



Forest Biomass as a Feedstock for Energy Production

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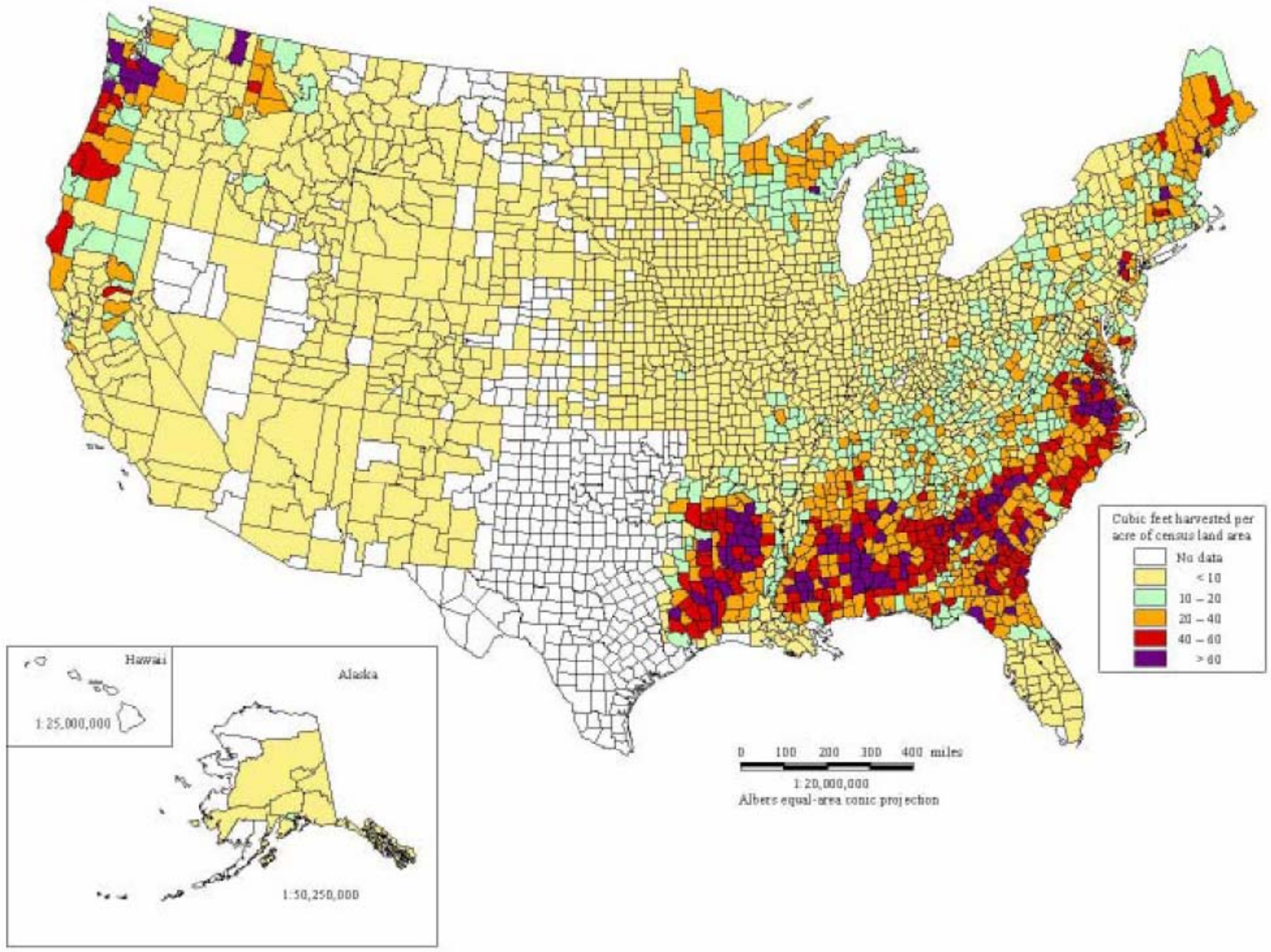
Outline

- Georgia's Forest Resources
- Integrated approach with the forest Industry
- Trees as dedicated energy crops
- Feedstock physical characteristics
- Feedstock availability
- Estimated costs

TYPES OF FOREST BIOMASS

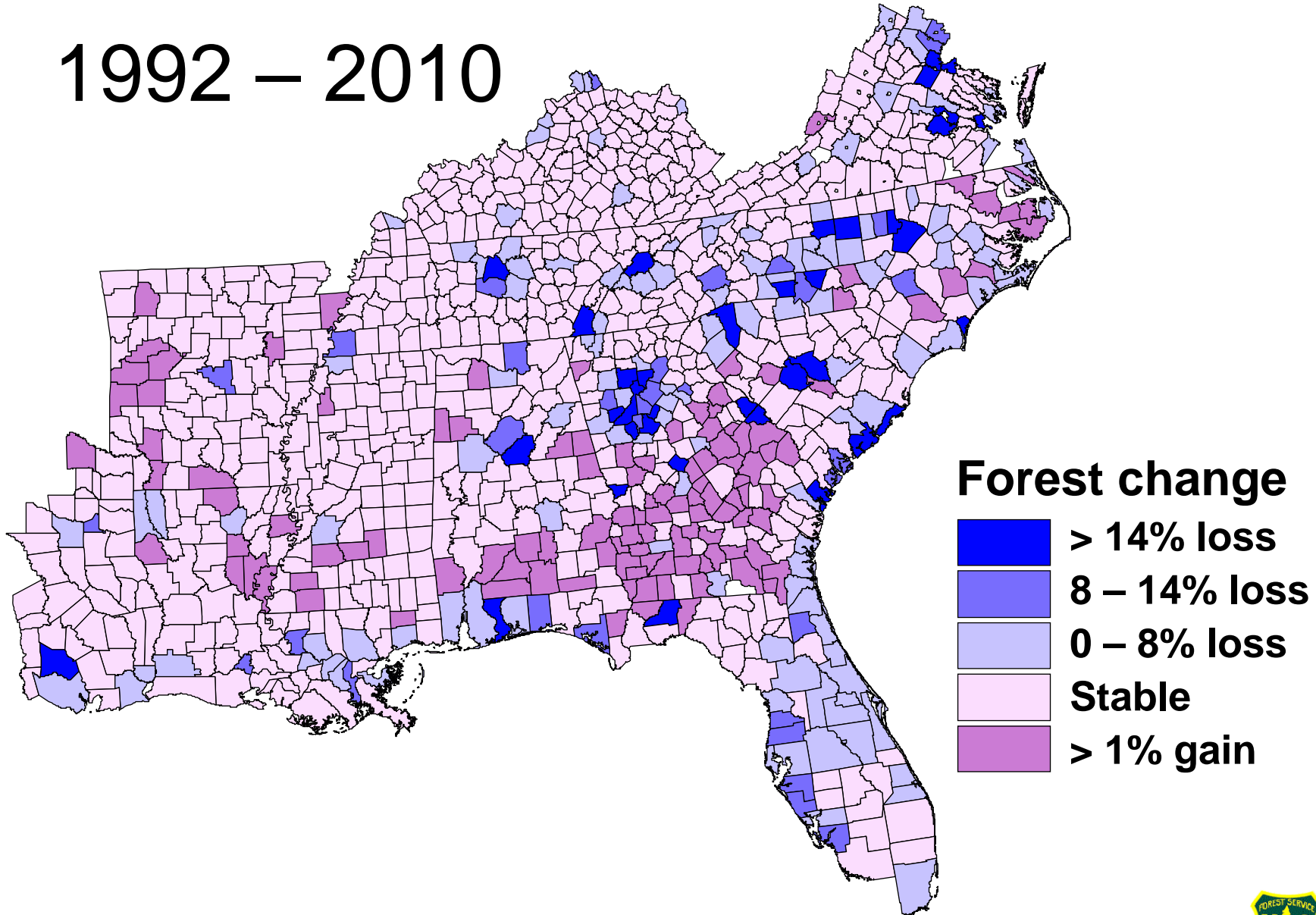


US Forest Product Output - 1996



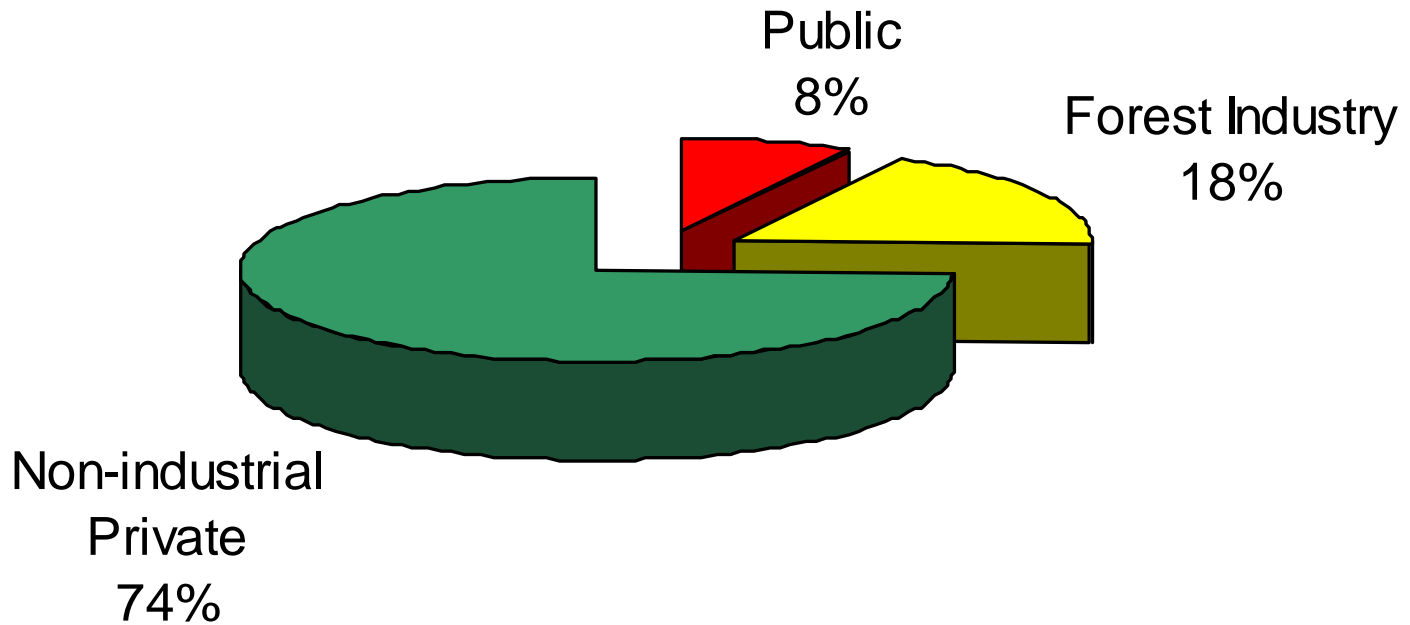


Forecast Change in Forestland 1992 – 2010



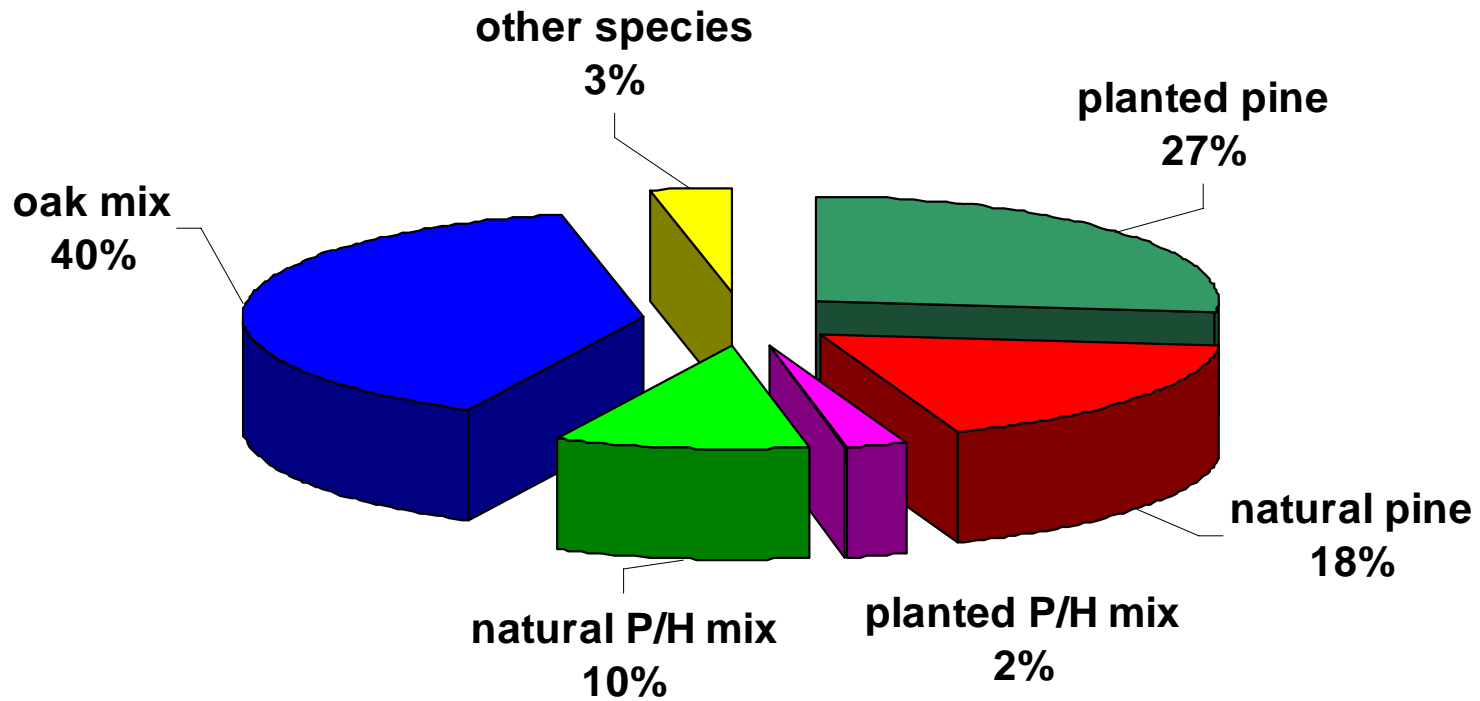


Forestland Ownership in Georgia - 2004



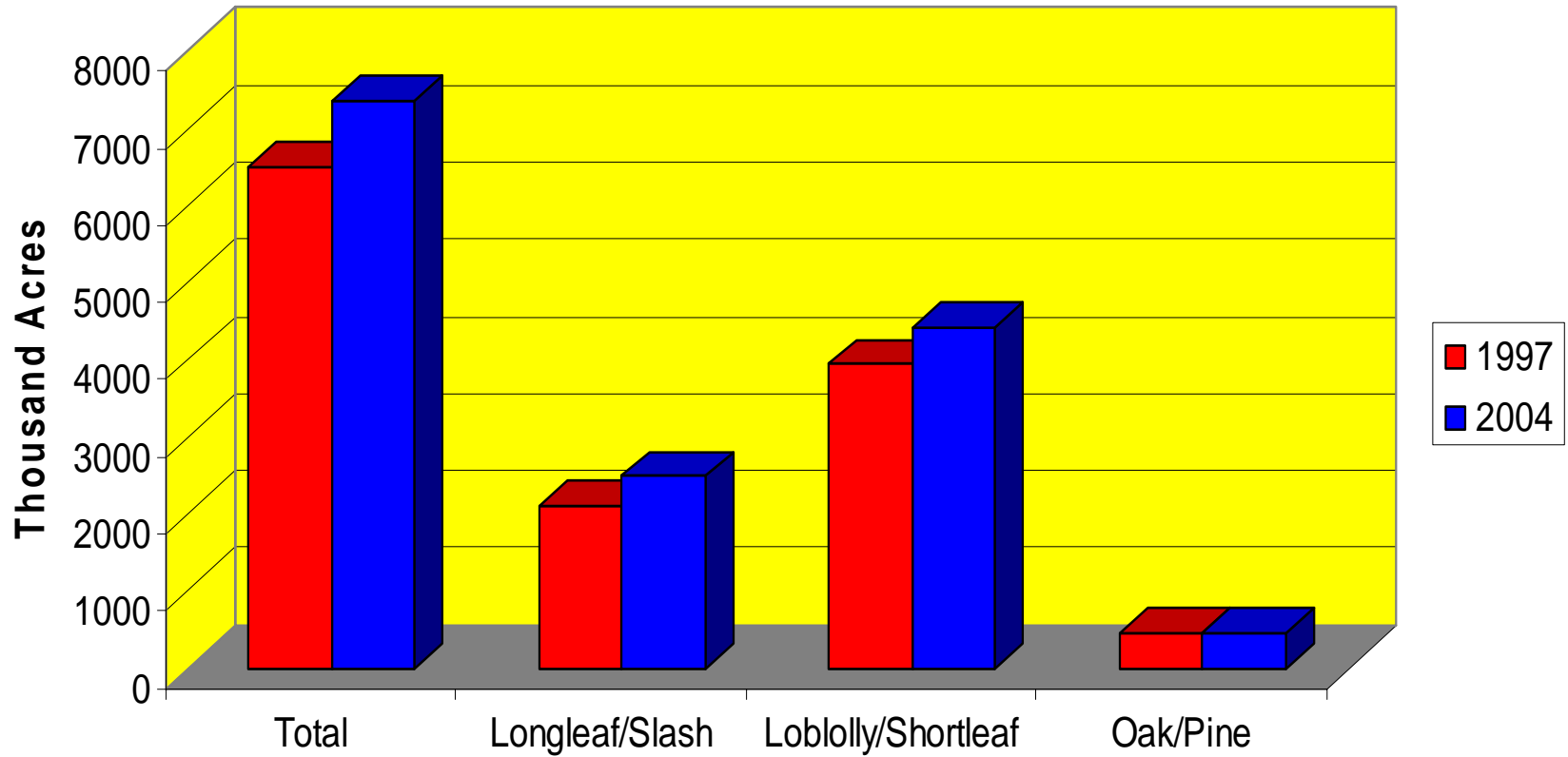


Forest Stand Types in Georgia



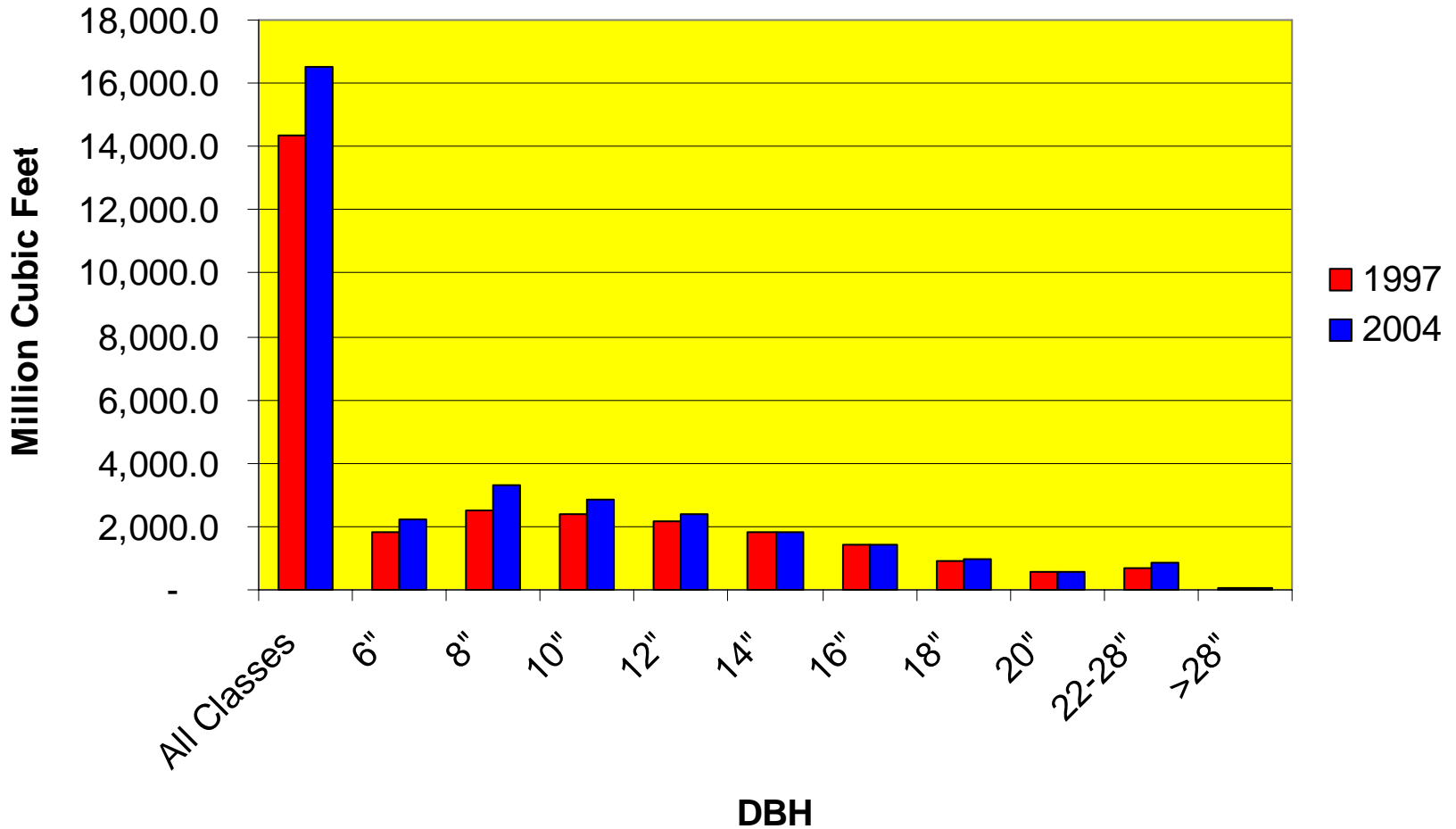


Georgia Planted Timberland



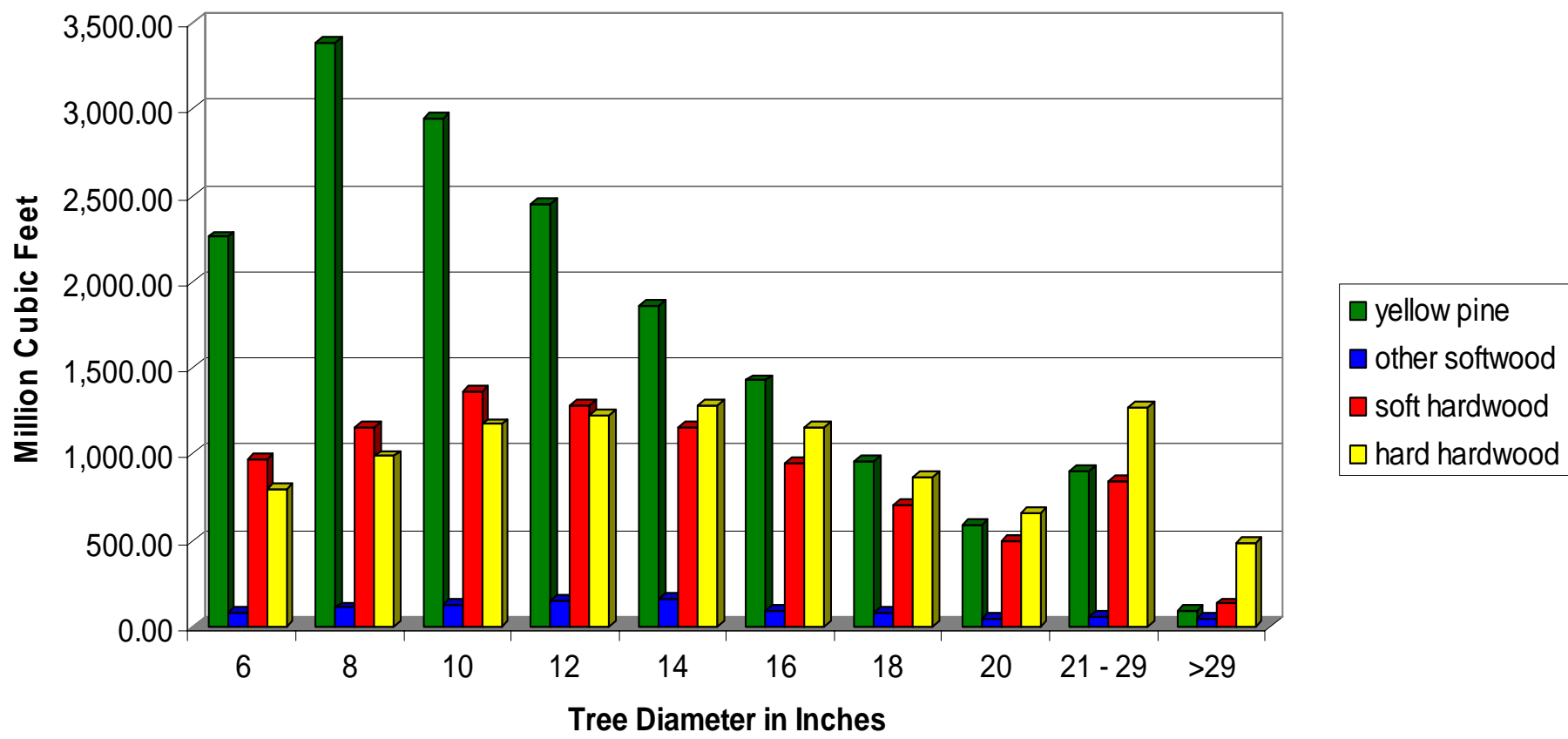


Volume of Yellow Pine Growing Stock by DBH - Georgia





Wood Volume of Trees By Species Group and Diameter Class in Georgia



Source: Forest Inventory and Analysis data, USFS Southern Research Station, 2004 data

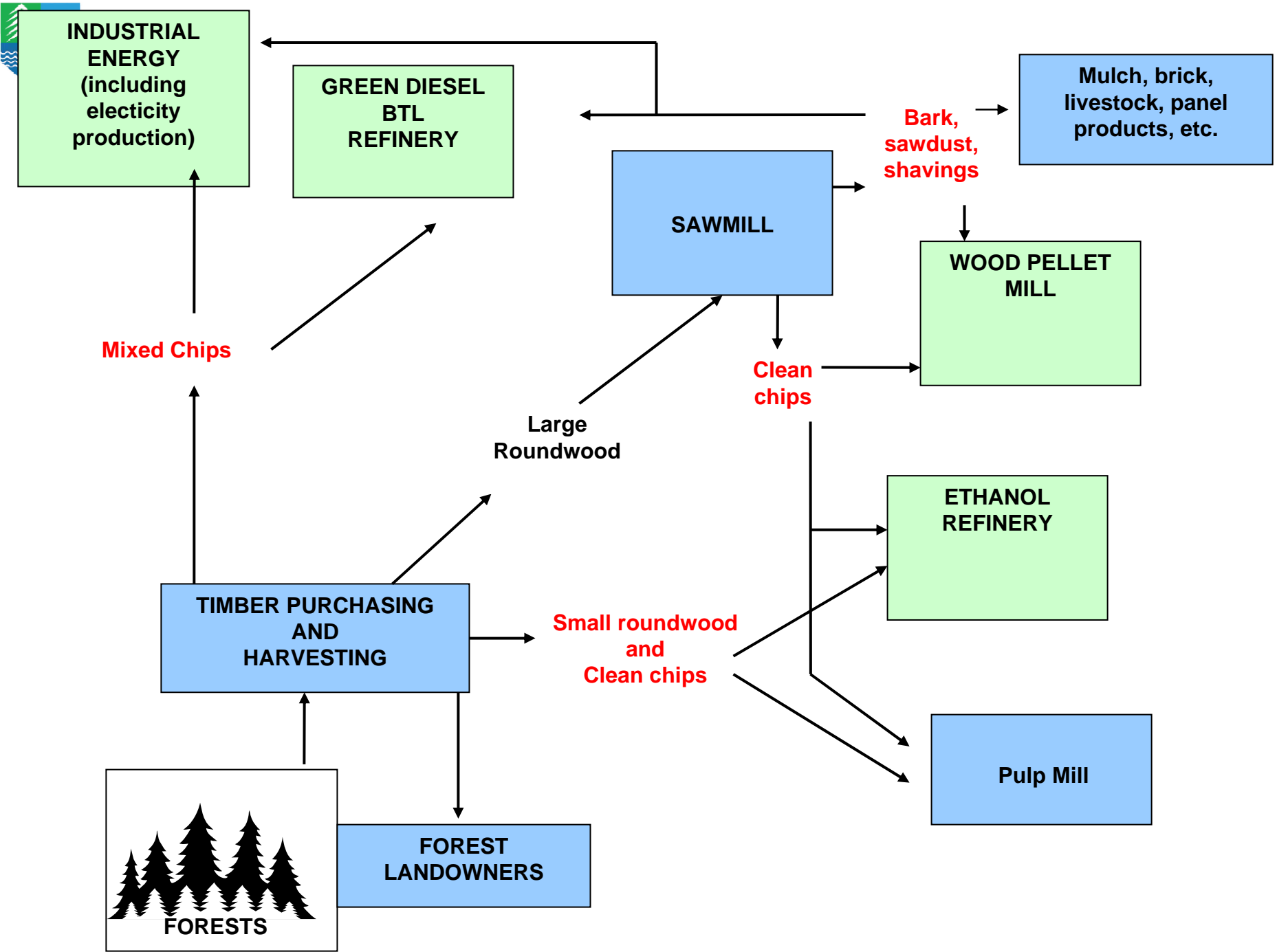


Integration of
energy industry
into
forest industry

Trees as
dedicated
energy
crops

MANAGED
FORESTS

FOREST PRODUCT
MANUFACTURING



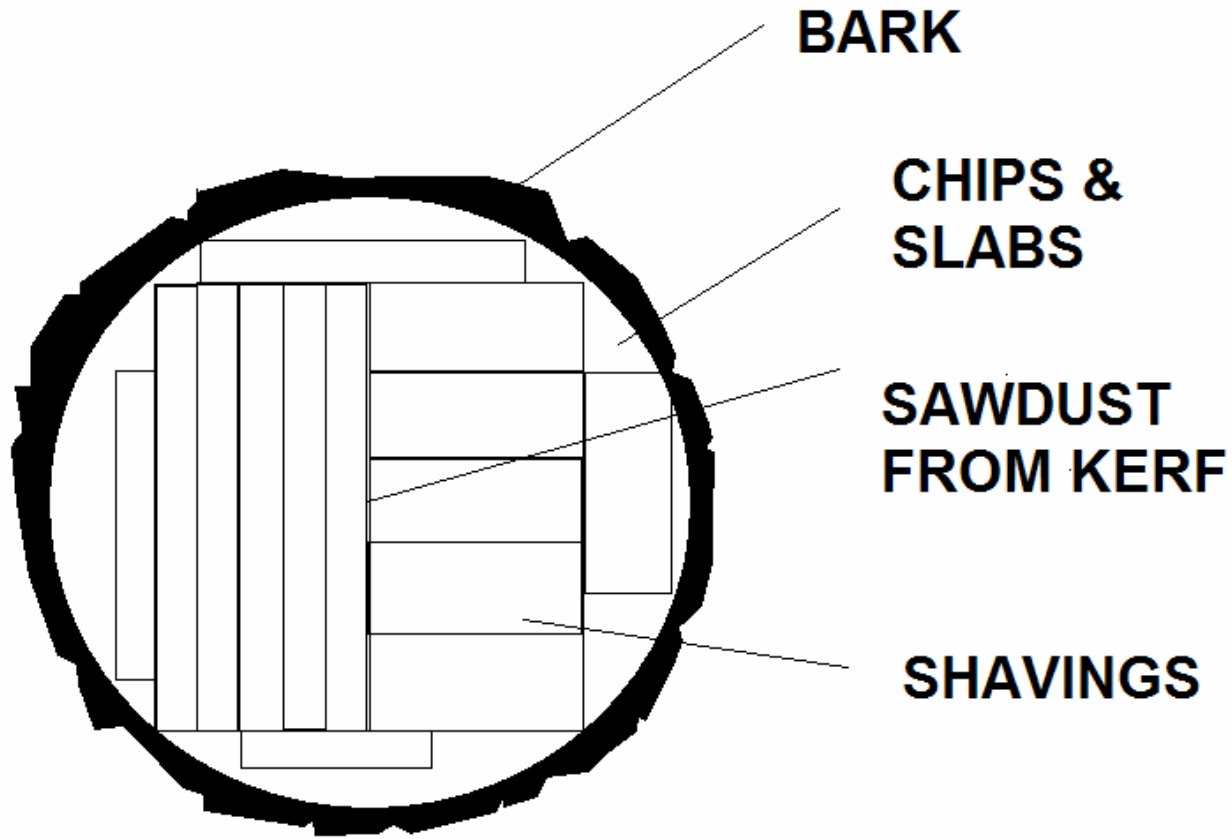


Biomass from the Forest





Forest Manufacturing Residues



BARK

**CHIPS &
SLABS**

**SAWDUST
FROM KERF**

SHAVINGS



Types of Forest Biomass Feedstocks

TYPES	SPECIES	COMMON SOURCES	USE
CLEAN CHIPS	MOSTLY PINE	ROUNDWOOD CHIPPERS AT LOGGING SITE CHIP MILLS BY-PRODUCT FROM SAWMILLS	PULP CELLULOSIC ETHANOL PELLETS
MIXED CHIPS (DIRTY CHIPS)	MIXED P/H	CHIPPERS OR TUB GRINDERS AT LOGGING SITE BY-PRODUCT FROM SAWMILLS WHERE SLABS ARE CHIPPED WITH BARK ON CHIPPED TREES FROM LAND CLEARING BY CONTRACTORS OR LANDFILLS	BOILER FUEL GASIFICATION TO CREATE NATURAL GAS REPLACEMENT GASIFICATION FOLLOWED BY FISHER TROPES TO PRODUCE GREEN DIESEL
BARK	PINE	BY-PRODUCT FROM SAWMILLS	BOILER FUEL OR GASIFICATION
SAWDUST	PINE OR HARDWOOD	BY-PRODUCT FROM SAWMILLS	ANIMAL BEDDING PANEL PRODUCTS BRICKS PELLETS
SHAVINGS	PINE OR HARDWOOD	BY-PRODUCT FROM SAWMILLS	ANIMAL BEDDING PELLETS
DRY BOILER CHIPS	MIXED PINE, OTHER SOFTWOOD, AND HARDWOOD	DEMOLITION WOOD CHIPPED BY CONTRACTORS OR LANDFILLS	BOILER FUEL OR GASIFICATION



Physical Characteristics of Forestry Feedstocks

TYPES	SPECIES	MOISTURE CONTENT	ENERGY VALUE BTU/LB	DENSITY green lbs/cu ft
CLEAN CHIPS	MOSTLY PINE	40-50	7000 - 10,000 btu/lb dry basis	23 (hdwd)
MIXED CHIPS (DIRTY CHIPS)	MIXED P/H	40-50		19
BARK	PINE	40-50		
SAWDUST	PINE OR HARDWOOD	40		23
SHAVINGS	PINE OR HARDWOOD	8		
DRY BOILER CHIPS	MIXED PINE, OTHER SOFTWOOD, AND HARDWOOD	12	3000 - 4800 btu lb green wood	11
				16



INDUSTRIAL ENERGY
(including electricity production)

GREEN DIESEL BTL REFINERY

SAWMILL

Mulch, brick, livestock, panel products, etc.

WOOD PELLET MILL

ETHANOL REFINERY

Pulp Mill

Mixed Chips

Large Roundwood

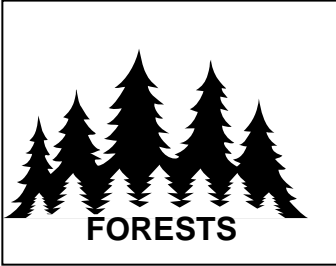
Clean chips

Bark, sawdust, shavings

Small roundwood and Clean chips

TIMBER PURCHASING AND HARVESTING

FOREST LANDOWNERS



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Integration with Forest Products Industry for Clean Pine Fiber from Pine Plantations

Loblolly pine yield (g tons/ac/yr) on average site:

Pulpwood	2.0
Small sawtimber	2.1
Large sawtimber	1.7

Source: Dickens, et al; Forest Economics papers using GaPPS, Univ. of Georgia; 2004

2222 2222 222



Yr 0.....thin at 15 yrs.....thin at 24 yrs.....harvest at Yr 33



Supplying a Bio-refinery with Clean Pine Fiber - Integrated Approach

- **Assume that 1,000,000 green tons are needed each year**
- **Assume that 10% can be obtained from sawmills in the form of chips and sawdust**
- **900,000 green tons needed from the forest**
- **900,000 tons divided by 2 tons per ac = 450,000 acres of pine plantations in active management within 75 miles are needed**
- **Harvests in natural stands will also supply significant amounts of fiber**



Supplying a Pellet Mill with Clean Pine Fiber

- **The best fiber is dry sawdust**
- **Green sawdust produced at sawmills is the likely source**
 - **Supply contract with sawmill**
 - **Conversion 300-350 tons sawdust per MMBF**
- **Pulpwood-sized logs can be converted to pellets through processing.**



Supplying a Bio-refinery with Mixed Chips

- **Potential sources are logging slash, wood from land clearing and tree trimming (urban), and mill residues**
- **Timber Product Output reports show that about 16% of the wood involved in timber harvests is logging slash – a harvested wood:logging slash ratio of 5:1**
- **If half of the logging slash can be efficiently collected, then one ton of logging slash can be produced for every 10 tons of wood product**
- **Locating near other forest products industries that use clean fiber or roundwood may be an advantage**
- **UGA Study Results will be presented.**



Pines as a Dedicated Energy Crop

Loblolly pine yield on average site:

6.48 green tons per acre per year

Slash pine yield on average site:

5.77 green tons per acre per year

Source: Dickens, et al; Forest Economics papers using GaPPS, Univ. of Georgia; 2004

222

2222

222222



Yr 0.....growth.....harvest at Yr 24



Supplying a Bio-refinery with Pines Dedicated to Energy

- **Assume that 1,000,000 green tons of clean fiber are needed each year**
- **Assume that 10% can be obtained from sawmills in the form of chips and sawdust**
- **900,000 green tons needed from the forest**
- **900,000 green tons divided by 6 tons per ac = 150,000 acres of pine plantations managed on a short rotation (24 years) within 75 miles are needed.**
- **The same 150,000 acres will likely supply 60,000 - 90,000 tons of mixed chips from logging residues**
- **Harvests in natural stands will also supply significant amounts of fiber**



Biomass Availability

- **Site specific**
- **Statewide**

- **Forest**
- **Mill Residues**
- **Other wood wastes**



Georgia Biomass from Forestry Sources – 2005 Statewide Report

Table 1. Wood Resources Generated and Amount Unutilized

Wood Resources	Units	Amount Generated	% Unutilized	Amount Available
Unmerchantable Timber (20 year Growth Cycle)	dry tons	13,260,175	100%	13,260,175
Harvesting Residues	dry tons	5,314,287	95%	5,048,572
Mill Residues	dry tons	7,970,276	1%	79,703
Urban Wood Waste @ \$12.50/dt	dry tons	86,209	100%	86,209
Pecan Shells	dry tons	22,297	95%	21,182
Paper Mill Sludge	dry tons	395,210	95%	375,449
Black Liquor Production	dry tons	12,066,840	0%	-
TOTAL		39,115,295		18,871,292

Source: General Bioenergy, Inc. 2005



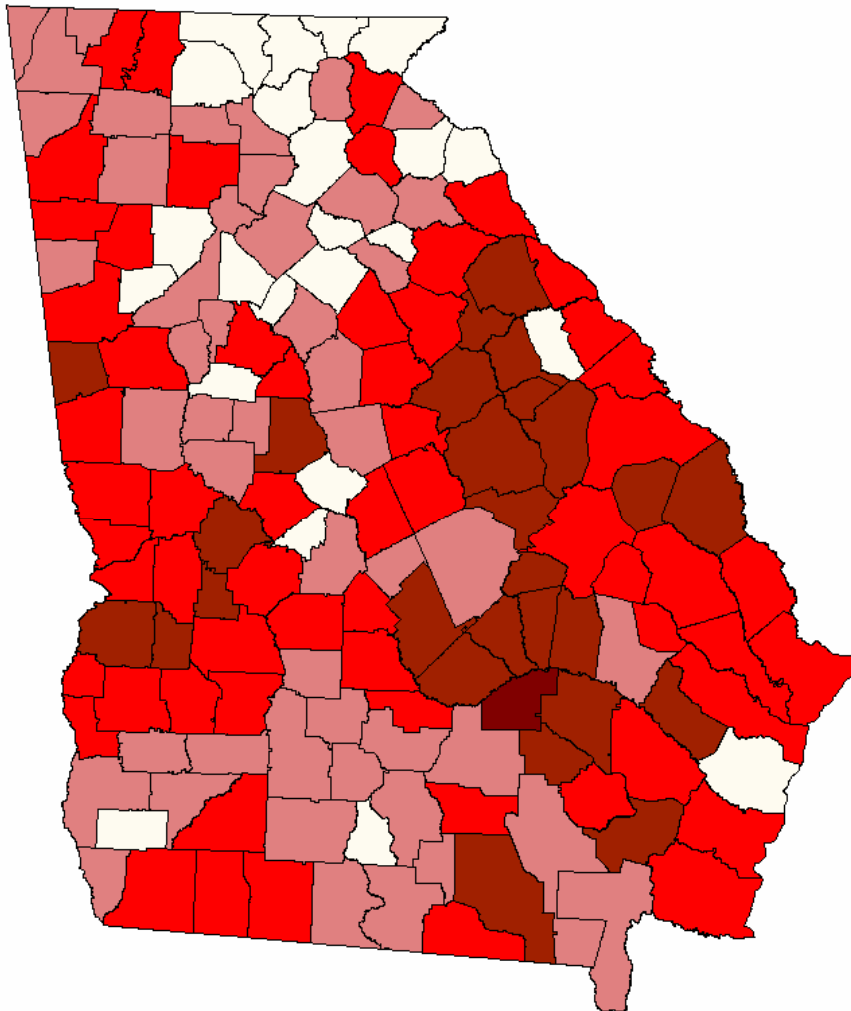
Georgia Biomass from Forestry Sources – 2005 Statewide Report

Table 1. Wood Resources Generated and Amount Unutilized

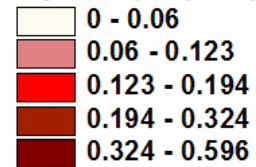
Wood Resources	Units	Amount Generated	% Utilized	Amount Available
Unmerchantable Timber (20 year Growth Cycle)	dry tons	13,260,175	100%	13,260,175
Harvesting Residues	dry tons	5,241,000	100%	5,241,000
Mill Residues	dry tons	1,000,000	100%	1,000,000
Urban Wood Waste	dry tons	86,209	100%	86,209
Pecan Shells	dry tons	22,297	95%	21,182
Paper Mill Sludge	dry tons	395,210	95%	375,449
Black Liquor Production	dry tons	12,066,840	0%	-
TOTAL		39,115,295		18,871,292

22% of Georgia's Energy Consumption

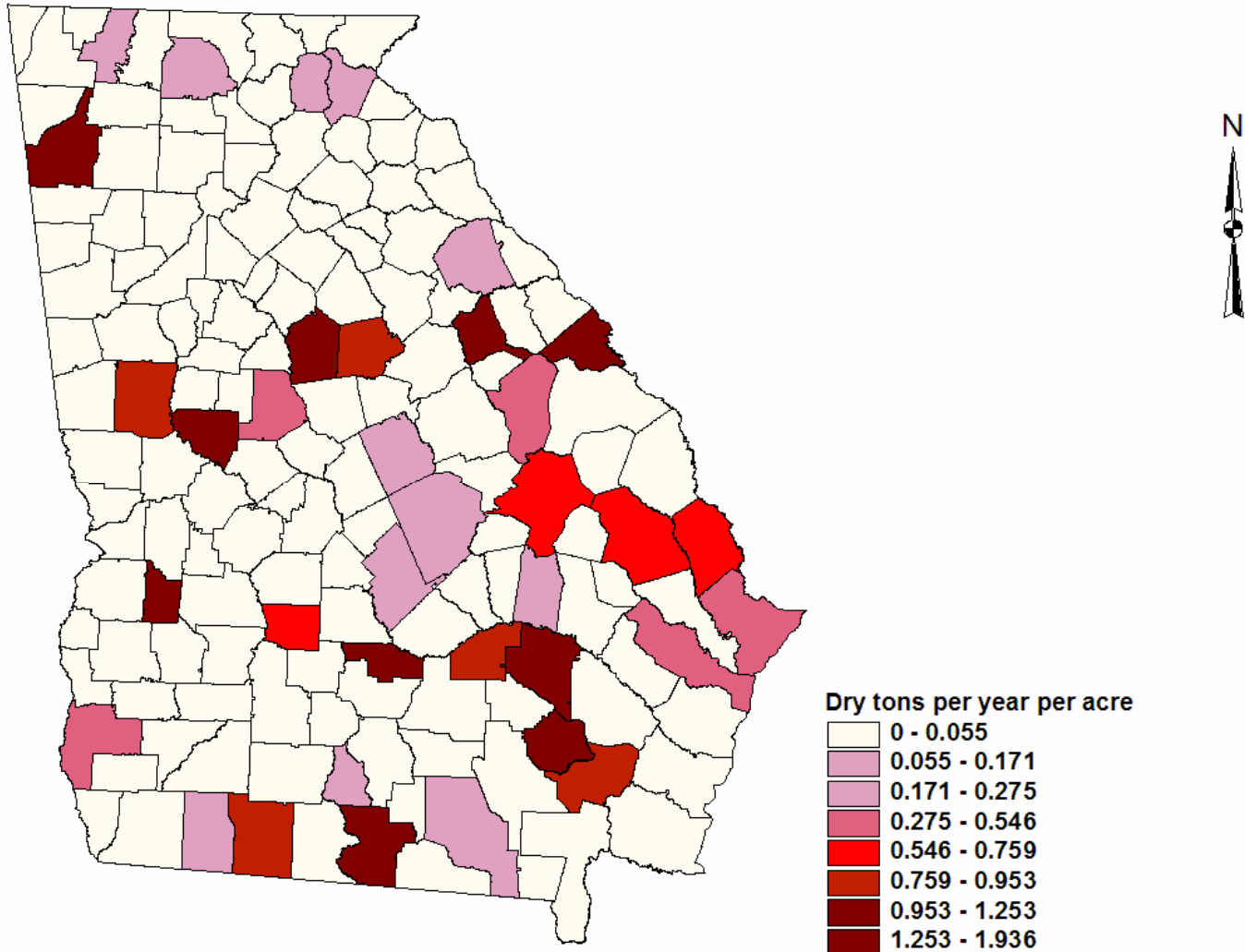
Georgia Logging Residues



Dry tons per year per acre (all land)



Georgia Forestry Biomass - Dry Mill Residues



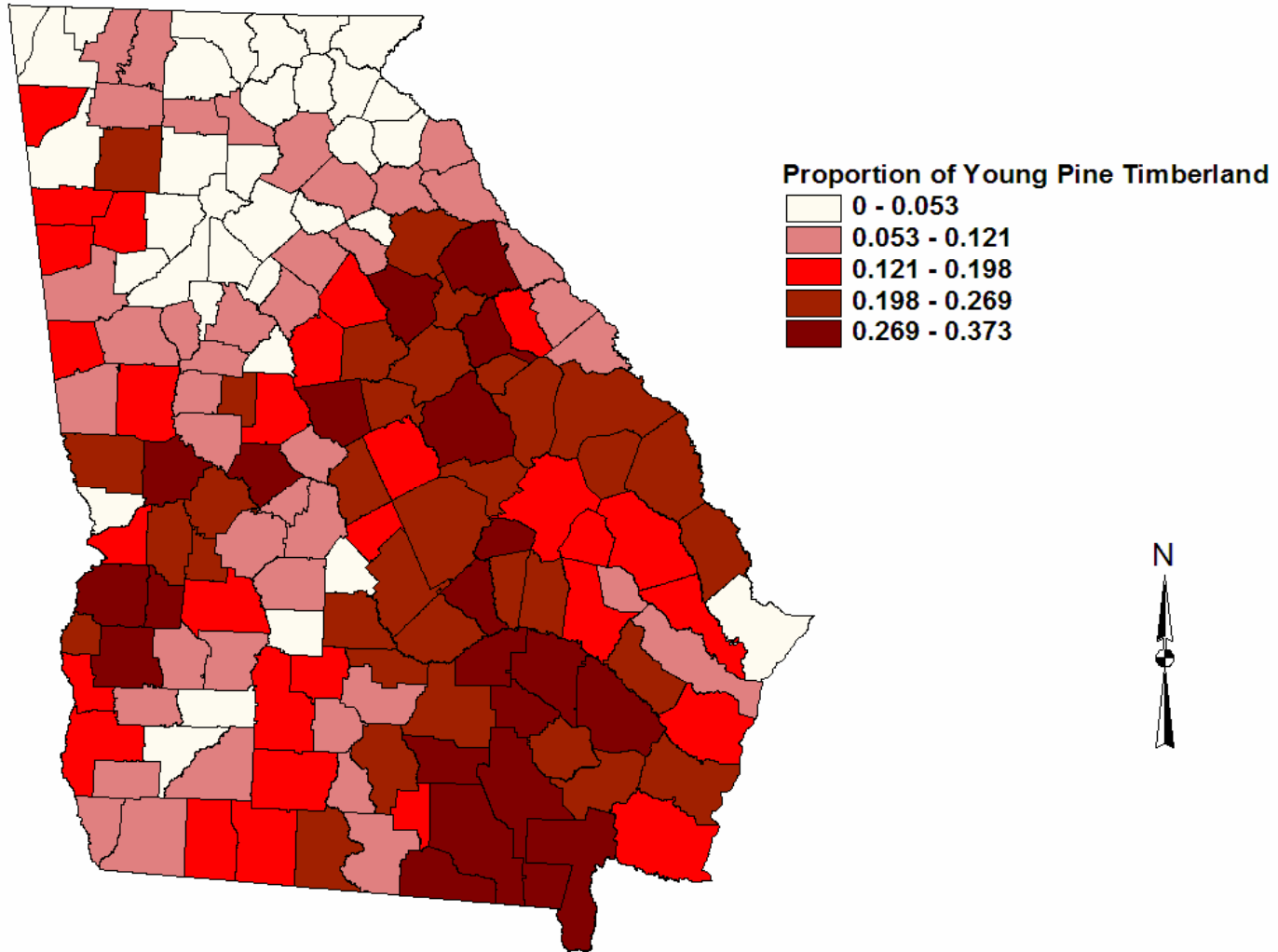
100 0 100 200 Miles



“Merchantable” Wood for Energy

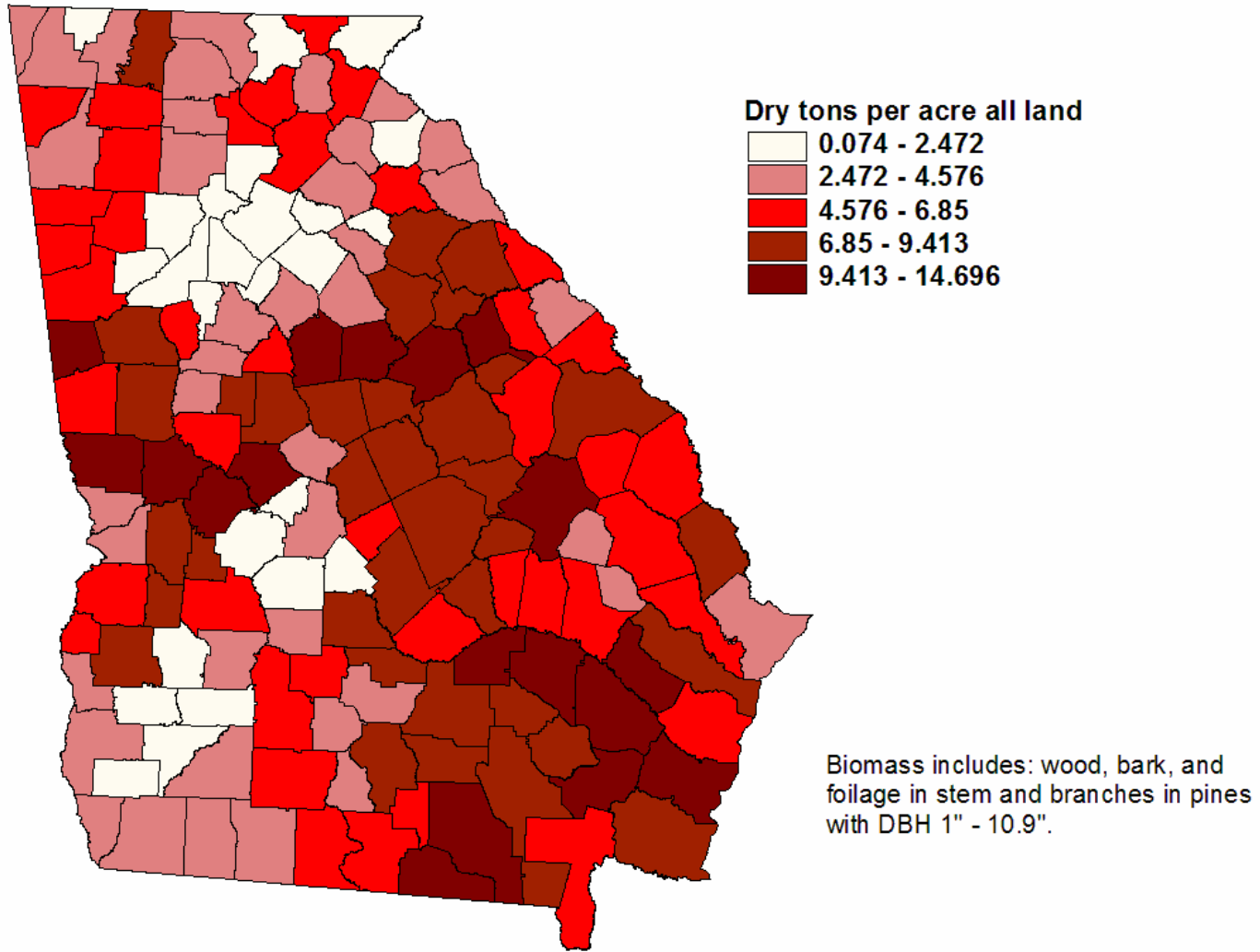
- **Wood in sound trees at least 5” in diameter at breast height. Wood is measured from stump height to a 4” top diameter.**
- **Softwood tree volume has increased an average of 5 million dry tons per year for the last seven years**
- **Lowest value “merchantable” wood is from first thinnings of pine plantations -- 5.6 million tons available annually**

Pine Timberland Less Than 20 years Old as Proportion of Total Land



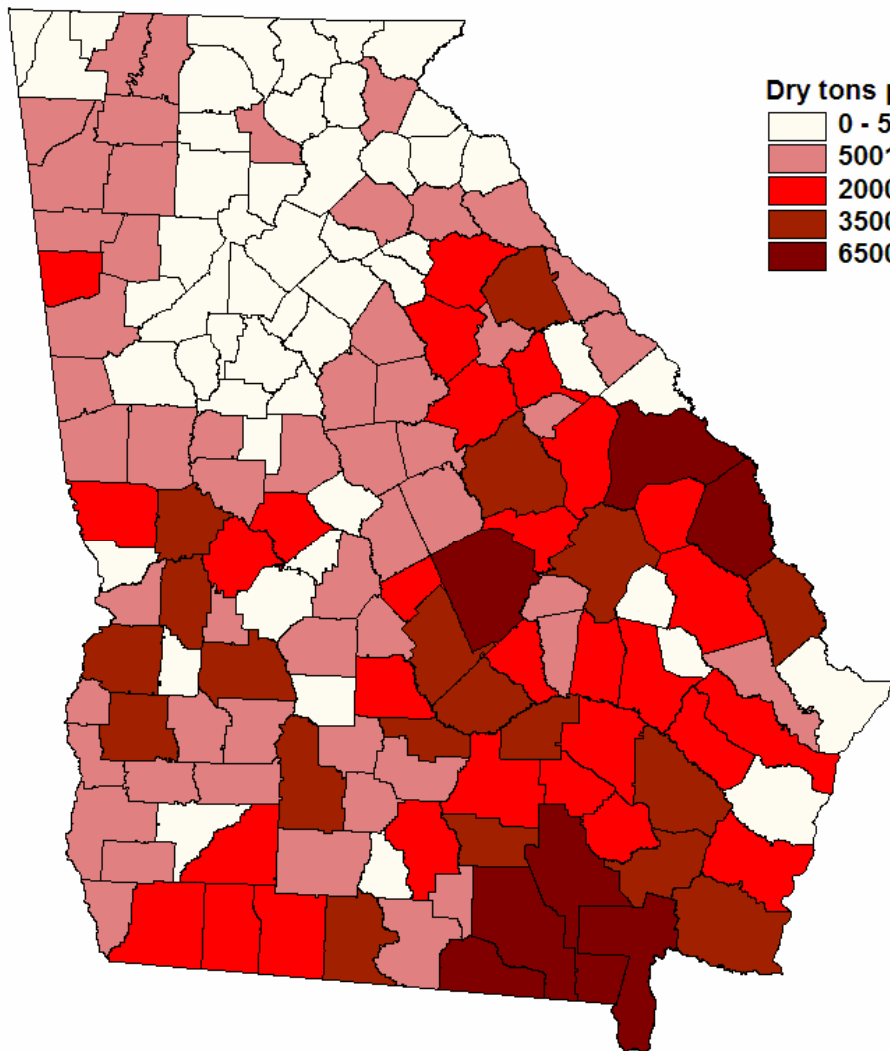
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All Biomass in Small Pines

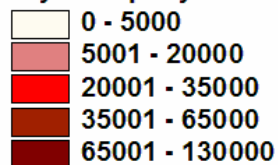


100 0 100 200 Miles

Potential Pine Fiber Harvest from First Thinnings of Pine Plantations



Dry tons per year



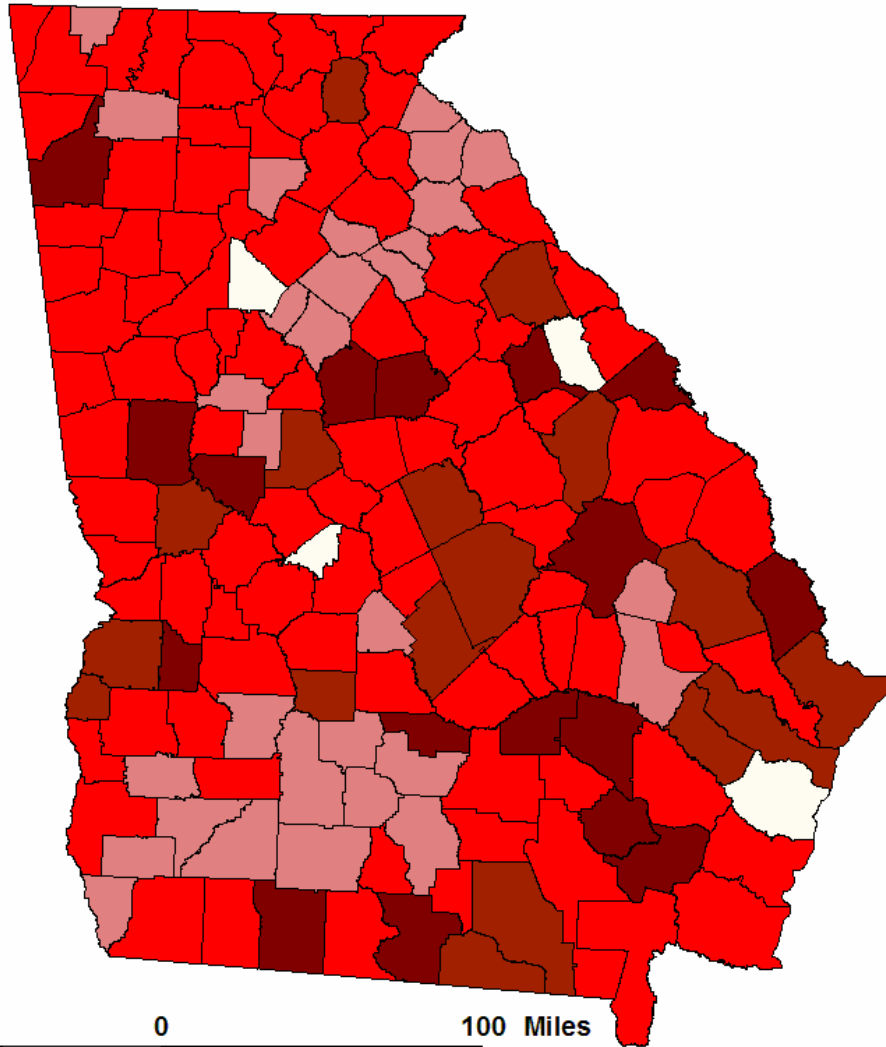
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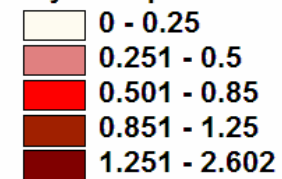
Assumptions: Pine plantations are thinned at age 15 with 10 dry tons per acre of wood being harvested.

100 0 100 200 Miles

**Annual Biomass Potential =
Non-merchantable Timber + Logging Residues + Dry Mill Residues +
Urban Wood Waste + Pecan Shells + First Thinnings of Pine Plantations**



dry tons per acre total land

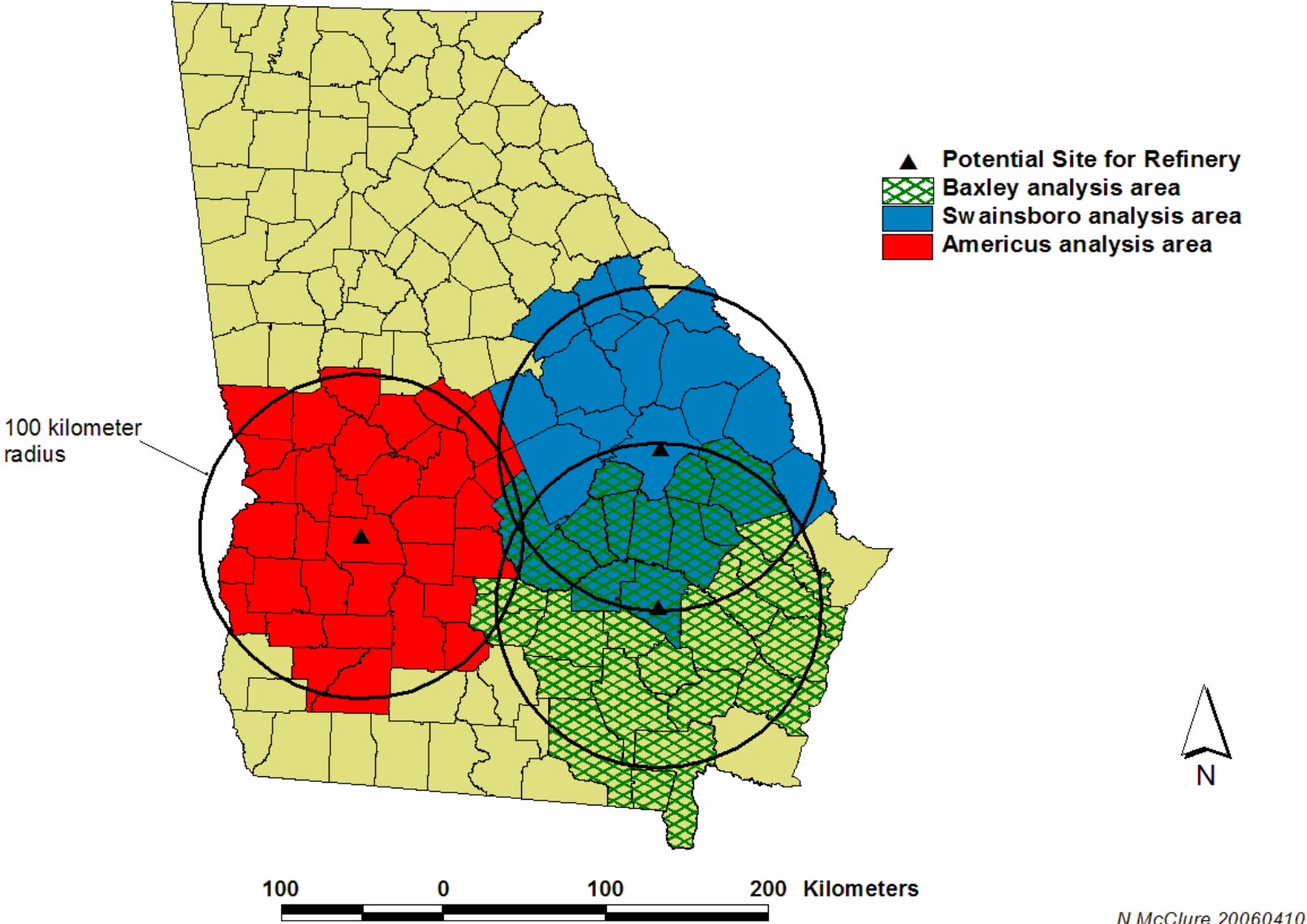




Biomass Availability – Specific Site Analysis

- **50 – 75 mile radius**
- **Forest type – pine, plantation, age, etc.**
- **Forest ownership**
- **Current wood volume**
- **Existing forest product mills - residues and usage**
- **Wood suppliers**

Figure 1 : Three Areas Examined for Biomass Procurement - Georgia, U.S.A.





Source	US dry tons	Recovery Rate	US dry tons to recover	Currently used
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Americus

Unmerchantable timber*	2,363,347	50%	1,181,674	0%
Logging slash	1,029,160	50%	514,580	5%
Dry mill residues	554,000	100%	554,000	99%
Papermill	1,924,098	100%	1,924,098	95%
Urban wood waste	171,831	50%	85,916	0%
Crop residues	1,897,224	50%	948,612	?
Total waste and by-product	7,939,660		5,208,879	
First thinnings of pine plantations	613,295	100%	613,295	
Total with first thinnings of pine	8,552,955		5,822,174	



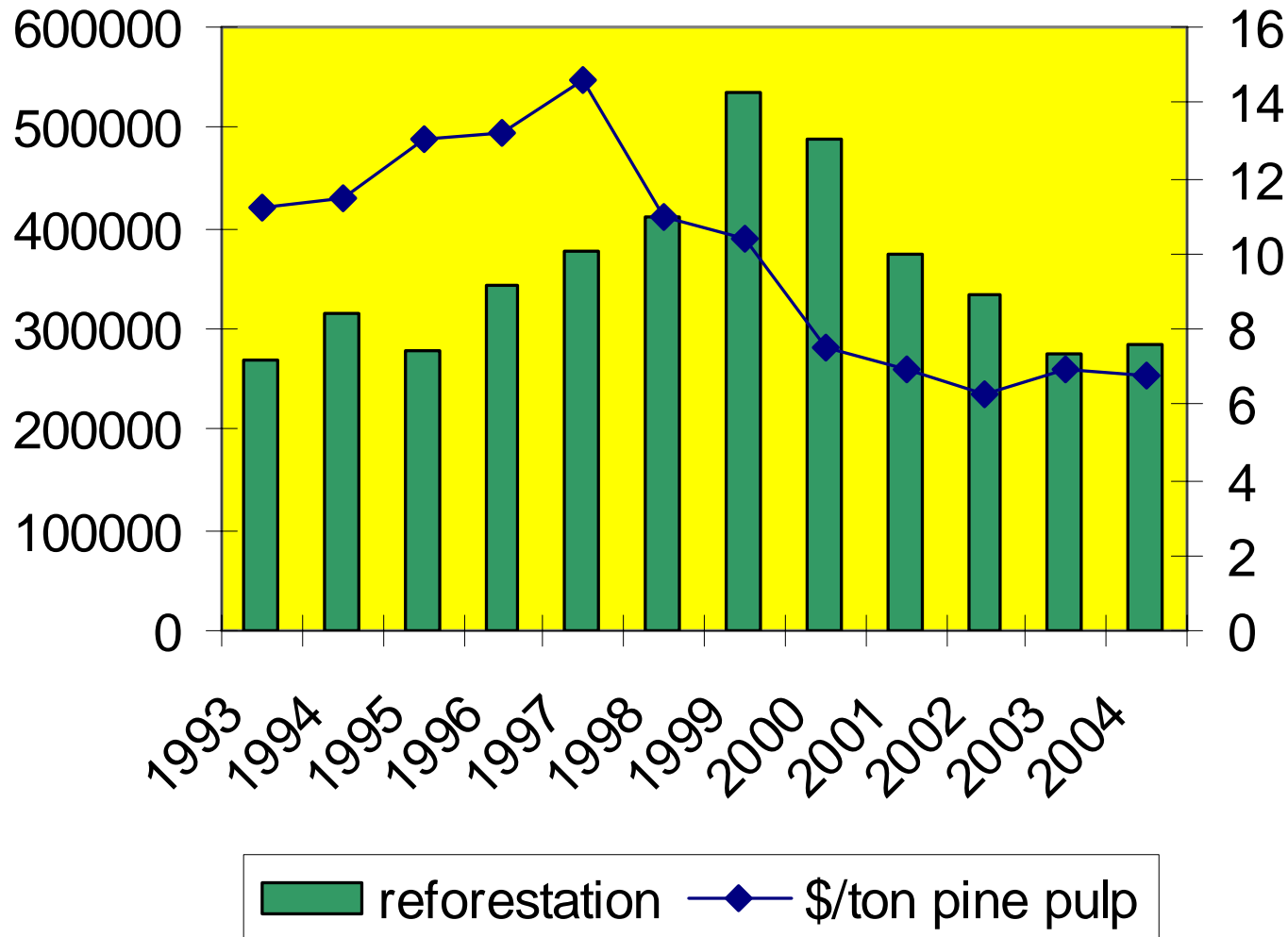
Table of Estimated Costs

US dollars/green short ton

Item	Logging slash and unmerchantable timber	Mill residues)	Merchantable timber (pulpwood)
Raw material	0 – 4	10-20	5 -7
Harvest operation	10-13	0	10-13
Delivery to mill	4.00 if <33 miles 5.80 if 45 miles 7.20 if 60 miles .12 per loaded ton per mile with \$100 minimum per load average load is 25 US tons		
Total cost (average freight distance of 45 mi)	16-23	16-26	21-26



Increase Timber Value – Increase Reforestation





References

- **Energy Information Administration, 2006**
- **General Bioenergy Incorporated, 2005**
- **Georgia Forestry Commission various research reports and records**
- **Timber Mart – South Timber Price reporting service**
- **University of Georgia School of Agriculture**
- **University of Georgia Warnell School of Forestry and Natural Resources**
- **U.S. Forest Service Southern Research Station - Southern Forest Resource Assessment, Forest Inventory and Analysis, Timber Product Output Reports**



How much ethanol can we produce in Georgia?

700 million gallons per year

Based on:

- Utilization of wood by other products remains at current level 19 million dry tons
- Wood volume growth continues at current level 28 million tons/ year
- Clean pine fiber is recovered from small merchantable trees (5 million tons) plus other trees currently classed non-merchantable (3.8 million tons)
- Conversion of pine fiber to ethanol is 80 gallons per dry ton