Adding Biofuel and Bioenergy Feedstock Options to Regional Forest Products Models

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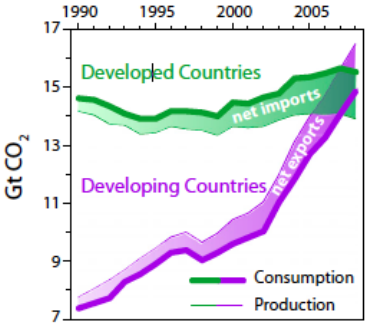
Woody biomass as biofuel and bioenergy feedstocks

- Woody biomass have different end uses
- Forests have many other socially beneficial values
- Economic, social, and ecological end uses will compete and complement each other at global scales
- Cost advantage of woody biomass over C4 grasses



Project Focus

- How much / How to allocate
- Competition for:
  - wood between biomass energy and other forest products industries
  - biomass between alternative biomass energy sectors
- Impact of international trade and U.S. biomass energy markets on the U.S. forest product sectors

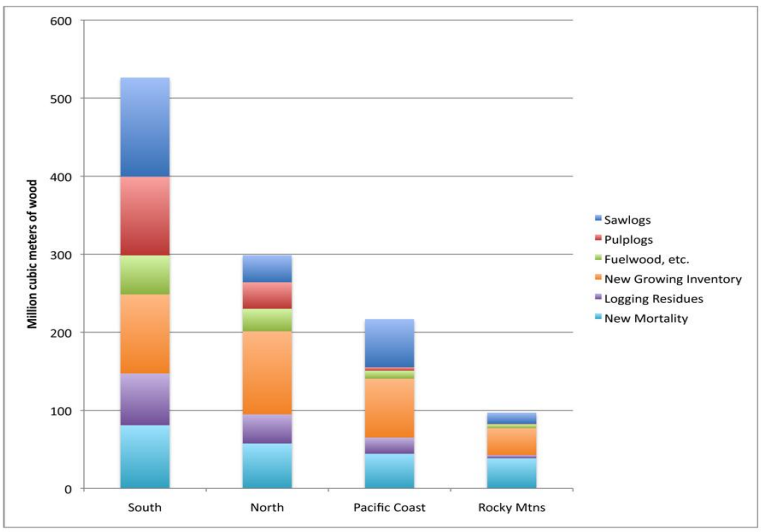
Key Background Studies

- The Billion-Ton-Update (2011)
  - Estimated biomass 83-102 million dry tons at year 2030, with price range $40-60/dry ton.
- The Southern Forest Futures Project
  - 170-336 million green tons by 2050
- Ince, *et. al.* (2011)*(*U.S. Forest Products Module for RPA Forest Assessment *)* 167-308 million cubic meters, pricing at $24-28/$m^3$

Limitations

- The Billion-Ton-Update and the Southern Forest Futures Project
  - Engineering approach
  - Arbitrary assumption for future biomass prices
  - The BTU 2011 has quasi-engineering competition between pulp and fuel in the US
- Ince, *et. al.* (2011)
  - Economic analysis
  - Did not differentiate bioenergy demand between electricity generation and liquid biofuel production
  - Conservative estimates of international competition for biofuels (most of competition is with wood heating)

The annual flux of wood for US regions – top 3 harvested, bottom 3 left in forest



International competition for wood chips

- Wood pellets
  - EU2020: increasing European bioenergy demand drives U.S. and Canadian wood pellet exports
  - Increasing demand from Asia and North America, could be a competitor for biofuel feedstocks
- Paper and pulp
  - Will growing paper demand from Asia met with waste paper and/or new chips

Example of Rapid Change in Low Value Feedstock Trade

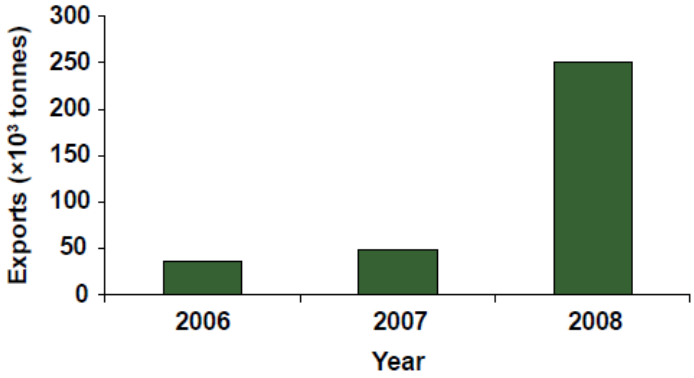


Figure 4—United States pellet and waste wood exports (U.S. International Trade Commission 2009).

Source: Spelter and Toth (2009)

84% of pellet biomass comes from un-modeled inventories

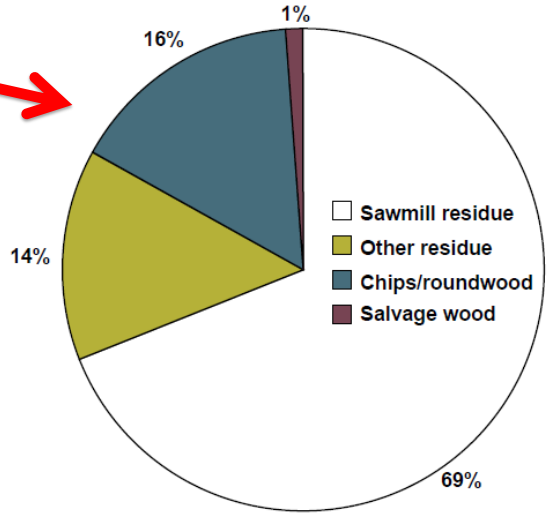
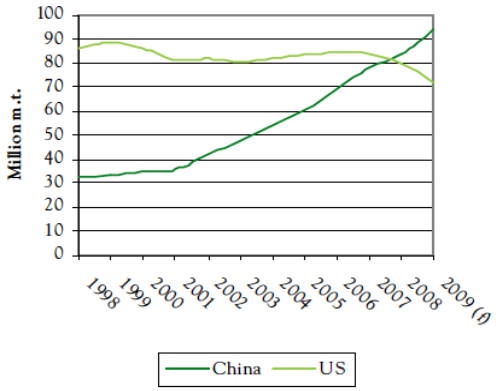


Figure 5—Fiber types used in the production of wood pellets in 2008.

Source: Spelter and Toth (2009)

GRAPH 8.1.1

Paper and paperboard production in China and United States, 1998-2009

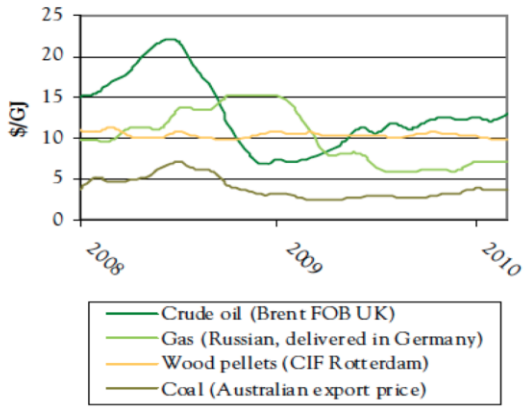


Note: f = forecast for 2009 for China.

Sources: FAOSTAT data, American Forest & Paper Association, China Paper Online, 2010.

GRAPH 9.1.1

Fuel price development, 2008-2010



Sources: IMF for coal, crude oil & natural gas prices; and Pellets@las for pellets, 2010.

U.S. Forest Products Module-Global Forest Products Model (USFPM/GFPM)

- Unlike national or local policy driven models, it tries to capture all production and trade in wood products
- Dynamic spatial partial equilibrium model
- Maximizes the consumer and producer surplus, subject to:
  - Material balance constraints
  - Trade inertia constraints
  - With possible market shifts, capacity and technology changes
- Three U.S. subregions: South, West, and North
- Trade connections between each U.S. region and rest of the world

GFPM structure

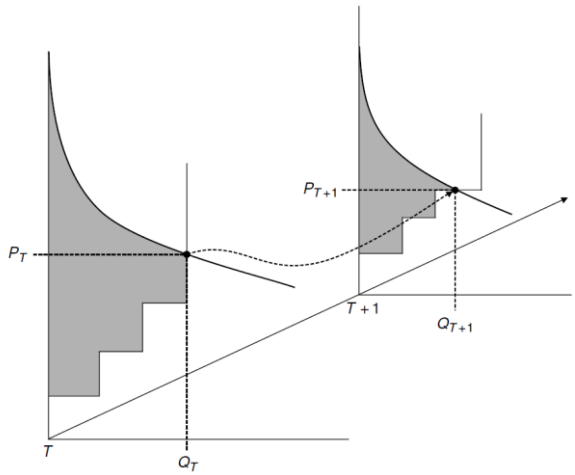
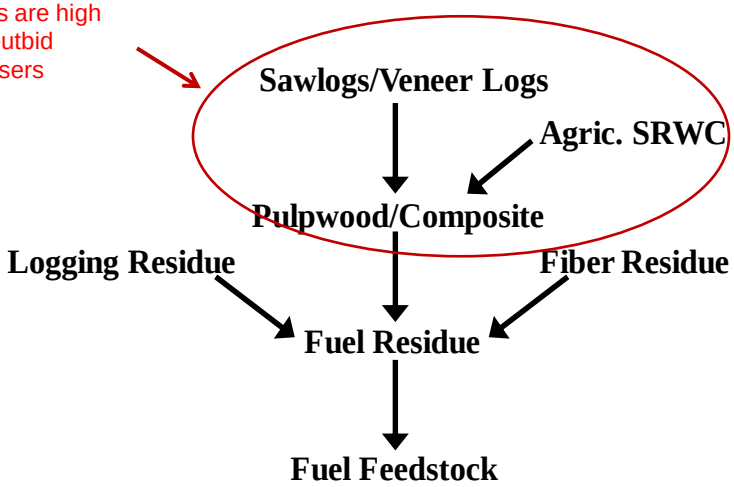


FIGURE 3.1 The GFPM simulates world forest product markets as a sequence of spatial equilibria that maximize consumer and producer surplus (shaded area).

Source: Buongiorno, *et. al.* 2003

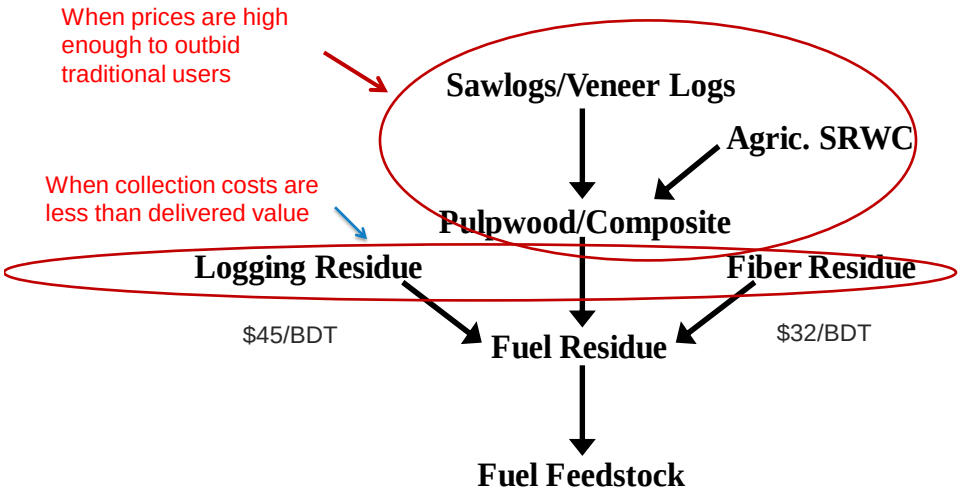
Fuel feedstock material flows in the USFPM/GFPM

When prices are high enough to outbid traditional users



Source: Adapted from USDA Forest Service Research Paper FPL–RP–662

Fuel feedstock material flows in the USFPM/GFPM



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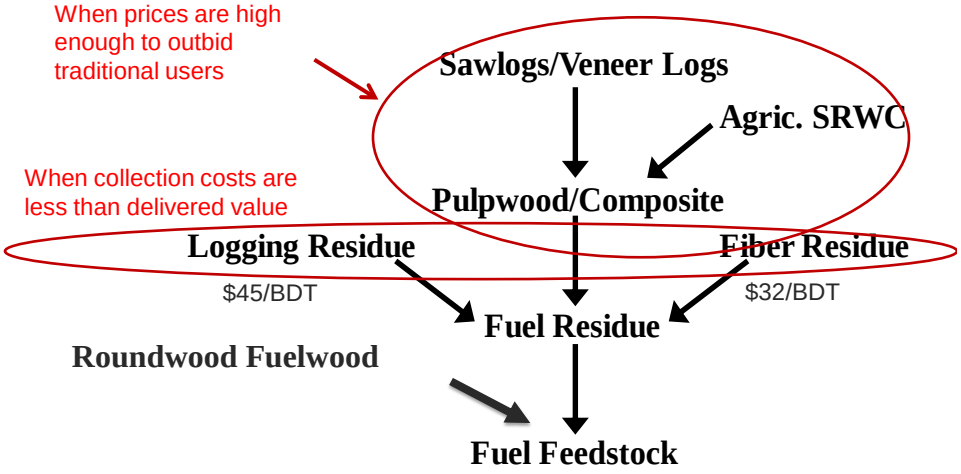
Fuel feedstock material flows in the USFPM/GPFM

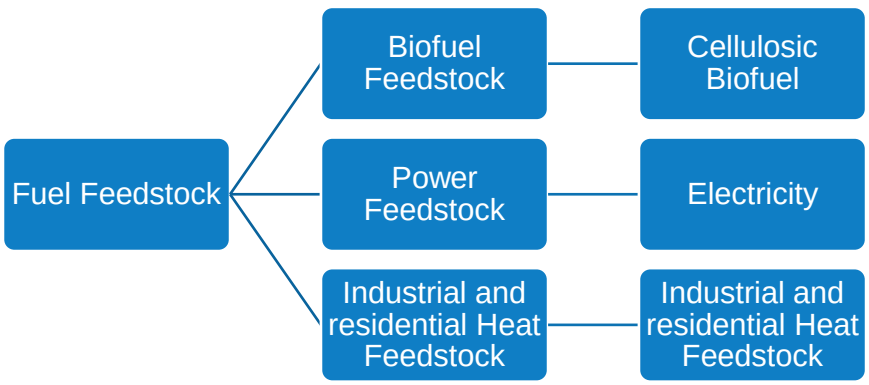


Source: Adapted from USDA Forest Service Research Paper FPL–RP–662

	North	South	West	U.S.
Roundwood Production	3,044,562	8,566,794	3,378,757	14,990,113
Sawlog and veneer logs	38%	43%	70%	48%
Pulpwood	31%	38%	5%	29%
Other	31%	19%	25%	23%
Total	100%	100%	100%	100%
Total Harvests (roundwood + other)	4,762,468	12,153,132	4,275,632	21,191,232
Roundwood/Total	64%	70%	79%	71%

Source: Smith (2009) Table 39 and 40. Unit mmcf – million cubic feet

Expansion in fuel feedstock end uses in USFPM/GFPM



How the market equilibriums were defined

- Demand of cellulosic biofuel, heat feedstock, electricity are defined by price elasticities.
- Exogenous changes shift the demand curves from period to period.
- Market equilibrium are determined by the equilibrium prices
- Economic growth and motor gasoline price are the main demand shifters
- Model were projected for 28 and 44 years

Base year inputs and parameters

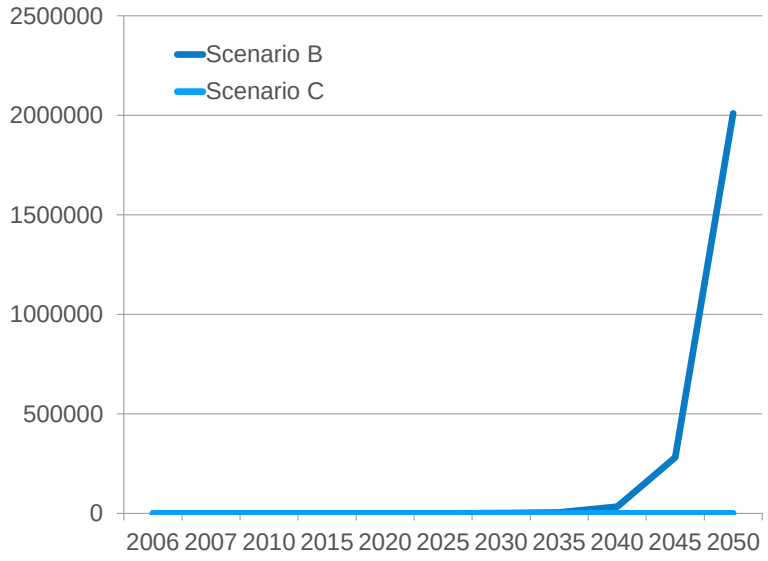
	Base Year Price	Base Year Quantity	Price Elasticity	Income Elasticity	Cross-Price Elasticity
Cellulosic Biofuel	2.03 ($/Gallon)	0 (Thousand Gallon)	-3.3	0.1	4.4
Electricity	89 ($/MWh)	36,600 (Thousand MWh)	-1.1	0.3	0.0
Heat Biomass	25 ($/CM)	25,000 (Thousand CM)	-0.9	0.2	1.5

Scenarios

Scenario	A	B	C	D	E	F
Timeline	2006-2050			2006-2034		
Gasoline price annual growth rate	3%	10%	3%	10%	10%	3%
Cellulosic Biofuel Base year demand	0	10	10	0	10	10
Manufacture cost growth rate	-0.2%					
GDP growth rate	2.10% - 2.8%					

Biofuel and rising gasoline prices

Cellulosic biofuel production (in thousand gallons)											
Scenario	2006	2007	2010	2015	2020	2025	2030	2035	2040	2045	2050
A	0	0	0.1	0.2	0.6	0.9	1.5	2.7	5.6	11	21
B	0.2	0.1	0.3	2.4	13	81	570	4,300	34,000	281,000	2,010,000
C	0.2	0.1	0.3	0.4	0.7	0.9	1.6	2.8	5.8	12	23
	2006	2007	2010	2013	2016	2019	2022	2025	2028	2031	2034
D	0	0	0.1	0.3	0.6	1.7	4.1	11	38	1356	445
E	0.2	0.1	0.3	0.4	1.6	4.5	14	46	166	604	1,996
F	0.2	0.1	0.3	0.4	0.6	0.6	0.2	0.3	0.6	0.3	0.1



Summary of a suite of global fossil fuel/ biofuel scenarios

- An assumption of 3% annual growth rate of motor gasoline price has small effect on biofuel production
- An assumption of 10 % annual growth rate of motor gasoline price is an extreme case, but is often claimed to be possible in the long term
- The base year quantity partially decided the growth of biofuel production
- Manufacture cost has minimal effect

Future Work

•Allow U.S. domestic and international trade of woody energy

•Run scenarios with unique regional supply sub-components (BioSum, SRTS, etc)

•Develop transparent supply side shifters, forest inventory changes

•Model the competition for wood energy from other energy price changes, e.g. natural gas/coal