Likelihood of developing wood-based bioenergy in southeastern United States

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Background

- 6 % of US energy is renewable energy
- 47% of renewable energy is from biomass
- Biomass can replace fossil fuels
- Biomass can be used to generate bioenergy
- Important for energy security and CO_2 emission reduction
- Improves biodiversity by reducing risk of forest fire and insect infestation
- Important source of biomass - woody residues
- Expected to account for 18-26% of biomass used for bioenergy by 2031

Background

- Sources of woody residues:
  - Mill residues
  - Logging residues
  - Urban wood residues (construction wood, trees)
- Almost 99% of mill residues is recycled or reused
- Alternative - logging residues (unused tree portions left after logging activities)
- Only 4% of logging residues was utilized in 2006
- Up to 70% of logging residues is available

Objective

- To determine likelihood of utilizing additional logging residues by mills by examining their spatial distribution in the southern United States

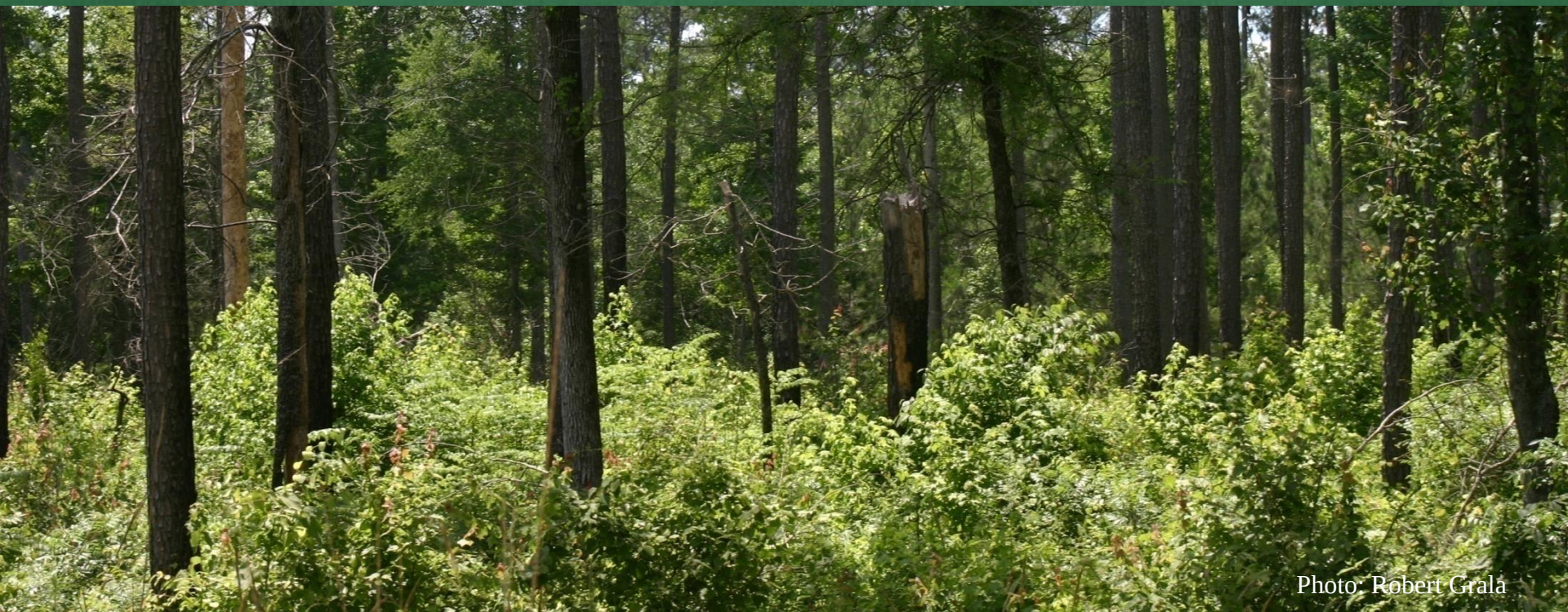
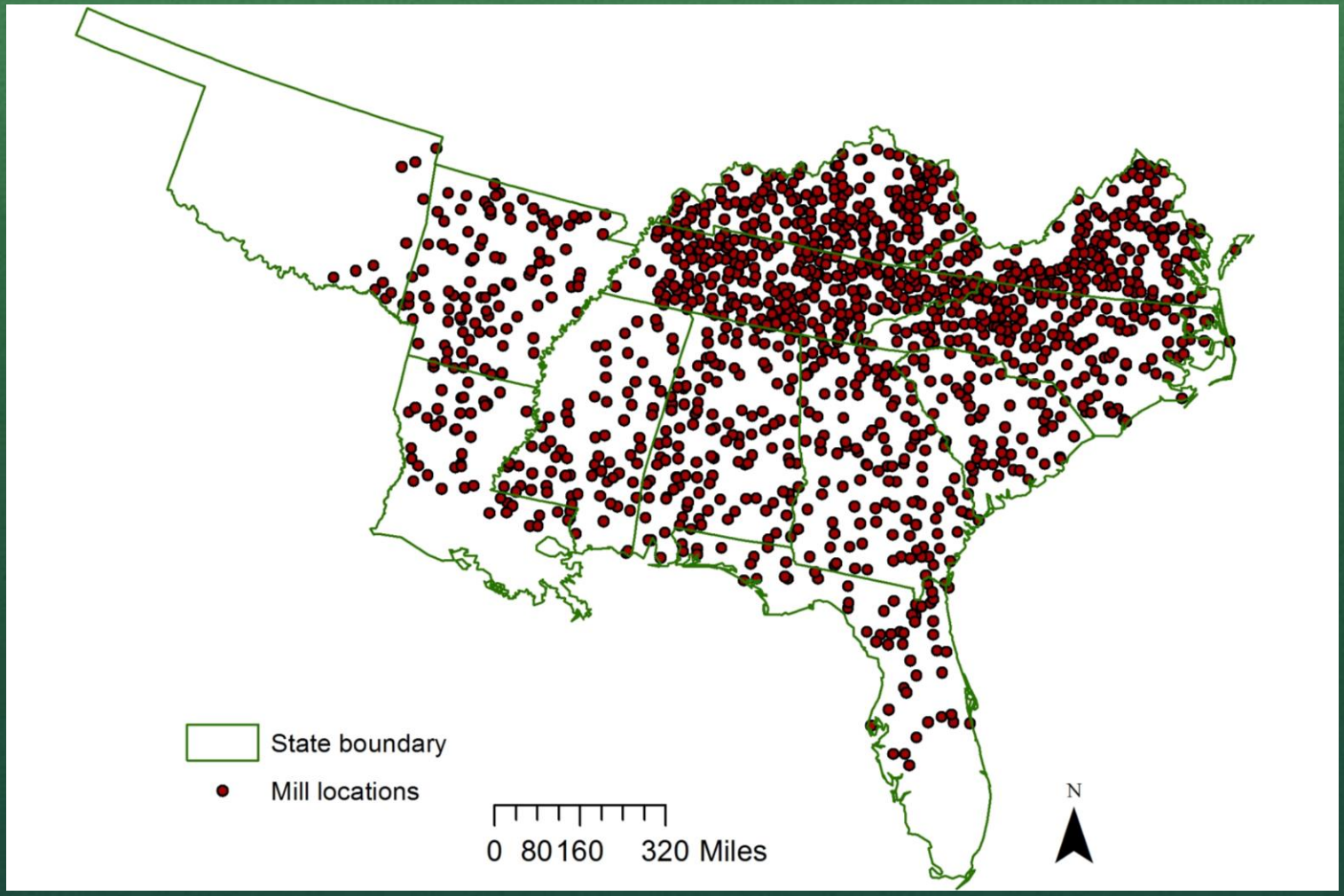


Photo: Robert Grala

Study Area



Methods

- Census survey of forest product manufacturers
- Mill location: List of the 2,138 forest product manufactures in 12 southern states from USDA Southern Research Station
- Mail Survey: (Tailored Dillman's Survey Designed Method)
  - Survey period: October-December 2012
  - Introductory letter followed by three letters with questionnaires

Photos: Robert Grala

Methods

- A spatial logistic regression model: slrm() of spatstat package in R.

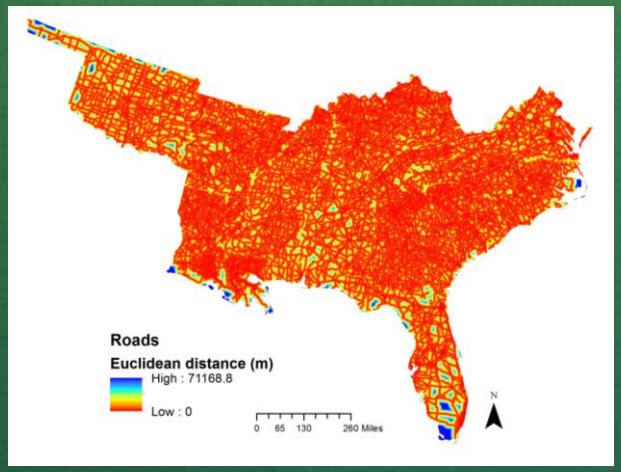
$$Logit\,(P(\,Y_i = 1\,)) = a + \Sigma_i\,\beta_i\,x_i + \gamma\,w_i + \varepsilon$$

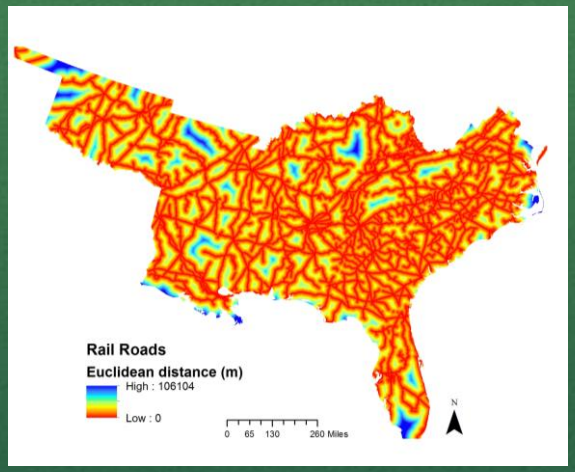
where,

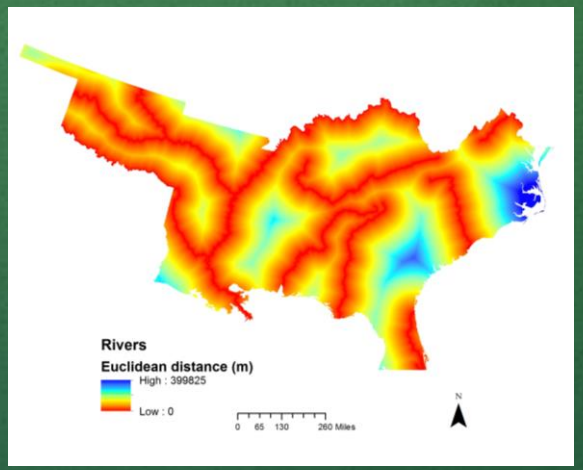
- Y_i is expected probability that mill will utilize additional logging residues for electricity on i^{th} plot
- x_i is a vector of additional individual-level covariates of interest (transportation network, forest cover, and proximity to cities)
- w_i is the weight function that describes influence of one plot onto neighboring plots and usually the distance between plots
- a , β_i, γ are an intercept, parameter estimates of explanatory variable, and a coefficient of spatial weight, respectively

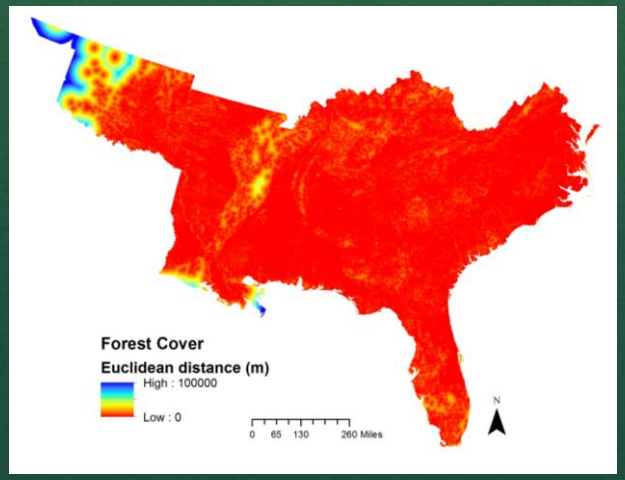
- Esri ArcGIS tools (spatial analyst) were used to prepare data and complete an analysis

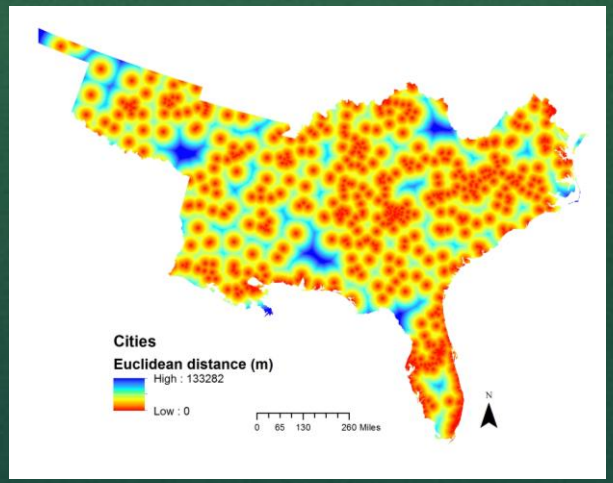
Data


Roads
Euclidean distance (m)
High : 71168.8
Low : 0
0 65 130 260 Miles
N

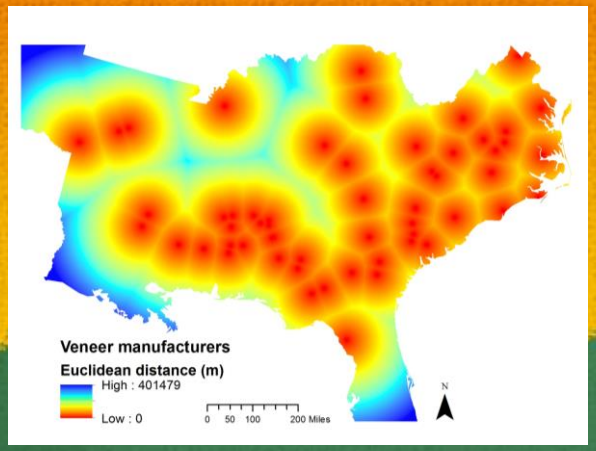

Rail Roads
Euclidean distance (m)
High : 106104
Low : 0
0 65 130 260 Miles
N

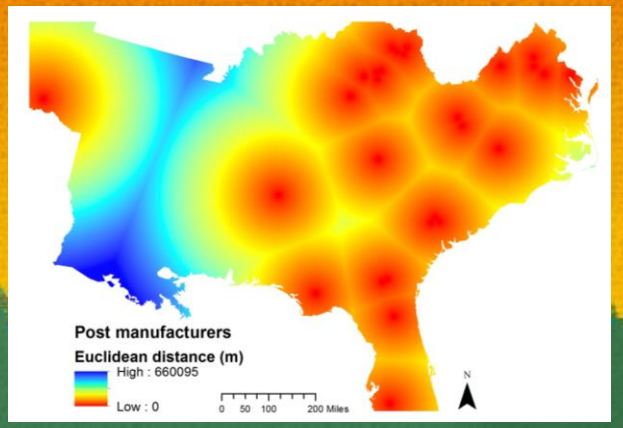

Rivers
Euclidean distance (m)
High : 399825
Low : 0
0 65 130 260 Miles
N

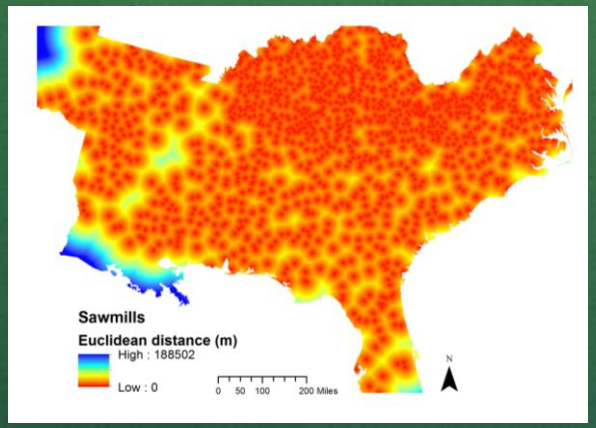

Forest Cover
Euclidean distance (m)
High : 100000
Low : 0
0 65 130 260 Miles
N

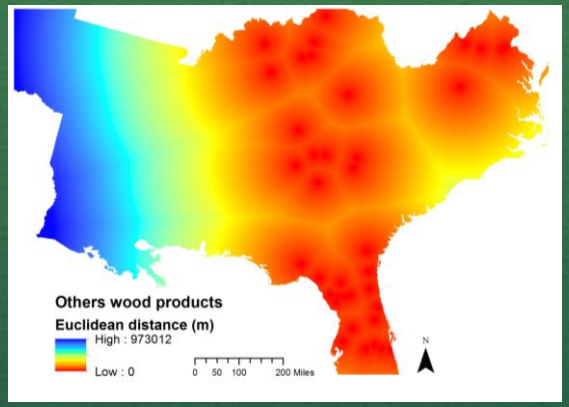

Cities
Euclidean distance (m)
High : 133282
Low : 0
0 65 130 260 Miles
N

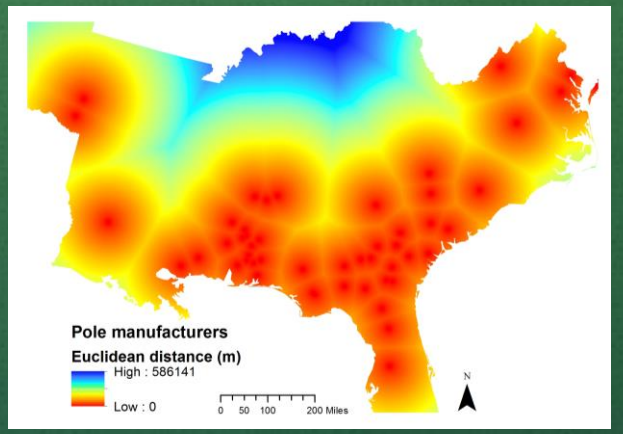
Data

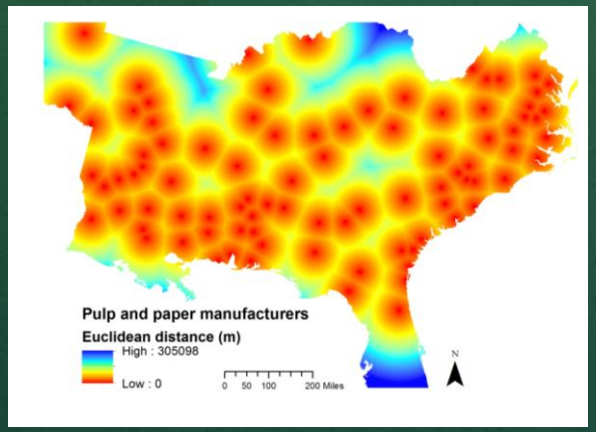

Veneer manufacturers
Euclidean distance (m)
High : 401479
Low : 0
0 50 100 200 Miles
N

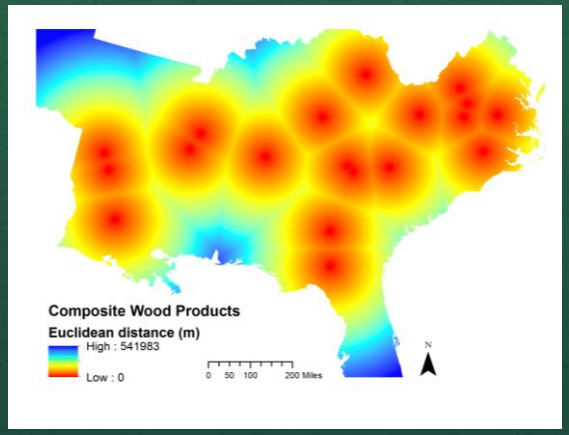

Post manufacturers
Euclidean distance (m)
High : 660095
Low : 0
0 50 100 200 Miles
N

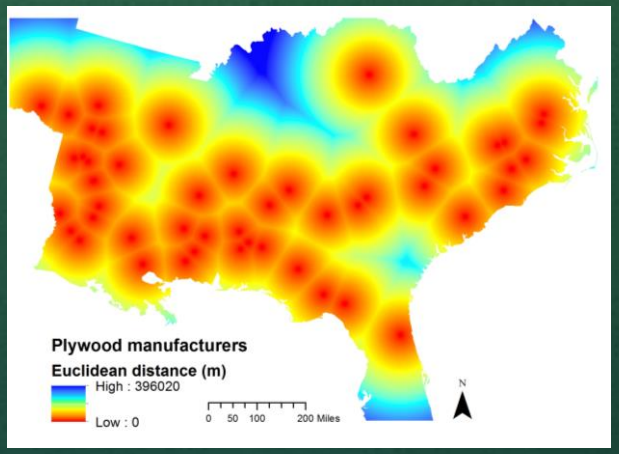

Sawmills
Euclidean distance (m)
High : 188502
Low : 0
0 50 100 200 Miles
N


Others wood products
Euclidean distance (m)
High : 973012
Low : 0
0 50 100 200 Miles
N


Pole manufacturers
Euclidean distance (m)
High : 586141
Low : 0
0 50 100 200 Miles
N


Pulp and paper manufacturers
Euclidean distance (m)
High : 305098
Low : 0
0 50 100 200 Miles
N

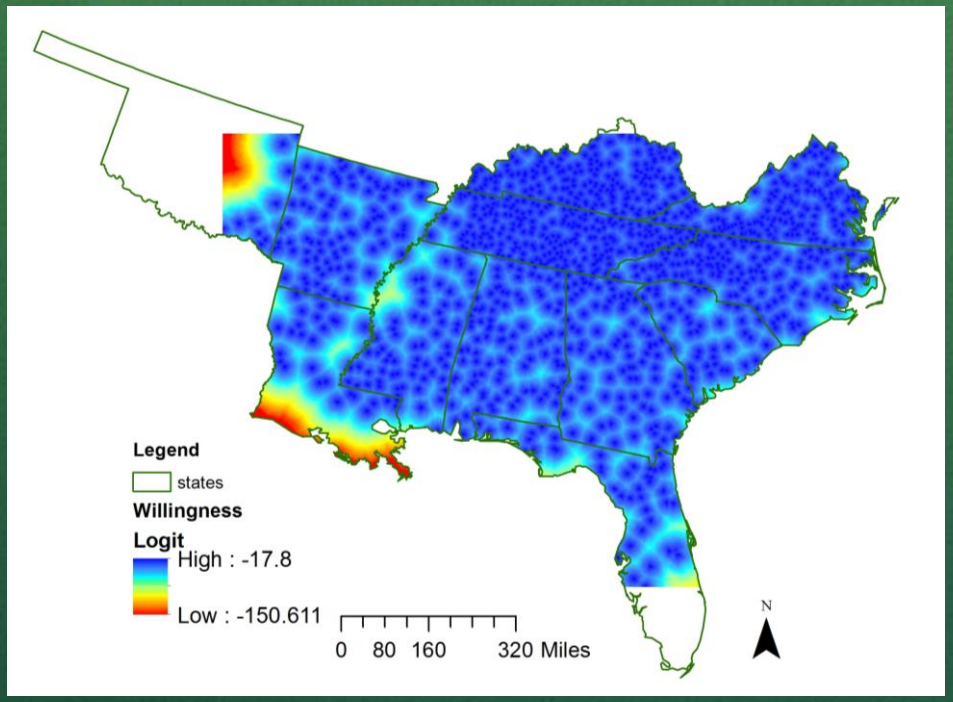

Composite Wood Products
Euclidean distance (m)
High : 541983
Low : 0
0 50 100 200 Miles
N

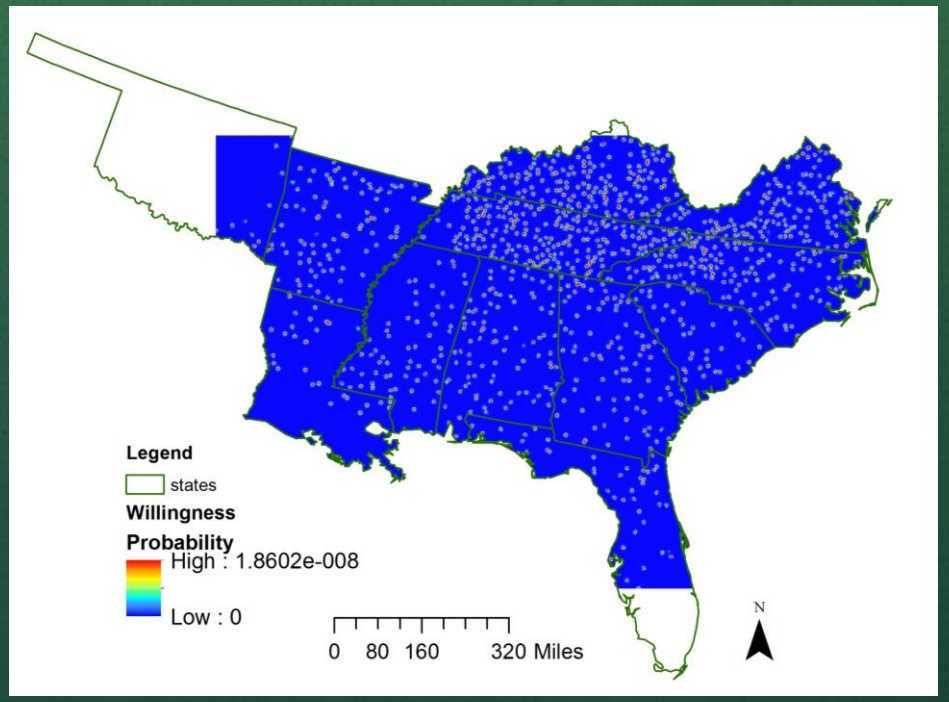

Plywood manufacturers
Euclidean distance (m)
High : 396020
Low : 0
0 50 100 200 Miles
N

Results

	Model 1		Model 2		Model 3		Model 4	
Variable	Estimates	p-value	Estimates	p-value	Estimates	p-value	Estimates	p-value
Intercept	-1.81E+01	1.00E-201	-1.84E+01	1.858E-287	-1.77E+01	0	-1.78E+01	0
Roads	-3.13E-04	1.65E-07	-3.09E-04	1.975E-07	-3.24E-04	7.59083E-08	-3.23E-04	7.9E-08
Sawmill	-6.20E-04	8.25E-81	-6.20E-04	8.1131E-81	-6.40E-04	3.34471E-82	-6.40E-04	2.9E-82
Pulp	-3.40E-06	4.10E-02	-3.06E-06	0.04826515	-1.72E-06	0.125067109		
Y (Lat.)	-5.89E-07	1.19E-01	-6.83E-07	0.05070756				
Rivers	1.81E-12	5.00E-01	-1.46E-06	0.12656136				
Cities	-1.25E-06	3.58E-01	-5.80E-07	0.43055196				
Other mills	1.07E-06	9.27E-01	1.24E-06	0.99594106				
Plywood	-1.08E-06	2.10E-01	1.52E-06	0.96211273				
Post	-1.51E-06	6.14E-02	-1.07E-07	0.45062328				
Rail roads	5.66E-06	0.810372						
X (Long.)	-6.65E-09	0.492024						
Forest cover	1.75E-05	0.695333						
Composite wood	3.17E-07	0.627805						
Pole	1.73E-06	0.963751						
Veneer	-1.62E-06	0.13138						
Loglikelihood	-5181.422		-5182.95		-5185.553		-5186.113	
AIC	10394.84		10368.86		10379.11		10378.23	

Results


Legend
states
Willingness
Logit
High : -17.8
Low : -150.611
0 80 160 320 Miles
N


Legend
states
Willingness
Probability
High : 1.8602e-008
Low : 0
0 80 160 320 Miles
N

Conclusion

- Willingness to utilize logging residues for electricity is very low
- North has more but not statistically significant
- Sawmill location and roads are sufficient conditions to increase willingness
- Tennessee and Kentucky are states where willingness is higher.

Conclusion

- Investment to increase capacity is very high (single unit may cost millions of dollars).
- Utilization of logging residues is limited, therefore, mills may have insignificant concerns related to transportation costs and other factors in the model.
- Upgrades and transportation cost optimization can increase mill willingness to utilize logging residues.
- Increased mill willingness would increase price mills are willing to pay for logging residues and increase a hauling distance. It would further increase feasibility of logging residues utilization.

Acknowledgements