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Potential Impact of Bio-Energy Demand on Southern Timber Markets and Existing Wood-based Industries

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Summary. The purpose of this research note is to identify key issues in the use of woody biomass as an energy source in the U.S. South and to investigate the likely consequences of these issues on the resource and the existing wood-based industry. Key characteristics of existing wood demand and potential energy-based demand are explored along with the unique spatial and temporal aspects of forest resource supply. The demand analysis focuses on the potential wood consumption implications of renewable energy policy, recently announced capacity, and the implications of how differences in price sensitivity will affect the current industry.

Over the next 5 -10 years the emerging role of conservation, wind, solar, energy crops and other renewable infrastructure are not likely to develop as fast as renewable energy demand. This will favor the use of wood as a feedstock in the first wave of bio-energy production. If the policy driven targets are to be met, logging residuals may play a relatively minor role as a feedstock. Its role may become more important after initial price impacts in the roundwood market. Even the short run changes in harvest quantities from bio-energy projects already announced can significantly impact the supply of "downstream" wood products dependent on larger trees

Given the inelastic (low price responsiveness) of supply and demand in wood markets, price impacts will be larger than harvest impacts. Bio-energy demand is likely to be less sensitive to wood price than existing industry in the short-run. This will lead to a decrease in existing industry capacity as bio-energy capacity increases.

Keywords. [Forthcoming]

Interest in using woody biomass for energy has historically been inversely correlated with the price of oil. The recognition of carbon's role in climate change and a national security interest in reducing dependence in offshore oil has recently solidified interest in renewable energy. Early studies into the sustainability of using wood for energy focused on the use of wood residuals from logging and manufacturing. The ambitious goals of proposed Renewable Fuel Standards (RFS) and Renewable Portfolio Standards (RPS) along with questions about the strategic implications of depending on residuals have renewed interest in examining the implication of these policies on the economic and biological sustainability of the resource. The focus on residuals in past studies also minimized concern about the impact on traditional industries.

The purpose of this research note is to identify key issues in the use of woody biomass as an energy source in the U.S. South and to investigate the likely consequences of these issues on the resource and the existing wood-based industry. Key characteristics of existing wood demand and

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potential energy-based demand are explored along with the unique spatial and temporal aspects of forest resource supply. The demand analysis focuses on the potential wood consumption implications of renewable energy policy, recently announced capacity, and the implications of how differences in price sensitivity will affect the current industry.

The analysis of wood biomass supply is based on modeling work that I have conducted over the last 20 years which provides detailed forest resource supply analysis of ownerships and subregions across the South. This focus on supply is driven by an interest in providing strategic analysis for resource management at a spatial scale useful to private and state-level decisionmakers. State level policies and private resource management decisions will determine the future of the southern forest resource.

Modeling Approach

The modeling approach builds on a few simple principles: 1) laws of supply and demand affect prices and resource decisions at a local as well as a regional level; 2) while economics analysis is often cast as either short-run or long-run, the most relevant time period for strategic analysis of forest resource management decisions is the medium-run (3-15 years); 3) there is ample evidence that demand is unpredictable at all spatial and temporal scales, but the medium run supply of forest resources in any given area is on the ground and can be modeled. In this note, woody biomass supply is modeled using the SubRegional Timber Supply (SRTS) model, which was funded originally by the U.S. Forest Service (USFS) and used in their South's Fourth Forest and Southern Forest Resource Assessments. It is currently supported and used by a consortium of 19 forest resource-based companies, energy firms, and consultants who are members of the Southern Forest Resource Assessment Consortium (SOFAC) at NC State University.

SRTS uses the U.S. Forest Service Forest Inventory and Analysis (FIA) dataset of inventory, growth, removals, and acreage by forest type, private ownership category, species group, and age class to model inventory change by product for small areas (typically the 58 FIA survey units in the southern region). The product inventory is assumed to shift a resource supply curve by owner and region. This detailed subregional supply is equilibrated with a regional demand curve. In each year product demand is shifted based on the user-defined scenario and supply is shifted by the biological accounting module. The market clearing price and harvest are calculated, harvest is passed to the biological accounting module, and inventory is updated for the next period's equilibrium calculation.

This note summarizes several projects that examine wood bio-energy supply and demand. Section one examines policy-driven demand for wood-based bio-energy and the potential role of logging residues to meet these policy goals. The next section explores the nature of wood energy supply and its implications for regional comparative advantage. Section three looks at two case studies where demand estimates are based on announced or planned bio-energy capacity. The impacts over time of logging residual utilization on wood prices and the future of the existing industries are examined. Finally, conclusions are drawn about potential impacts and the key unknowns that will affect the resource and the transition to wood-based energy.

Policy-Based Demand

A recent study by Galik, Abt, and Wu (in press) looks at the potential regional demand for biomass in Virginia, North Carolina, and South Carolina. We linked the tri-state biomass power capacity to the Energy Information Agency (EIA) regional estimates. We then used this linkage

to examine the regional demand impact of EIA's hypothetical Renewable Portfolio Standard (RPS) and Renewable Fuel Standard (RFS) scenarios.

Figure 1 shows the result of comparing the potential demand from two trends compared to the currently available logging residuals. The demand trends are 1) projected energy trends for the region without policy change, and 2) the 25% scenario reflecting these state's share of the regional RPS/RFS scenario. Logging residuals are converted to energy equivalent (100 mil MMBTU). While residuals might be a sufficient source for the next decade under the business-as-usual scenario (demand trend 1), the potential policy changes could lead to demand for wood biomass that far exceeds available residuals and may equal total current use of small diameter trees.

This type of structural shift would obviously lead to silvicultural, technological, and land use changes that are not reflected in current biomass supply numbers. It is clear, however, that the transition period could have significant impacts on resource use and current resource users.

North Carolina is currently the only southern state that has passed mandatory RPS legislation. The legislation requires that renewable energy proportion increases in a series of steps that achieve 12.5% of the total energy portfolio by 2021. Assuming energy demand in NC follows historical trends, Figure 2 shows the potential demand for woody biomass if it makes up 12% or 70% of the renewable portfolio. Twelve percent represents an estimate of the current role of woody biomass in renewable energy in the state. Seventy percent is an estimate based on evidence that the initial surge in providing renewable energy may be largely wood-based.

An estimate of available logging residuals over the next 20 years assuming 40% recovery is also shown in figure 2. This estimate is based on a SRTS model run with demand for pulpwood increasing at 0.5% per year and demand for other wood products remaining constant. Residual estimates are based on factors from state level USFS studies. As shown in the graph, if wood's role doesn't increase, available residuals will be exhausted by 2014. If wood provides 70% of the initial portfolio, logging residuals would provide less than half of the woody feedstock in the short-run and less than 10 percent by the time the renewable goal is met.

A parallel study was done using Georgia's proposed RPS legislation. The results were similar (Figure 3). If wood-based feedstocks are going to provide a significant contribution to renewable energy, the logging residuals component will not be sufficient and may play only a small role in the portfolio. These studies show that RPS/RFS policies have the potential to cause structural shifts in wood markets and residuals have limited potential to help meet these goals.

Key unknowns regarding future biomass energy demand are:

1) How the portfolio of energy conversion technologies and associated feedstock demands will evolve over time and across regions.
2) How price sensitive the derived demand for feedstocks will be
3) How fast conservation, alternative energy crops or alternative silvicultural management can develop

To address the first question two case studies were analyzed. The demand scenarios for these studies were based on announced plant technologies and capacities. The impact of these planned demand scenarios are discussed in Case Study section below.

Biomass Supply

The Galik, Abt, and Wu manuscript (in press) describes a conceptual model of biomass supply. Figures 4 and 5 show biomass supply curves for each of the FIA survey units in VA, NC, and SC. The coastal plain regions (VA1, NC1, NC2, SC1, SC2) dominate the pine supply. For these curves the on-site price of woody biomass from logging residuals was assumed to be $1/green ton. The harvest and delivery cost was taken as the difference between stumpage and delivered prices for pulpwood in the region. While this may differ from logging residual harvest and delivery, the regional comparative advantage should be similar.

The supply curve starts at the estimated delivery cost of logging residuals. The horizontal length of the curve is 40% of total logging residuals available in the region at current harvest levels. In reality as the market for logging residuals develops the price for residuals will be bid up and more residuals will be available at higher prices. Energy firms are likely to use a mix of roundwood and residuals as local conditions dictate. The simple curves shown here hold prices constant until available residues are exhausted. Prices then increase to reflect the purchase of small trees (pulpwood). As prices continue to increase, harvest quantities increase reflecting estimated availability of biomass from trees and the resulting logging residuals.

For pine the curves not only illustrate the dominance of the coastal plain they show a relationship between residual availability and delivered price of roundwood. There is a significant positive correlation ($r > 0.5$) between residual quantities and roundwood prices. This reflects the link between current industry location, harvest levels and higher prices. Together with the conclusion above that logging residuals are not sufficient to meet current policy objectives; this correlation has strategic implications for the bio-energy industry. Locating where residuals are concentrated means that you will likely be competing in a higher priced roundwood market as residuals are exhausted.

The hardwood supply curves (Figure 5) show that the resource is less spatially concentrated. For these three states it also shows that there is little correlation between residual quantities and roundwood prices. The strategic location decision for hardwoods exhibits some win-win choices where residuals are abundant and roundwood prices are low. Relative to pine, hardwoods produce more logging residuals per acre harvested but have higher logging and transportation cost. This is illustrated by the more price responsive supply in the roundwood portion of the curve. While the roundwood supply price elasticity is assumed to be 0.3 in both pine and hardwood, each acre of hardwood harvest provides up to 40% logging residuals compared to pine's 15-20%.

Many other factors will influence the location decision, e.g. access to transportation networks, deep water ports, labor and energy cost, and contractual supply opportunities. The interaction between spatial resource distributions, harvest and transportation cost, and roundwood prices are the focus of these curves.

Spatial variation over time

The supply discussion above focuses on the interaction of logging residual and roundwood markets across regions. To address the sustainability of the resource with increased demand it is important address the time dimension of the interaction. Unlike annual crops, changes in harvest and regeneration of forests change the age class distribution of the resource which affects quantities and product mix of the inventory for decades. For example, increased utilization of young trees will influence availability of solid wood products based on larger trees in the next decade.

A bio-energy firm that based its location decision on current residuals faces at least two possible outcomes. Future residual availability is directly linked to the sustainability of current harvest. Beyond being dependent on the economic viability of the current industry, the long term sustainability of current harvest is determined by its growth rate, management/ownership, and age-class distribution. It will also be affected by land-use change drivers like urbanization and agricultural profitability.

Figures 6 and 7 show the current distribution of logging residuals by species group in the South. As discussed earlier for the Mid-Atlantic States, pine residuals tend to be located in the coastal plain, while hardwoods are distributed throughout the region. Using the SRTS model linked to land use change forecasts from the Southern Forest Resource Assessment, the change in residual availability over time is shown in Figures 8 and 9. Light green means that residual quantities stay relatively steady over the 2005-2025 period. Dark green and blue areas increase their logging residual quantities, while orange and red areas decrease. Note that many regions with large percentage changes may be relatively insignificant components of regional supply. South Florida for example has very little forestland and as a consequence no significant industry capacity. The resulting lack of harvest leads to large potential percentage increases in harvest/residuals from this small base.

Focusing on the coastal plain in Figures 8 and 9, these projections show that southern GA and northern FL, for example, can maintain or expand current pine harvest/residuals while the coastal plain regions of NC and VA may not sustain current production levels. Hardwood harvest/residuals in southeast GA and northeast FL, however, will not necessarily follow the same trend.

Previous research by Ray Sheffield of the US Forest Service shows that across the south, growth/harvest ratios go through 15-25 year cycles. Regions with high growth/removal ratios decrease and vice versa. High harvest levels change the age class structure of the forest which affects growth, and low harvest levels tend to attract additional industry capacity. Thus, current growth/removal ratios are not necessarily good sustainability indicators. They indicate whether the region is at a peak or valley in long-run growth/harvest cycles.

The medium-run supply-demand outlook over time – 2 case studies

The demand analysis above indicates that potential policy driven demands will lead to structural change in markets. The supply analysis emphasizes the spatial and temporal dynamics of supply. The last part of the paper attempts to synthesize these issues in two case studies. The case studies examine the medium run impact of announced bio-energy capacity in two regions, the gulf region (southern AL and GA, and northern FL) and the state of North Carolina. The analysis focuses on the impact on roundwood markets, the potential importance of residuals, and the impact on existing wood-based industry over time.

Gulf Coast Case Study

Estimates of the announced biomass capacity for the gulf region were provided by F&W Forestry Services in spring of 2008. At that time 3 bio-energy plants existed and another 15 were proposed or under construction. The primary feedstock species group was pine with a potential consumption of 5.75 mill. green tons annually.

Figure 10 shows the current distribution of pine pulpwood harvest in the region. For the baseline business-as-usual (BAU) scenario a SRTS run was made assuming a 0.5%/yr increase in

pulpwood demand and a no-demand increase for other products. The 5.75 mill. green ton capacity was assumed to shift the demand curve 0.575 mill. green tons per year for the 10 years between 2007 and 2016. For simplicity the demand was assumed to use 100% pine feedstock.

To test the sensitivity of results to logging residual utilization, the demand was assumed to first utilize residuals assuming 15% - 45% availability of residuals. Figure 11 shows the shifts in roundwood demand for different residual utilization assumptions. The baseline (no biomass demand) increases through time reflecting the 0.5%/yr increase assumed for the existing industry. Figure 11 shows that if 45% of pine residuals are utilized by the bio-energy industry, demand for roundwood is delayed until 2013 and then represents less than a 10% increase in demand. If, however, only 15% of residuals are recovered, the impact on roundwood demand is immediate and significant, leading to a 50% increase in pulpwood stumpage prices by the end of the projection.

Figures 12 and 13 show the pine pulpwood market summaries for the baseline (no biomass demand) and the minimum residual utilization scenarios. Note that in the baseline no energy demand scenario (Figure 12) inventory and harvest are increasing and prices decrease slightly. The increase in inventory shifts the supply curve outward faster than the assumed increase in demand, so prices drop and harvest increases. In the scenario where residuals provide the least buffer (Figure 13), the inventory peaks after 10 years and the increasing demand and decreasing supply lead to price increases and harvest reductions.

Figures 14 and 15 show the delayed impact on the small sawtimber market. This impact is based only on the decreased inventory of small sawtimber due to increase pulpwood harvest.

Figure 16 shows that under each of the scenarios harvest levels converge by 2023. For the high biomass roundwood demand scenarios the trajectory reflects the increase in demand for the 2007 to 2016 period. After the demand peak in 2016, the declining inventory and inward supply shifts lead to reduced harvest at higher prices relative to the baseline.

A key question in the development of this new demand is the implications for the current wood-based industries. This will be determined by the relative price responsiveness of wood demand between the two industry components. Existing data for the traditional industry indicates that derived wood demand is price inelastic. For these projections it was assumed to be 0.3 which implies that a 10 percent increase in price will lead to a 3 percent decrease in harvest. If bio-energy demand has the same price responsiveness, then the two industry components would reduce harvest proportionately as prices increase.

Since bio-energy demand is policy driven, has significant economies of scale, and has the ability to pass costs to the end user, one possible scenario would be to treat bio-energy demand as insensitive to wood price in the short run. Over several years, substitutes for wood in the form of bio-energy crops may develop and other renewable energy sources may be able to meet a larger portion of mandated targets so that bio-energy demand becomes more price responsive in the long-run.

Figure 17 shows the estimated capacity changes for the traditional industry under various residual availability assumptions. If 45% of logging residuals are utilized, then traditional industry capacity drops less than 5% from the baseline scenario. If residuals are not utilized extensively, then the industry drops from a 19.5 million green ton per capacity to a 16 million ton capacity.

North Carolina

A similar analysis was conducted for the North Carolina where 5.17 mill green tons of bio-energy capacity have been announced (NC Division of Forestry, citation). One key difference from the gulf study is that both pine and hardwood demand are assumed to be affected. The baseline market situation is different as well. Pine pulpwood inventories are projected to be flat and there is upward price pressure due to increasing pulpwood demand for both pine and hardwood. In the NC projection, the price consequences of the increased demand were higher with both pine and hardwood pulpwood price doubling in the 15% logging residual utilization scenario. Under this scenario and assuming bio-energy demand is not wood price sensitive in the short-run, NC's traditional industry capacity drops from 18 mill green ton per year capacity to 14 mill green tons at the end of the projection. If 45% of residuals are utilized there is less than a 3% impact on projected capacity.

Caveats and Conclusions

Factors which may alleviate some of the biomass demand impacts:

1. Biomass demand is likely to be price responsive to wood prices in the long-run
2. Higher prices will lead to silvicultural responses that will favor production of biomass feedstock, possibly at the expense of solid-wood products
3. Higher prices will accelerate development and deployment of alternative technologies and feedstocks.
4. The current recession could lower competition from traditional wood-based industries.
5. Not all planned bio-energy plants will be built in the current economic environment.
6. Carbon cap and trade policies and the accounting rules applied to forests and wood-based energy will likely dominate these impacts.

Factors which may exacerbate biomass demand impacts:

1. Research development and infrastructure to deploy alternative feedstocks and technologies may significantly lag the increased demand for renewable energy.
2. Loss of timberland to urbanization and recent reductions in tree planting may constrain supply in certain regions.
3. Current low roundwood prices favor substitution of roundwood for residuals as a feedstock.
4. Many more bio-energy plants have been announced since these scenarios were first developed.
5. Some of the announced capacity exists to satisfy wood-energy demand based on European renewable energy policy. The southern resource is a key component in global fiber supply.

Key Conclusions

Over the next 5 -10 years the emerging role of conservation, wind, solar, energy crops and other renewable infrastructure are not likely to develop as fast as renewable energy demand. This will favor the use of wood as a feedstock in the first wave of bio-energy production.

If the policy driven targets are to be met, logging residuals may play a relatively minor role as a feedstock. Its role may become more important after initial price impacts in the roundwood market.

Given the inelastic (low price responsiveness) of supply and demand in wood markets, price impacts will be larger than harvest impacts.

The species mix and spatial allocation of this new demand will be key factors determining how existing industries will be affected.

Short run changes in harvest quantities for small trees can significantly impact long run sustainability of the resource and the “downstream” wood products dependent on larger trees.

Bio-energy demand is likely to be less sensitive to wood price than existing industry in the short-run. This will lead to a decrease in existing industry capacity as bio-energy capacity increases.

Carbon markets and the treatment of harvest for bio-energy in those markets will likely redefine the comparative advantage of wood and agricultural-based bio-energy feedstocks.

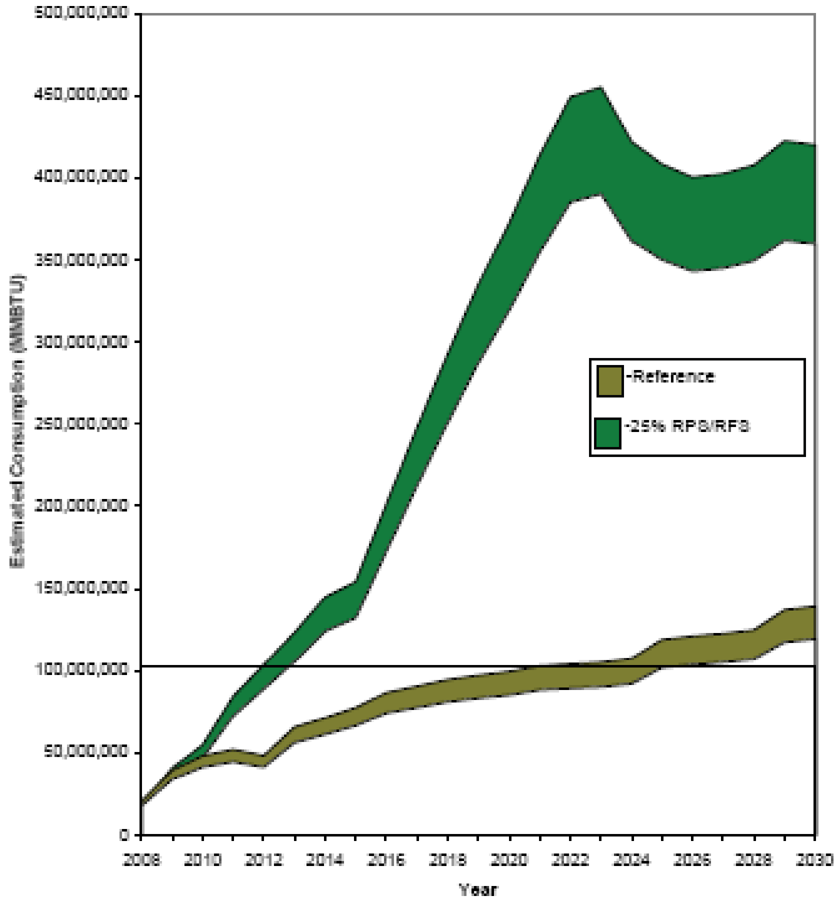

Figure 1. Potential consumption of wood in Virginia, North Carolina and South Carolina based on a business as usual reference case and based on EIA’s RPS/RFS demand scenario. An estimate of currently available logging residuals is shown as a horizontal line.

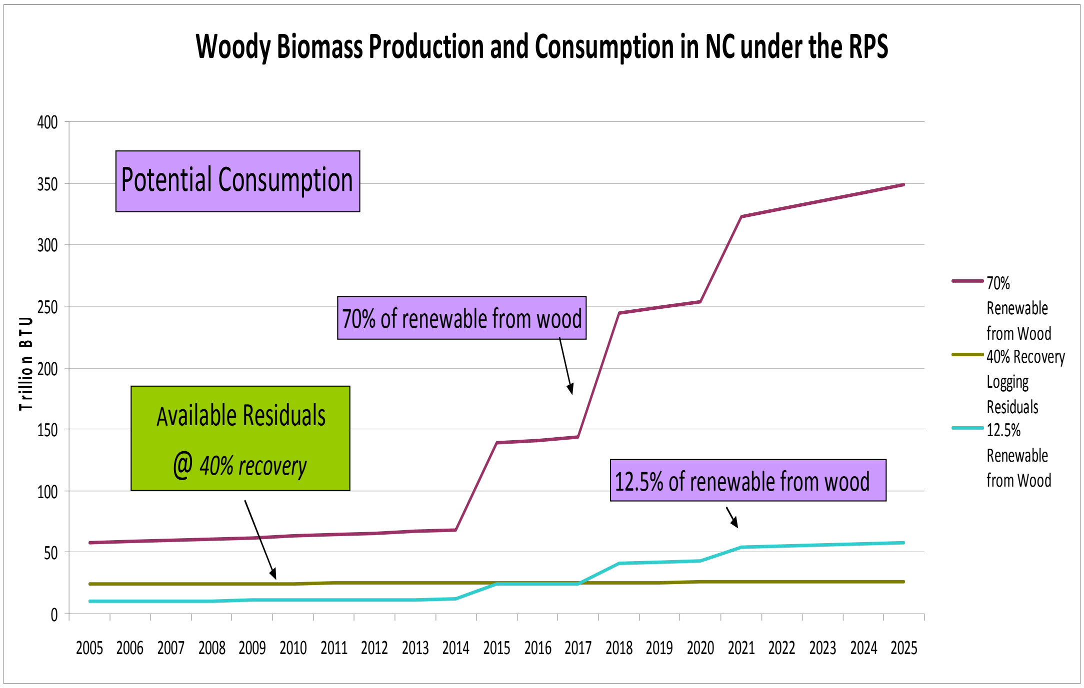

Figure 2. Estimates of wood consumption needed to meet North Carolina's renewable energy targets assuming 12.5% vs. 70% of the renewable portfolio is based on wood. Projected available residuals under a business as usual scenario are shown in green.

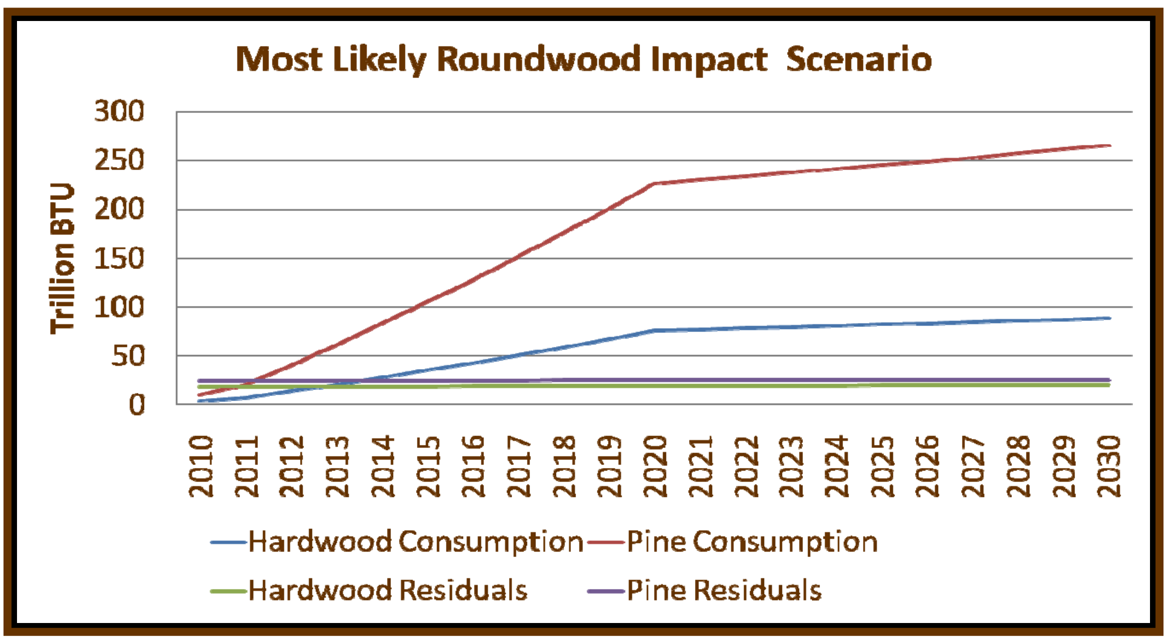

Figure 3. Projected consumption and available residuals using Georgia's proposed RPS legislation.

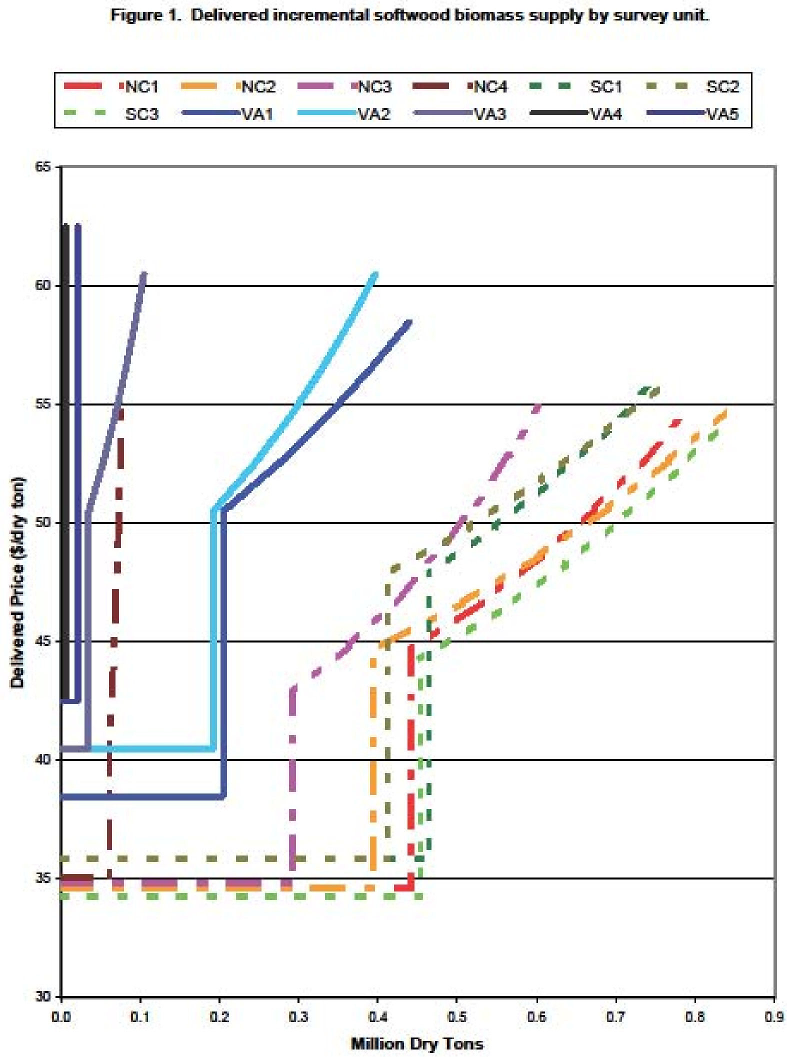

Figure 4. Pine biomass supply curves for sub-regions of Virginia, North Carolina and South Carolina. The horizontal component reflects the quantity and price of logging residuals. The vertical component reflects roundwood prices in the area. The price responsive roundwood supply component reflects the availability of roundwood and associated residuals at higher prices.

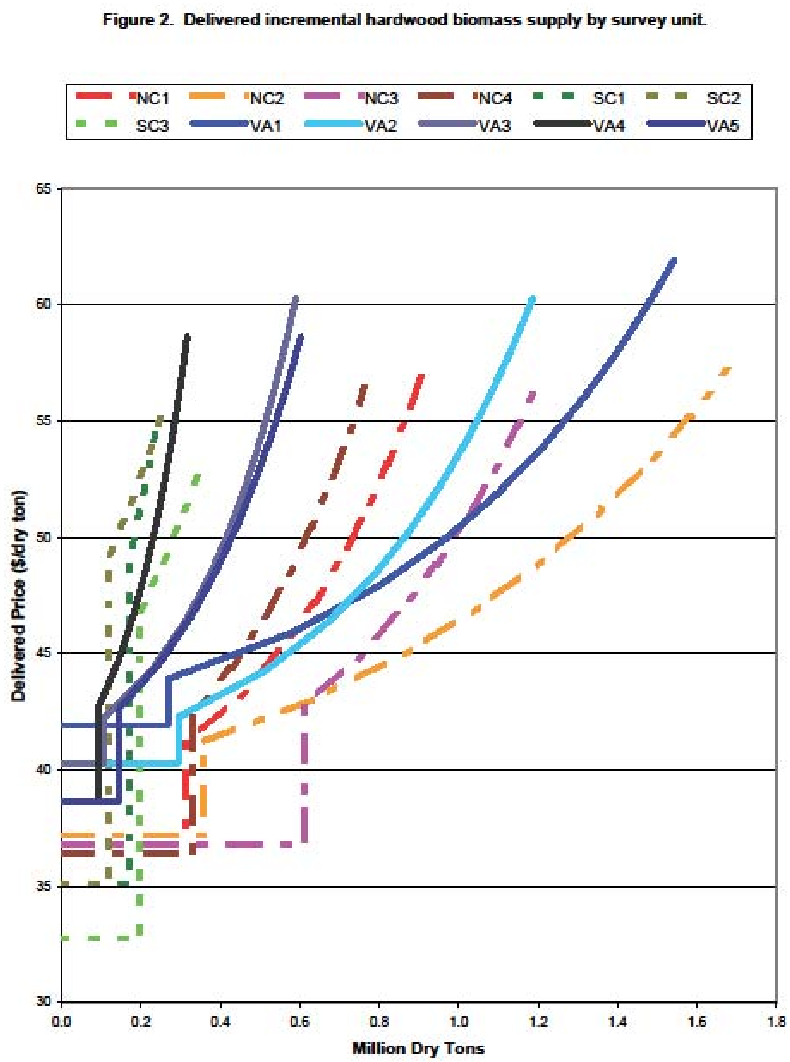

Figure 5. Hardwood biomass supply curves for sub-regions of Virginia, North Carolina and South Carolina. The horizontal component reflects the quantity and price of logging residuals. The vertical component reflects roundwood prices in the area. The price responsive roundwood supply component reflects the availability of roundwood and associated residuals at higher prices.

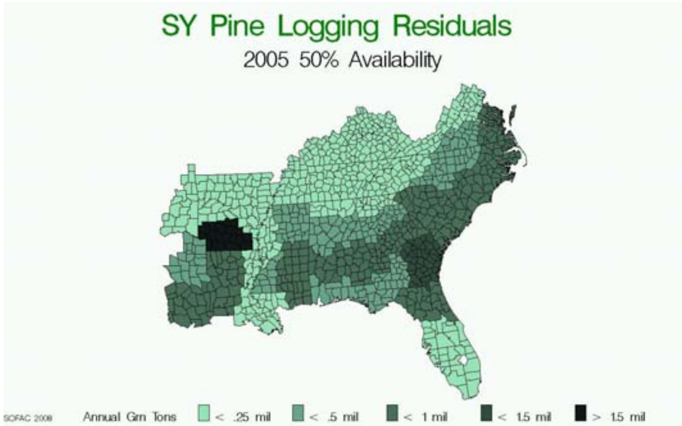

Figure 6. Pine

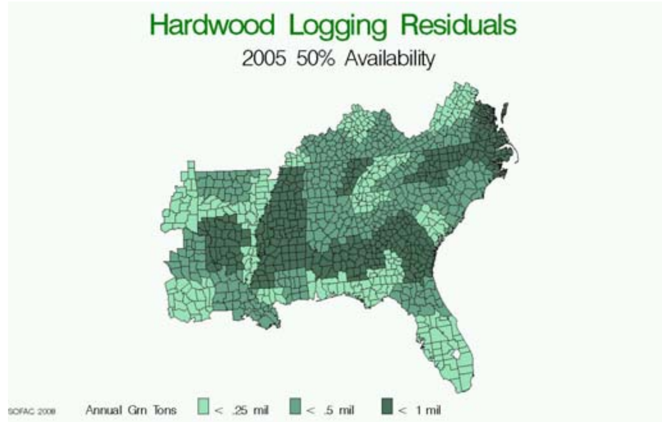

Figure 7. Hardwood

Spatial distribution of pine logging residuals.

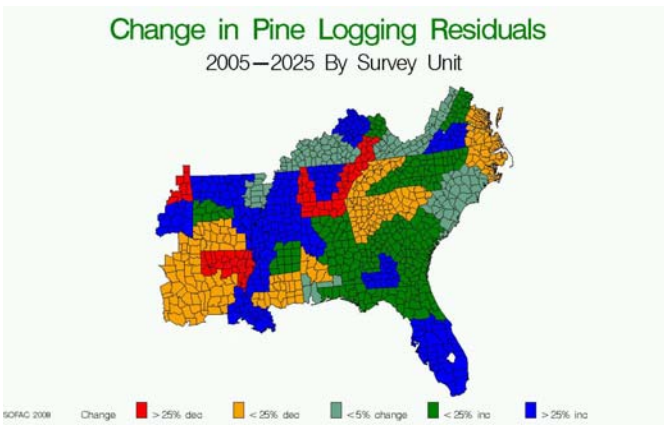

Figure 8. Pine

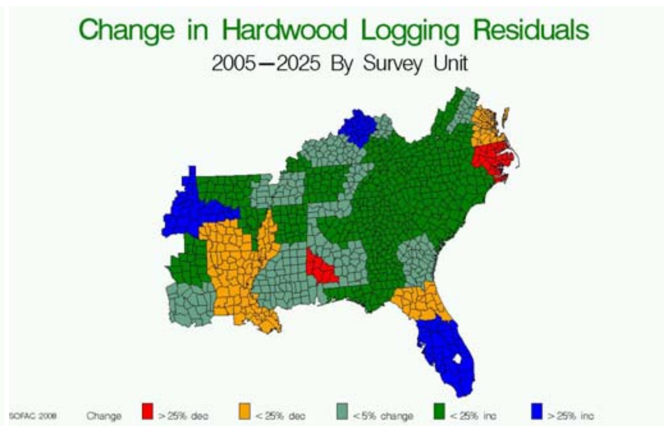

Figure 9. Hardwood

Change in logging residual availability from 2005 to 2025 under a business as usual baseline scenario.

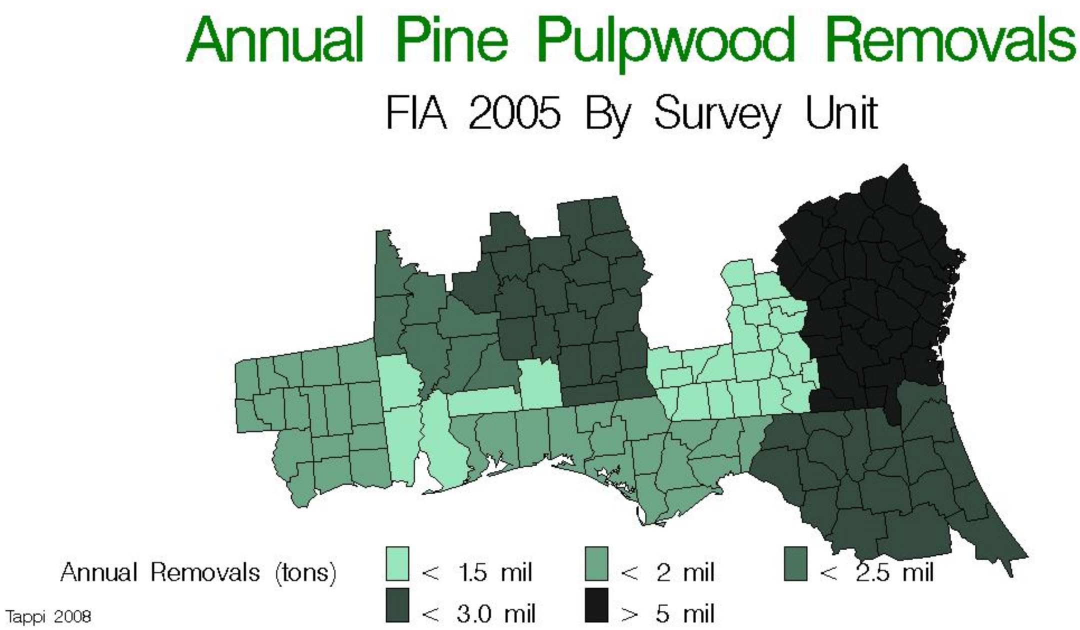

Figure 10. Gulf region pine pulpwood removals

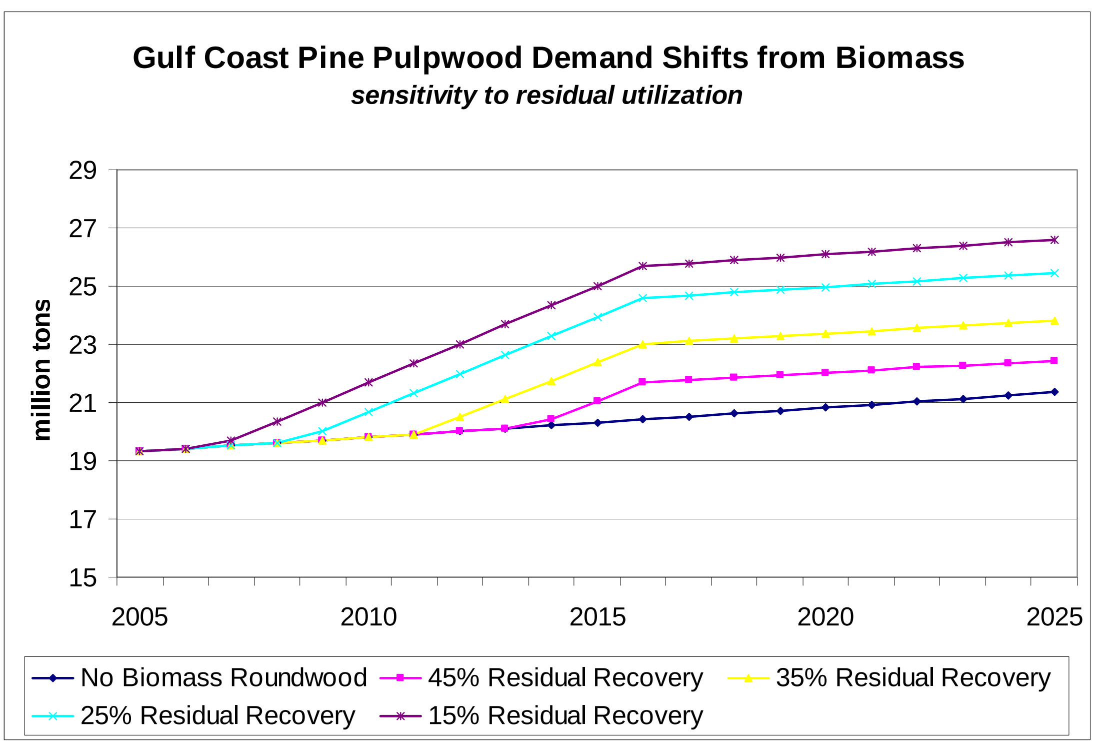

Figure 11. Demand shifts for pine pulpwood in the gulf region under different residual utilization scenarios.

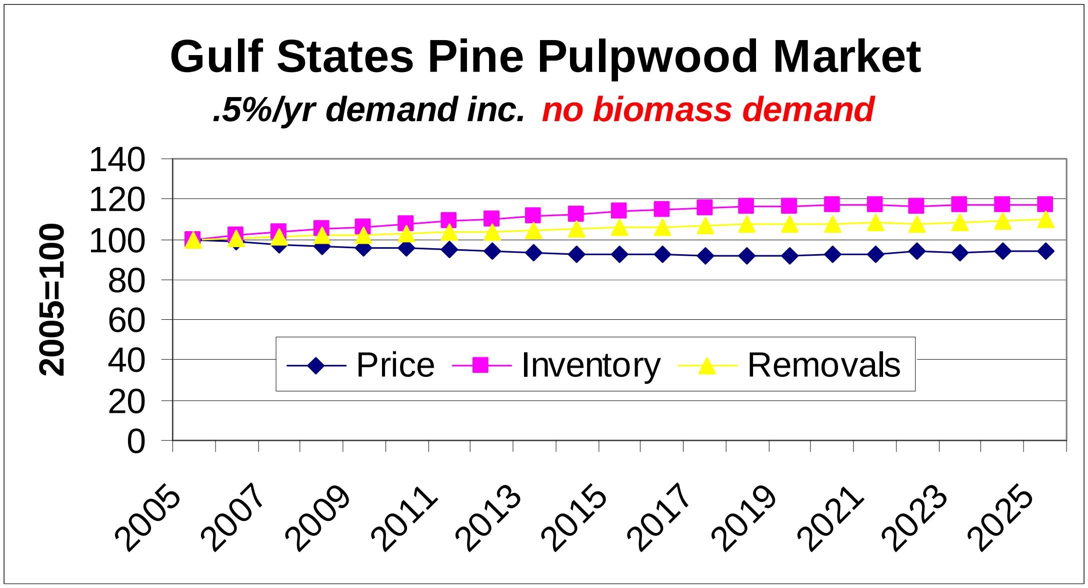

Figure 12. Market outlook for gulf region pine pulpwood under a business as usual scenario.

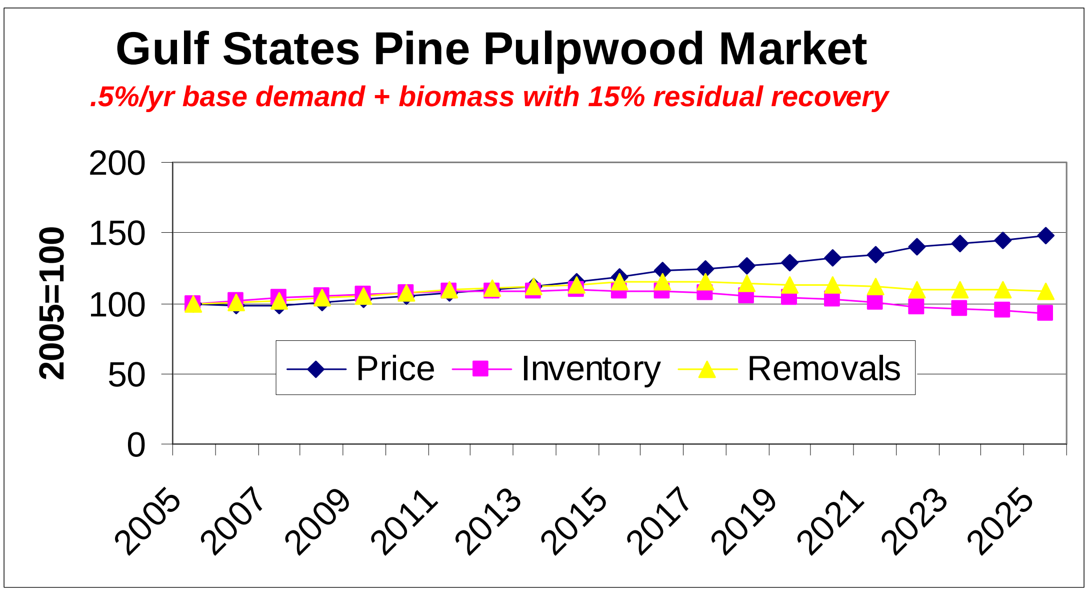

Figure 13. Market outlook for gulf region pine pulpwood with planned biomass demand and 15% utilization of available logging residuals.

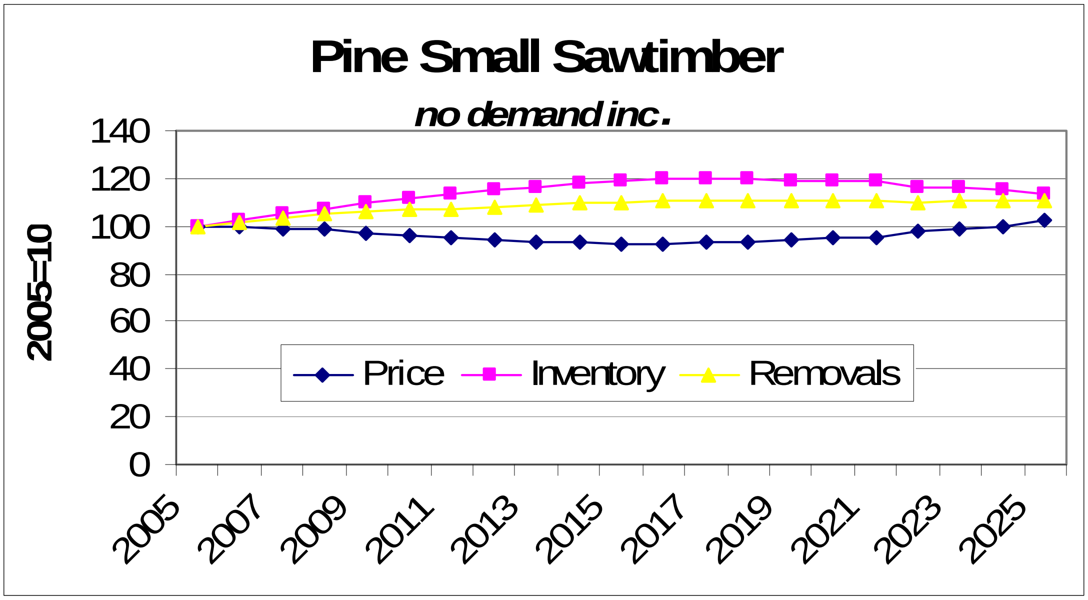

Figure 14. Market outlook for gulf region pine small sawtimber under a business as usual scenario.

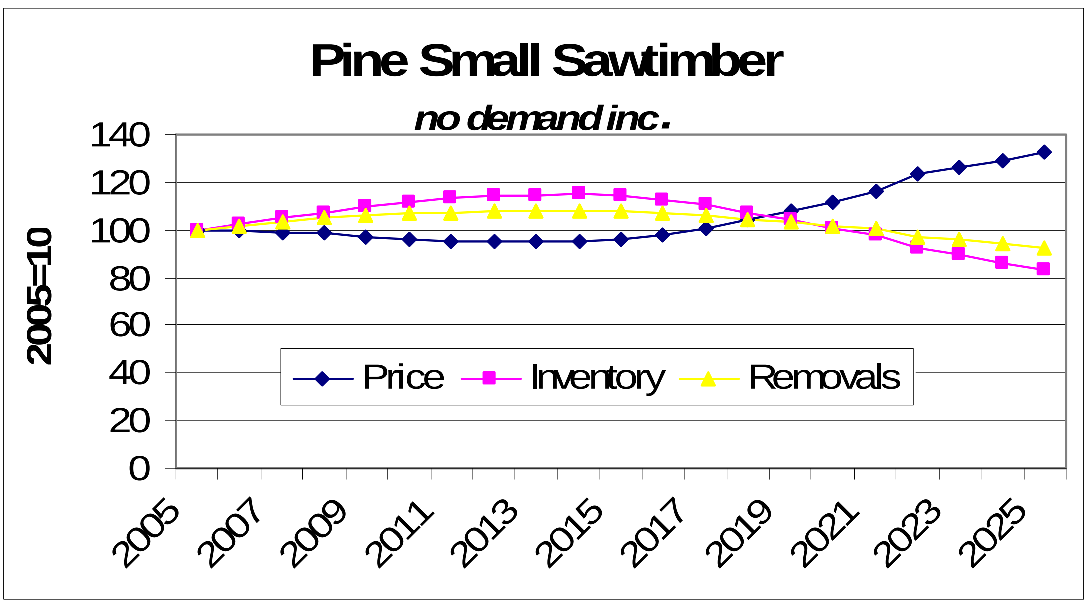

Figure 15. Market outlook for gulf region pine pulpwood with planned biomass demand and 15% utilization of available logging residuals.

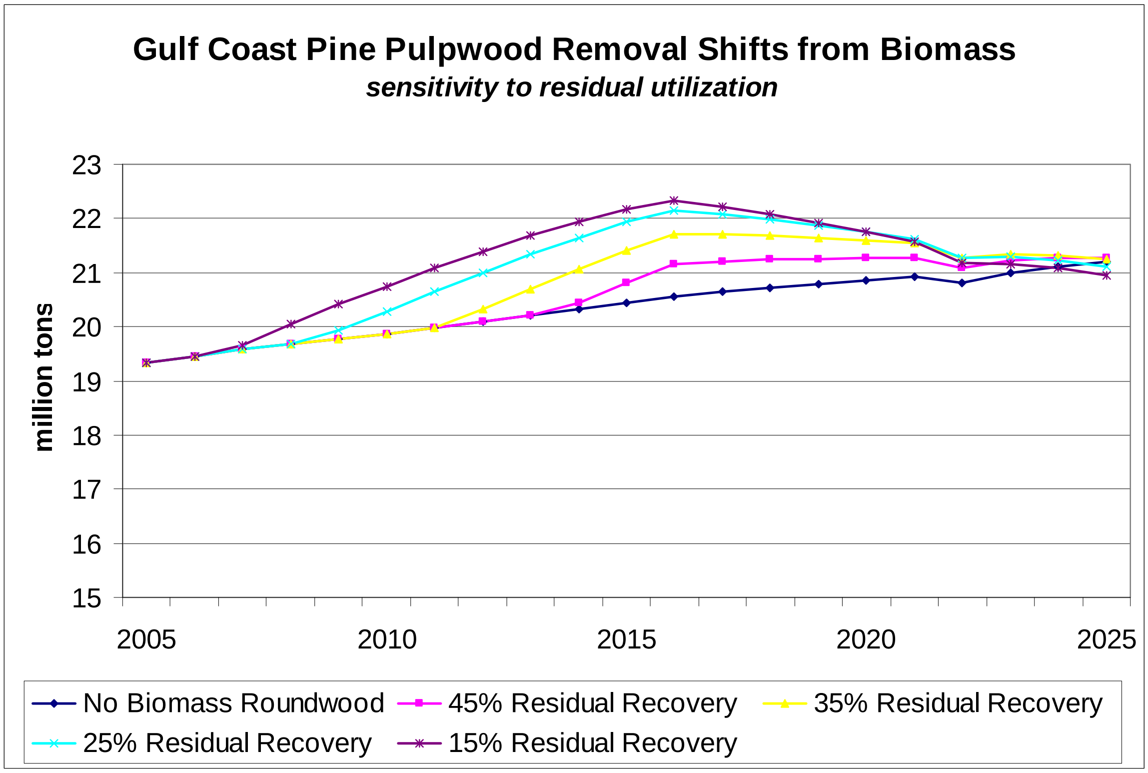

Figure 16. Harvest projections based on biomass demand shifts in Figure 11.

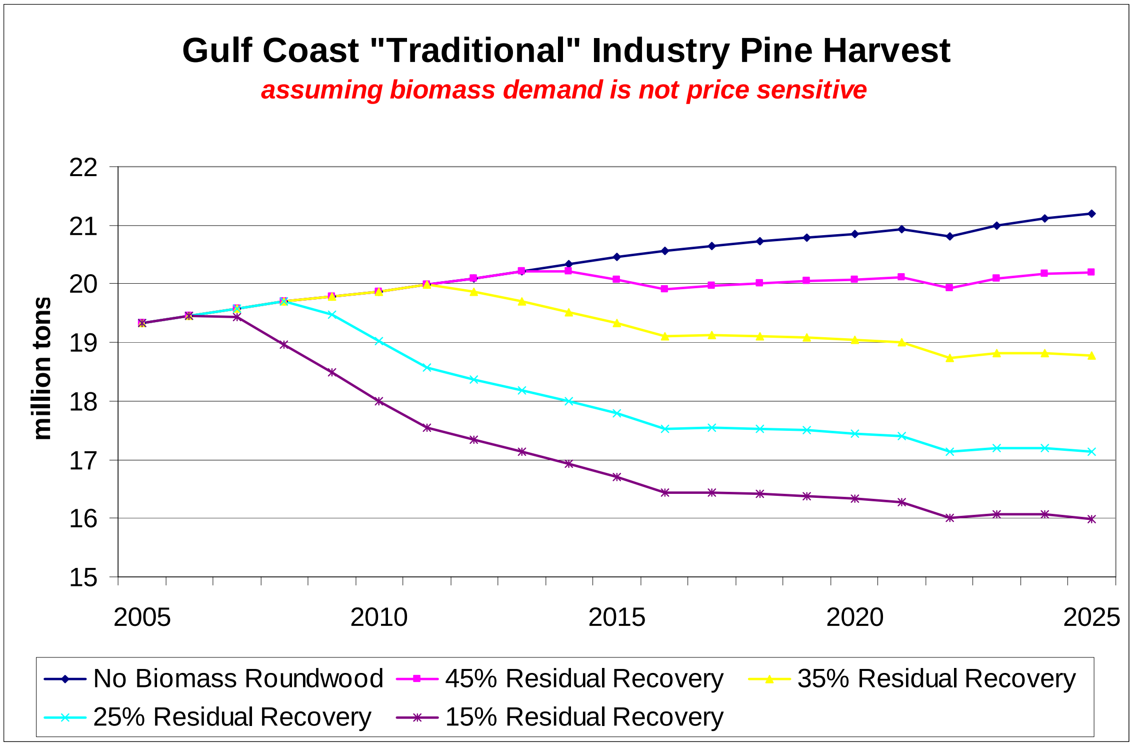

Figure 17. Capacity trends for existing pulpwood users with biomass demand and different levels of residual utilization.