Western Forest Economists Meeting
Olympia, WA
6/4/2018

The effect of price on the financial performance of biofuel and biochar production using forest biomass feedstock

Robert Campbell[1,2], Nate Anderson[2], Helen Naughton[1], Daren Daugaard

[1]University of Montana

[2]USFS Rocky Mountain Research Station

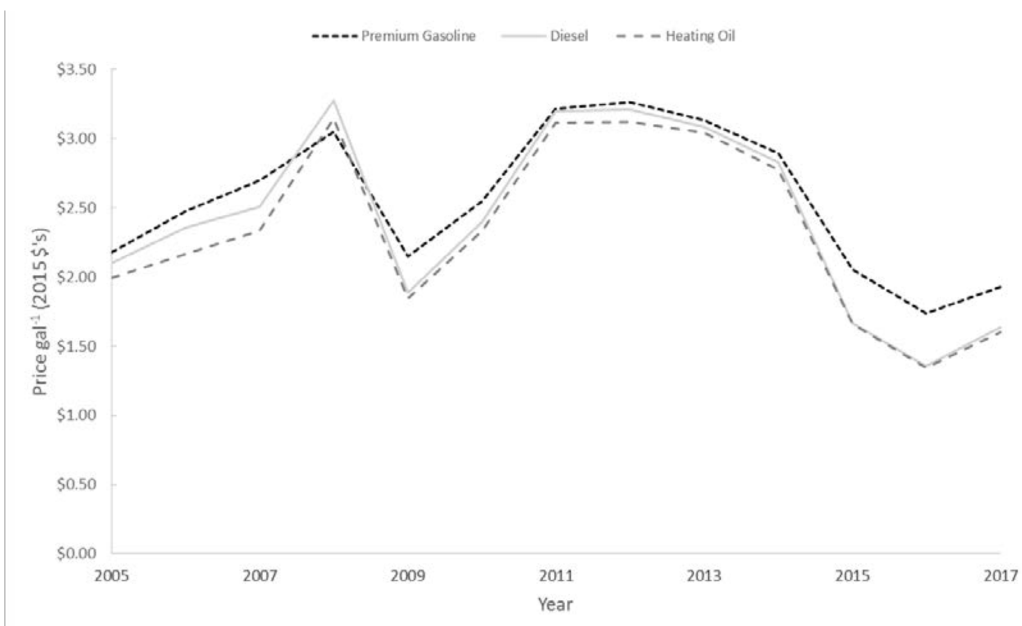
This research was supported by AFRI Grant 2013-68005-21298
from the USDA National Institute of Food and Agriculture

Forest Biomass in the Rockies

- Large areas of beetle-effected or unhealthy forests in need of management
- Substantial stocks of woody biomass associated with forest management not suitable for conventional wood products
- Potential supply of feedstock for cellulosic biofuel production

Inability to Meet U.S. Biofuel Targets

- Energy Independence and Security Act of 2007 set biofuel blending targets (36 billion gal annually by 2022)
- Targets for cellulosic biofuel have never been met
- Despite financial incentives from RINs ($2.50 gal^{-1})
- Low fuel prices are commonly cited as a contributing factor



Biochar Production to Improve Financial Outcomes

- Byproduct of thermochemical conversion
- Agricultural soil amendment
- Revenue generating coproduct
- Substantial uncertainty in market demand and prices exists
- Reported prices range from <\$100 t^{-1} to >\$2,500 t^{-1}

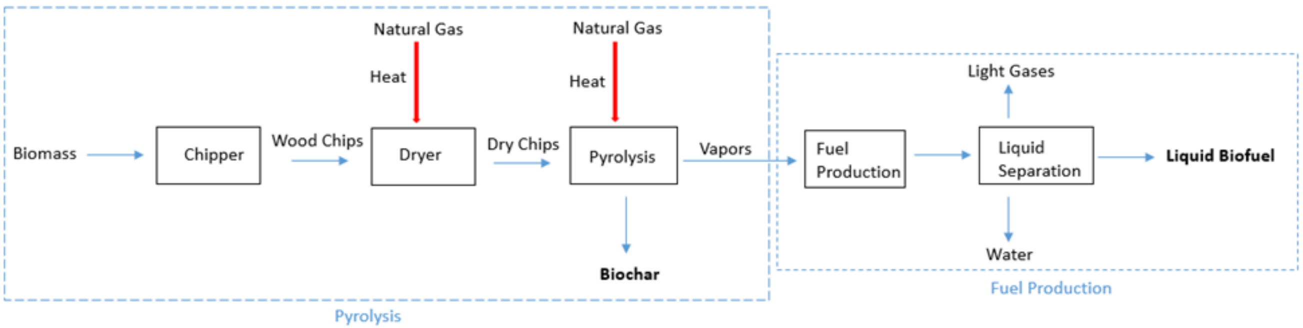
Objectives

- Conduct comparative technoeconomic analysis of two different pyrolysis production technologies
  1. Coproduction <u>or</u> biochar-only
  2. <u>Only</u> biochar (less capital intensive)
- Identify combination of market conditions and policy environment necessary for biofuel production to be financially viable
- Inform efficient investment and effective operating decisions to increase biofuel production

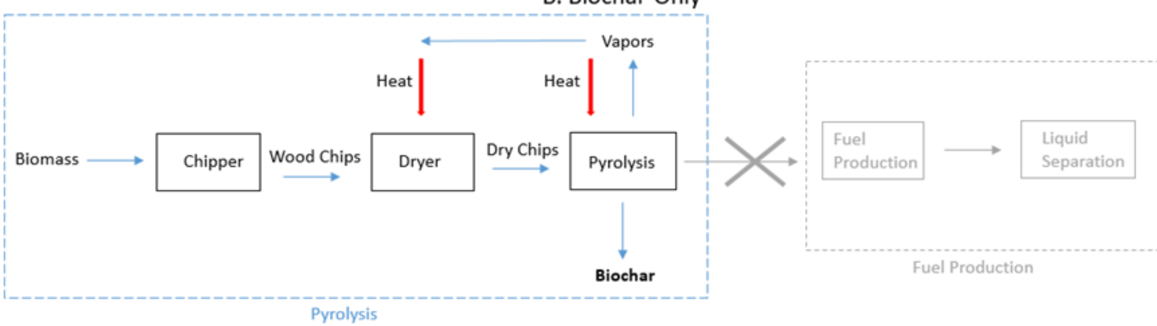
Thermochemical Conversion Pathway 1

- Auger-Based Pyrolysis

A. Biofuel and Biochar Coproduction

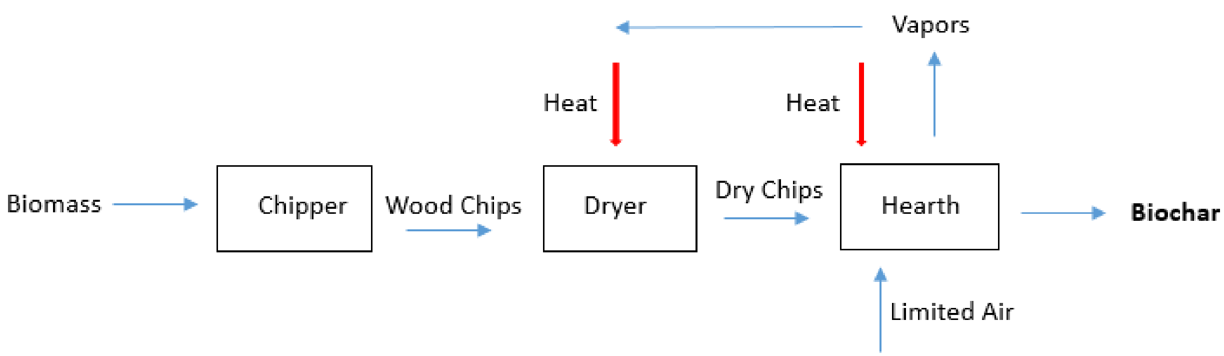


B. Biochar-Only

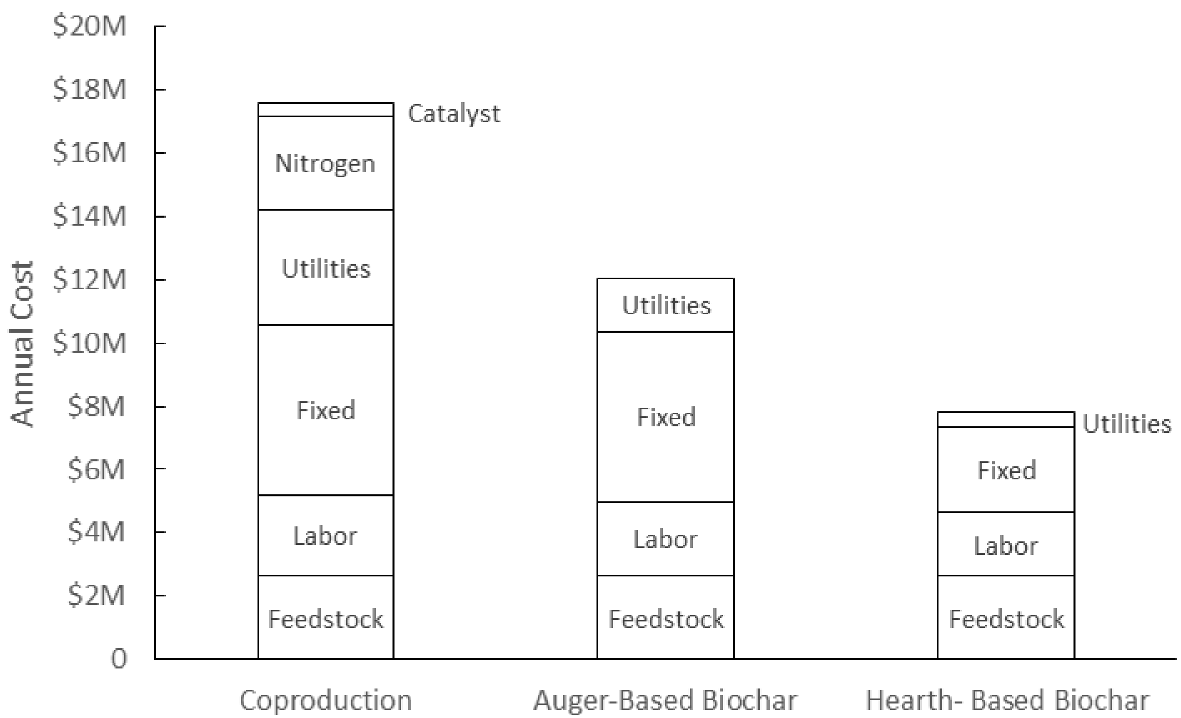


Thermochemical Conversion Pathway 2

- Hearth-Based Biochar



Operating Costs



Four Scenarios

1. Coproduction of Biofuel and Biochar
2. Coproduction with $2.50 RINs
3. Auger Biochar-Only
4. Hearth Biochar-Only

Technoeconomic Analysis with Monte Carlo Simulation

Inputs

Production data

- Feedstock processing capacity
- Product conversion rate

Capital costs

- Equipment
- Buildings
- Construction & Engineering
- Land
- Working capital

Operating costs

- Feedstock
- Labor
- Maintenance
- Utilities
- Consumables

Economic variables

- Product selling prices
- RINs
- Discount rate
- Financing
- Depreciation
- Taxes

Outputs

Discounted cash flows → **Net Present Value (NPV)**

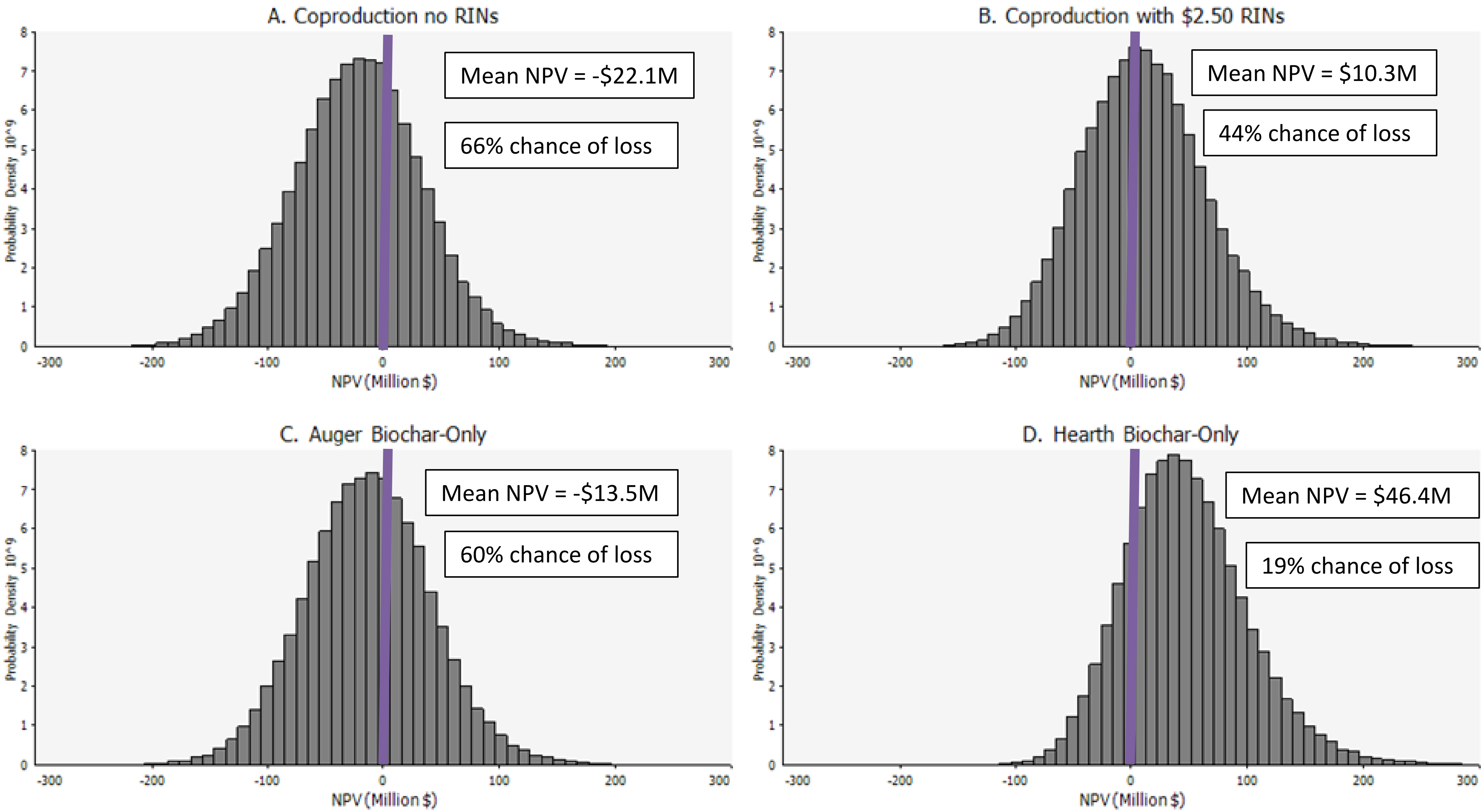
Discounted cash flows with target NPV=0 → **Minimum Selling Price**

Monte Carlo Simulation → **Distribution of NPV outcomes**

Monte Carlo Simulation: Random Inputs

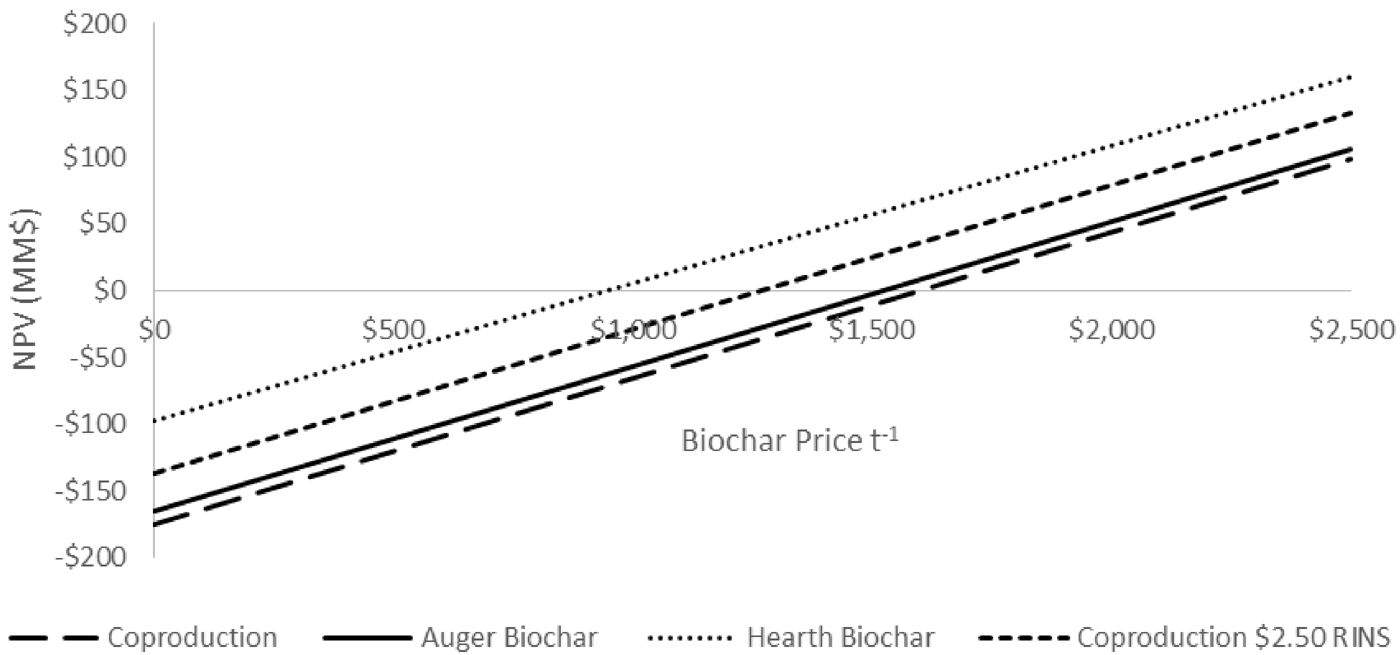
Variable	Minimum	Base-Case	Maximum
Biochar price	$ 71 t^{-1}	$1292 t^{-1}	$2,512 t^{-1}
Biofuel price	$1.54 gal^{-1}	$2.48 gal^{-1}	$3.22 gal^{-1}
Biochar conversion rate	22%	27%	32%
Biofuel conversion rate	7%	9%	11%
Discount Rate	4%	10%	16%
Feedstock Price	$0 t^{-1}	$40 t^{-1}	$80 t^{-1}
Capital Investment	-30%	$39M - $77M	+30%

Results: NPV Distributions



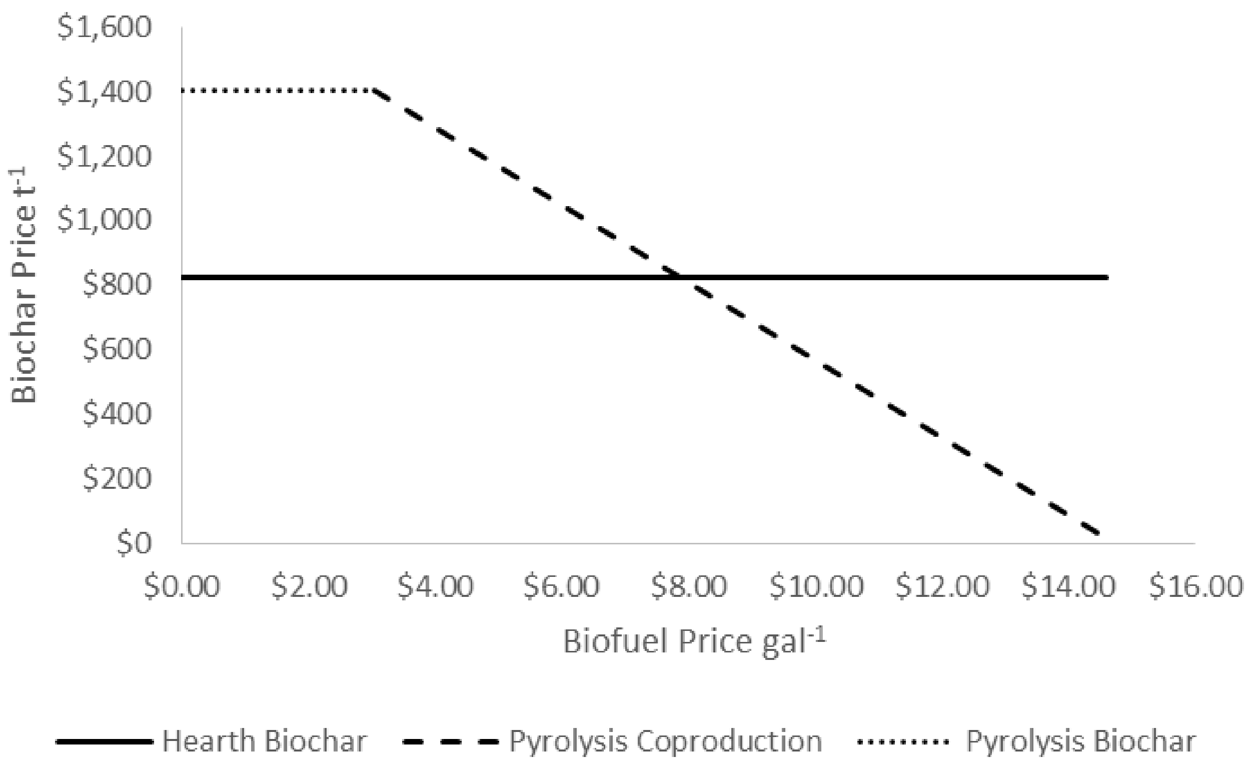
Results: NPV and Biochar Price

	Coproduction (No RINs)	Auger Biochar-Only	Coproduction ($2.5 RINs)	Hearth Biochar
Minimum Biochar Price	$1,483	$1,403	$1,181	$826



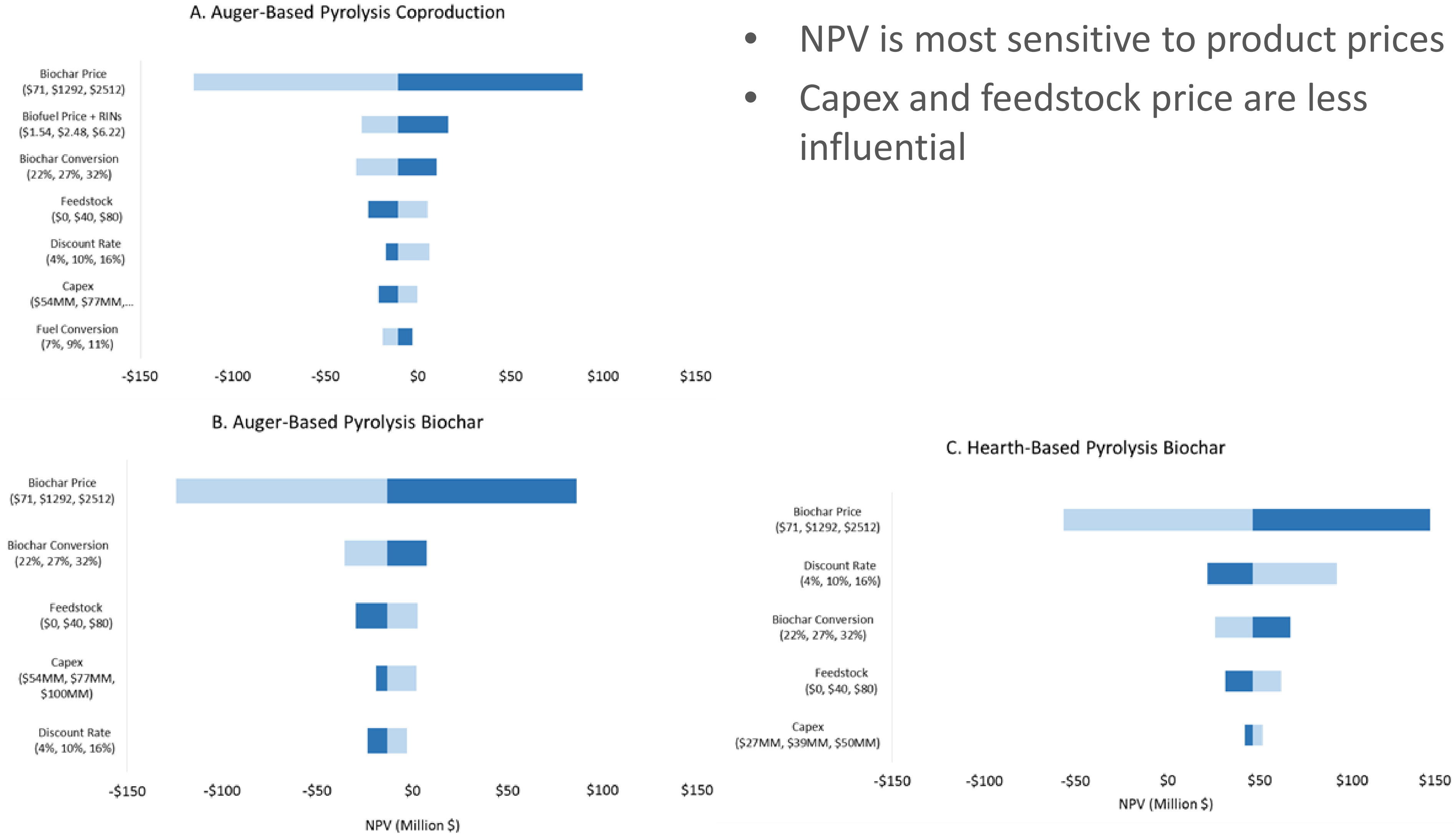
Results: Combinations of Biofuel and Biochar Prices for NPV=0

- Biofuel price >$3.05 gal^{-1} for coproduction > biochar-only
- Minimum biofuel price = $4.12 gal^{-1} (RINs of $1.64)
- Biofuel price >$7.82 for coproduction > hearth biochar



Results: Sensitivity to Key Inputs

- NPV is most sensitive to product prices
- Capex and feedstock price are less influential



Key Findings

- Profitability is most sensitive to product market conditions
- Biofuel production has lagged behind targets largely due to market prices that are too low to support growth in the cellulosic biofuel industry
- Biochar coproduction has the potential to support biofuel production under certain market conditions
- Biochar offers promise as a stand-alone industry
- However, heavy reliance on biochar is likely to remain risky until more robust markets and more stable prices for the product emerges

Questions?

Mt Townsend, Olympic National Forest, 6/3/18

Appendix: Cost and Production Characteristics

	Auger-Based Coproduction	Auger-Based Biochar-only	Hearth-Based Biochar
Total Capital Investment	$76.7 MM	$76.7 MM	$38.7 MM
Fixed Capital Investment	$69.0 MM	$69.0 MM	$34.7 MM
Working Capital [a]	$6.9 MM	$6.9 MM	$3.5 MM
Land [b]	$836 M	$836 M	$504 M
Annual Fixed Operating Expenses	$5.4 MM	$5.4 MM	$2.8 MM
Maintenance [c]	$3.8 MM	$3.8 MM	$1.8MM
Insurance and Taxes [d]	$1.5 MM	$1.5 MM	$774 M
Annual Labor Expense	$2.6 MM	$2.4 MM	$2.0 MM
Annual Variable Expenses	$6.4 MM	$1.7 MM	$474 M
Natural Gas	$1.98 MM	$0	$356 M
Electricity	$1.63 MM	$1.63 MM	$111 M
Diesel	$39 M	$39 M	$5.9 M
Catalyst	$459 M	$0	$0
Nitrogen	$2.93 MM	$0	$0
Water	$9.7 M	$9.7 M	$9.7 M
Production Characteristics			
Annual Feedstock Consumption	65.7 M t	65.7 M t	65.7 M t
Annual Biofuel Production	1.8 MM gal	0 gal	0 gal
Annual Biochar Production	17.7 M t	17.7 M t	17.7 M t
Biofuel Conversion Rate	9%	0%	0%
Biochar Conversion Rate	27%	27%	27%
Annual Operating Time	6,570 h	6,570 h	6,570 h

Appendix: Financial Accounting Assumptions

Parameter	Input Value	Source
Nominal discount rate	7.5%	Petter and Tyner (2014)
Inflation rate	2.5%	Petter and Tyner (2014)
Real discount rate	10%	Petter and Tyner (2014)
Loan financing	80% loan	De Jong et al. (2015)
Loan interest rate	8% APR	Zhao et al. (2016)
Loan term	10 years	Zhao et al. (2016)
Federal income tax rate	21%	United States Congress (2018)
Plant life	20 years	Wright et al. (2010)
Depreciation	Variable declining balance (MACRS)	Peters et al. (2003)
	7 year period	
Construction spending		Zhao et al. (2016)
Year 1	8% of FCI and land	
Year 2	60% of FCI	
Year 3	32% of FCI and working capital	