Evaluating the impact of feedstock quality on delivered cost: Two case studies from the US Southeast region

Laurence Eaton*, Matthew Langholtz, Craig Brandt, Erin Webb, Mark Downing

Oak Ridge National Laboratory

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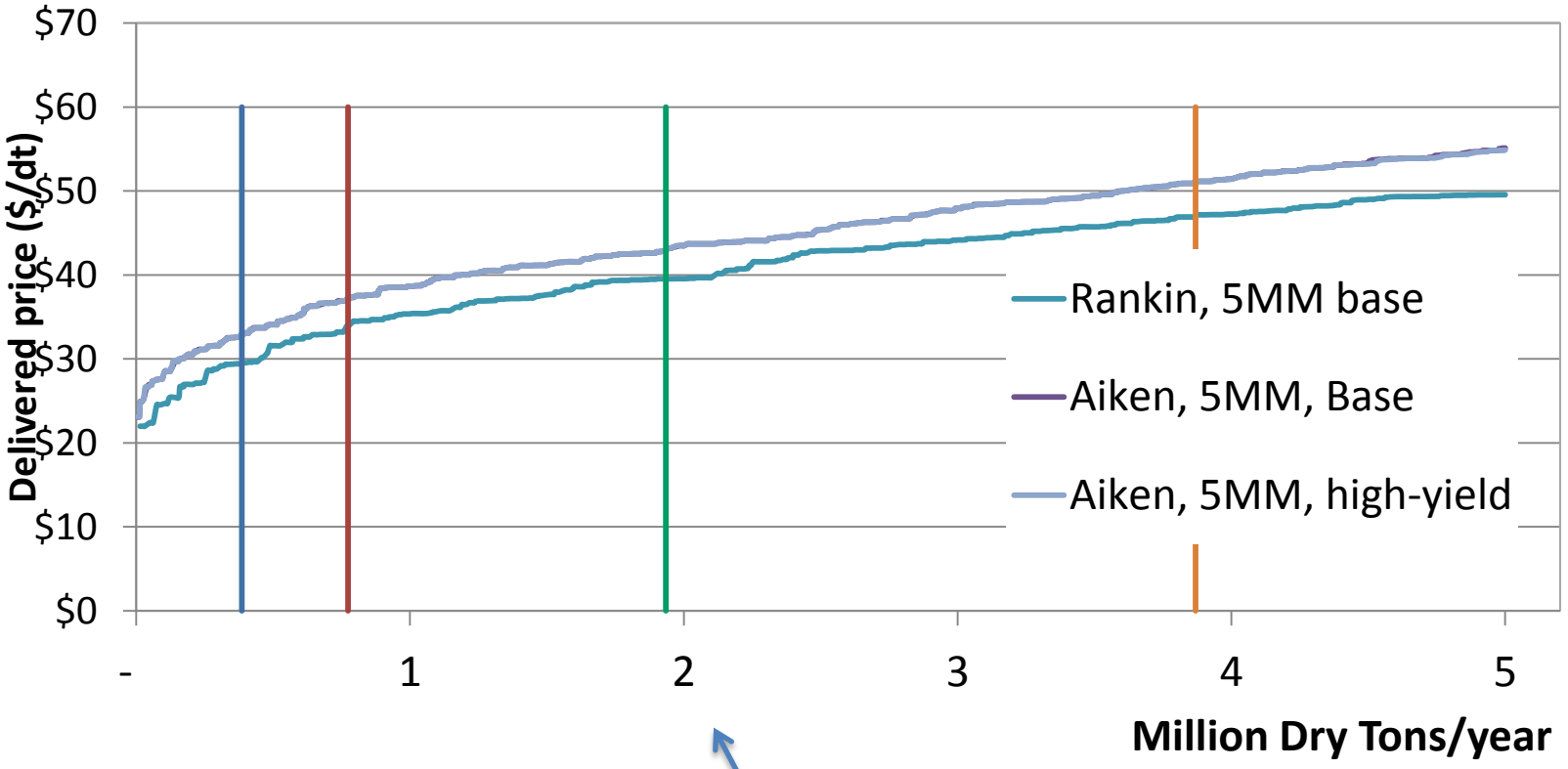
Motivation

- Forest resources represent significant quantity of projected biomass for new uses (between 178-367 MMDT/yr, 23-33% of primary resources in 2030) but vary in
  - Quality, price availability, yield assumptions
- What is the delivered cost of woody feedstocks that incorporate feedstock quality and yield growth?
- What is impact of feedstock supply mix when the cost to clean up lower quality feedstocks is incorporated into delivered cost.
- Fits within a multi-lab study of optimal facility size for wood-using thermochemical conversion facility in US Southeast, though applicable to biopower

Initial Results from Two Sites



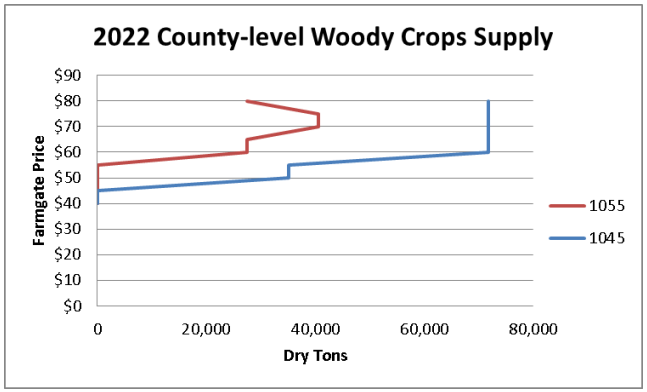
Three curves shown, no difference between Base and HY implies no SRWC supplying feedstock demand

1.9 Million DT/year = ~164 Mil gal/yr

Methodology: Resource Potential Estimates

- Utilized Billion Ton Projections
  - Nutshell: BT2 provides gross potential of dedicated energy crops (from cropland and pasture) and primary forest and agricultural residues
- Supply curves of resources potentially available at farmgate/forest landing prices of $40-80/dry ton
- Assume all forecasted demands (food, feed, fiber, exports) are met before energy crops are grown
  - Relative prices and returns are explicitly accounted for, used a profit maximizing model that chooses highest profiting crop for landowner subject to existing market and environmental sustainability constraints
  - Energy crops compete for land with traditional crops and pasture systems as well as other energy crops
- Residues are available in all years; however, woody crops (non-coppice) begin to mature by 2021

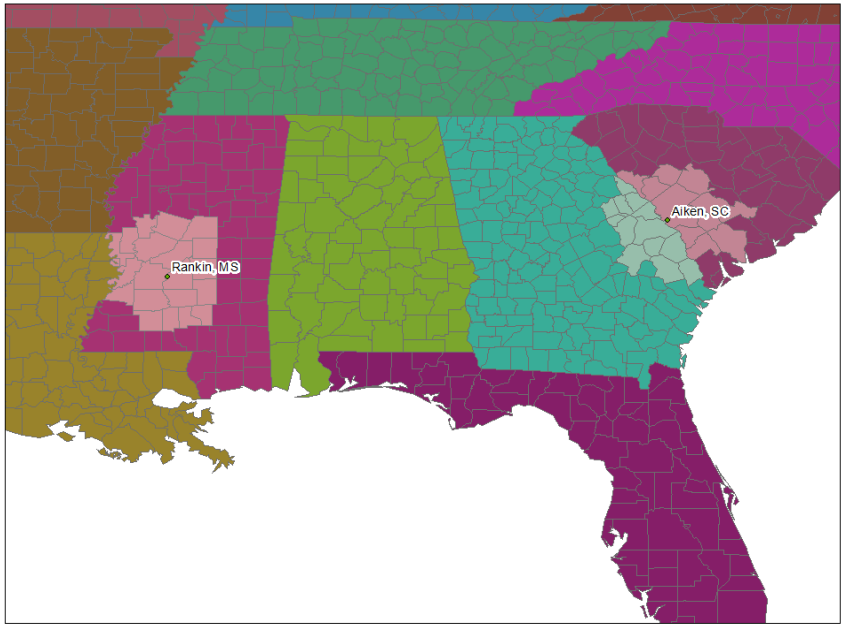
Methodology: Resource Potential Estimates (continued)



- The BT2 included some instances of competition among dedicated energy feedstocks
  - Avoided these irregularities by removing projected prices for herbaceous feedstocks altogether
  - Areas where woody-using facilities would be cited would be unlikely to provide landowners with long-term contracts for grasses
- Resources considered for facilities:
  - Primary Forest Resources include: Logging Residues, Forestland thinnings, Non-coppice Woody Crops, Pulpwood for Bioenergy
- "Smoothed" SRWC production to account for flexibility in harvest length
  - Averaged projected harvests in 2022 across stands maturing in 2021-2023

Methodology: Throat Supply Curves

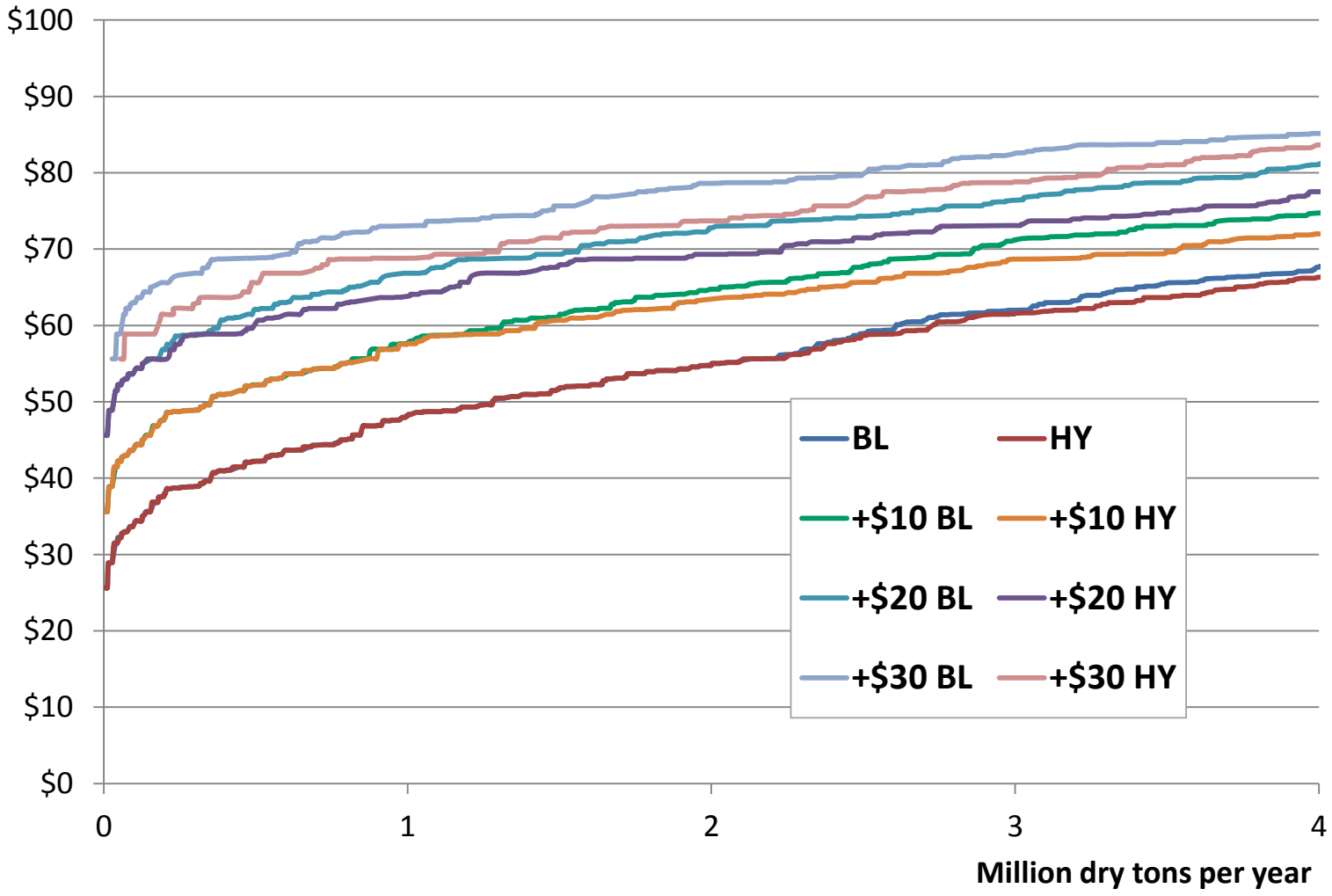
- BT2 Supplies are estimated at the farmgate/forest landing
  - Do NOT include transportation, logistics, storage, and pre-processing needed to get supplies to biomass using facilities
- Supply Characterization Model (formerly ORIBAS) estimates the delivered cost of feedstocks
  - Dumps all feedstocks at county centroids, solves location for facility at optimal road network intersections and feedstock supply
  - Executed model to solve locations to supply 5 million dry tons/year, chose two potential sites
    - #1 Rank: Rankin, Mississippi (High Density)
    - #5 Rank: Aiken, South Carolina (Low Density)



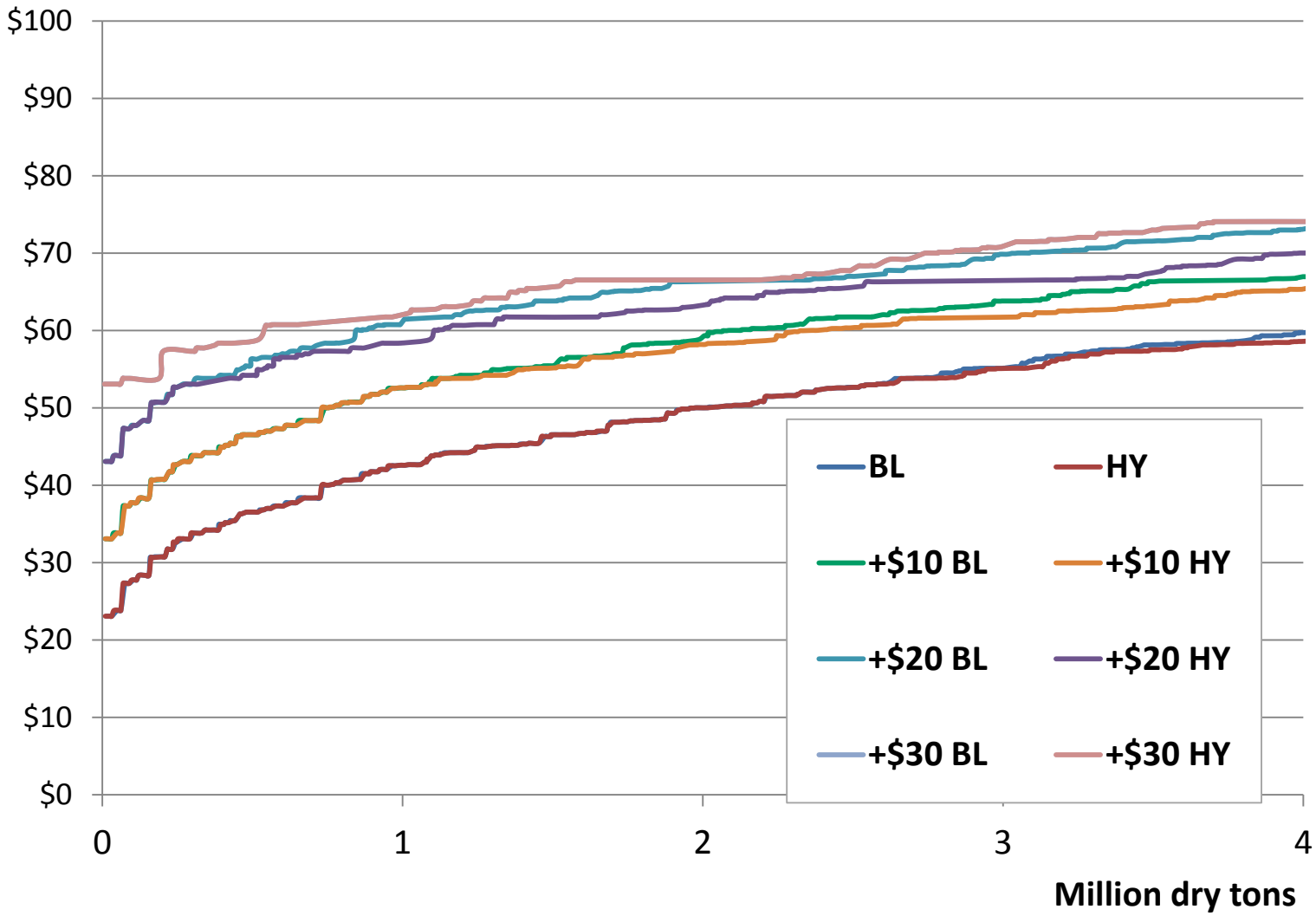
Methodology: Feedstock Quality

- Disaggregated the primary forest feedstock base into two feedstock categories
  - Low Quality: Thinnings, Residues
  - High Quality: Pulpwood for bioenergy, SRWC (predominantly pine in this region)
- Forced cleaning of Low Quality Resources at +10/dt cost increments to identify when High Quality Resources gain a competitive advantage over Low Quality Resources (effectively “tax” low quality)
- Used Baseline Scenario and High Yield (3%) Scenario

Low Density, Aiken, SC



High Density, Rankin, MS



Results

Aiken, SC	Facility Size (dry tons/day)			
	551	1102	2205	5512
	Marginal Delivery Price ($/dt)			
Baseline	$ 37.60	$ 40.96	$ 44.76	$ 54.57
+10	$ 47.60	$ 50.96	$ 54.76	$ 64.30
+20	$ 56.84	$ 60.69	$ 64.39	$ 72.22
+30	$ 65.62	$ 68.71	$ 71.84	$ 78.13
High Yield	$ 37.60	$ 40.96	$ 44.76	$ 54.57
+10	$ 47.60	$ 50.96	$ 54.76	$ 63.09
+20	$ 55.62	$ 58.87	$ 62.77	$ 69.05
+30	$ 61.46	$ 63.65	$ 68.71	$ 73.65
	Percentage of Supply as SRWC			
Baseline	0%	0%	0%	0%
+10	0%	0%	0%	1%
+20	14%	7%	3%	17%
+30	3%	37%	38%	48%
High Yield	0%	0%	0%	0%
+10	0%	0%	0%	12%
+20	28%	36%	30%	40%
+30	81%	83%	70%	68%

Low Q and High Q Feedstocks at $0/dt pre-processing costs

Results

Rankin, MS	Facility Size (dt/day)			
	551	1102	2205	5512
	Marginal Delivery Price ($/dt)			
Baseline	$ 30.75	$ 34.21	$ 40.33	$ 49.85
+10	$ 40.75	$ 44.21	$ 50.33	$ 58.56
+20	$ 50.75	$ 54.20	$ 58.35	$ 66.52
+30	$ 57.31	$ 58.35	$ 61.74	$ 66.52
High Yield	$ 30.75	$ 34.21	$ 40.33	$ 49.85
+10	$ 40.75	$ 44.21	$ 50.33	$ 58.07
+20	$ 50.75	$ 53.81	$ 57.31	$ 62.98
+30	$ 57.31	$ 58.35	$ 61.74	$ 66.52
	Percentage as SRWC			
Baseline	0%	0%	0%	0%
+10	0%	0%	0%	3%
+20	0%	13%	9%	40%
+30	66%	67%	95%	85%
High Yield	0%	0%	0%	0%
+10	0%	0%	0%	12%
+20	0%	33%	28%	44%
+30	66%	67%	95%	85%

Low Q and High Q Feedstocks at $0/dt pre-processing costs

Results, continued

Aiken, SC	Facility Size (dt/day)			
	551	1102	2205	5512
	Delivery Price Delta (increasing tax)			
Baseline				
+10	$ 10.00	$ 10.00	$ 10.00	$ 9.73
+20	$ 19.24	$ 19.73	$ 19.63	$ 17.65
+30	$ 28.02	$ 27.75	$ 27.08	$ 23.56
High Yield				
+10	$ 10.00	$ 10.00	$ 10.00	$ 8.52
+20	$ 18.02	$ 17.91	$ 18.01	$ 14.48
+30	$ 23.86	$ 22.69	$ 23.95	$ 19.08

Rankin, MS	Facility Size (dt/day)			
	551	1102	2205	5512
	Delivery Price Delta (increasing tax)			
Baseline				
+10	$ 10.00	$ 10.00	$ 10.00	$ 8.71
+20	$ 20.00	$ 19.99	$ 18.02	$ 16.67
+30	$ 26.56	$ 24.14	$ 21.41	$ 16.67
High Yield				
+10	$ 10.00	$ 10.00	$ 10.00	$ 8.22
+20	$ 20.00	$ 19.60	$ 16.98	$ 13.13
+30	$ 26.56	$ 24.14	$ 21.41	$ 16.67

Discussion

- "Throat" supply curves for these two regions are very elastic (high responsiveness of quantity to price)
- Divergence of Baseline and High Yield occurs at larger facilities sizes and higher low quality feedstock taxes
- SRWC begin to feed facility demand at pre-processing costs of $10/dt for the Aiken, SC site, and $20/dt for the Rankin, MS site
- The difference between the Baseline and High Yield throat curves and those with pre-processing costs decrease with facility size and level of pre-processing "tax"

Conclusions and Final Thoughts

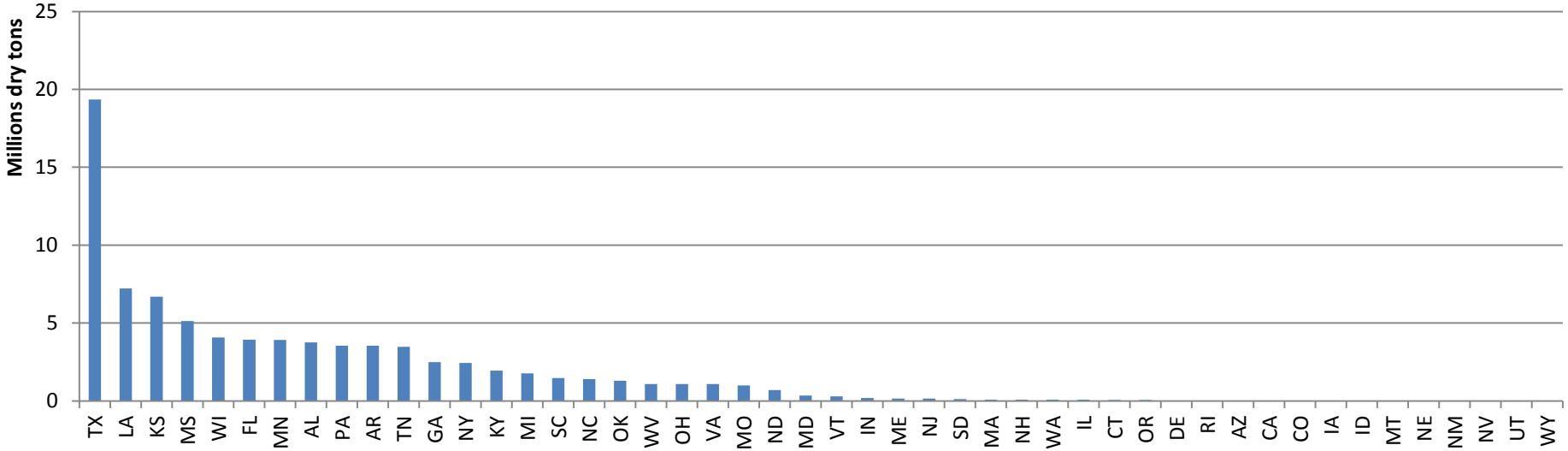
- The price premium for delivered SRWC is $10-20/dt in the representative “low density” region; $20-30/dt for “high density” area
- Region supply inventories is next step, residues are only available when logging is present
- The price of delivered feedstock is reduced for facility when it can receive many feedstock types, increased when feedstock quality is critical technical constraint
- Results only suggest feedstock mix from First of a Kind Facility, More facilities=higher prices

Thank you for your time!

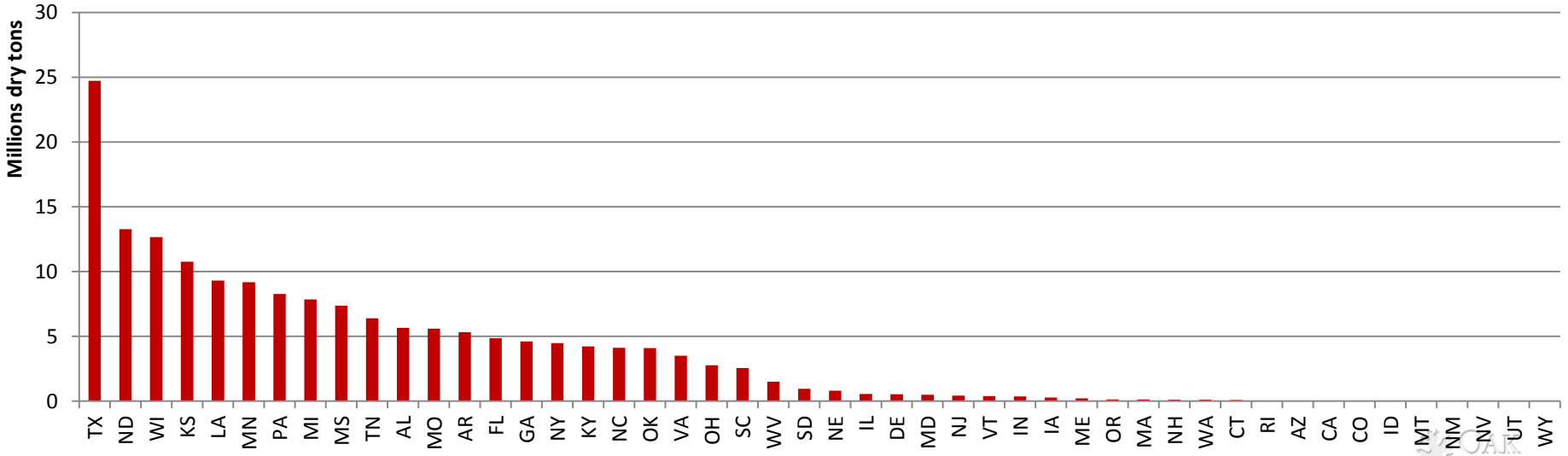
Laurence Eaton

Eatonlm@ornl.gov

2022 Projected Woody Crops Production, Baseline, $60/dt

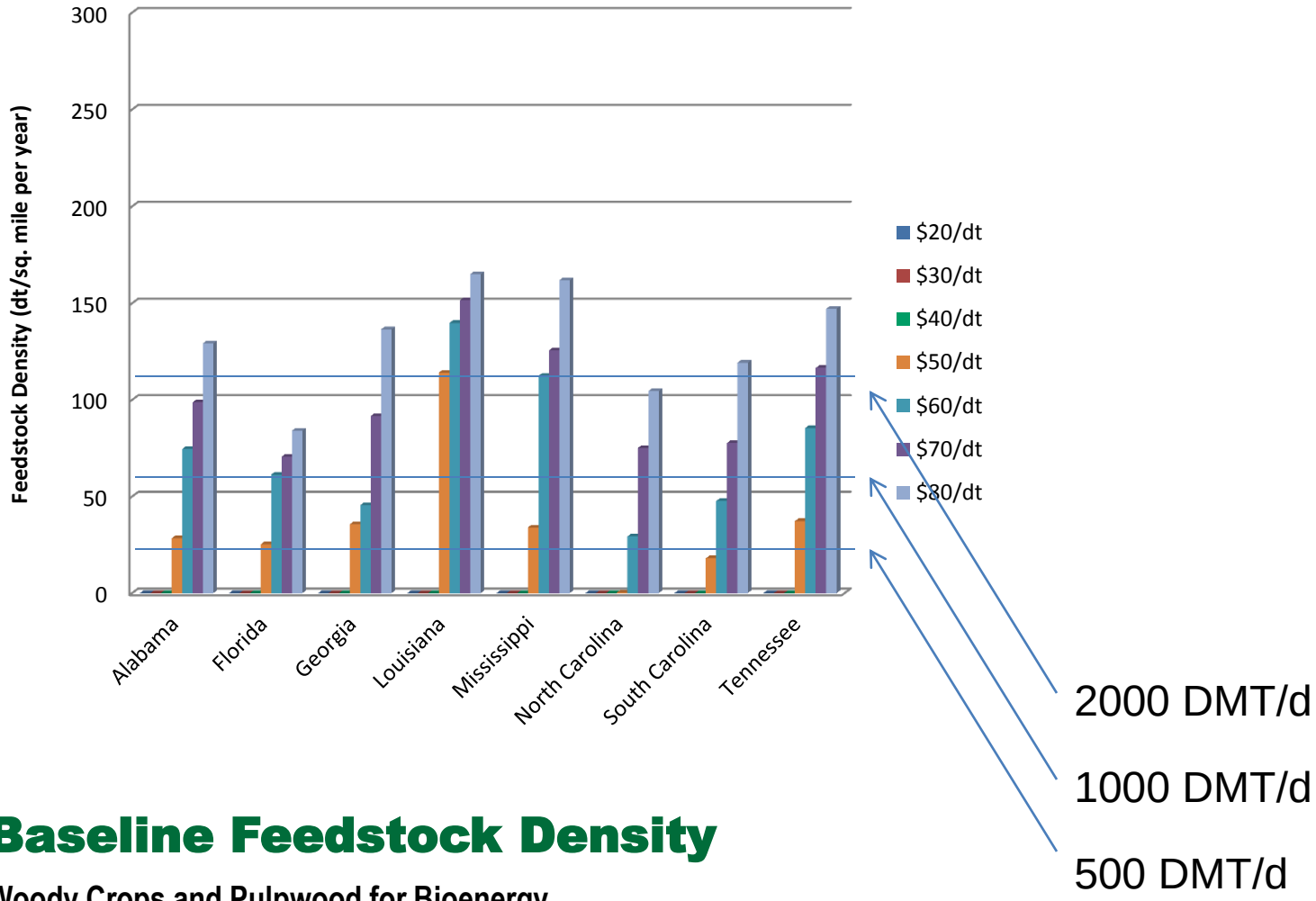


2022 Projected Woody Crops Production, High Yield (3%), $60/dt



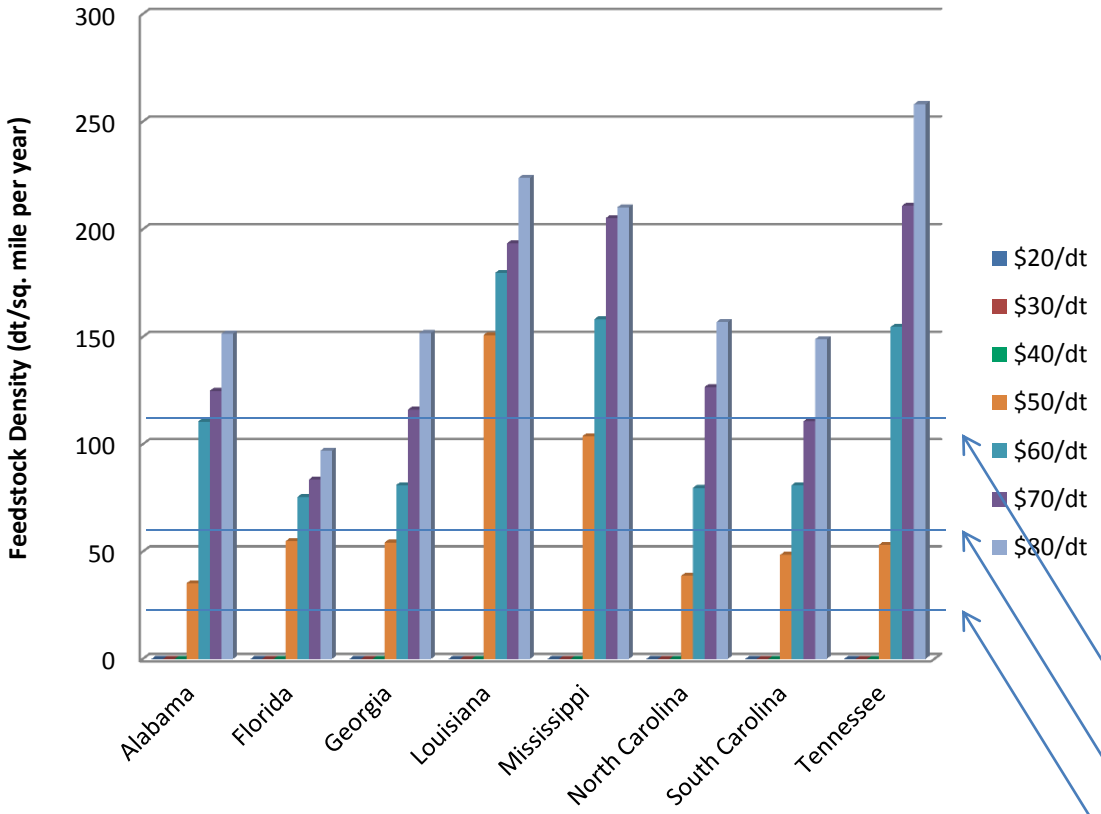
Initial Findings

- Total available supply/total acreage of state
- Ballpark estimates for 50 mile radius around facility (operating 365 d/yr, 20% field to throat loss)
  - 500 DT/d=29 dt/mi^2
  - 1000 DT/d=58 dt/mi^2
  - 2000 DT/d=116 dt/mi^2
  - 5000 DT/d=290 dt/mi^2
  - 7500 DT/d=436 dt/mi^2
  - 10000 DT/d=581 dt/mi^2



Baseline Feedstock Density

Woody Crops and Pulpwood for Bioenergy



2000 DMT/d

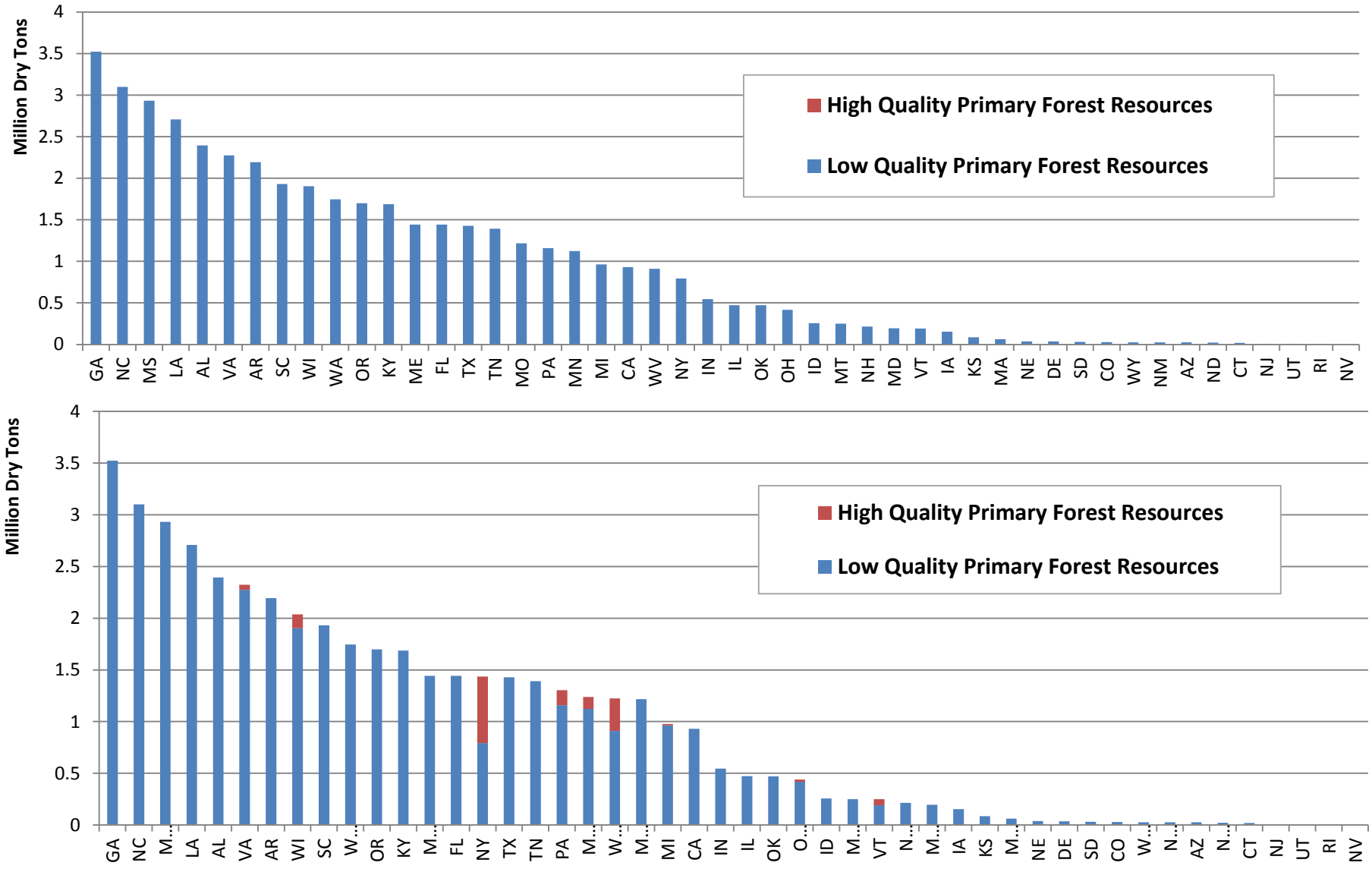
1000 DMT/d

500 DMT/d

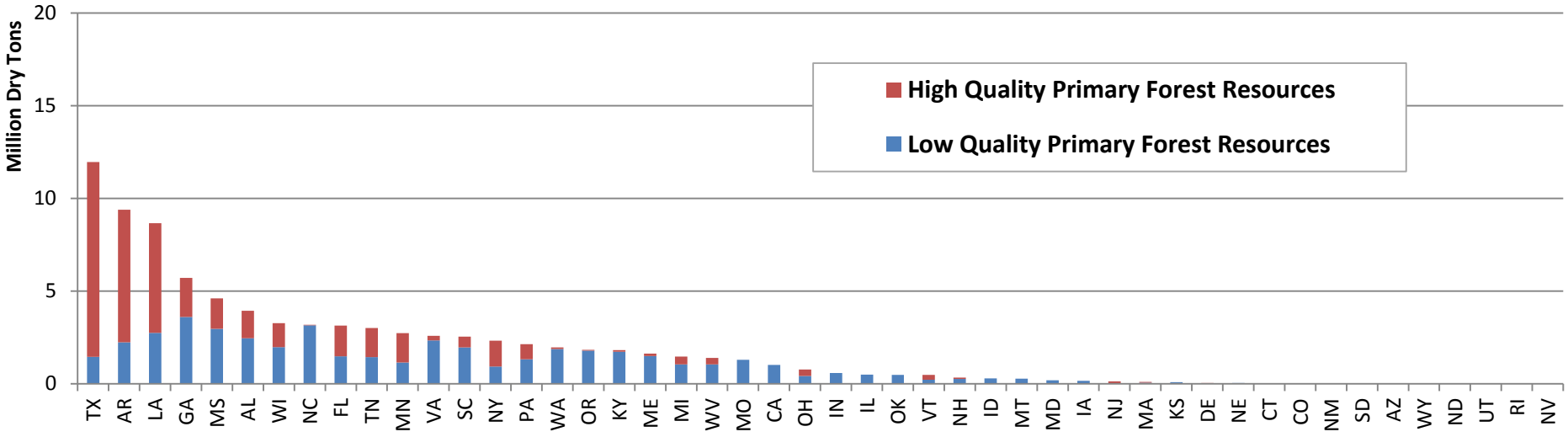
High-Yield (3%) Feedstock Density

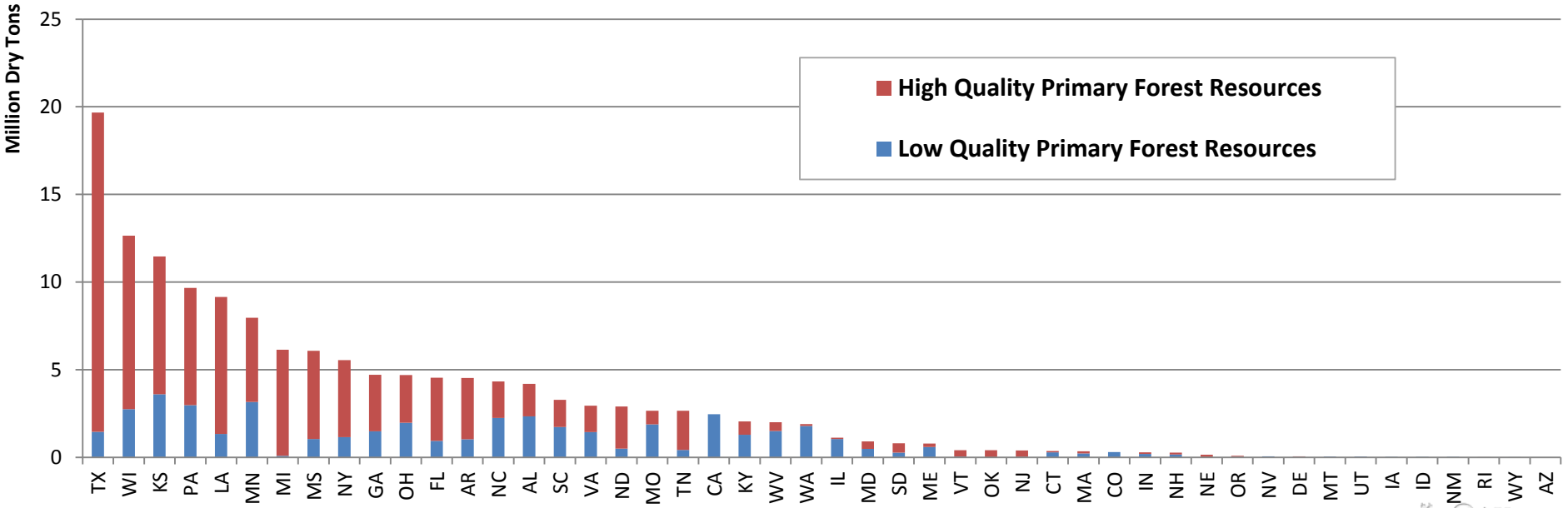
Woody Crops and Pulpwood for Bioenergy

$40/dt Baseline vs. High Yield 2022

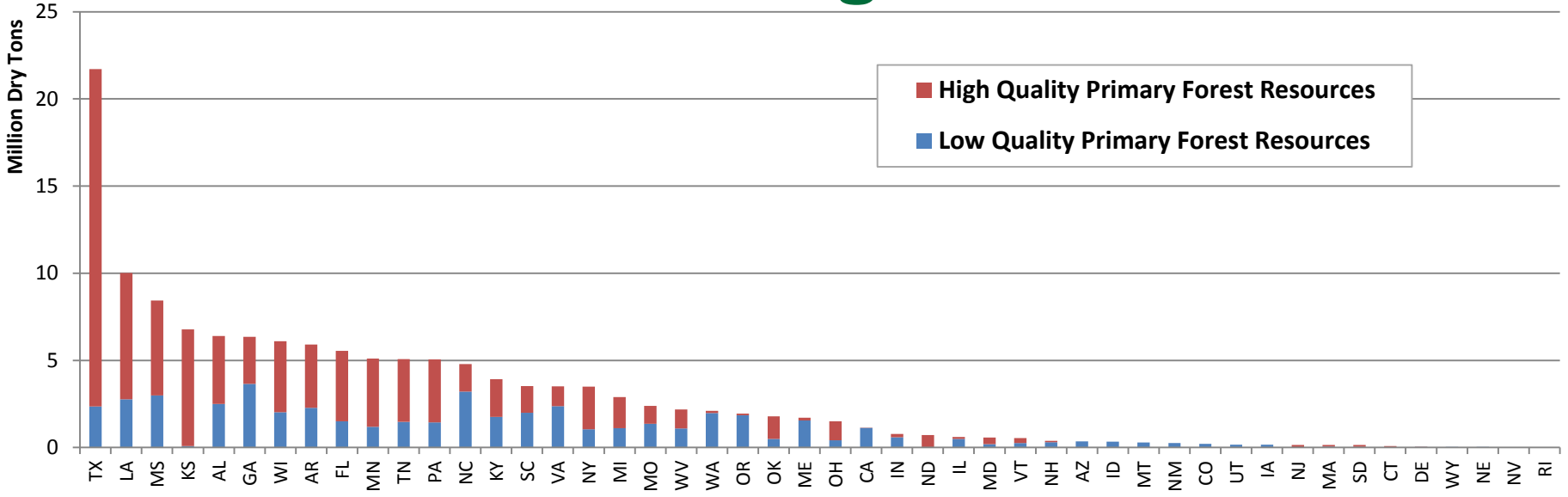


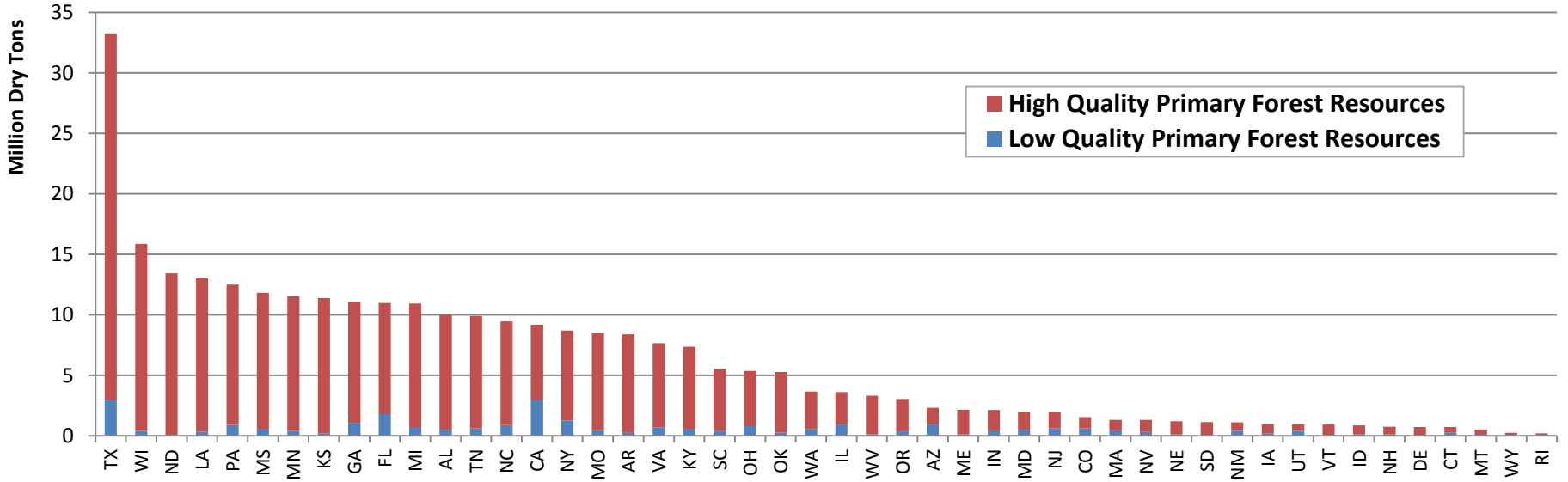
$50/dt Baseline vs. High Yield 2022





$60/dt Baseline vs. High Yield 2022





Initial Screening

- Total available supply/total acreage of county

- Ballpark estimates for 50 mile radius around facility (operating 365 d/yr, 20% field to throat loss)
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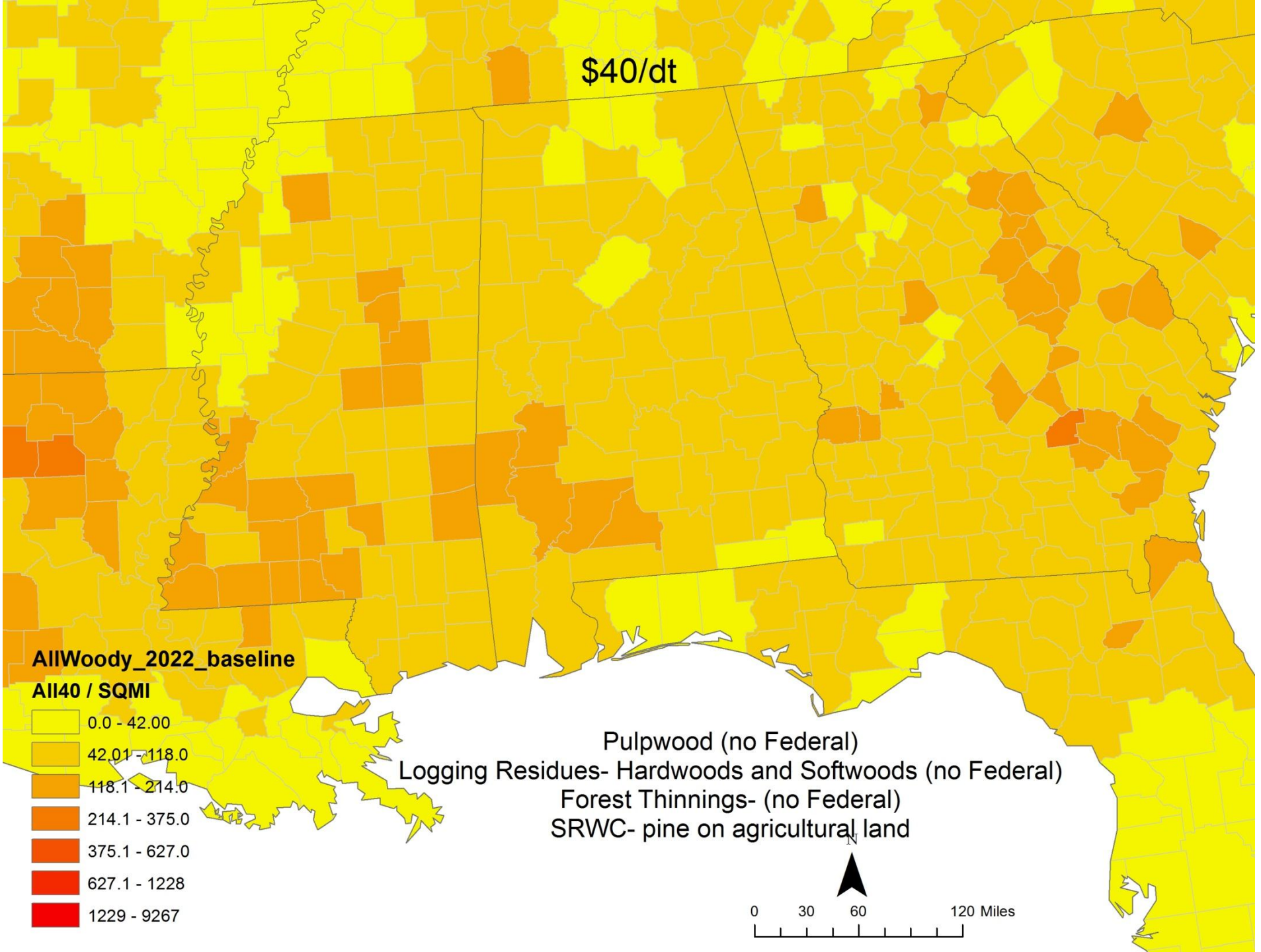
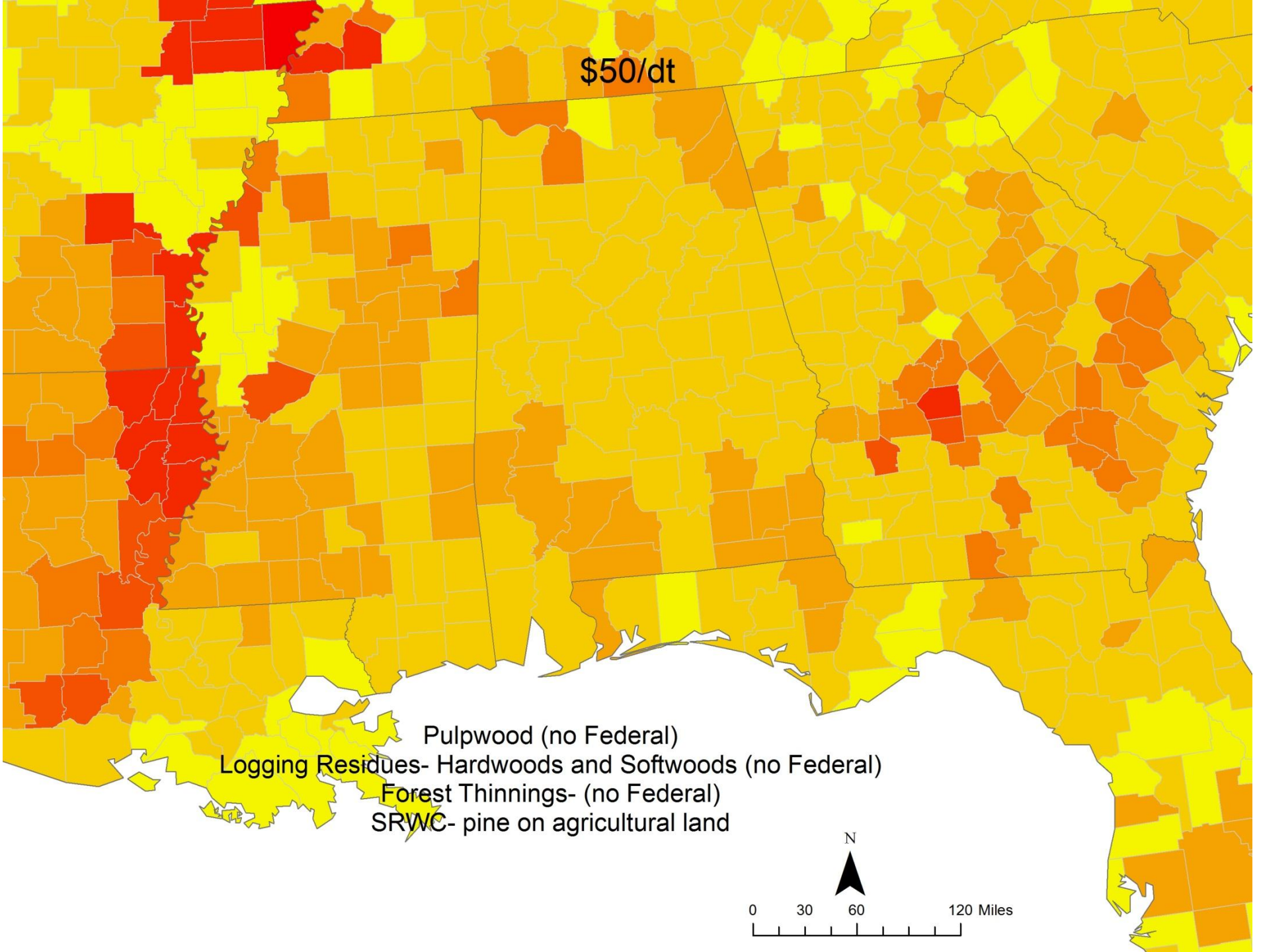

$40/dt
AllWoody_2022_baseline
All40 / SQMI
0.0 - 42.00
42.01 - 118.0
118.1 - 214.0
214.1 - 375.0
375.1 - 627.0
627.1 - 1228
1229 - 9267
Pulpwood (no Federal)
Logging Residues- Hardwoods and Softwoods (no Federal)
Forest Thinnings- (no Federal)
SRWC- pine on agricultural land
N
0
30
60
120 Miles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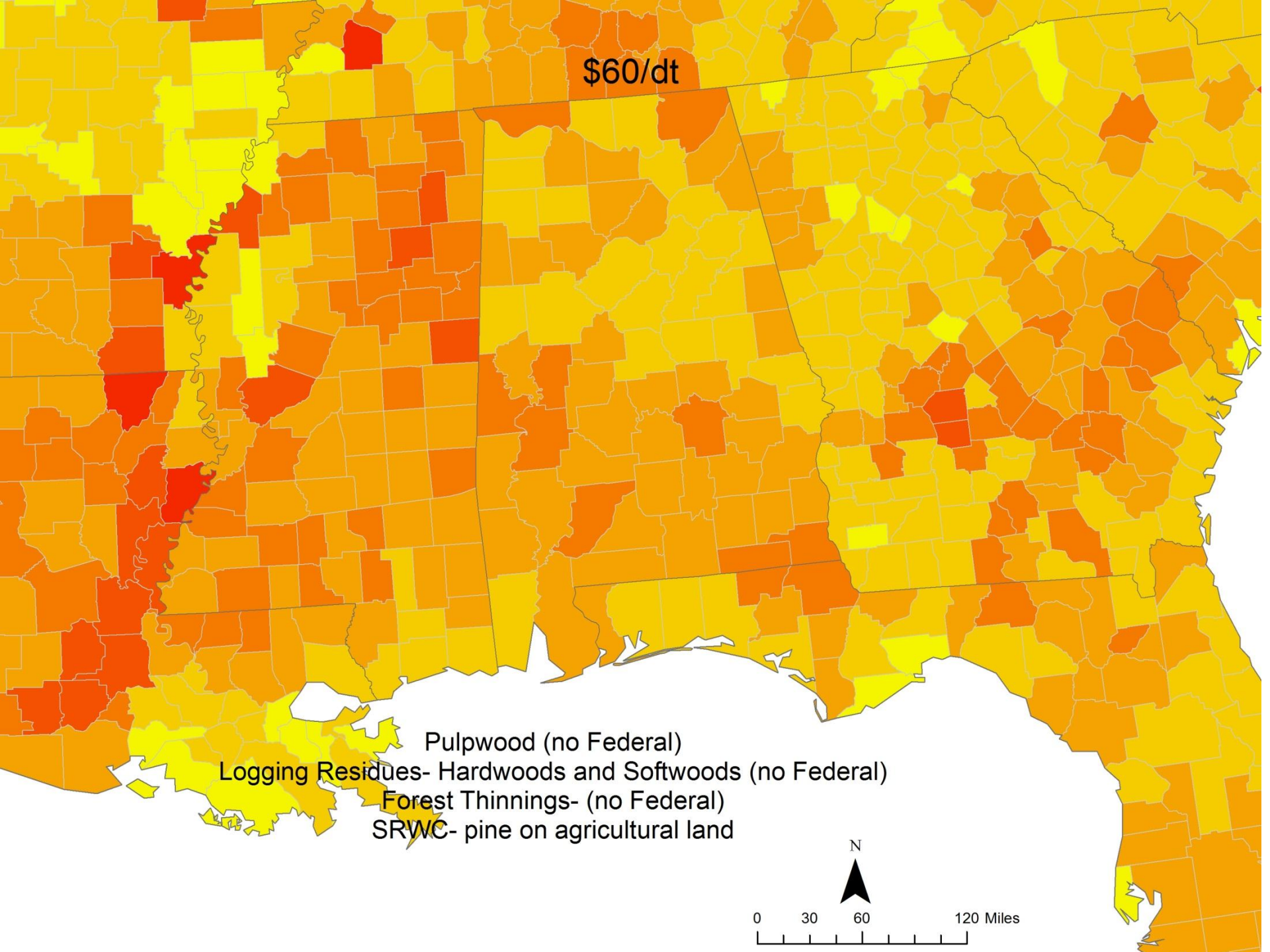
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