

Economic, Environmental and Social Analysis of a Pulp Mill

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ECONOMIC

Road Network: ESRI networked road shapefile was used to route the residual volumes to a facility. Unit variable cost for a 45-ft drop center tractor trailer that hauls **15.6 BDT** residuals assuming 35% moisture content, loaded and unloaded, was calculated based on assumed road speeds and operational and maintenance costs for the truck.¹ Fixed costs were determined through personal communication with Dr. John Sessions, OSU Forestry Dept. Travel time over each road segment in the network was calculated based on assigned road speed and the length of the segment. Travel time was then multiplied by the unit variable cost for the given road segment type to give the \$/BDT for the road segment.

Unit Fixed Cost			
Load/Grind	Bring Residue to Landing	Wait Time of Truck	
\$21/BDT	+ \$15/BDT	+ \$3.5/BDT	= \$39.50/BDT

Unit Variable Cost						
	Paved (\$/hr)	Gravel (\$/hr)	Dirt (\$/hr)	Paved (\$/BDT-min)	Gravel (\$/BDT-min)	Dirt (\$/BDT-min)
Empty	\$ 99.96	\$ 77.62	\$ 73.71	0.107	0.083	0.079
Loaded	\$ 118.37	\$ 86.29	\$ 82.07	0.126	0.092	0.088

Max Variable Cost = \$68/BDT - \$39.50/BDT = **\$28.5/BDT**

Travel time (min) = (road_segment_i (mi) * (60 min/hr)) / speed_i (mph)
Cost to Traverse a Road Segment = Travel_time (min) * (road_type_{j,empty} + road_type_{j,loaded})

Feedstock Data Source: FIA points represent forest landings where slash piles are stored and chipped into waiting chip vans. A 30-year average residual volume is associated with each FIA point. The volumes are determined through the **NARA OSU Forest Economics team** dynamic spatial-equilibrium forest products market model².

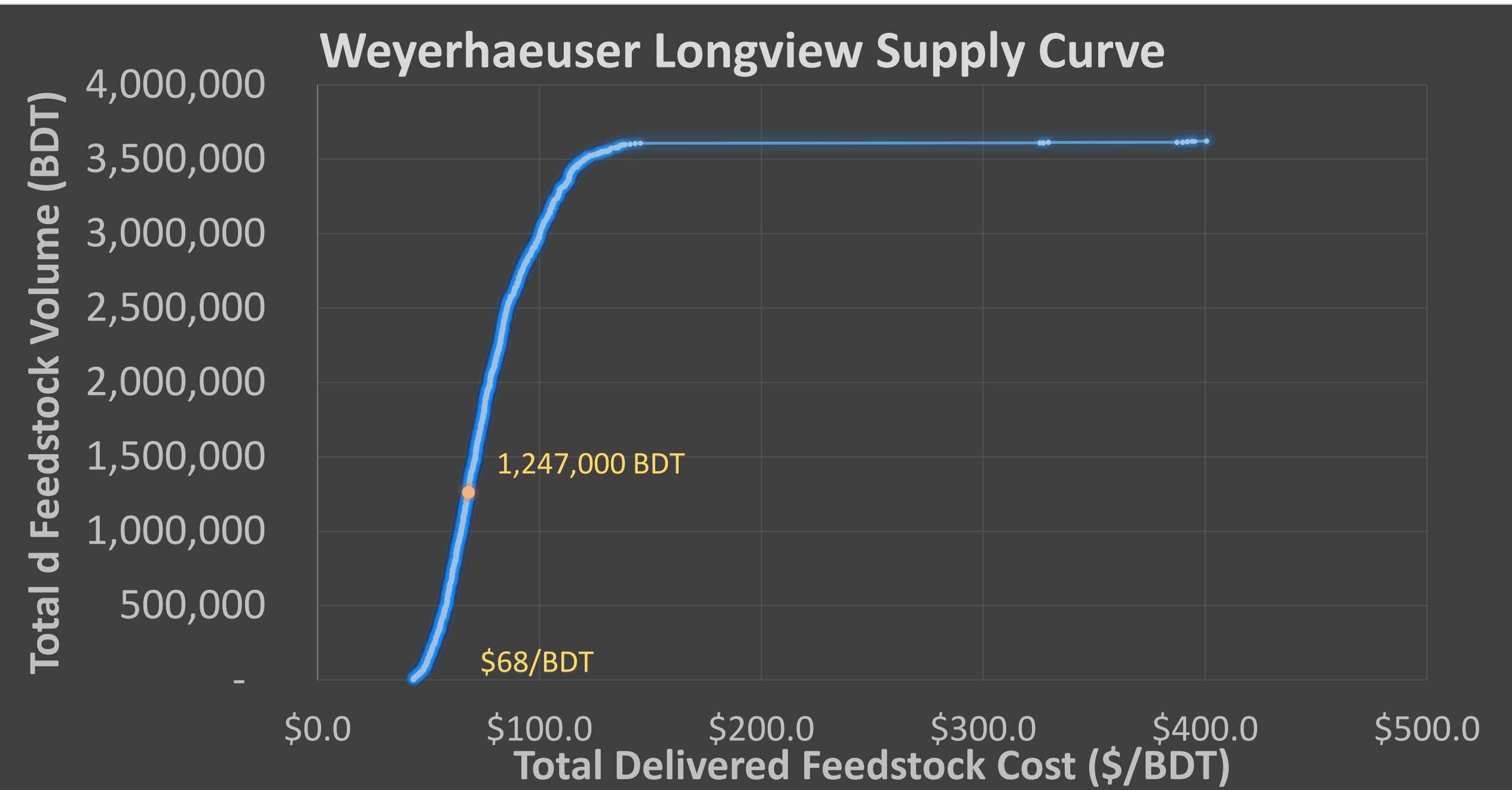


Table 1. PNW_ESRI_roads table is the attribute table for the networked road shapefile seen in the figure. Each road segment is listed in the table and has a defined speed limit and road length. From that, time (min), unloaded cost, loaded cost, total cost, and total GWP are calculated.

PNW_roads_ESRI											
	FULLNAME	Length mi	NARA Speed	Time_min	unl unit cost	load unit cost	loaded cost	unloaded cost	Total Cost	Unit GWP Cost	GWP Total
	Slaughterhouse Creek Rd	0.678797	30	1.357593	0.107	0.126	0.171057	0.145262	0.316319	0.1272	0.172686
▶	Slaughterhouse Creek Rd	2.578026	30	5.156052	0.107	0.126	0.649663	0.551698	1.20136	0.1272	0.65585
	Slaughterhouse Creek Rd	0.329112	30	0.658225	0.107	0.126	0.082936	0.07043	0.153366	0.1272	0.083726
	Nfd 115 Rd	0.752583	30	1.505166	0.107	0.126	0.189651	0.161053	0.350704	0.1272	0.191457
	Nfd 115 Rd	0.960881	30	1.921762	0.107	0.126	0.242142	0.205629	0.447771	0.1272	0.244448
	Nfd 115 Rd	0.69398	30	1.387961	0.107	0.126	0.174883	0.148512	0.323395	0.1272	0.176549
	Nfd 115 Rd	0.253274	30	0.506549	0.107	0.126	0.063825	0.054201	0.118026	0.1272	0.064433

References
1. Zamora-Cristales R, Sessions J, Murphy G, Boston K. Economic Impact of Truck- Machine Interference in Forest Biomass Recovery Operations on Steep Terrain. For Prod J. 2013;63(5-6):162-73.
2. Adams DM, Latta GS. Costs and regional impacts of restoration thinning programs on the national forests in eastern Oregon. CANADIAN JOURNAL OF FOREST RESEARCH. 2005;35(6):1319-30.

ENVIRONMENTAL

Unit Fixed Cost

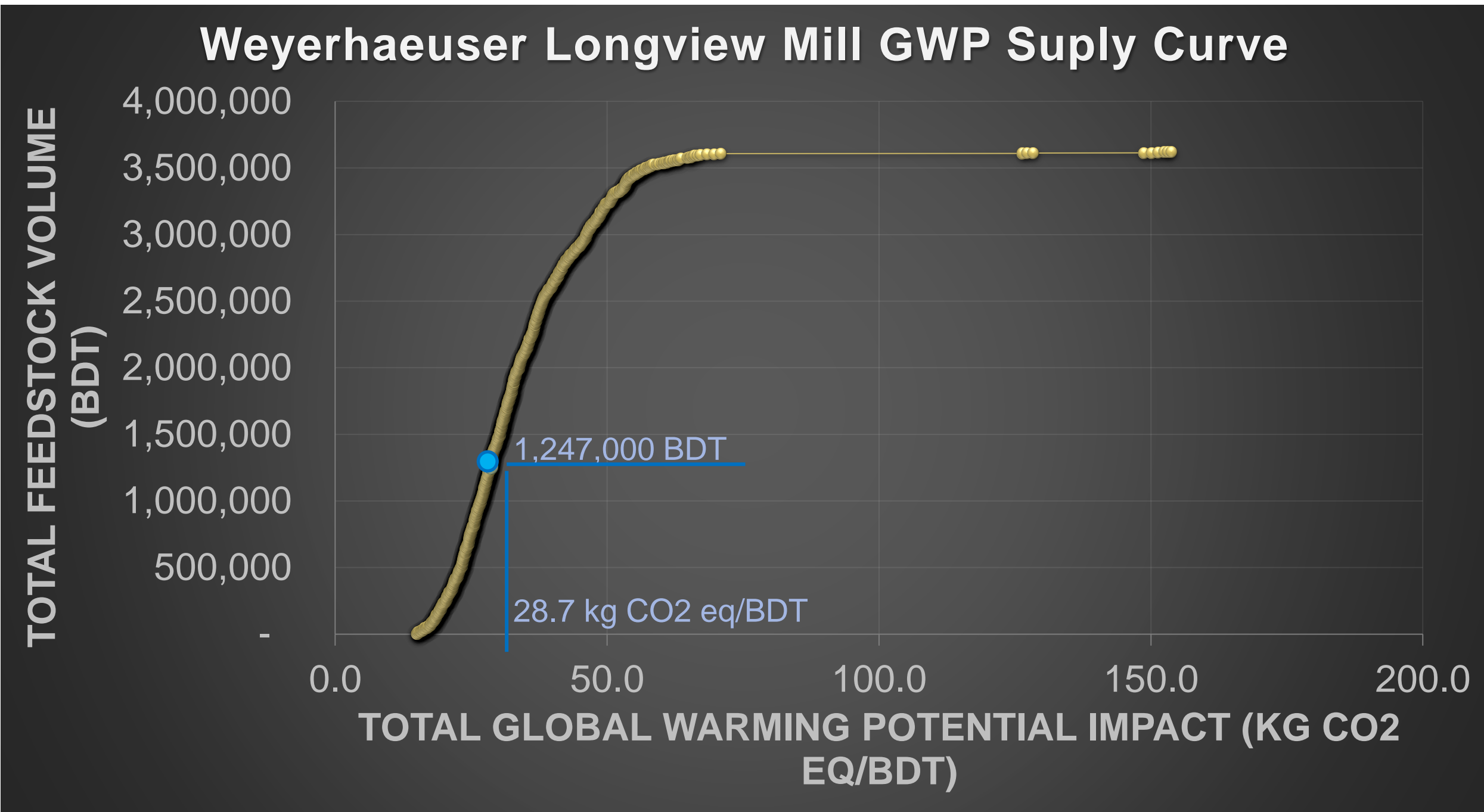
	Global warming (kg CO2 eq/hr)	Production Rate (BDT/hr)	Wait Time (hr)	Fixed Cost (kg CO2 eq/BDT)
Horizontal Grinder	3.05E+02	3.00E+01		1.02E+01
Front Loader	6.08E+01	3.00E+01		2.03E+00
130 CY Chip Van Idle	1.19E+01		1.23	0.94

Total Fixed Cost
13.12 kg CO2 eq / BDT

Unit Variable Cost

	Global warming (kg CO2 eq/hr)	Payload (BDT)	Variable Cost (kg CO2 eq / BDT-min)
130 cy Chip Van Gravel	5.65E+01	15.6	0.0604
130 CY Chip Van Highway	1.19E+02	15.6	0.1272

GWP = Global Warming Potential



Global warming data for each equipment was determined by the **NARA LCA team at UW**.

Community Impact Analysis (CIA) spreadsheet provided by **NARA CIA Team at UW** and used to calculate regional economic impacts and jobs added.

SOCIAL

County	State	Sum of Total Variable Cost (\$)	Sum of Total Fixed Cost (\$)
CLACKAMAS	Oregon	790,250	1,362,152
CLARK	Washington	430,126	1,084,041
CLATSOP	Oregon	3,846,621	7,818,801
COLUMBIA	Oregon	920,377	3,228,865
COWLITZ	Washington	1,654,418	5,585,094
GRAYS HARBOR	Washington	1,916,608	3,104,110
KING	Washington	19,511	27,466
LEWIS	Washington	3,549,273	7,812,478
MARION	Oregon	172,335	261,571
MASON	Washington	1,129,479	1,732,757
MULTNOMAH	Oregon	181,592	365,989
PACIFIC	Washington	3,663,392	6,118,976
PIERCE	Washington	201,146	299,617
POLK	Oregon	314,735	458,866
SKAMANIA	Washington	837,305	1,382,044
THURSTON	Washington	1,236,230	2,291,484
TILLAMOOK	Oregon	721,732	1,064,257
WAHIAKUM	Washington	1,154,036	3,138,772
WASHINGTON	Oregon	852,311	1,653,231
YAMHILL	Oregon	307,195	466,175
Grand Total		23,898,671	49,256,745

Table 2. Output table from running Network Analyst in GIS and calculating fixed and variable costs along each route from FIA pt to IBR for a marginal cost of \$68/BDT. The total costs are then summed by county in which each FIA pt resides.

County	Sector	GDP Change (\$MM)	Impact
Clackamas	FARMS (1)	0	0.031
Clackamas	FORFISH (15)	1.362	1.380
Clackamas	OGEXTRACT (20)	0	0.000
Clackamas	MINING (21)	0	0.001
Clackamas	MINESUP (28)	0	0.000
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Clackamas	RAIL (333)	0	0.001
Clackamas	WATER (334)	0	0.002
Clackamas	TRUCK (335)	0.79	0.858
Clackamas	TRANSIT (336)	0	0.003
Clackamas	PIPE (337)	0	0.000

Table 4. CIA summary table of market sector impact for all counties.

Sector	GDP Change	Impacts	Unit	Sector Description
FARMS (1)	0	\$2.567	\$MM	Farms
FORFISH (15)	49.747	\$53.528	\$MM	Forestry fishing and related activities
OGEXTRACT (20)	0	\$0.056	\$MM	Oil and gas extraction
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CHEM (120)	413	\$557.559	\$MM	Chemical Products
PLASTIC (142)	0	\$3.219	\$MM	Plastic and rubber
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RAIL (333)	0	\$2.586	\$MM	Rail transportation
TRUCK (335)	24.1	\$30.399	\$MM	Truch transportation
TRANSIT (336)	0	\$0.239	\$MM	Transit and ground transportation

RESULTS

VALUE ADDED		\$226.863	\$MM
EMPLOYMENT		2,921	persons
SECTOR IMPACTS	\$486.847	\$857.823	\$MM
Value Added/employee		\$77,662	/person



Northwest Advanced Renewables Alliance

