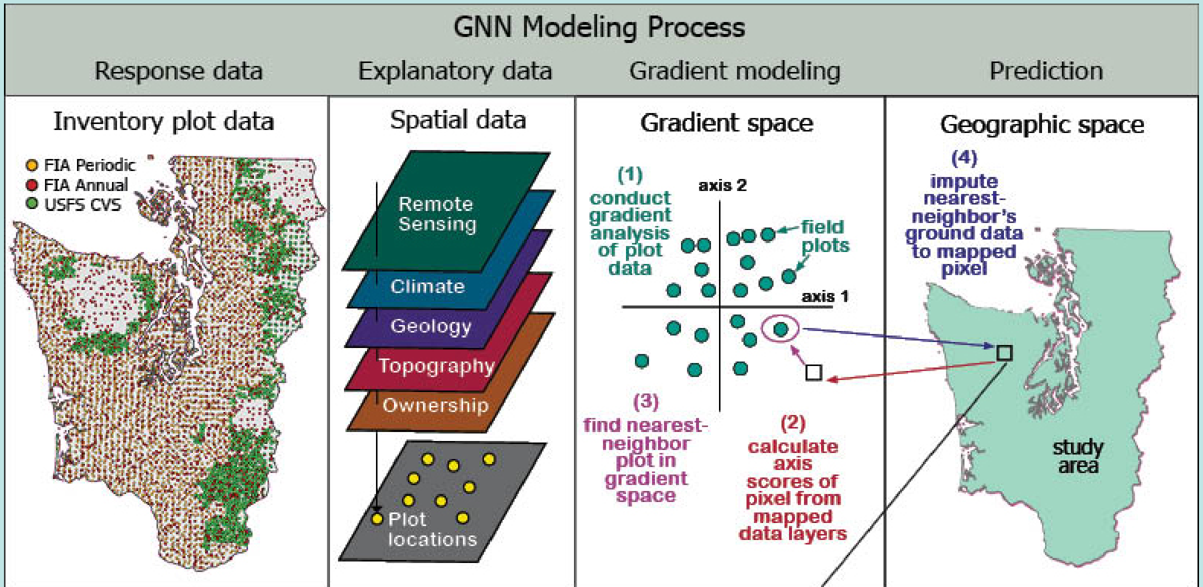
Used Spatial Analytics Model to estimate post-timber harvest biomass availability over the next 30 years

Data analysis by Rogers/Comnick – University of Washington

Input Layers



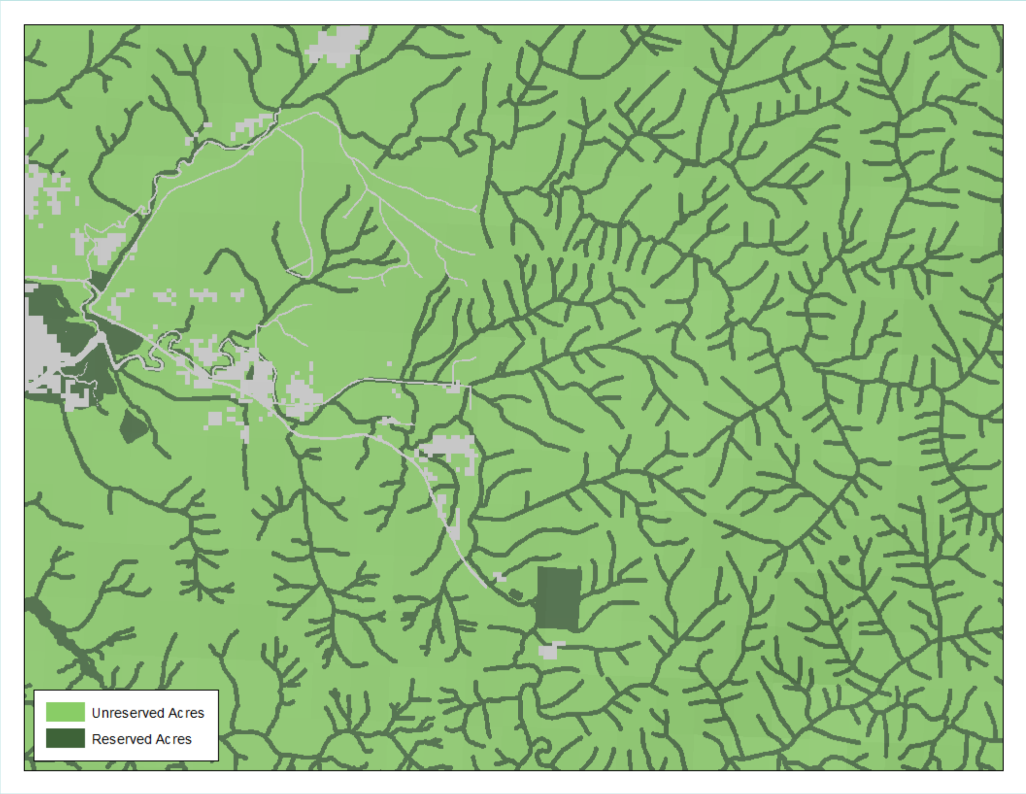
Forest Inventory



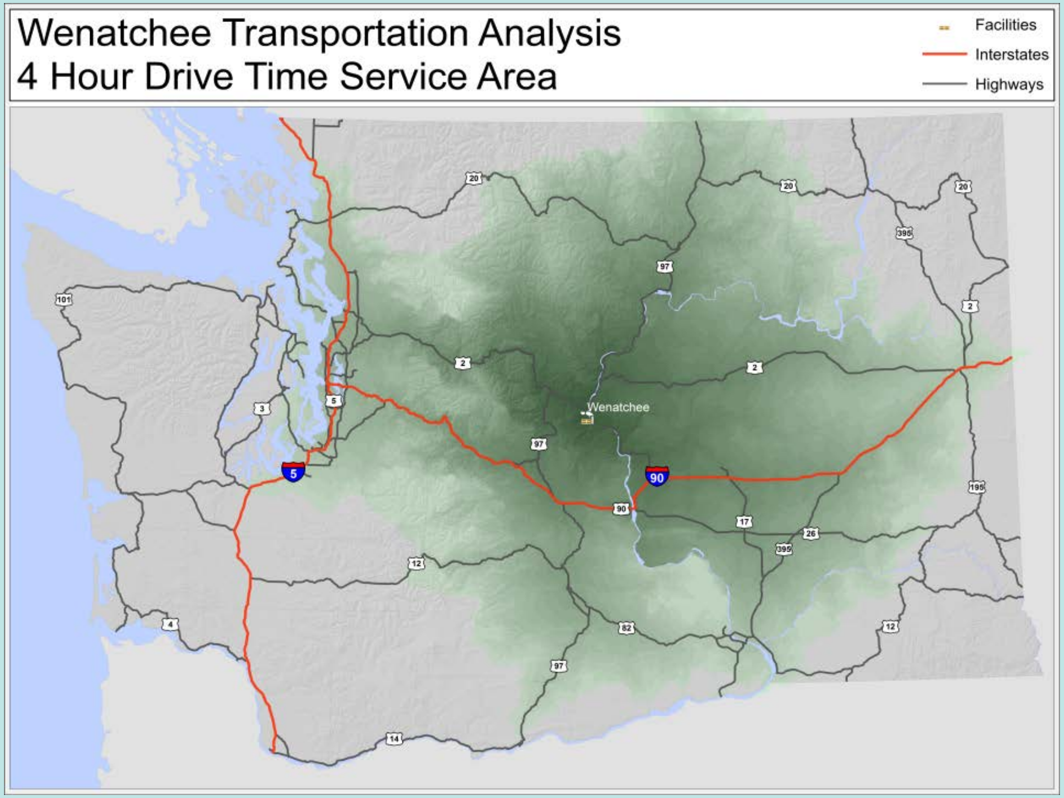
Detailed list of plot attributes

Plot ID	Basal area conifers	Diameter diversity index	Canopy cover %	Old growth structure index	SnagTPH > 50 cm dbh	Vegetation class	LSOG	Etc...
5441	26.1851	3.0	83.3792	7.8123	0.0	8	N	...
...	...	...	...	...	...	...	...	...

Site-Specific Detail…

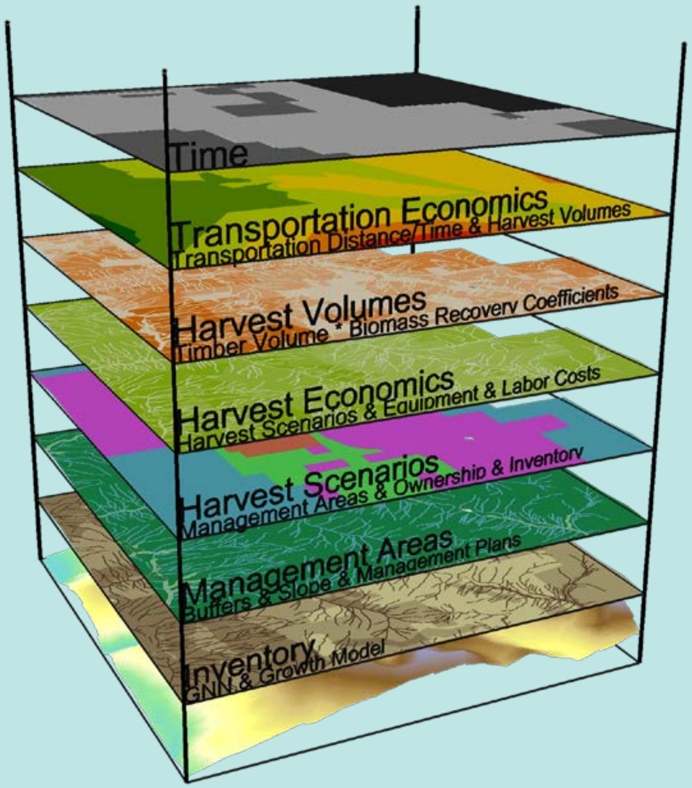


Transportation Modeling



Harvest Model

Outputs

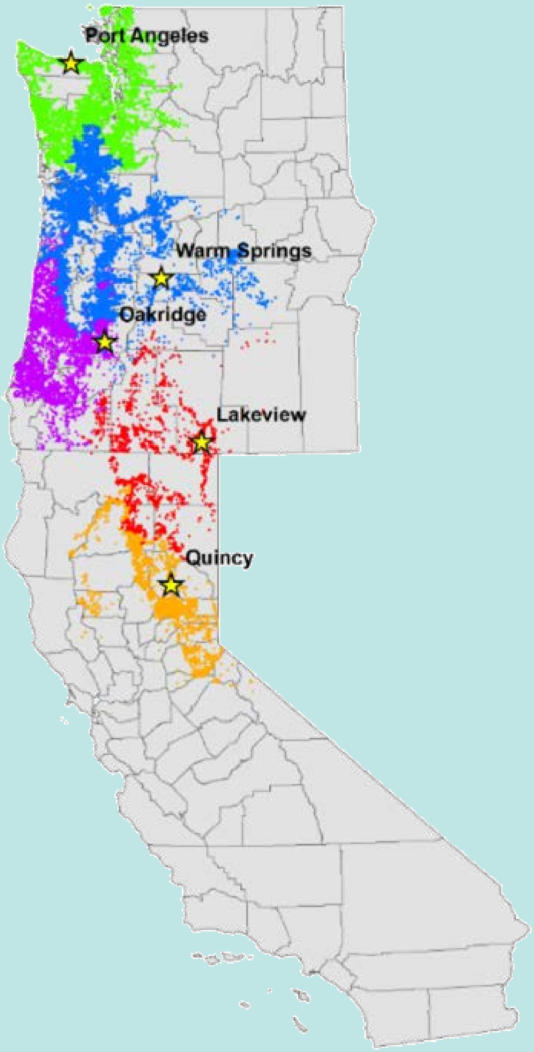

Time
Transportation Economics
Transportation Distance/Time & Harvest Volumes
Harvest Volumes
Timber Volume * Biomass Recovery Coefficients
Harvest Economics
Harvest Scenarios & Equipment & Labor Costs
Harvest Scenarios
Management Areas & Ownership & Inventory
Management Areas
Buffers & Slope & Management Plans
Inventory
GNN & Growth Model

Modeled Average Annual Timber Harvest and Roadside Biomass Supply for WA, OR, CA

Harvested Acres	Saw timber MMBF*	Roadside Tons** Pulp	Roadside Tons** Tops	Roadside Tons ** Branches	Roadside Tons** Total	Tons* * /Acre
301,524	6,445	3,837,415	459,069	5,708,874	10,005,358	33.2

**** Bone Dry Metric tons**

Scenario Locations



Scenario Location	Habitat type	% ground-based acres	Average BDT/ac
Port Angeles	Coastal wet	69%	39.1
Warm Springs	Inland Dry	72%	24.3
Oakridge	Coastal Dry	63%	29.1
Lakeview	Inland Dry	80%	20.9
Quincy	Inland Wet	71%	31.6

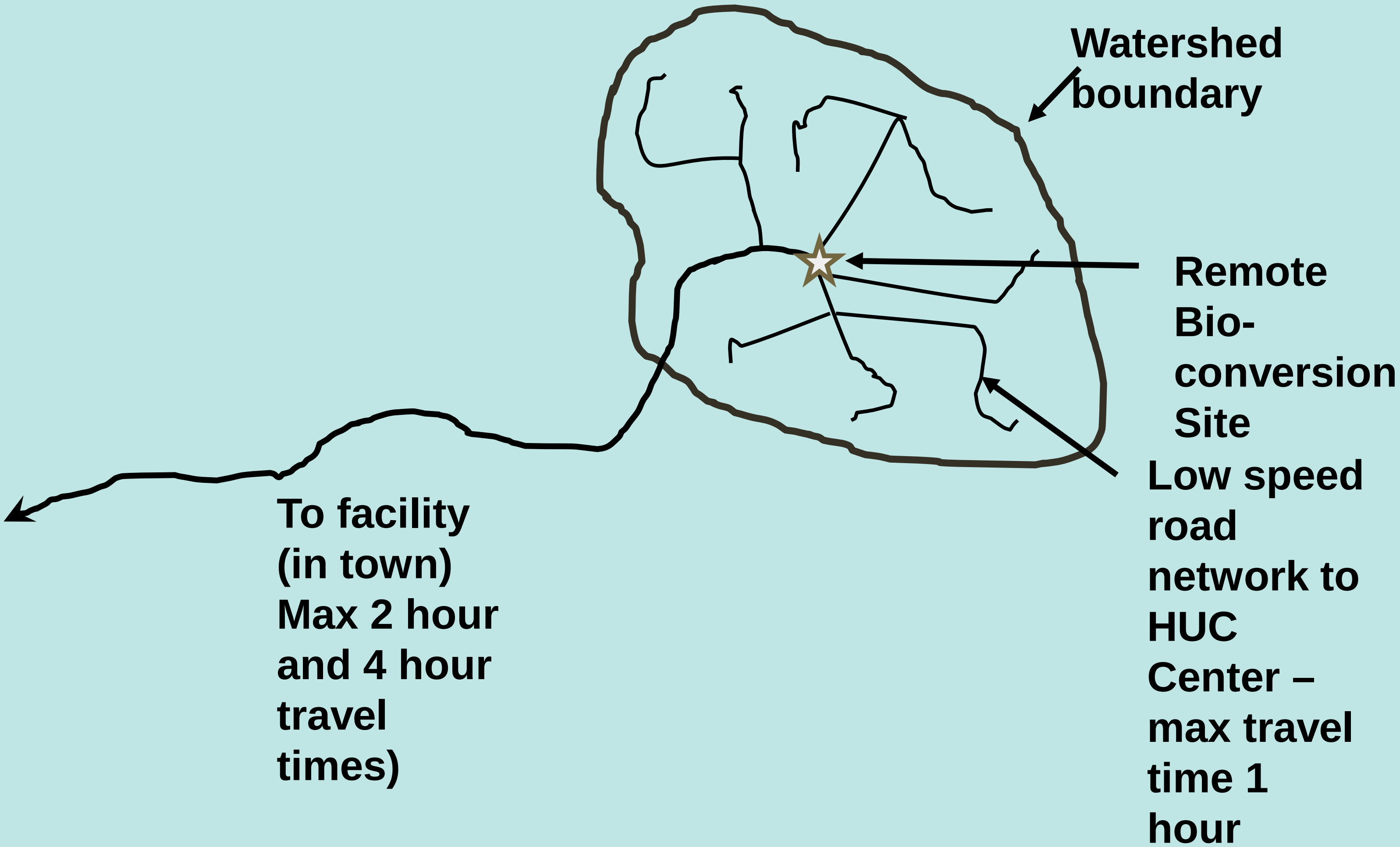
Haul Distance Impacts

Maximum drive time from BCT to point of sale	average distance from BCT to point of sale		volume (BDT at roadside)		distance impact on recoverable volume
	4 hours	2 hours	4 hours	2 hours	
Pt Angeles	118.9	44.9	831,273	150,759	**18%**
Warm Springs	128.9	58.4	1,457,766	91,926	**6%**
Oakridge	121.9	48.7	2,121,756	313,326	**15%**
Lakeview	128.1	44.6	897,293	61,576	**7%**
Quincy	100.6	51.3	972,936	297,890	**31%**
All scenarios	121.4	49.9	6,281,024	915,476	**15%**

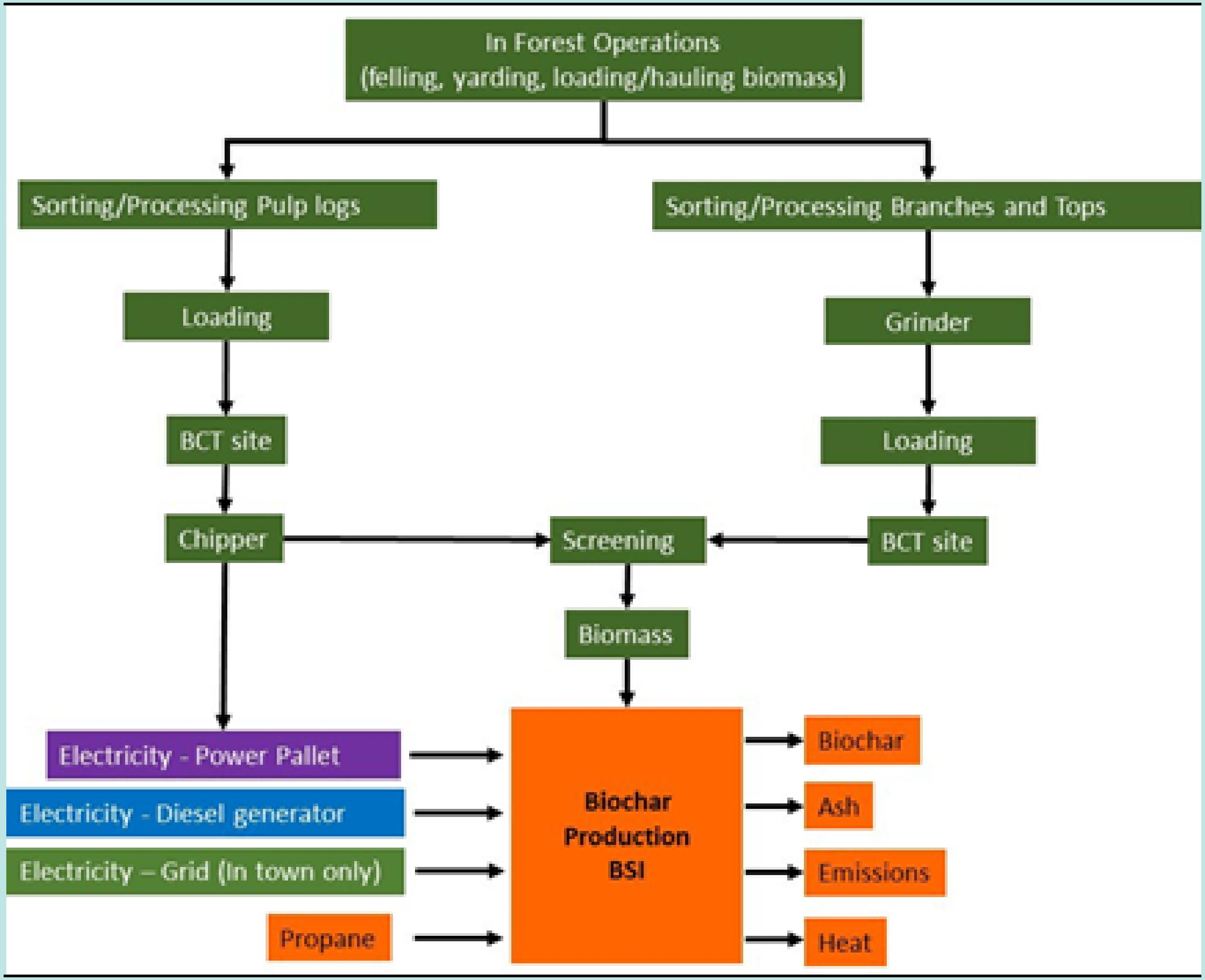
Potential Acres and Yield

Scenario	Drive Time (hrs) - center of watershed to town	Haul Distance (miles)	Percent Recovery	acres/ year	clean chip (pulp) BDT	chip or grind (tops only) BDT	ground material (branches only)	total residues at landing or roadside BDT	BDT/acre
All (5)	4	121.4	100% roadside	211,120	2,346,566	303,130	3,631,329	6,281,024	29.8
All (5)	2	49.9	100% roadside	32,639	362,291	43,332	509,853	915,476	28.0
All (5)	4	131.5	> 10 BDT/ac and 50% roadside	57,487	663,262	81,567	1,012,571	1,757,400	30.6
All (5)	2	57.0	> 10 BDT/ac and 50% roadside	6,084	65,152	9,153	110,743	185,049	30.4

In-woods Scenarios



Life Cycle Assessment
System Boundaries – Biochar Production

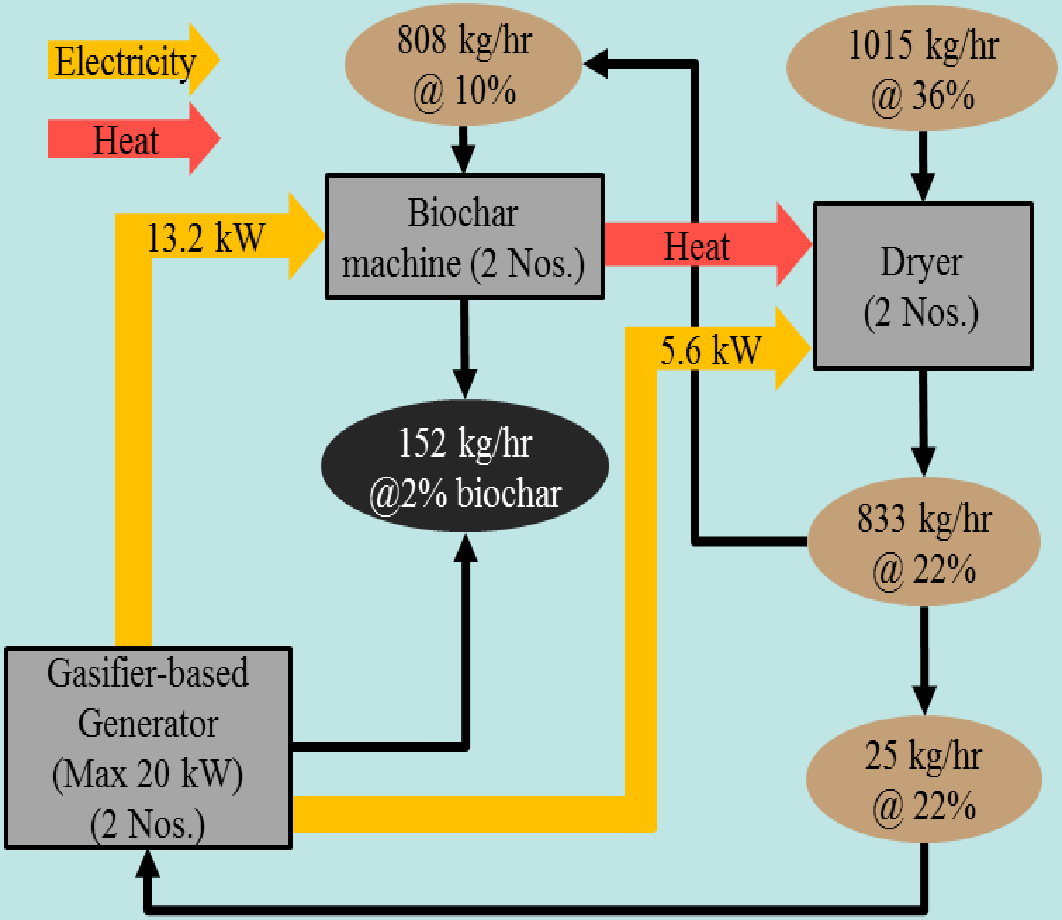


Slash Recovery Operations

Biochar Production System

BSI Biochar Machine

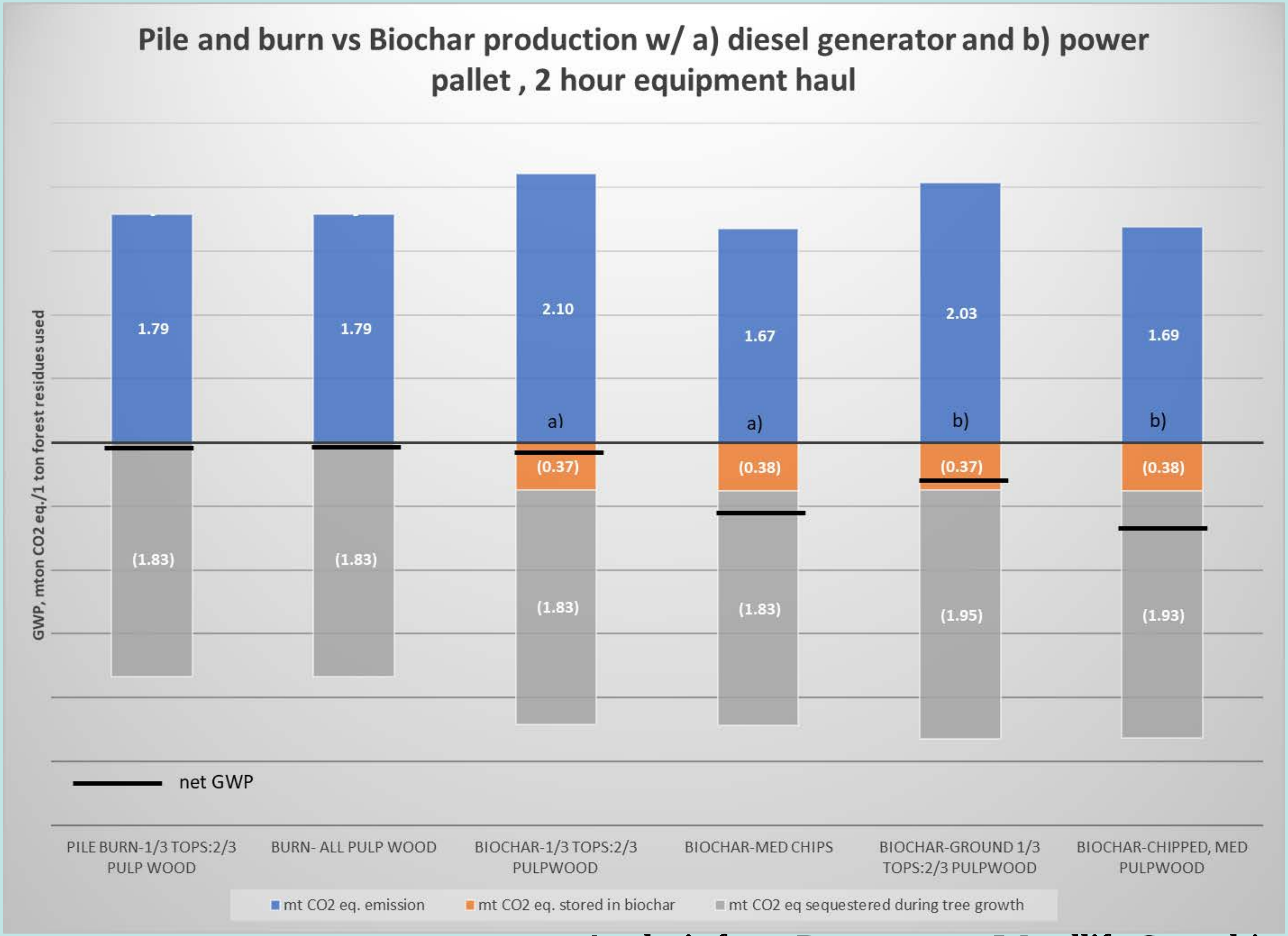
Biochar Solutions, Inc



Mass balance, heat, and electricity requirements of an integrated biochar production system

Analysis Conditions courtesy of Bilek/Sahoo – USFS FPL

Carbon Footprint of Alternatives



Analysis from Puettmann – Woodlife Consulting

Capital costs included in biochar production system

	No of units	Equipment	Description	Purchase price($)	Economic life (year)	Salvage Value (%)	Reference
Biochar	2	Dryer	Beltomatic 123B (3.6 m x 0.69 m)	45,000	25	20	Manufacturer price
	2	Biochar machine	Biochar Solutions, Inc., 0.5 Tonnes/hr	340,000	10	20	Manufacturer price
	2	Genset	20 kW, PP20GT gasifier	35,000	18	10	Manufacturer price
			Biochar production facility	*955,000*			

Data courtesy of Bilek/Sahoo – USFS FPL

Annual operating costs incurred in biochar production systems

Sl no	Descriptions	Units	Biochar	Comments
1	Feedstocks [a]	$/ODMT	14.0	Micro-chipping and transportation
2	Relocations [b]	$/year	34,400	Assuming two relocations in a year
3	Repair and maintenance [c]	$/year	10,750	20% of SLD
4	Consumables [d]	$/year	10,683	Annual usage of diesel and propane
5	Packaging [e]	$/ODMT	124.1	
6	Finished good transportation [f]	$/ODMT	52.0	
7	Labor[g]	$/Year	170,150	
8	Insurance and miscellaneous [h]	$/2000 hrs	11,100	

Data courtesy of Bilek/Sahoo – USFS FPL

Financial performance of portable BCT systems

		Before finance and tax	Before tax	After tax
Biochar	Total cost ($, $\times 10^6$)	**$2.9**		
	MSP ($/ODMT)	1044.2	941.3	962.8
	Nominal IRR	16.5%	19.8%	14.4%
	Break-even delivered feedstock cost ($/green tonne)	10.3	23.4	20.1
	Break-even product value [short-term operating]($/ODMT)	710.1		
	Break-even product value [medium-term operating]($/ODMT)	588.7		

Data courtesy of Bilek/Sahoo – USFS FPL

There is a Reason Why...

Biochar Production System

Oregon Kiln

Biochar Production System

Air Burner

Carbon Footprint per metric ton of feedstock

equipment type			using diesel generator		using a power pallet			
Feedstock type	Pile burn-1/3 tops:2/3 Pulp wood	Burn- All pulp wood	Biochar-1/3 tops:2/3 pulpwoo d	Biochar-med chips	Biochar-ground 1/3 tops:2/3 pulpwoo d	Biochar-Chipped, med pulpwoo d	Biochar Oregon Kiln	Biochar Air Burner
mt CO_2 eq. emission	1.79	1.79	2.10	1.67	2.03	1.69	0.84	0.86
mt CO_2 eq. stored in biochar	-	-	(0.37)	(0.38)	(0.37)	0.38)	(0.56)	(0.65)
mt CO_2 eq sequestered during tree growth	(1.83)	(1.83)	(1.83)	(1.83)	(1.95)	(1.93)	(1.83)	(1.83)
Net mt CO_2 eq	(0.04)	(0.04)	(0.10)	(0.54)	(0.29)	(0.63)	(1.55)	(1.63)

Conclusions - LCA of Biochar

- Large data uncertainty in the biochar systems (F(feedstock quality, MC, distance, and system used))
- Biochar quality parameter will affect LCA results
- Boutique markets are needed for financial viability
- Small scale systems could fit in certain situations
- Wider systems perspective needs to be integrated for the full picture

Thank You!

For further Information:

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