Mill capacity and willingness to utilize additional logging residues for electricity in southern United States

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Background

- Concerns related energy security and climate change.
- Kyoto Protocol and Copenhagen Summit set goals to lower CO_2emissions
  - 17% below 2005 levels by 2020, 42% by 2030 and 83% by 2050 in US.
- 8% of US energy is from renewable sources and 4% is from biomass
- United States set goal to increase renewable energy to 16% by 2025

Forests cover
- U.S.: 33% (810 million acres)
- Southeastern United States: 50% (267 million acres)
- Mississippi: 65% (19.5 million acres)
- Different policy for sustainable usage of a forest biomass
  - USDA Woody Biomass Policy

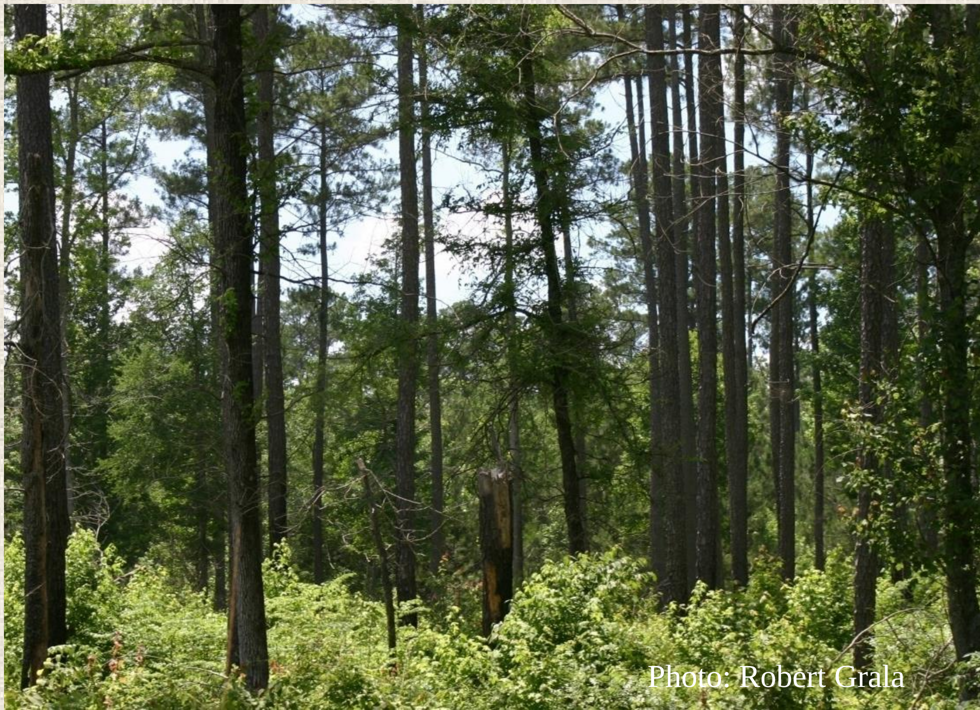


Photo: Robert Grala

Background

- A billion ton of dry biomass available
    - could potentially replace 30% of national petroleum use
- Woody biomass accounted for 70% of total biomass
- Woody residues expected to account for 18-26% of biomass used by 2031
- Mill residues, logging residues, and urban woody waste

- Only 1.5 % of mill residues not reused
- Urban woody waste not reliable
- Of total woody biomass used for bioenergy, almost 75% was recovered from forests
- Recoverable logging residues: **36.2 million dry ton** for U.S. based on 1997 FIA data

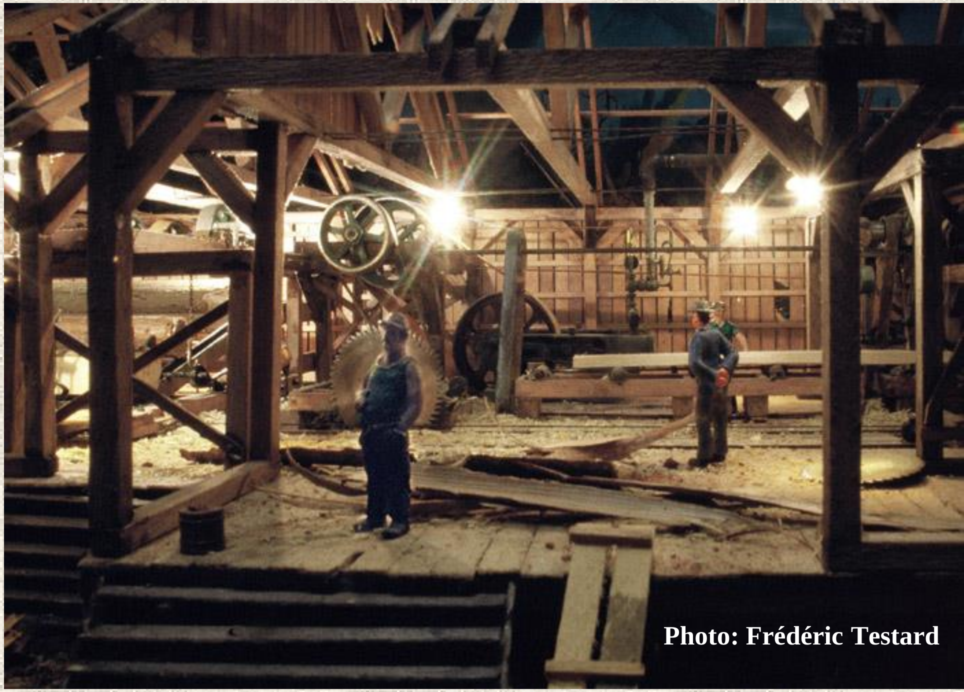


Photo: Frédéric Testard

Research Objectives

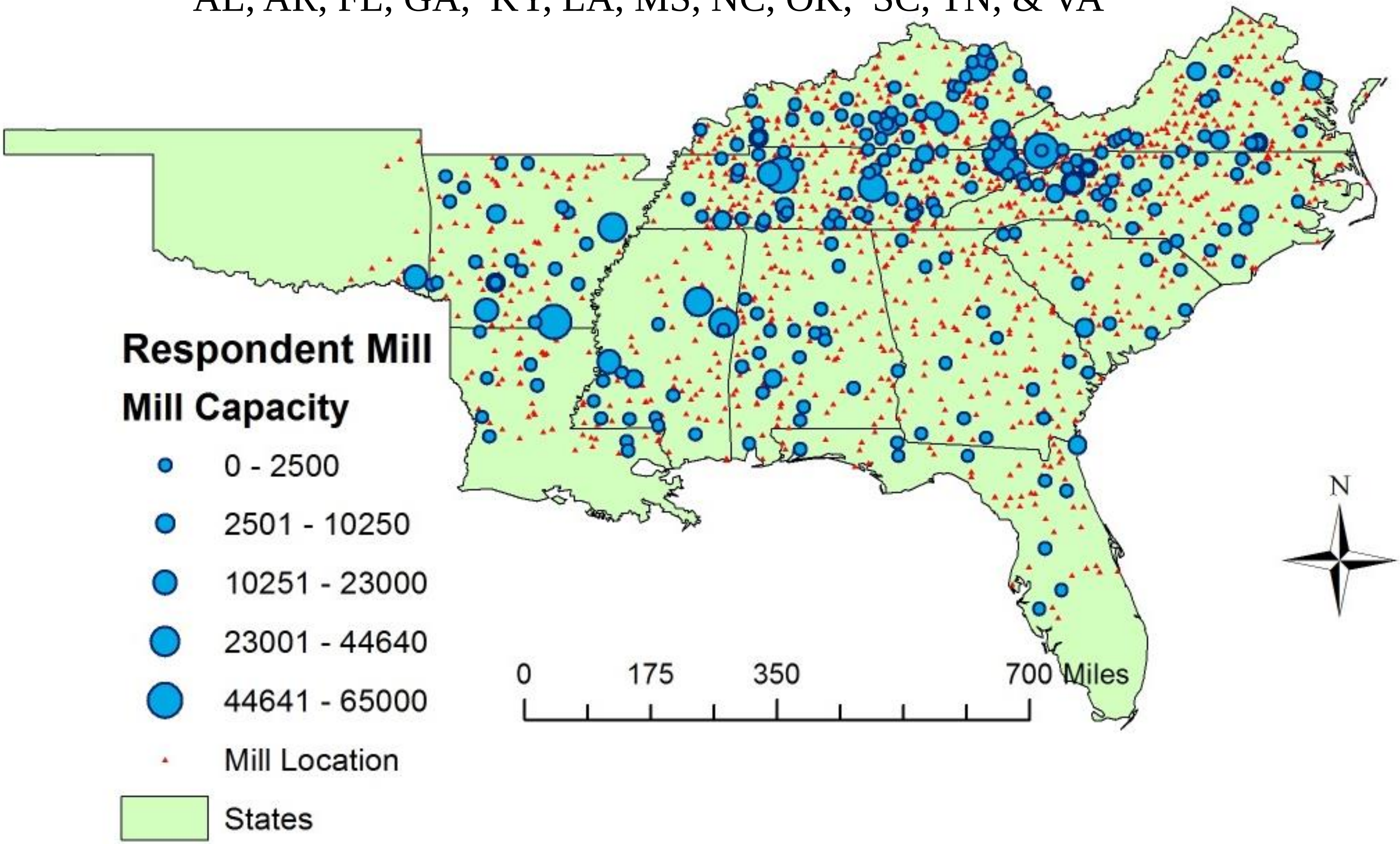
To quantify mill capacity and willingness to utilize additional logging residues for electricity production and identify factors limiting additional utilization.

Photo: Robert Grala

Study Area

12 States in southeastern United States:

AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, & VA



Methods: Census survey

- Census survey of forest product manufacturers
- Tailored Design Dillman Method - four mail contacts
- Test for non-response bias
  - Test between first and last fifty responses
  - Test of distribution of responding mills in 12 states compared to all mills
  - Test of distribution of mill types in responses compared to all mills

Photo: Grant Wright Christian,
Treasury Relief Art Project, 1937-38

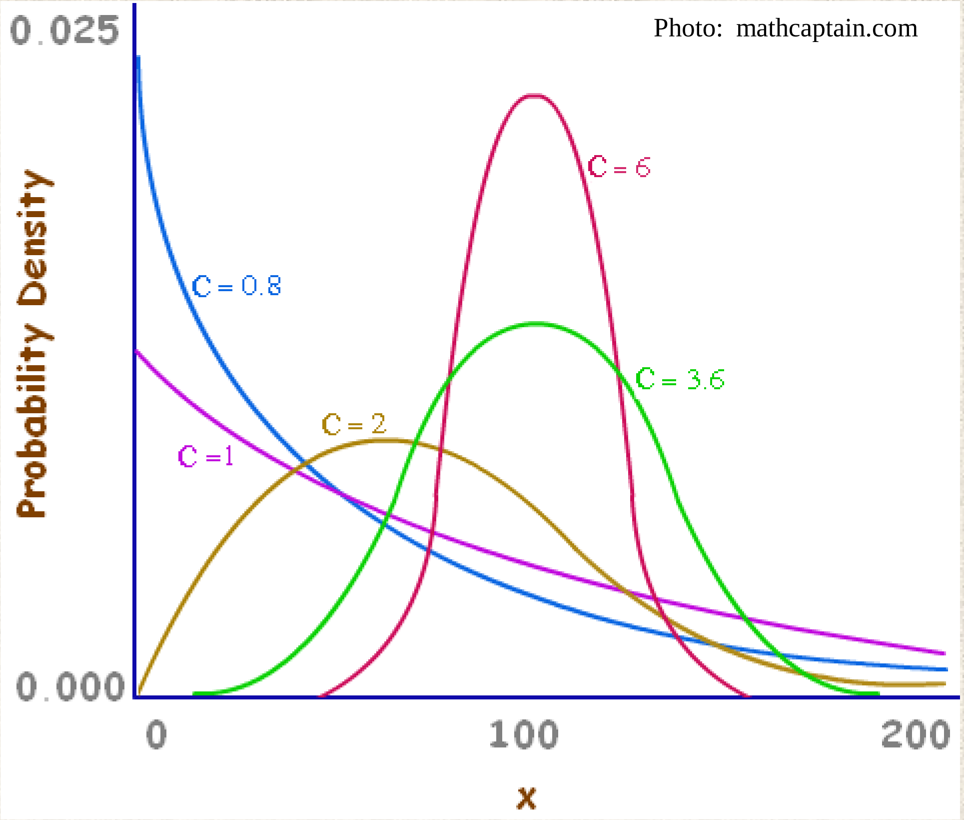
Methods: Data distribution

- Test of normality
  - Kolmogorov-Smirnov one sample goodness-of-fit test

H_0: $F_0(x) = F(x)$, where F(x) has a normal distribution

$$D = sup \mid S(x) - F_0(x) \mid$$

where, $S(x) = (n_1 >= x) / N$



Methods: Hypothesis testing

- **Wilcoxon Mann Whitney Test**
  - Measures if the two groups of data are identically distributed

$$T = S - \frac{n_1(n_1 - 1)}{2}$$

when the sample size is large enough,

$$Z = \frac{T \pm 0.5 - \frac{n_1(N+1)}{2}}{\sqrt{\frac{n_1 n_2 (N+1)}{12}}} \; where, \qquad Z\{ \begin{matrix} -Z_{1L}\, if \;\; T_1 < n_1\,(N+1)/2 \\ Z_{1R}\, if \;\; T_1 > n_1\,(N+1)/2 \end{matrix}$$

- **Kruskal Wallis Test**
  - Measures if all groups of data are identically distributed or if there are significant variations among these groups

$$\text{H} = \frac{12}{N(N+1)} \sum_{i-1}^{k} \frac{Ri^2}{n_i} - 3(N+1)$$

R_i is rank sum per group

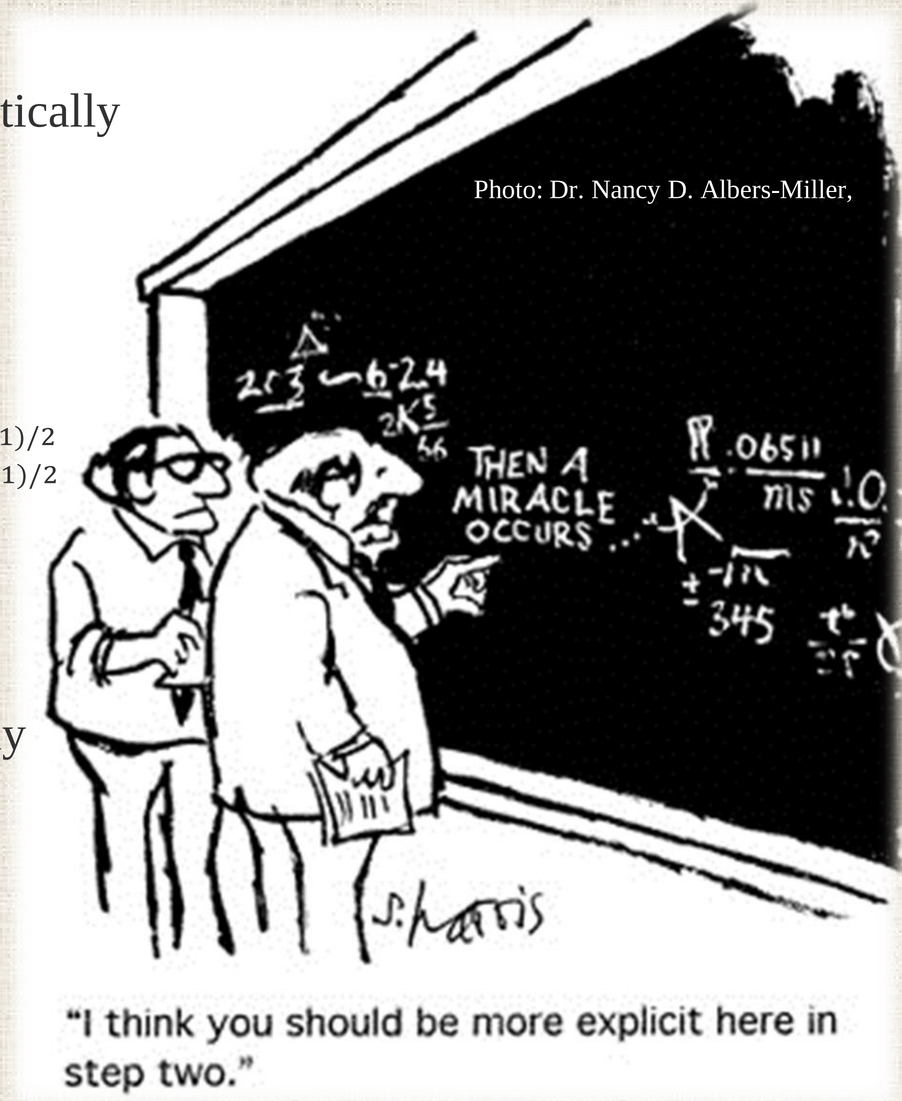


Photo: Dr. Nancy D. Albers-Miller,

Results: Mill responses

- Total mills: 2,138.
- Adjusted response rate : 19.9%

- Non Response bias Test
  - No significant differences were observed between early and late responses on any variable between first and last 50 observations
  - No significant differences were observed in distribution of mill types in responses compared to all mills (p-value = 0.468)
  - No significant differences were observed in distribution of responding mills in 12 states compared to all mills (p-value= *0.863)*

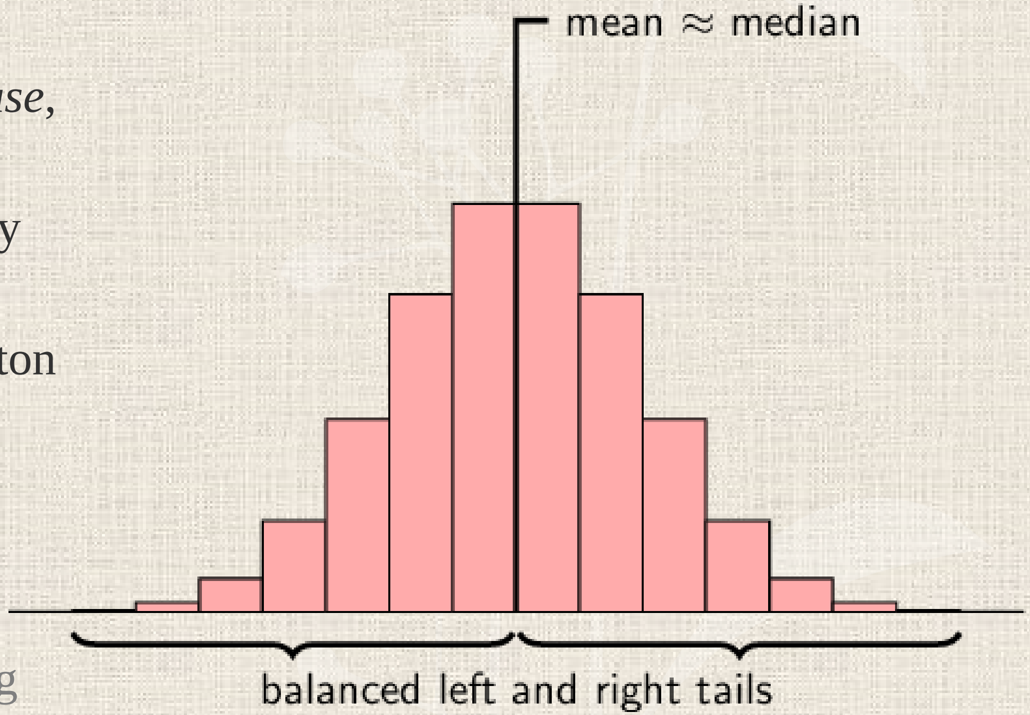
Results: Descriptive Statistics

Variable	Variable description	N	Mean	SD
cap	Mill capacity to utilize wood residues to produce energy (green tons/month).	176	3691.96	10302.26
use	Amount of woody residues utilized by mill (green tons/month).	208	3460.11	8137.52
disp	Amount of woody residues disposed off by mill (green tons/month).	182	2680.43	6038.08
upgrade	1 if mill upgraded equipment to produce electricity from wood residues 0 if not.	228	0.02	0.13
future	1 if mill considered future upgrades to produce electricity from wood residues, 0 if not.	239	0.08	0.26
will	1 if mill was willing to utilize additional logging residues to produce electricity, 0 if not.	227	0.11	0.31
gprice	Maximum gate price mills were willing to pay for additional logging residues ($ per green ton).	34	11.92	9.95
haul	Maximum actual hauling distance over which logging residues were delivered (miles).	39	48.79	44.61
ehaul	Maximum economic hauling distance over which logging residues can be delivered (miles).	68	57.78	41.64

N: Number of Observation, SD: Standard Deviation

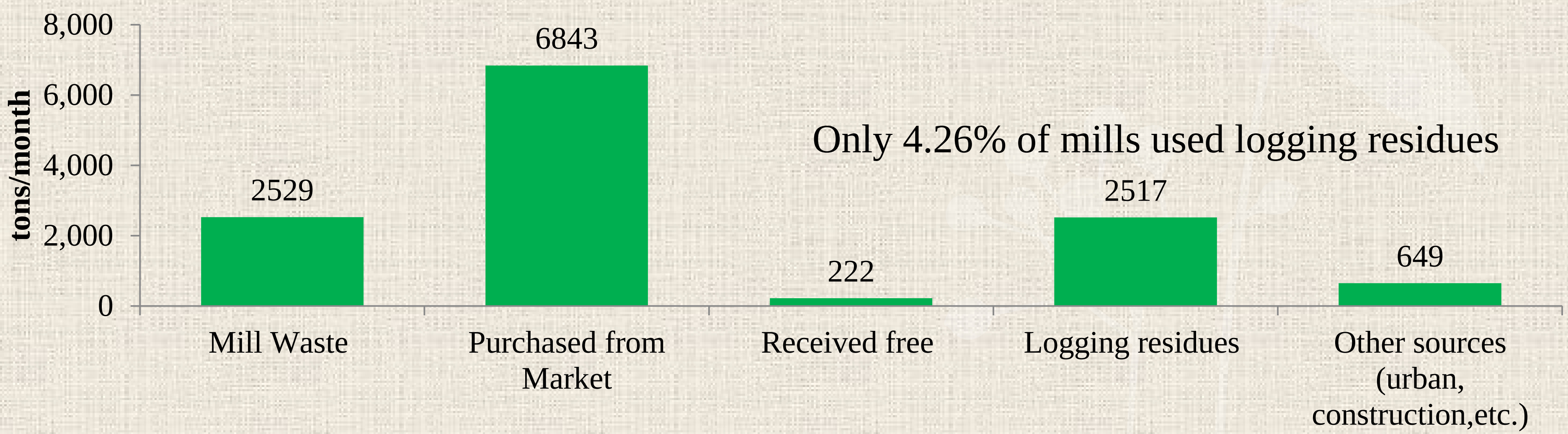
Results: Data distribution

- Normality
  - Mill capacity to utilize woody residues (*cap*, $p < 0.0001$)
  - Amount of residues used in mill (*use*, $p < 0.0001$)
  - Amount of residues disposed off by mill (*disp*, $p < 0.0001$)
  - Price mill were willing to pay per ton at gate (*gprice*, $p < 0.0001$)
  - Distance considered economically feasible to haul logging residues (*ehaul*, $p < 0.0001$)
  - Actual distance over which logging residues (*haul*, $p = 0.0645$)

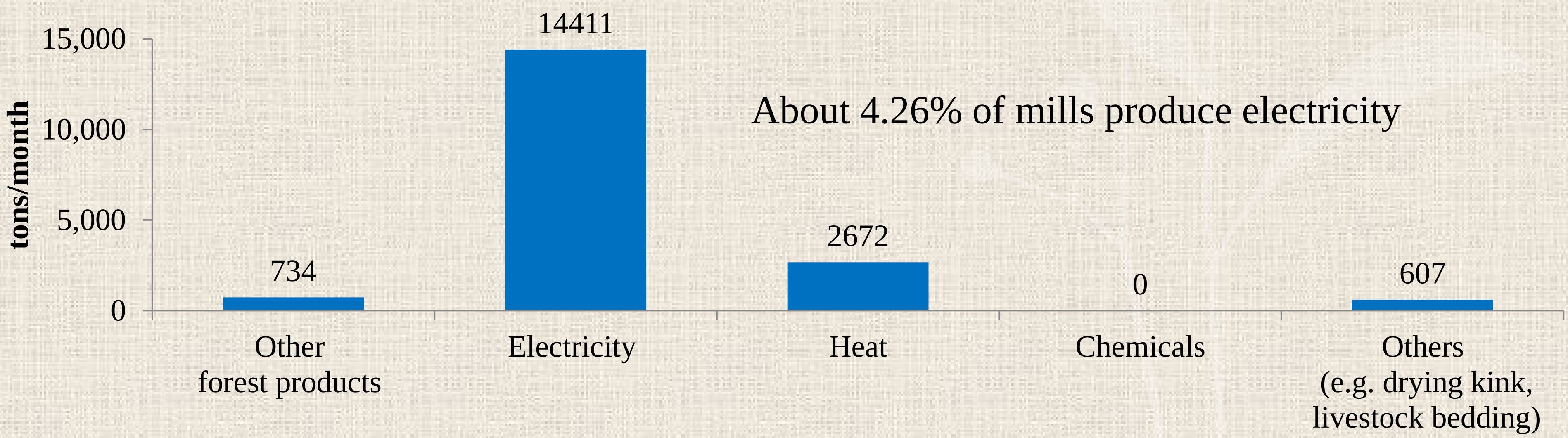


Results: Sources and reuse

Sources of woody residues used in 2012



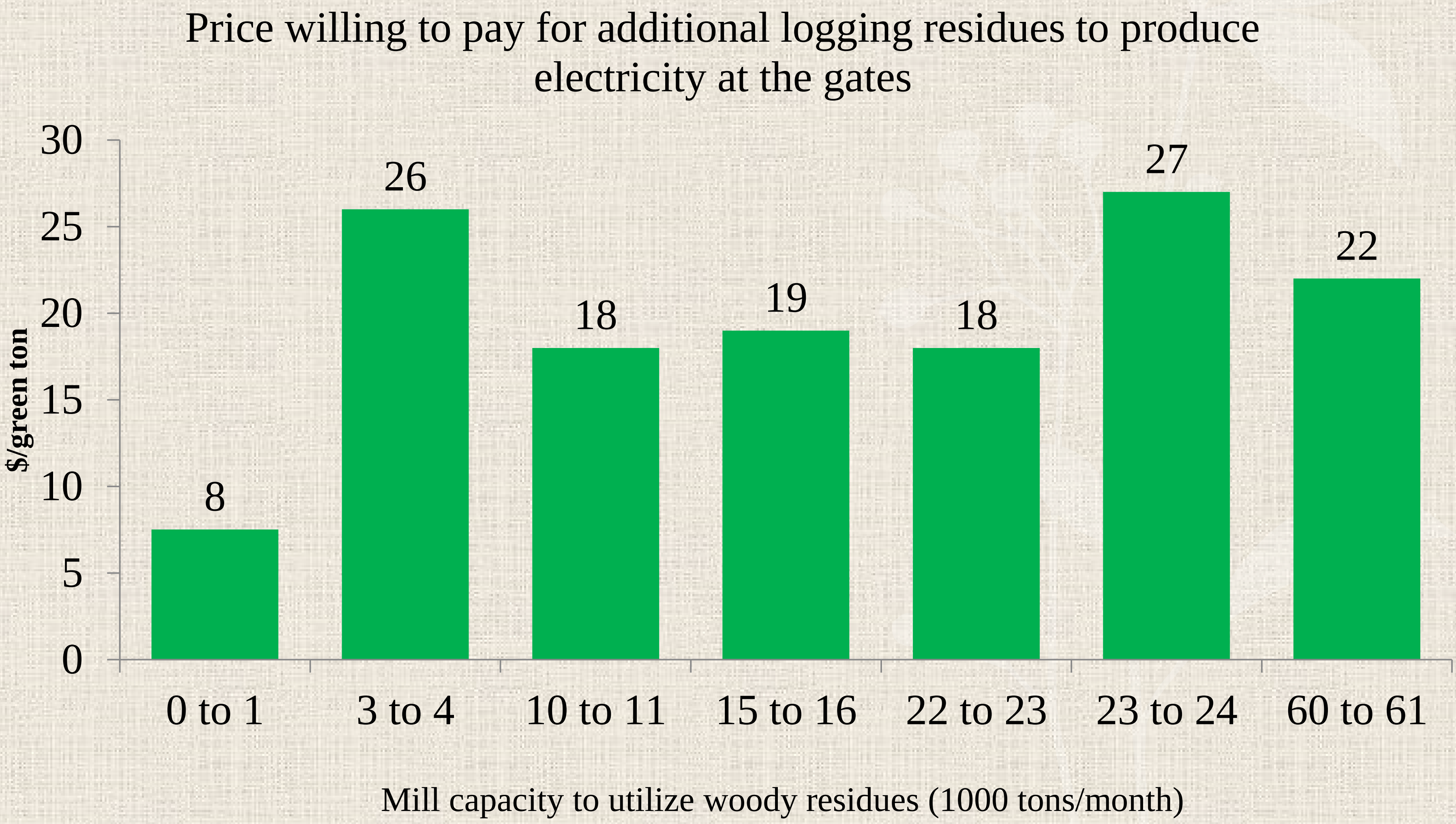
Recycling\Reuse of mill residues



Results: Impact Analysis

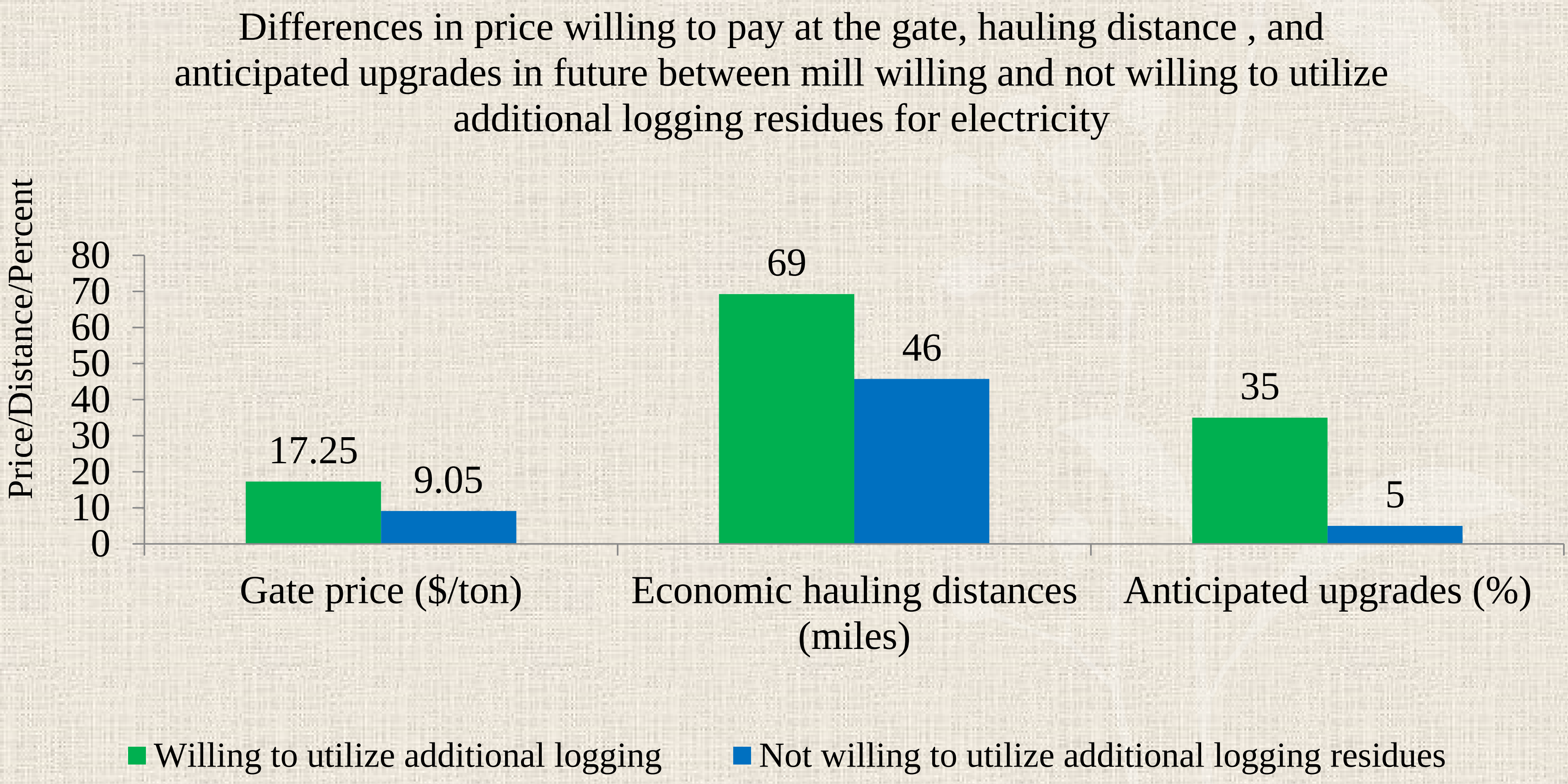
Variable	Mill Type	Capacity	Willingness	Variable Description
will	p<.0001	p<.0001		Willingness to utilize additional logging residues to produce electricity
cap	p=0002			Mill capacity to utilize woody residues to produce bioenergy
use	p<.0001	p<.0001		Utilization of woody residues
disp	p=0.0039	p<.0001		Disposal of mill residues
upgrade	p=0.0029	p<.0001		Past upgrades
future		p=0.0063	p<.00001	Anticipated upgrades in the future
gprice		p=0.0063	p=0.0286	Price willing to pay for additional logging residues at the gate
ehaul			p=0.0219	Distance over which logging residues could be hauled economically
tcost	p=0.006			Transporting cost as a limitation
lstoreb	p=*0.011*			Importance of storage space at the mill

Results



Price willing to pay for additional logging residues to produce electricity at the gates
$/green ton
0
5
10
15
20
25
30
8
26
18
19
18
27
22
0 to 1
3 to 4
10 to 11
15 to 16
22 to 23
23 to 24
60 to 61
Mill capacity to utilize woody residues (1000 tons/month)

Results


Differences in price willing to pay at the gate, hauling distance , and anticipated upgrades in future between mill willing and not willing to utilize additional logging residues for electricity
Price/Distance/Percent
80
70
60
50
40
30
20
10
0
17.25
9.05
69
46
35
5
Gate price ($/ton)
Economic hauling distances (miles)
Anticipated upgrades (%)
Willing to utilize additional logging
Not willing to utilize additional logging residues

Conclusions

- Woody biomass use: not to reduce CO_2 emission/ substitute energy demand, but for disposal as easy and useful method.
- Electricity production: very few but very high utilization.
- Not all mills can utilize logging residues for electricity
  - Saw mills have small operations, pulp mills have higher investments and energy demand.
- Target mills: pulp paper and composite products for competitive advantage
  - Use of biomass for energy would increase price
  - Using additional logging residues could help them
  - Equipment and supply chain more friendly to recover logging residues.

Photo: Robert Grala

Conclusions

- Larger capacity had better chances of additional utilization, higher willingness to use, upgrade, and pay
- Capacity => 3000 tons/month mills were willing to pay price above $18 per green ton ($14.00 per green ton for fuel wood makes hauling biomass economic)
- Mill willingness increased gate price for logging residues
- Willingness and capacity shifts the demand curve outward.
- Incentives to increase willingness
- Policy can have significant impact on demand
- Economic sustainability is unknown ($40 per dry ton of residues if hauled over 35 miles)

Acknowledgement

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