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Effect of Policies on Pellet Production and Forests in the U.S. South

A Technical Document Supporting the Forest Service Update of the 2010 RPA Assessment

Karen Lee Abt, Robert C. Abt, Christopher S. Galik, and Kenneth E. Skog

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ABSTRACT

Current policies in the European Union (EU) requiring renewable and low greenhouse gas-emitting energy are affecting wood products manufacturing and forests in the United States. These policies have led to increased U.S. pellet production and export to the EU, which has in turn affected U.S. forests and other wood products manufacturing. At this time, the primary exporting region in the United States is the South, and the primary importing countries in the EU are the United Kingdom, Belgium, and the Netherlands. The policies and some Member State subsidies are expected to continue in place until at least 2020, with the potential to continue beyond that date. Key drivers of U.S. pellet feedstock supply include both the age structure of current timber inventory and the policies that define sustainability. Also influencing the effect of increased demand for timber for pellets are the price-inelastic supply and demand. A simulation of the market responses to increases in both pellet and other bioenergy demand in the U.S. South suggests that prices will increase for timber as harvest increases, and will in turn lead to long-term changes in inventory and forest land area.

Keywords: Bioenergy, biomass, Renewable Energy Directive, timber supply, wood pellets.

KEY FINDINGS

1. The key driver of U.S. pellet demand, and thus U.S. pellet production and export, is the Renewable Energy Directive of the European Union (EU). This policy and the implementing regulations at both the EU and Member State levels are in flux, but there has already been an impact on demand for wood feedstock in the U.S. South, and this demand is expected to increase over the next 5 to 10 years.

2. Key drivers of U.S. pellet feedstock supply from forests include the characteristics of current inventory and the policies that define sustainability. Limitations on greenhouse gas emissions, land use change, and certification requirements will directly limit the inventory available for pellet feedstock and/or will increase the costs of procuring this feedstock.

3. Key drivers of competition (price and quantity) include the price-inelastic demand for feedstock from both traditional producers and policy-induced bioenergy producers as well as a price-inelastic supply response for feedstock. Combined, these result in a higher percentage change in price than the associated percentage change in quantity harvested when pellet feedstock demand increases.

4. An expected increase in U.S. demand for solid wood products will likely result in increased mill residues. This could reduce demand for smaller-sized timber as feedstock for pellet, pulp, or composite panel production, thus reducing timber feedstock price for pellets. Conversely, an increase in U.S. demand for paper products could increase competition for timber feedstock and lead to increases in timber feedstock price for pellets.

5. The combination of increased pellet feedstock demand, the age class distribution of inventory, and the inelastic supply response of landowners to a change in price have led to increased pellet feedstock prices and increased harvests in the U.S. South (Lang 2014). The precise extent of these impacts in the future will depend on sustainability policies in the EU and the Member States and on the amount of subsidy provided by Member States for energy produced from imported biomass.

6. In a simulation of timber markets where increases in demand for timber from the U.S. Coastal South derive from both pellet and other bioenergy demand, we found that:

   (a) Non-sawtimber feedstock prices continue to rise through the end of the projected increase in pellet demand (2020), and then fall as additional timberland is converted from marginal agricultural land, leading to eventual relative increases in inventory.

   (b) Even assuming full utilization of mill residues and increased utilization of logging residues, harvest of pine and hardwood non-sawtimber feedstock increases. Under these assumed demands, hardwood harvest levels remain low enough that hardwood inventories continue to increase, although these end at lower levels than under the baseline scenarios (those modeled without new bioenergy demands). Increased pine harvest leads to increased investment (planting), which leads to ending inventory levels that are higher than under the baseline.

   (c) There would be shifts in harvest among subregions and shifts in production from traditional wood products to pellet production.

   (d) Timberland area increases with an increase in demand for feedstock for pellets as more plantations are established on marginal agricultural land (assuming that forest land rents increase with increases in non-sawtimber feedstock prices, and that changes in land use are tied to forest land rents).

   (e) If we extrapolate these simulation results to a demand scenario where pellet demand continues to increase beyond 2020, we would expect the simulations to show prices remaining high or continuing to increase, and would show timberland area, harvest, and logging residue use for pellets continuing to increase.

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INTRODUCTION

The use of woody biomass from forests as feedstock for the production of wood pellets is not new, but the recent increase in pellet production due to international policies is changing markets for wood products in the United States. The key policy is the European Union (EU) Renewable Energy Directive,[1] which requires that a percentage of each Member State's energy be generated using renewable fuels. This requirement is contributing to increased U.S. production and export of wood pellets, thus contributing to an increase in the capacity for pellet feedstock production from 3.8 million green short tons (mgt) in 2008 to 19.9 mgt in 2013, with additional anticipated increases rising as high as 25.9 mgt by 2020 for total U.S. pellet production capacity (Forisk Consulting 2014).[2]

The large-scale production of pellets for export is increasing in the United States (Pirraglia and others 2010a, Spelter and Toth 2009), and most of the new production is in the U.S. South. Figure 1 shows the evolution of overall pellet production capacity by U.S. region over the last decade (Forisk Consulting 2014). The U.S. South currently contains more than 62 percent of total U.S. pellet production capacity, up from 12 percent in 2003. Figure 2 shows that the U.S. South accounts for 81 percent of total announced pellet capacity (Forisk Consulting 2014). Nearly all of this new capacity was developed to produce pellets for export to EU Member States (Forisk Consulting 2014, U.S. Department of Commerce 2014). Research suggests that biomass energy could represent a cost-effective renewable energy strategy for reducing greenhouse gas (GHG) emissions (Ehrig and Behrendt 2013), although the GHG intensity of biomass energy is highly dependent on the feedstock and processing methods used (Stephenson and MacKay 2014).

Historically, wood bioenergy demands have played a small role in overall U.S. domestic energy production (Ince and others 2011). These domestic trends are projected to change due to several State-level requirements [often called renewable portfolio standards (RPS)] that a portion of electricity be generated from renewable sources (Bredhoeft and Bowman 2014). These State requirements result in a projection that the use of wood and other biomass will increase at an average annual rate of 4.4 percent from 2014 through 2040, though the portion attributed to wood is not identified (U.S. Department of Energy, Energy Information Administration 2014). These domestic increases could contribute to bioenergy impacts on U.S. forests.

Existing and proposed U.S. policies previously examined for their impact on U.S. forests include: (1) the Renewable Fuel Standard for transportation fuel production (RFS, enacted with the Energy Independence and Security Act of 2007[3]) (Galik and others 2009, Gan and Smith 2006, Ince and others 2011, Perez-Verdin and others 2009, Perlack and others 2005); (2) State-level renewable portfolio standards for electric power production (Abt and others 2010, Rossi and others 2010); and (3) potential Federal renewable portfolio standards for electric power production (Abt and Abt 2013, Abt and others 2012, English and others 2010). While there are differences in technologies that use wood for biofuels production or for electric power production, these uses will have a similar impact on forests. One area of potential difference, however, is in the producers' willingness to use logging residues (also called forest or harvest residues) as a feedstock.

[1] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (known as the Renewable Energy Directive). OJ L 140/16. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN. [Date accessed: August 6, 2014].

[2] Since the data used in this study were distributed, Forisk has modified their projection by (a) changing the feedstock-to-pellet ratio, resulting in a net increase in wood demands; and (b) changing the total demand as a result of actions that occurred in the U.K., resulting in a net decrease in wood demands.

[3] Energy Independence and Security Act of 2007. Pub.L. 110-140. 121 Stat. 1492. http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/html/PLAW-110publ140.htm. [Date accessed: August 6, 2014].

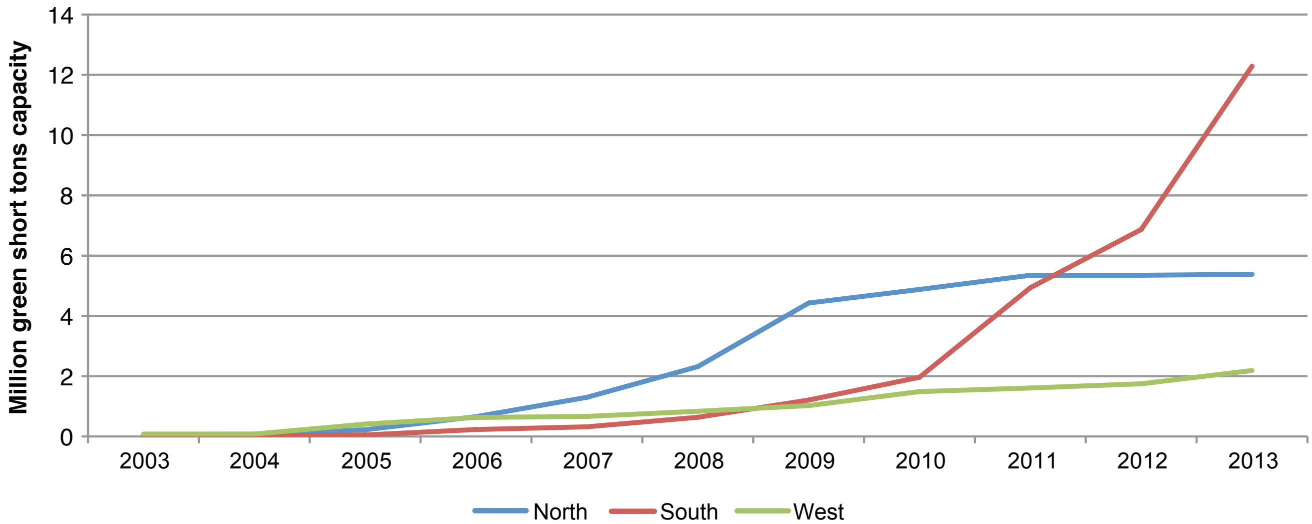

Figure 1—Growth in pellet production capacity by U.S. region from 2003 through 2013. Source: Forisk Consulting (2014).

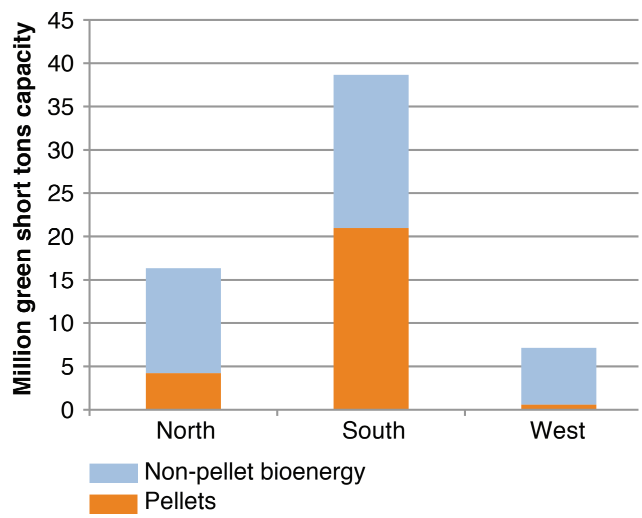

Figure 2—Announced bioenergy capacity by U.S. region. Source: Forisk Consulting (2014).

Pellets were given a unique harmonized trade code at the beginning of 2012, so pellet export data are available from January 2012 to May 2014. For this period, 98 percent of U.S. exports were to the EU, dominated by the United Kingdom (53 percent), Belgium (21 percent) and the Netherlands (14 percent) (U.S. Department of Commerce 2014) (fig. 3). Future exports are expected to be predominantly to these same countries, assuming current policies continue. For the same period, 99.9 percent of U.S. pellet exports to the EU were from ports in the South, dominated by Savannah, GA (27 percent), Panama City, FL (23 percent), and Newport News, VA (20 percent). There is some discussion in the literature of the potential for non-EU countries to become pellet importers (Roos and Brackley 2012, WRI 2014), particularly the Pacific Rim countries, but there are currently few U.S. exports to these countries.

Thus, we focus our analysis on current and projected U.S. South pellet production for export to the EU and the resulting impacts on forests and traditional wood products in the South. Following a discussion of a conceptual economic model of wood products markets, we discuss the existing and potential policies in the United States and abroad that could influence pellet production, and thus U.S. forests. We summarize the projections of pellet demand from both U.S. and international sources, and then simulate the effects of these changes on forests in the U.S. South.

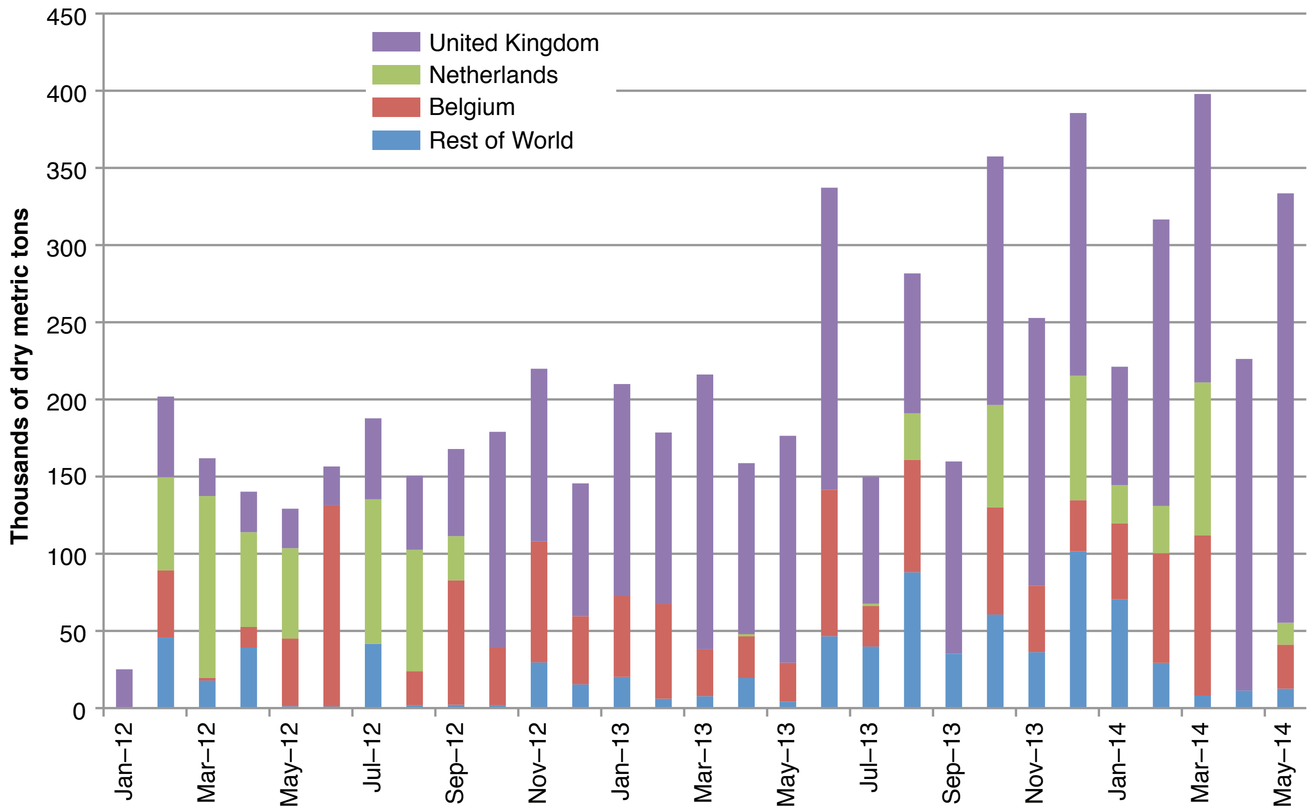

Figure 3—Destination of pellet exports from the United States for January 2012 to May 2014. Source: U.S. Department of Commerce (2014).

ECONOMIC MODEL OF PELLET FEEDSTOCK MARKETS IN THE UNITED STATES

Domestic and foreign policies that promote or require renewable electricity production affect both the supply of and demand for wood feedstock. Changes in the supply and demand of wood feedstock will affect U.S. forests, forest management, forest landowners, and other users of forest products. Numerous studies have evaluated U.S. timber markets. These have concluded that both timber supply and timber demand are relatively inelastic, meaning that small changes in demand or supply can result in sizable changes in wood price (Abt and Ahn 2003, Abt and others 2009, Beach and others 2005, Galik and others 2009, Pattanayak and others 2002, Prestemon and Abt 2002, Wu and others 2011). These inelastic price responses can be seen in figure 4, where a shift in demand from D_0 to D_1 leads to notably larger price changes (P_0 to P_1) than quantity changes (Q_0 to Q_1).

The impacts of a growing U.S. pellet export market, particularly the impact on traditional wood markets, can be described using an economic model of supply and demand for wood biomass. Market prices and quantities of biomass harvested are determined by the interaction of biomass supply and biomass demand. Biomass supply (quantity provided at each given price) for any given user is the sum of a set of interlinked regional wood supply functions, including supply functions for timber, mill residues (clean wood chips, shavings, sawdust, and bark from the production of lumber, veneer, and other solid wood products), and logging residues (limbs, tops, and leaves from harvest operations and cull in standing timber). Timber supply can be described by multiple functions based on species, size, and grade. In this section, we specify the supply (and demand) of timber products as pine or hardwood and as sawtimber and non-sawtimber. Sawtimber includes timber that is large enough and of high enough quality to be milled into lumber, veneer, or other solid wood products.[4] Non-sawtimber includes all smaller and lower grade timber products. Total biomass demand (quantity purchased at each given price) is derived from the demand for paper, lumber, panels, and energy.

[4] Hardwood sawtimber is 13 inches or greater diameter at breast height; pine sawtimber is 11 inches or greater diameter at breast height.

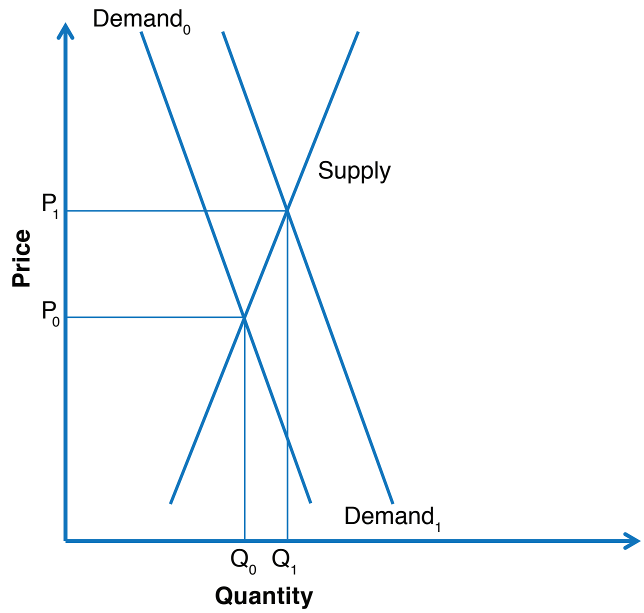

Figure 4—Hypothetical timber market, showing inelastic baseline demand and supply and an increase in demand, with the resulting changes in prices and quantity.

Biomass Supply

The supply of biomass, in the form of timber, mill residues, and logging residues, can be defined as separate but interlinked supply functions (Skog and others 2014). Logging residue supply is linked to the level of timber supply because it is a by- or co-product of the harvesting process. Mill residues are linked to the supply of sawtimber used in sawmills or veneer/plywood mills because they are a profit-adding co-product of the milling process.

Timber supply—The supply of timber, whether for use in pellets or traditional products, will increase with the offered price. The level of timber inventory in a region is included in the supply function as a proxy for the timber production base capacity. As inventory increases, the base capacity, at the current marginal cost, is expected to increase, and thus more timber can be supplied at a given price.

Timber inventory and timber supply are typically estimated by species group (e.g., pine and hardwood) and by size and grade (e.g., non-sawtimber and sawtimber). While total timber inventory is relatively fixed at any point in time, growth in timber inventory in a given size/grade is affected by changes in age class distributions, distribution of forest types, species mix, and by changes in land use between forest and agricultural use. Inventory by size/grade is also affected by harvesting, forest management practices (including frequency of harvest), and the planting response to current and expected future market demands. Timber supply is assumed to increase with increases in price (movement along the supply curve), and is assumed to shift outward with increases in timber inventory (shifts in the supply curve), but the response to price increases can take up to 10 to 15 years in forestry.

Policies that increase near-term pellet demand have the potential to affect future timber supply by altering, over time, the measured inventory by age class, and thus the future costs of wood feedstock. For example, current harvests of timber, with attendant regeneration, will result in a relative increase in inventory of young timber stands in a few years. This constitutes a relative shift in the supply curve for young timber over that time. A future increase in inventory in young timber stands would reduce costs—all else held constant—and would lower the equilibrium timber price. An avoidance of harvest and resultant relative decrease in future inventory of young timber stands is assumed to have the opposite effect.

Inventory is also reduced when areas are no longer available for harvesting, such as when land is protected by governments or conservation easements, or when, for example, an international policy limits the areas where harvests can occur to provide wood feedstock for pellets. Such restrictions would not be expected to affect the demand of timber by the non-pellet users, but would increase the marginal costs for supply of feedstock for non-sawtimber. If EU energy policies require the use of only certified wood, this too could add costs to pellet feedstock procurement.

Policies could also influence timber inventory if they limit the size or grade of timber that can be used as feedstock for pellets. Actual use of a given size/grade of timber depends on the price buyers are willing to pay. For example, a small sawtimber-sized tree may be used for lumber, pulp, or composite panels, depending on the end use of the highest bidder. A policy limiting the size or grade of timber that can be used has the effect of reducing the inventory available and thus increasing marginal costs, which is expected to lead to higher prices for feedstock for pellet producers if nothing else changes.

Logging residue supply—Logging residues (also known as forest residues) are jointly produced and sometimes left or burned on site when timber is harvested for lumber, paper, pellets, or panel production. Collection of logging residues for fuel or other uses has not been the norm, though logging residues are often assumed to be a key component of renewable biomass supply for fuels or electricity production (Gan and Smith 2006, Perlack and others 2005, U.S. Department of Energy 2011). While logging residues are of lower quality than timber (they contain more dirt and bark), they may provide a cheaper source of feedstock for production processes that can accommodate the lower quality. In addition, as timber feedstock costs increase, the net cost of logging residues, including the cost to clean the feedstock, may be less than the cost of using timber as feedstock. Given the quality variation and the uncertainty in delivered price, it is unclear how frequently logging residue will be used for feedstock as wood biomass demand increases.

Regardless of the quality issue, the supply of logging residues at a given time is limited by the amount of total timber removed for other products. The need to leave residues to maintain ecological functions also limits the logging residue supply. One estimate is that, on average, 35 percent of residue should remain in the forest (Perlack and others 2005). In addition, there is evidence that the sustained removal of coarse logging residues (diameters >0.1 m) may reduce the overall carbon stored in the forest (Stephenson and MacKay 2014), which could affect future decisions regarding forest sustainability.

Including the removal of logging residues in a harvest operation would provide new revenue for a landowner, reducing the cost per unit for all wood removed. This would increase landowners' net revenue, and thus the aggregate level of timber supply in an area would increase, all else held equal. At some value for logging residues and timber products, timber buyers would be expected to seek harvest locations with a higher proportion of logging residues (assuming the same level of other products), which are likely to be hardwood stands. The subsequent increase in the production of hardwood sawtimber would likely decrease hardwood sawtimber prices, as additional hardwood sawtimber would be available. This could also have implications for pine harvests as higher residue stands are sought, and could result in a similar increase in pine sawtimber and drop in pine sawtimber prices. The points at which logging residue and timber prices will lead to these changes in harvest location are unknown.

Mill residue supply—The supply of mill residues provided for a particular use is determined by the price offered for that use and the total amount of residue generated by solid wood products manufacturing. Because these residues are clean and dry, they are the preferred feedstock for pulp, panel, and pellet producers. Currently, of the total production of 103 million oven dry tons of mill residues produced each year in the United States, only an estimated 7 million tons are unused, with the remainder used for paper products or onsite energy production (U.S. Department of Energy 2011). Total quantity of mill residues, however, is expected to respond little to increases in prices for mill residues because the residues are a co-product tied to a much more valuable product. In addition, we expect that increasing efficiency in lumber production and potential increases in onsite demand for energy by sawmills will decrease the quantity of mill residues available per unit input of saw logs (U.S. Department of Energy 2011).

Biomass Demand

Demand for biomass feedstock for traditional uses (e.g., pulp and paper, composite panels) and bioenergy uses (e.g., electricity, liquid fuels, combined heat and power, pellets) form an aggregate demand for wood feedstock.

The least expensive and cleanest source of biomass—mill residues—will likely be the preferred feedstock for traditional and some bioenergy uses. When all mill residues are consumed in a local area, then the demand will be for the next cheapest source that meets production needs (either timber sources or logging residues). If the delivered price of logging residues is greater than or equal to the delivered non-sawtimber price, then buyers may favor the cleaner non-sawtimber. As the delivered price of non-sawtimber increases, however, logging residues could be used, provided the cost of cleaning the residues is less than the difference in the two feedstocks' prices. As demand for feedstock increases, it is also possible that smaller sized sawtimber could be used as feedstock for pulp, pellets, or composites.

Subsidies or requirements for renewable energy can result in an increase in demand for wood feedstock, as represented in figure 4 by an outward shift in the demand curve. With an increase in feedstock price, industries that do not receive a subsidy are expected to reduce consumption of those feedstocks (to a limited degree). Because feedstock demand for pulp and solid wood uses is relatively unresponsive to change in feedstock price (inelastic), increased demand for non-sawtimber is expected to lead to large price increases but small harvest increases. Energy subsidies have to drive up prices notably to cause a modest shift in non-sawtimber feedstock use from pulp and panel uses to pellet use.

The amount of each type of biomass feedstock purchased will be determined by the demand from paper and paperboard, lumber, composite panel, and bioenergy producers and by the price of biomass feedstock. Demand will decrease as feedstock price increases, representing movement along the demand curve. While the demand for biomass feedstock for traditional producers has been shown to be relatively unresponsive to price increases (inelastic) (Abt and Ahn 2003), the demand response from bioenergy producers is unknown. Policies or technologies used could limit power generators' ability to substitute other energy feedstocks for wood biomass, leading to a less elastic response, or policies could be revised in response to unanticipated price increases, allowing a more elastic response.

Summary

A conceptual economic model can be used to describe the combined effects of an increased demand for wood used for energy with new or existing regulations regarding what feedstocks may be used. We can use this model to predict a variety of outcomes, including prices and harvest levels for mill residues, non-sawtimber, sawtimber, and logging residues.

The demand for timber is relatively price inelastic, indicating that the quantity demanded will not decline proportionately with increases in price. In addition, pellet producers, to date, have not indicated that logging residues will be a significant part of their current or anticipated feedstock (Forisk Consulting 2014), which will likely increase the demand for timber. The supply of timber is also relatively price inelastic in the short run, indicating that the quantity supplied will not increase proportionately with increases in price. This means that the market will be slow to adjust to rapid increases in the demand for timber used for renewable energy. This will likely lead to some type of leakage or displacement in the market in the short run; i.e., either demand will be met by imports from another region or country, or mill production will be reduced due to the high feedstock prices.

Biomass feedstock demand will be affected by the level of renewable energy goals and by the amount of subsidy supplied by individual governments. Supply will be affected by the specific requirements of (e.g., forest certification) or restrictions in policies enacted to ensure GHG emission reductions, such as limits on transportation GHG emissions. Policies to ensure the sustainability of forests, such as prohibitions on the use of roundwood or harvest exclusions in areas that are traditionally open to harvest in the United States, will also affect feedstock supply.

INTERNATIONAL AND DOMESTIC POLICIES INFLUENCING PELLET PRODUCTION

A broad range of policies is expected to affect the production, prices, and export of wood pellets from the United States, and thus U.S. forests and traditional wood products. These policies range from prohibitions on putting wood waste in landfills to renewable energy production targets and direct subsidies. These may affect pellet prices and production locally, nationally, and/or internationally. Below we discuss the international policies, domestic U.S. policies, and trade policies most relevant to U.S. pellet production and export, and thus of most importance to forests in the U.S. South.

Current International Policies

This section reviews international policies that we believe have the most potential to affect pellet production in the U.S. South. These include: (1) the 2009 EU Renewable Energy Directive (RED) (see footnote 1) and related guidance, comprising several EU directives and decisions (described below) that require each Member State to use renewables for a fixed percentage of their total energy consumption by 2020; and (2) the accompanying EU sustainability guidelines on (a) greenhouse gas emission reductions and (b) forest land use/sustainability criteria. Because rules for solid biomass are not mandatory at the EU level (EU GHG and sustainability criteria are currently presented only as guidelines) and there are varying member country rules, there is not yet and may never be a single EU policy that will govern the impact of the RED on U.S. forests. To a smaller extent, there is the possibility that international trade policies could influence pellet trade and thus U.S. forests.

European Union Renewable Energy Directive—The 2009 EU Renewable Energy Directive (RED) (see footnote 1) and related guidance are likely the most significant international policies affecting U.S. pellet manufacturing and thus U.S. forests. These related policies are sometimes called the "20/20/20 by 2020" policies, and require (1) a 20-percent EU-wide renewable energy component, with each Member State generating a set share of renewable energy (RED); (2) a 20-percent reduction in GHG emissions, which is accomplished through a minimum

GHG reduction from the fossil fuel comparator (RED), Member State-total GHG reduction contributions compared to 1990,[5] and from Member State annual emission allocations for the period from 2013 to 2020;[6] and (3) a 20-percent improvement in efficiency.[7] Combined, these policy initiatives seek to promote renewable, low-GHG, and efficient sources of energy.

At the individual country and sub-national levels, a variety of policies affects the production, importation, and/or use of woody biomass bioenergy. As noted in reviews by Goh and others (2013b), Lamers and others (2014a), and Thrän and others (2014), EU and individual Member State bioenergy policies include a mix of tax exemptions, mandatory targets, electric power feed-in tariffs, and direct subsidies. In addition, the Member States have a variety of solid biomass sustainability policies. Policies of Member States will ultimately determine the criteria against which biomass is judged to meet these objectives. Though often modeled on EU-issued guidance, these Member State policies do, and will continue to, vary with regard to wood feedstock chain of custody, sustainability, and net GHG emissions requirements. Because of the variation in these policies, as well as the quantity of other renewable sources in each Member State, there is likely to be wide variation in the volume of biomass demanded by individual Member States.

One crucial effect of the RED is the adoption by some Member States of subsidies for certain kinds of renewable energy production, including the use of biomass. These subsidies are a market intervention that could be interpreted to be either the cause or result of market imperfections. For example, the policy and subsidy could be assumed to correct the imperfection that results from the free emission or sequestration of carbon, or the policy and subsidy could be assumed to cause a market imperfection by subsidizing one sector at the expense of another.

The RED does not currently include any accounting of biogenic carbon (carbon in the forest itself), nor does it include any GHG emissions that result from indirect land use change. The exclusion of biogenic carbon derives from the assumption that GHG emitted through wood combustion is balanced with re-sequestration as the forest regrows. In addition, the RED accounting does not include any GHG emissions changes resulting from indirect land use change.

The importance of subsidy support in driving imports is evident in the recent biomass trade data from the Netherlands. For January–September 2012 and December 2013–May 2014, U.S. pellet exports to the Netherlands made up 19 and 13 percent, respectively, of total exports, compared to just 3 percent in the intervening period (see fig. 3). (U.S. Department of Commerce, Bureau of the Census 2014). The decrease coincided with the phase-out of a key subsidy (Milieukwaliteit Elektriciteitsproductie, or MEP) for electricity production (Natural Resources Canada 2013). The recent increase is attributed to new co-fire capacity coming online (E.ON. 2014). Expected biomass contributions to power production in the Netherlands remain high well into the future (USDA Foreign Agricultural Service 2013). In addition, renewable energy regulations in the Netherlands are expected to be reformulated and reissued in the near future, potentially extending the subsidy for bioenergy facilities (Lexology 2014).

To illustrate the importance of the Member State subsidies, we calculate a set of break-even prices for stumpage sourced from the U.S. South based on assumptions regarding production, prices, and subsidies that we extracted from the literature and available databases for pellet consumers in the United Kingdom.[8] A full exploration of the influence of the subsidies on facility investment decisions would require information on fuel costs, the attributes of alternative generation technologies (e.g., base load versus peaking), the costs of alternative generation technologies, and/or the capital costs of conversion. Alternatively, we compare the value of United Kingdom Renewable Obligation Certificates (ROCs) to fuel-switching decisions in facilities where wood pellets and other fuels are fungible; specifically, where these fuels are already being co-fired with coal. ROCs are granted to an energy facility based on the amount of renewable energy produced. Although relevant to a much smaller number of facilities, it nonetheless offers insight into the value of ROCs to wood pellet markets.

Based on the number of ROCs issued for a particular technology in a given year, the cost of coal, the energy content of coal, the energy content of wood pellets, and the value of ROCs both earned for and paid in lieu of

[5] Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020. OJ L 140/136. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0136:0148:EN:PDF. [Date accessed: August 6, 2014].

[6] Decision 2013/162/EU. Commission decision of 26 March 2013 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council. OJ L 90/106. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:090:0106:0110:EN:PDF. [Date accessed: August 6, 2014].

[7] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. OJ L 315/1. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF. [Date accessed: August 7, 2014].

[8] Details of the assumptions are available from the authors.

complying with the generation requirements, we estimate a break-even price for pellets at which cogenerators would be indifferent to using either wood pellets or coal. This assumes no additional costs are encountered in switching between fuels, either direct capital costs or indirect costs attributable to efficiency losses.

Using projected pellet prices from RISI, Inc. (2013), we can compare these break-even pellet prices to projected pellet prices to see when an operator would choose to use pellets over coal. In situations where continuing to use coal is cheaper than the pellet price, pellets would not be used. In situations where the pellet price is lower than the cost of continuing to use coal, the difference between the RISI-projected price and the calculated break-even price can be used to calculate the maximum stumpage price a pellet producer would be willing to pay to continue supplying pellets to a coal facility.

Using RISI-reported estimates of pulpwood required (2.24 green short tons/tonne of pellets) and the average proportion of delivered pellet price that is attributable to wood costs (0.354), and assuming that stumpage represents one-third of delivered costs, we calculate an estimated maximum stumpage price an energy producer would be willing to pay. Although there are other methods, we calculate these estimates using a baseline stumpage price (from RISI wood cost data) and then assume that all pellet price increases result in proportionally higher stumpage prices being paid (i.e., for every $1 of increased pellet price, total wood costs increase by $0.354, of which 33 percent is attributable to stumpage costs). Table 1 shows these hypothetical break-even stumpage prices. An alternative analysis assuming that all other costs remain constant and that any additional revenue is available to pay higher stumpage prices (not reported here) shows similar results. Depending on one's perspective, this is either a worst-case or a best-case scenario representing maximum potential stumpage price changes.

EU renewable energy policy continues to evolve. On January 22, 2014, the EU announced its 2030 energy framework and objectives, which include a requirement for 40-percent GHG reduction, a minimum renewable contribution of 27 percent at EU level (but not translated to Member State targets), and a target energy efficiency improvement of 25 percent (European Commission 2014a, 2014b). The effect of the new objectives on pellet markets is unclear and will likely remain so until the European Commission, Parliament, and/or Council provides further clarification. A recent EU Commission staff working document (European Commission 2014c) evaluated the current conditions with respect to the solid biomass guidelines and sustainability and concluded that the current array of Member State policies did not pose a distortion risk to EU markets. The paper also reiterates the EU Commission position that solid biomass sustainability would continue to be monitored through 2020.

EU sustainability guidelines and Member State sustainability policies—EU bioenergy demand and supply are also influenced by policies seeking to ensure use of biomass for energy that result in real GHG emission reductions without imperiling the sustainability of bioenergy feedstock. These sustainability criteria are an area of uncertainty in pellet market development. The EU has established general guidelines (table 2) by which Member States can develop their own policies on the use of solid or gaseous biomass for electricity production and heating/cooling (European Commission 2010). Included in the guidelines are requirements for GHG emission reductions relative to a fossil fuel alternative, provisions

Table 1—Break-even stumpage price on a dollar per green ton pulpwood basis, where additional profits were allocated to wood procurement proportional to other costs

Type (and size) of power plant facility	2013–14	2014–15	2015–16	2016–17
Co-firing (low-range)	NA	NA	NA	NA
Co-firing (mid-range)	$11.21	$11.50	NA	NA
Co-firing (high-range)	$12.03	$13.98	$13.94	$13.68
Co-firing with CHP (low-range)	$12.85	$13.15	$14.76	$14.50
Co-firing with CHP (mid-range)	$15.33	$15.62	$15.58	$15.33
Co-firing with CHP (high-range)	$16.15	$18.09	$18.06	$17.80

NA indicates that even with the subsidy and penalties, pellets would not be preferred over coal for this size and type of power plant facility. CHP=combined heat and power.

to ensure the sustainability of the land use from which the biomass is derived, and requirements for biomass chain of custody and sourcing (European Commission 2010). These guidelines do not address the accounting of biogenic carbon, nor do they address indirect land use effects from the production of biomass (Stephenson and MacKay 2014).

Three Member States have also developed their own sustainability policies: the United Kingdom, the Netherlands, and Germany (Pelkmans and others 2014). The GHG reduction requirements are reported in table 3. In the Netherlands, NTA8080/81 addresses many of the same objectives outlined in EU guidance, but also includes requirements for social and economic impacts. Though once linked to eligibility for the Netherlands support scheme (*Subsidieregeling duurzame energieproductie*, or SDE), it is unclear how NTA8080/81 will affect future large-scale pellet combustion operations (Junginger and Sikkema 2009). These policies meet all EU sustainability guidelines outlined in table 2. In Germany, a sustainability ordinance guides the use of biomass within that country, mirroring the EU 2010 guidance for both GHG and land sustainability. Similarly, the United Kingdom has land use sustainability policies in place to guide the use of solid biomass in the generation of heat/cooling/electricity that are compatible with those outlined in the 2010 EU guidance document (United Kingdom Department of Energy and Climate Change 2011, 2013).

The GHG reduction potential of woody biomass has been the subject of considerable debate in recent years (Colnes and others 2012, Galik and Abt 2012, Latta and others 2013, Manomet Center for Conservation Sciences 2010), and some suggest that the magnitude of biomass demand combined with increasing competition for other uses will make it difficult to meet sustainability criteria in North America (Hewitt 2011). EU sustainability criteria could conceivably limit the supply of Southern U.S. biomass to European renewable energy markets in favor of other world suppliers that can more easily meet the criteria (Lamers and others 2014b, Schueler and others 2013). In an analysis of the potential restrictions imposed by increasingly stringent GHG controls, Lamers and others (2014a) projected that the majority of non-EU supply would still originate from the United States in all but a few scenarios. Despite this relative export advantage, absolute export volumes were projected to fall with increasing criteria stringency, and Indonesia and Malaysia were projected to contribute the largest amount of biomass under the most stringent of GHG policies.

Dwivedi and others (2011, 2014) evaluate the GHG intensity of Southeastern U.S. pellet production and its subsequent transportation to and consumption in a United Kingdom power generation facility, finding significant emissions reduction potential as compared to coal (50–68 percent). Consistent with current EU guidance, the authors do not consider biogenic emissions associated with pellet combustion, assuming that stand replanting immediately after harvest and eventual regrowth will offset pellet combustion emissions. They also do not consider the extra radiative forcing effect of the net increase in carbon dioxide

Table 2—EU sustainability guidance for solid and gaseous biomass used for electricity production and heating/cooling

Target/objective	Requirement
GHG reductions	• Wastes/residues are bound only by GHG reduction requirements, not other parts of sustainability criteria. For solid/gaseous biomass used for heating/cooling/electricity, GHG reductions are tied to products, not feedstocks (Article 17(1); Annex II). • Minimum GHG reductions below a fossil fuel alternative of 35% in 2009, 50% by 1/1/2017, and 60% by 1/1/2018. For solid/gaseous biomass used for heating/cooling/electricity, incentives should be given for increased conversion efficiency (Article 17(2)).
Land use and production	• Prohibits material from high biodiversity value areas (Article 17(3)) • Prohibits material from conversion of high-carbon stock areas (Article 17(4)) • Prohibits material from undrained peatland (Article 17(5)) • Requires EU-sourced material to be produced in accordance with applicable regulations (Article 17(6))
Sourcing/ chain-of-custody	• Requires operators to verify chain of custody using mass balance approach[a] (Article 18(1))

[a]Mass balance approach means that the sustainability characteristics of every shipment must match the characteristics of the inputs to that shipment.
Source: European Commission (2010). GHG=greenhouse gas.

Table 3—EU solid biomass guidelines and select EU Member State solid biomass standards and regulations

Sustainability provision	EU solid biomass guidelines[a]	United Kingdom[b]	Netherlands NTA8080/81[c]	Germany[d]
Minimum GHG reductions	Reduction from a fossil fuel alternative of 35% by January 1, 2009; 50% by January 1, 2017; and 60% by January 1, 2018	New dedicated biomass power (with or without CHP): 240 kg CO_2e/MWh electricity from 1 April 2014 to 31 March 2020 200 kg CO_2e/MWh electricity from 1 April 2020 to 31 March 2025 180 kg CO_2e/MWh electricity from 1 April 2025 to 31 March 2030 All other biomass power, including co-firing coal stations, coal stations converting to biomass, and existing dedicated biomass power (with or without CHP): 285 kg CO_2e/MWh electricity from 1 April 2014 to 31 March 2020 200 kg CO_2e/MWh electricity from 1 April 2020 to 31 March 2025	50-70%	35-60%
Exclusion of high biodiversity lands	•	•	◊	•
Exclusion of protected areas	•	•	◊	•
Exclusion of recently converted high carbon lands	•	•	•	•
Exclusion of undrained peatlands	•	•	•	•
Exclusion of converted forests	•	•	•	•
Requires mass balance chain of custody	•	•	•	•

• Meets EU-RED criteria for biofuels and bioliquids.

◊ Exceeds EU-RED criteria.

GHG=greenhouse gas; CHP=combined heat and power.

[a] From Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (known as the Renewable Energy Directive). OJ L 140/16. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN. [Date accessed: August 6, 2014].

[b] From UK Office of Gas and Electricity Markets, Decision184/11. December 19, 2011. Renewables obligation: sustainability criteria for solid and gaseous biomass for generators (greater than 50 kW). https://www.ofgem.gov.uk/publications-and-updates/renewables-obligation-sustainability-criteria-solid-and-gaseous-biomass-generators-greater-50-kw?docid=329&refer=Sustainability/Environment/RenewablObl/FuelledStations/ro-sustainability. [Date accessed: August 18, 2014]. See also http://www.natlawreview.com/article/united-kingdom-government-confirms-change-to-sustainability-criteria-biomass. [Date accessed: December 6, 2013].

[c] From http://www.sustainable-biomass.org/publicaties/4717. [Date accessed: November 26, 2013]. Low and high end of GHG requirements refer to reductions relative to natural gas and coal/other sources, respectively, against NL reference emissions and coal/other sources, respectively, against EU reference emissions. Covered work in protected areas or areas of high conservation value also extends to 5-km buffer around protected areas.

[d] From http://www.ble.de/EN/02_Control/05_SustainableBiomassProduction/01_InformationMaterials/InformationMaterials.html?nn=2448336. [Date accessed: November 26, 2013].

in the atmosphere for a period after pellet combustion until carbon recovers to a level that would have occurred without pellet production and use. For the methods used, the estimated net emissions levels may meet the net emissions targets; however, the ability of southern woody biomass to comply with EU GHG criteria will ultimately depend on the selected GHG accounting methods and actual domestic pellet production methods. For example, current GHG calculation approaches for liquid transportation fuels as outlined in the RED (see footnote 1) include only emissions attributable to production (including land use change), processing, and transportation of feedstock and the resulting fuel; emissions from the fuel itself are not considered in the calculation.

Stephenson and MacKay (2014) extend this analysis to include biogenic carbon and indirect land use using a life-cycle analysis tool and counterfactual scenarios to identify the most efficient pathways for biomass energy development in the United Kingdom. Current EU GHG emissions accounting rules do not consider either indirect land use change or changes in biogenic carbon stocks that could result from an increase in harvest to produce feedstock for pellets to produce renewable energy. However, these aspects could influence both the type and origin of feedstocks that would meet EU renewable energy needs. There remains the possibility that the United Kingdom and/or EU regulators could incorporate these two additions to the GHG accounting rules.

A second area of uncertainty in the sustainability requirements is the need to demonstrate compliance with land use restrictions and chain-of-custody provisions of the sustainability criteria. For many of the countries, including the United Kingdom, the sustainability requirements can be met at least partially through certification of the forest by independent third-party schemes, including the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) (table 4). Several overviews of these schemes, including a benchmarking of these schemes to the United Kingdom regulations, have concluded that these schemes may require additional inputs to meet the land and chain-of-custody requirements of the EU guidelines and Member State regulations (see Kittler and others 2012, Ladanai and Vinterbäck 2010, Scarlat and Dallemand 2011, United Kingdom Department of Energy and Climate Change 2014, van Dam and others 2010, Vis and others 2008).

In addition to the two approved certification schemes (FSC and PEFC), legality and sustainability can be demonstrated using specific evidence to meet each of the United Kingdom sustainability criteria (United Kingdom Department of Energy and Climate Change 2014).

Trade—One complication in the development of sustainability criteria is that they should be compatible with international treaties and trade agreements. For example, sustainability criteria may be vulnerable to challenge under World Trade Organization (WTO) agreements if they discriminate against products sourced from particular countries (Mitchell and Tran 2010). Trade modeling that includes EU biofuel tariffs suggests that patterns of trade may be altered by the EU biofuel policy (Burrell and others 2012), raising the potential for a challenge. A challenge to the tariff-related sustainability criteria (e.g., on biofuels) by an accusing (injured) country potentially could be successful if the EU is shown to be applying a tariff on imports from the accusing country that is higher than the tariff applied to any other WTO-signatory country or countries (the bedrock "Most Favored Nation" principle codified in the WTO). Further, a challenge to non-tariff aspects of sustainability criteria might be successful if an accusing country can prove that the standards applied to imports from the accusing country are more stringent than those required of domestic or EU producers of biofuel sources (the second bedrock principle of the WTO, "National Treatment"), or that the criteria are deemed "arbitrary" barriers to foreign producers. For example, the requirement of fiber source certification before wood pellets receive credit under the EU's 2020 targets on energy from renewables may be deemed improperly favorable to domestic/EU producers. Swinbank (2009) expressed doubts that EU sustainability criteria will be found to be WTO-compatible, owing in part to the potentially arbitrary nature of GHG limits. In 2013, Argentina filed a complaint with the WTO alleging that, in fact, these criteria were arbitrary, though no resolution of the complaint has been announced.

Others suggest that a General Exception may be available under Article XX of the General Agreement on Tariffs and Trade (GATT). This exception would allow differential treatment across products and production techniques, especially as it pertains to the conservation of natural resources, so long as differentiating criteria are not deemed arbitrary and unjustifiable (Ackrill and Kay 2011, Mitchell and Tran 2010). Mitchell and Tran (2010) note that the environmental sustainability criteria for biofuels could be found inconsistent with GATT unless an Article XX exception can be defended. On the other hand, Ackrill and Kay (2011) suggest that EU biofuels sustainability criteria were developed to be compatible with the WTO.

Current Domestic Policies

There are no current policies that specifically encourage or discourage the use of wood pellets in the United States, although there are many existing and potential future policies that could influence both the production and consumption of pellets or other wood for bioenergy production. Historically, the U.S. pellet market has

Table 4—Major certification schemes and their compliance with the subset of provisions of EU-RED most relevant to woody biomass production in the U.S. South

Criteria outlined by EU biofuels sustainability criteria (2009/28/EC)	Forest Stewardship Council	Programme for the Endorsement of Forest Certification	Sustainable Forestry Initiative	American Tree Farm System
Exclusion of lands with high biodiversity value	•	○	•	–
Exclusion of wetlands and continuously forested areas	•	○	•	•
Exclusion of lands designated for nature purposes as of January 2008	•	○	•	•
Exclusion of biodiverse forest with no significant human intervention	•	○	•	•
Exclusion of peatland unless proven that draining of previously undrained soil is not involved	–	–	–	–
Condition of good agricultural practice: integrated pest management techniques, chemicals	•	–	•	•
Reporting obligation to the EC on soil impacts in regions that are significant source of feedstock	•	•	•	–
Reporting obligation to the EC on water impacts in regions that are significant source of feedstock	•	•	•	•
Reporting obligation to the EC on air impacts in regions that are significant source of feedstock	–	–	–	–
Reporting obligation to the EC on social impacts in regions that are significant source of feedstock: child labor, wages, freedom of unions/association, land use rights	•	•	•	–

• Meets or exceeds EU-RED criteria with specific criteria and indicators identified.

○ Meets or exceeds EU-RED criteria without specific criteria and indicators identified.

– Does not meet EU-RED criteria. Specific criteria and indicators may or may not be identified.

Adapted from Kittler and others (2012).

produced bagged pellets for use in residential wood pellet stoves, but the large-scale production of bulk pellets for export is a relatively new phenomenon. Both Federal and State policies will influence the future of bioenergy production and consumption in the United States.

Federal—Current U.S. Federal laws that could indirectly influence pellet production, and thus U.S. forests, include the Energy Independence and Security Act of 2007 (EISA) (see footnote 2) and the Agriculture Act of 2014.[9] EISA governs the requirements for cellulosic biofuels and limits the type of wood feedstock that can be used when meeting these requirements. EISA requires that any woody biomass used to meet the renewable fuels standard comes only from non-Federal and non-ecologically sensitive lands, and can only come from (a) roundwood and mill residue from existing plantations; (b) slash and precommercial thinnings; or (c) wildfire hazard reduction materials. EISA will affect pellet production if (a) cellulosic biofuels become a commercially viable product and begin to affect timber harvests, and/or (b) international policies or subsequent domestic policies use the EISA feedstock limits as a basis for their own sustainability criteria. These would affect forests because limiting the type and location of inventory available for pellet production could change the procurement costs for some wood feedstocks. The Agriculture Act of 2014 authorizes continuation of several research and demonstration programs, which are not expected to significantly affect biomass markets.

[9] Agriculture Act of 2014. Pub. L. 113-79, 128 Stat. 649. http://www.gpo.gov/fdsys/pkg/PLAW-113publ79/html/PLAW-113publ79.htm. [Date accessed: August 6, 2014].

Perhaps the most notable current and proposed policies are taking the form of regulations promulgated by the U.S. Environmental Protection Agency (EPA). These policies include proposed new source performance standards (NSPS),[10] proposed guidelines for regulating carbon emissions from fossil fuel power plants under section 111(d),[11] and the adopted Boiler Maximum Achievable Control Technology (MACT) rule[12] under the Clean Air Act of 1970[13] (CAA), as well as Non-Hazardous Secondary Material (NHSM) regulations[14] under the Resource Conservation and Recovery Act of 1976[15] (Probert 2012; Tarr and Adair 2014; U.S. Department of Energy, Energy Information Administration 2013). The proposed NSPS and guidelines for regulating existing sources under section 111(d) of the CAA have the potential to increase the demand for bioenergy in the United States. The degree to which they influence domestic demand for bioenergy production is dependent, in part, on rules governing biogenic carbon accounting processes, which are still under development by the EPA. If these accounting processes show biomass to be GHG-beneficial relative to other fuels, there will be increased incentive to use domestic biomass resources in electricity generation facilities within the United States. Alternatively, CAA, Boiler MACT, and NHSM regulations have the potential to increase the costs of biomass use, including pellet production, by requiring additional pollution abatement practices or technology. The precise impacts of both sets of drivers are currently unknown.

Other Federal policies that could be enacted include possible extensions to the Federal biomass production tax credit or a Federal renewable portfolio/clean electricity standard, the latter of which has been repeatedly introduced in Congress in recent years with little legislative traction. These standards could require a renewable component of national electricity production. There are no laws or policies currently under consideration on these topics.

State—State-level renewable portfolio standards (RPS) have the potential to influence pellet consumption for energy production. A summary of these policies and the potential and requirements for wood biomass use from State RPS is presented as part of the 2014 Annual Energy Outlook (Bredhoeft and Bowman 2014). Use of woody biomass for energy is still more expensive than other carbon-based energy, and State-level policies often do not provide subsidies for biomass use. Thus, the cost of biomass energy production may still exceed the cost of producing energy with natural gas even when a penalty is applied. Consumers in the United States have not demonstrated a strong financial commitment to the use of renewable, low-carbon energy (Neff 2012), and thus utilities have little incentive (in most States) to pass on added costs to consumers. Utilities will likely choose the least costly method of meeting State RPS requirements, which may not include burning biomass. In addition to State RPS policies, multiple regulations promulgated by or under consideration by the EPA (discussed above) will affect how GHG emissions from biomass combustion are accounted for, which may in turn alter behavior and/or State requirements for biomass energy use.

Forestry best management practices, or BMPs, may provide some information for compliance with sustainability criteria. The breadth and depth of BMPs vary from State to State, as do implementation rates (Ice and others 2010). Within States, implementation rates also vary by both year and provision (e.g., Alabama Forestry Commission 2013, Georgia Forestry Commission 2011, Simpson and others 2011). By themselves, BMPs may not satisfy EU sustainability requirements (Kittler and others 2012).

Pellet production may also be affected by the adoption of State-level guidelines or restrictions that influence the volume and manner in which biomass may be harvested, sometimes called biomass harvesting guidelines. Model guidelines drafted by the Forest Guild exist for the Northeast, Northwest, and Southeast United States. Guidelines have been adopted in several States, including Massachusetts, Kentucky, Maryland, Maine, Michigan, Minnesota, Missouri, Pennsylvania, Indiana, South Carolina, and Wisconsin (Kittler and others 2012). These guidelines supplement any State-level forestry best management practices. Though content varies between

[10] EPA National Emission Standards for Hazardous Air Pollutants: Off-Site Waste and Recovery Operations—Proposed Rule. 79 Fed. Reg. 37850 (proposed July 2, 2014) (to be codified at 40 CFR pt. 63). http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2012-0360-0001. [Date accessed: August 6, 2014].

[11] EPA Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units—Proposed Rule. 79 Fed. Reg. 34830 (proposed June 18, 2014) (to be codified at 40 CFR pt. 60). http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013-0602-0001. [Date accessed: August 6, 2014].

[12] EPA National Emissions Standards for Hazardous Air Pollutants for Area Sources: Industrial, Commercial, and Institutional Boilers. Final Rule. 78 Fed Reg. 7487. 40 CFR Part 63. https://federalregister.gov/a/2012-31645. [Date accessed: August 14, 2014].

[13] Clean Air Act of 1970. Pub. L. 159 (July 14, 1955) 69 Stat. 322, and the amendments made by subsequent enactments. 42 U.S.C. 7401–7626. http://www.epw.senate.gov/envlaws/cleanair.pdf. [Date accessed: August 6, 2014].

[14] EPA Commercial and Industrial Solid Waste Incineration Units: Non-Hazardous Secondary Materials That Are Solid Waste—Final Rule. 78 Fed. Reg. 9112 (February 7, 2013). 40 CFR Parts 60 and 241. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-RCRA-2008-0329-1981. [Date accessed: August 6, 2014].

[15] Resource Conservation and Recovery Act of 1976. Pub. L. 94-580. 90 Stat. 2795. 42 USC 82 part 6901. http://www.gpo.gov/fdsys/pkg/STATUTE-90/pdf/STATUTE-90-Pg2795.pdf. [Date accessed: August 6, 2014].

individual guidelines, most place emphasis on defining the allowable removal of down woody debris (Kittler and others 2012), which will determine the amount of logging residue that can be removed from a harvested site. One exception is the harvesting rules adopted in Massachusetts, which apply only to biomass harvested to meet their RPS.[16] These rules require a GHG reduction and an efficiency level in the production of energy from biomass. They also place the following limits on qualifying biomass harvests: (1) biomass fuel can make up no more than 30 percent of a harvest by weight; (2) it must derive only from thinning and residues; (3) harvests must leave 75 percent of logging residues on good soils and all residues on poor soils; and (4) removals must not come from steep slopes, old growth, naturally down woody material, or cavity trees.

Summary—Policies

The primary policy expected to influence U.S. forests through the pellet market is the EU Renewable Energy Directive, as well as the implementing policies for this directive. The direct effect is on demand—a requirement for a percentage of energy to come from renewable sources has resulted in an increase in co-firing and direct firing of pellets for electricity using imported pellets, primarily in the United Kingdom, the Netherlands, and Belgium. In two of these circumstances, the Member State government subsidizes the use of pellets for electricity, and withdrawal of those subsidies would likely reduce the demand for U.S. pellets. In addition to the impact on demand, the sustainability rules with respect to GHG emissions, land use change, and chain of custody have the potential to either limit the availability of inventory for harvest or directly increase the costs of supplying feedstock for pellet production, either of which would shift the supply curve inward and raise prices.

U.S. policies that could have an influence on pellet production and export include the regulation of GHG emissions under the CAA, the Federal EISA, State RPS, and State biomass harvesting guidelines/requirements. Regulations promulgated under the CAA could affect both the amount of wood used for domestic energy production and the cost of pellet production for export. Depending on rulemaking timelines, EPA policy could also provide a model for EU accounting of GHG emissions from the production of U.S. wood pellets. Similarly, the EISA land use requirements could be the basis for EU requirements for ensuring the sustainability of land from which wood for pellets is sourced.

[16] Massachusetts 225 CMR 14.00. http://www.mass.gov/eea/docs/doer/renewables/biomass/225-cmr-14-00-final-reg-doer-081712-clean-copy.pdf. [Date accessed: November 6, 2014].

PROJECTED PELLET DEMAND

Research has explored the role of global bioenergy policies in driving demand for biomass (Goh and others 2013a; Joudrey and others 2012; Junginger and others 2009, 2011; Lamers and others 2012; Sikkema and others 2011; USDA Forest Service 2012). Most of this work has focused on the development of markets and on shifting trade patterns over the last 3 to 5 years. Given the significant role the EU is expected to play in future pellet markets, projections of global pellet demand tend to be EU-focused (Lamers and others 2014a). In conducting these projections, researchers caution that macroeconomic modeling of trade flows may not adequately characterize market development, especially as it pertains to policy uncertainty, timing considerations, and logistics (Lamers and others 2014b). We discuss projections of EU pellet imports, U.S. pellet manufacturing capacity, and U.S. pellet production. We also show how these projections compare to current wood products output in the U.S. South.

A doubling of biomass electricity production is expected in the EU between 2011 and 2020 (Beurskens and others 2011). Using the Member State National Renewable Energy Action Plans for several countries, Joudrey and others (2012) show projected 2020 estimates of total biomass demand, domestic biomass supply, and expected biomass imports. Of the seven countries shown, domestic supply is shown to be insufficient for five, while the other two do not include an estimate of domestic supply. These plans indicate that pellet imports are expected to be crucial to meet renewable energy requirements, but the plans alone are insufficient to project EU-wide biomass imports.

Hewitt (2011) also finds that solid biomass production within the EU is unlikely to meet projected biomass demands. In light of this gap, woody biomass from the U.S. South is expected to play an important role in meeting EU bioenergy targets over the next decade (Beurskens and others 2011, Goh and others 2013b, Joudrey and others 2012).

Cocchi and others (2011) summarize nine projections of EU pellet imports from worldwide supply regions. For 2020, the various projections range from 15 to 80 million dry metric tons (mt). Only two projections were made beyond 2020—one in 2025 at about 28 million dry mt and one in 2030 for about 42 million dry mt. For the low estimate from Cocchi and others (2011), the U.S. South is expected to supply about 36 percent and Canada about 28 percent of the import estimate, with the remainder supplied by Brazil, Russia, New Zealand, and Australia. Under the higher estimate from Cocchi and others (2011), the volumes from the United States and Canada are not expected to increase, so the additional imports come from increases in African, South American, and Russian production. Estimates provided by Goh and others (2013b) also suggest that southern pellets could provide over one-third of total EU energy imports by 2020.

Projections made by RISI Inc. (2013) show a more than 250-percent increase in pellet production between 2011 and 2015, and a nearly 70-percent increase between 2015 and 2020. Forisk Consulting (2014), which projects changes in bioenergy production capacity based on operating and announced facilities, projects an increase of 450 percent in pellet production in the U.S. South between 2011 and 2015, and another 22 percent between 2015 and 2020. These forecasted increases in pellet production from Cocchi and others (2011), Forisk Consulting (2014), and RISI Inc. (2013) can be translated roughly into green short tons (table 5). The projected wood input use for southern pellet production ranges from 9 mgt to 27 mgt in 2015 to as high as 49 mgt in 2020.

Despite the focus on the EU as a driver of pellet market development, potential exists for growth of pellet markets in South America, Asia, and Africa (Goh and others 2013a, Pirraglia and others 2010b). Lamers and others (2014b) estimate an unmet demand of 3 million dry mt in Japan and 4 million dry mt in South Korea by 2020. Potential competition for EU imports from these countries may be minimized by the historical pattern of biomass trade in this region and/or through application of sustainability criteria, which would direct non-eligible biomass to markets with less restrictive policies in place (Brackley 2013, Lamers and others 2014b, Roos and Brackley 2012). Alternatively, market development in East Asia could divert Canadian exports away from the EU while also stimulating the expansion of existing pellet production capacity in Southeast Asia and Australia (Goh and others 2013a). Wood Resources International (WRI 2014) discusses the possible exports from both Eastern Canada and British Columbia. These two geographic areas are competitors with the U.S. South for the export of pellets to the United Kingdom, and relative costs and relative anticipated GHG emissions reductions could affect the proportion of United Kingdom and EU pellets that the U.S. South supplies (Stephenson and MacKay 2014).

Acknowledging the complex role of public policy in wood pellet market evolution, global pellet markets are likely to experience strong growth in the coming years. Imports by the EU alone are expected to grow over the next decade in response to renewable energy and GHG emission reduction targets. The extent to which pellets from the U.S. South are able to supply these markets depends on the magnitude of the energy targets themselves, the level of subsidies/mandates for renewable energy, the content of governing sustainability criteria, and the evolution of complementary and competing wood products industries.

As noted above in the discussion of the economic model, the demand for woody biomass is a derived demand from the markets for solid wood, paper and paperboard, composite panels, and energy. At this time, EU policies instituted in 2009 requiring renewable energy to make up a percentage of total energy production are driving demand for U.S. pellets. Pellet mills are quick to construct, and production and start-up can easily occur within 5 years, and possibly as soon as 12-18 months, following an announcement of intent to construct. Operating pellet capacity in the U.S. South was 2.5 times greater in 2013 than in 2011 (Forisk Consulting 2014), reflecting this quick start-up time. The most recent timber production data reflect this increase in pellet production, as discussed below.

Table 5—Forecasted range of pellet and non-pellet wood input demands for 2015 and 2020

Forecasted region and product	2015	2020
	million green short tons	
U.S. pellet production	13 to 38	28 to 46
U.S. South pellet production	9 to 27	9 to 49
U.S. non-pellet bioenergy production	25 to 56	30 to 68
U.S. South non-pellet bioenergy production	6 to 21	10 to 29

Sources: range derived from Cocchi and others (2011), Forisk Consulting (2014), and RISI Inc. (2013). RISI Inc. data extrapolated to 2020. Forisk Consulting data assumed 50% capacity utilization in the first year and 100% thereafter. Conversions to green short tons based on 2 green tons per dry ton and 0.9072 metric tonnes per dry ton.

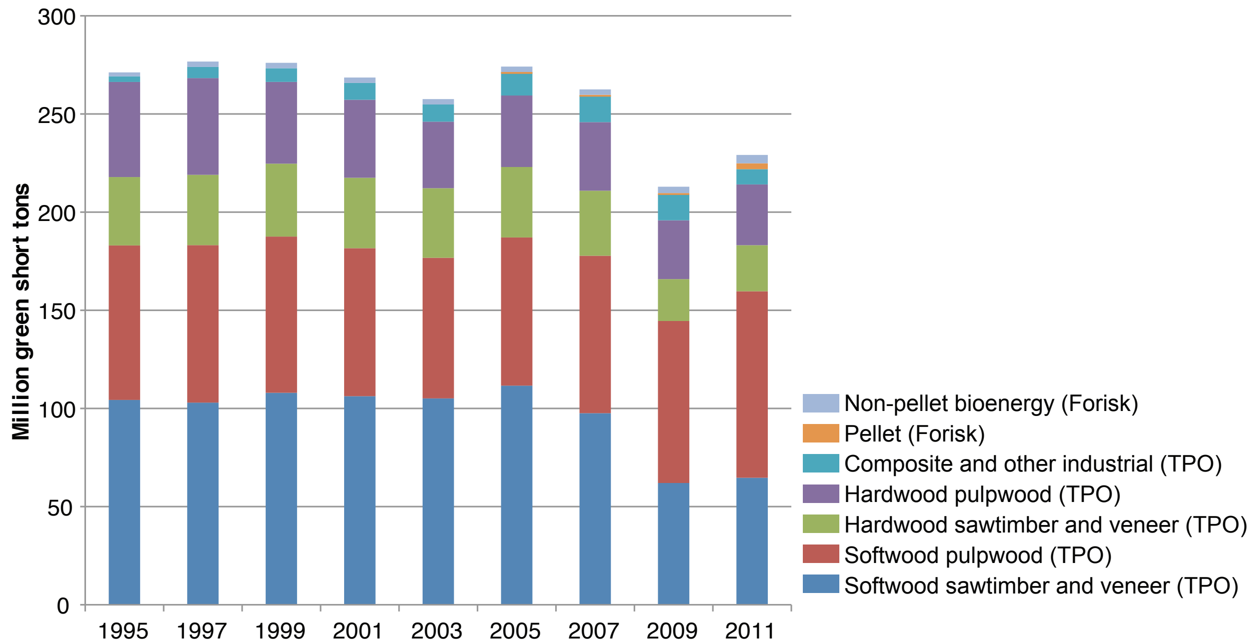

Figure 5—Timber product output (TPO) removals for U.S. South (excluding Texas) for 1995–2011.
Sources: Forisk Consulting (2014) for pellet and bioenergy; all other from USDA Forest Service (2014b).

Figure 5 shows the historical levels of timber removals from the U.S. South from 1995 through 2011. This includes removals for softwood and hardwood pulpwood and sawtimber, and for industrial wood products and composites. The most recently available Timber Product Output (TPO) data are from 2011 (USDA Forest Service 2014b), with consistent data back to 1995. Because data for Texas are not available in a comparable form for 2011, we excluded Texas from the TPO data and from the Forisk data used in this figure. These data also do not include logging residue removals.

The TPO data are derived from surveys of both traditional wood processing facilities (pulp, paper, and composite mills) as well as from bioenergy and pellet producers. We used the Forisk Consulting adjusted operating capacities to represent total bioenergy production levels, and thus subtracted the bioenergy and pellet production from the TPO category of "other industrial wood." "Pulpwood" in the TPO data represents delivered wood at pulp and paper mills; pulpwood-sized material used in bioenergy mills is categorized in "other industrial wood." Forisk Consulting data are derived from surveys of operating and announced bioenergy producers (Forisk Consulting 2014).

The effects of the 2008–09 recession can be seen in softwood sawtimber removals, with a decline from 2005 through 2009 and some recovery beginning in 2011. Softwood pulpwood removals do not show any recessionary effects, and are level to rising from 2003 through 2011. This could be a result of lower mill residue availability from the decline in the sawtimber markets and/or from a continued strong demand in paperboard manufacturing. Hardwood removals are less than half of pine removals for this region, with hardwood pulpwood showing a long-term decline from 1995 through 2009, with a leveling off in 2011.

Focusing on the use of non-sawtimber (pulpwood, composites, and mill residues) using information from the announcing companies (Forisk Consulting 2014), we calculated the projected non-sawtimber bioenergy feedstock needs as a proportion of total non-sawtimber removals in 2011 (fig. 6). The use of non-sawtimber as feedstock for both pellets and other bioenergy is shown in this figure and relies on the announcing company's perceptions of the future prices and availability of all eligible feedstocks. These projections include capacity for both pellet and non-pellet production, the latter of which includes generation of non-pellet electricity and combined heat and power. These companies may also have incorporated projections of the availability of mill residues through a projected housing recovery. With these caveats, the feedstock needs for the announced non-pellet bioenergy plus pellet capacities approaches 40 percent of total 2011 non-sawtimber removals. This increase would imply a noticeable shift in the bar graph segments in figure 5 if extended into the future.

Primary feedstock sources for pellet production are mill residues and both pine and hardwood non-sawtimber, all of which are classified as a clean feedstock with little or

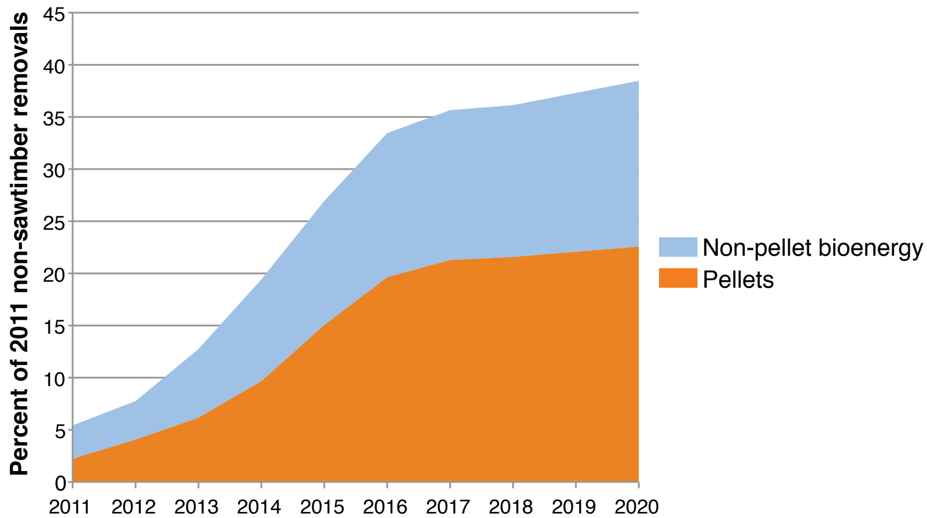

Figure 6—Existing (2011-2013) and announced (2014–2020) bioenergy capacity as a percent of total 2011 TPO non-sawtimber removals in the U.S. South (excluding Texas). Sources: Forisk Consulting (2014), USDA Forest Service (2014b).

no bark. While other types of bioenergy producers are more likely to use logging residues (Forisk Consulting 2014), figure 7 shows that the proportion of projected pellet feedstock expected to come from mill residues declines through 2016, while the proportion from non-sawtimber increases. These projections, made by the companies making the announcements (from Forisk Consulting 2014), likely assume that the relative prices for feedstocks will not change. A rise in non-sawtimber prices could lead to changes in the actual feedstock mix at pellet plants.

MODELING THE EFFECT OF BIOENERGY AND TRADITIONAL WOOD DEMAND ON FORESTS IN THE U.S. COASTAL SOUTH

Changes in the demand for bioenergy, which are driving changes in pellet production in the Southern United States, have the potential to affect existing forests, forest management, and forest landowners. Using the most recent Forest Inventory and Analysis (FIA) data for timber inventory and harvest (USDA Forest Service 2014a) and the most recent current and projected feedstock consumption by pellet mills and other bioenergy producers (Forisk Consulting 2014), we simulated the impact of projected wood demand for traditional wood products and bioenergy on timber markets and forests. We do not model forest or life-cycle carbon outcomes from the two scenarios we use, and we identify this as a future research need to fully understand the GHG impacts of increased bioenergy demand. We also do not impose any limitations on timber that can be used for supply, such as requirements for certification or alternative sustainability criteria.

Scenario Development and Model Assumptions

The Subregional Timber Supply model, or SRTS (Abt and others 2009), is a simulation framework based on published empirical estimates of supply, demand, and land use coefficients for the U.S. South. SRTS allows investigation of the impact of an array of traditional and bioenergy demand scenarios under varying assumptions for logging and sawmill residue utilization. The model allocates wood demand to forest survey units (portions of States) based on supply characteristics by forest type, ownership, and age class status of the forest.

In addition to developing a projection for the U.S. Coastal South region (fig. 8 and table 6), we explored subregional impacts by multi-State regions:

- Southeast Coast, including parts of Alabama, Florida, and Georgia
- Gulf Coast, including parts of Louisiana, Mississippi, and Texas
- Mid-Atlantic Coast, including parts of North Carolina, South Carolina, and Virginia.

The long-run (15+ years out) impact of pellet demand on resources and markets depends on the current and projected composition of the inventory and current and projected traditional and non-pellet bioenergy demands. Short-run timber supply (current to about 15 years out), on the other hand, reflects past management and planting, which determines current species mix, age class distributions, and current competitiveness with alternate land uses (mainly agriculture). The starting inventory for each species group, owner, age class, and broad management type was derived from the most recent FIA survey data. For the simulations below, we made the following assumptions:

1. Pine mill residues substitute for pine non-sawtimber as a bioenergy feedstock (for co-firing with coal or for pellet production). This means that the projection of sawtimber demand, derived in part from the projected housing start recovery, will affect bioenergy feedstock demand for non-sawtimber.

2. Hardwood harvests generate twice as much logging residue as pine harvests on a per unit basis, so logging residue availability depends on species used to meet both traditional and bioenergy demand. Typical measures of logging residues include the use of rough and rotten trees, which are a larger part of hardwood inventory than of pine inventory. We instead classify rough and rotten trees into inventory (assuming they can provide clean chips for pellets), so standing rough and rotten trees are not included in the simulation as logging residues.

3. There is significant flexibility in the woody material that can be used in local boilers, including logging residues. Pellet production, however, depends on clean chips from roundwood sources with limited ability to use the limbs and tops of trees. Logging residues (which, as defined here, do not include rough and rotten standing trees) are a byproduct of harvest and can substitute for non-sawtimber or mill residue in co-firing of coal electric power plants, but may be less suitable for use in making pellets.

4. Higher timber prices are assumed to lead to higher land rents, and empirical evidence indicates that timberland increases when land rents increase (Hardie and others 2000). Pine plantations are assumed to increase at twice the rate of natural forest types when timberland area is increasing, but decrease proportionately when timberland area is decreasing (i.e., when timber prices decline). Thus, these changes in plantation areas derive partly from changes in total timberland area and partly from changes in natural timberland. Note that there are no studies using post-1997 data to support this assumption.

5. The demand price elasticity is assumed to be 0.2 for pine and hardwood, consistent with the empirical literature on aggregate elasticities (Abt and Ahn 2003). Supply inventory elasticities are assumed to be 1.0 for pine and 0.6 for hardwoods. The pine supply price elasticity varies from 0.3 for non-sawtimber to 0.5 for sawtimber, while the hardwood supply price elasticity is assumed to be 0.5 for all products (Beach and others 2005, Pattanayak and others 2002).

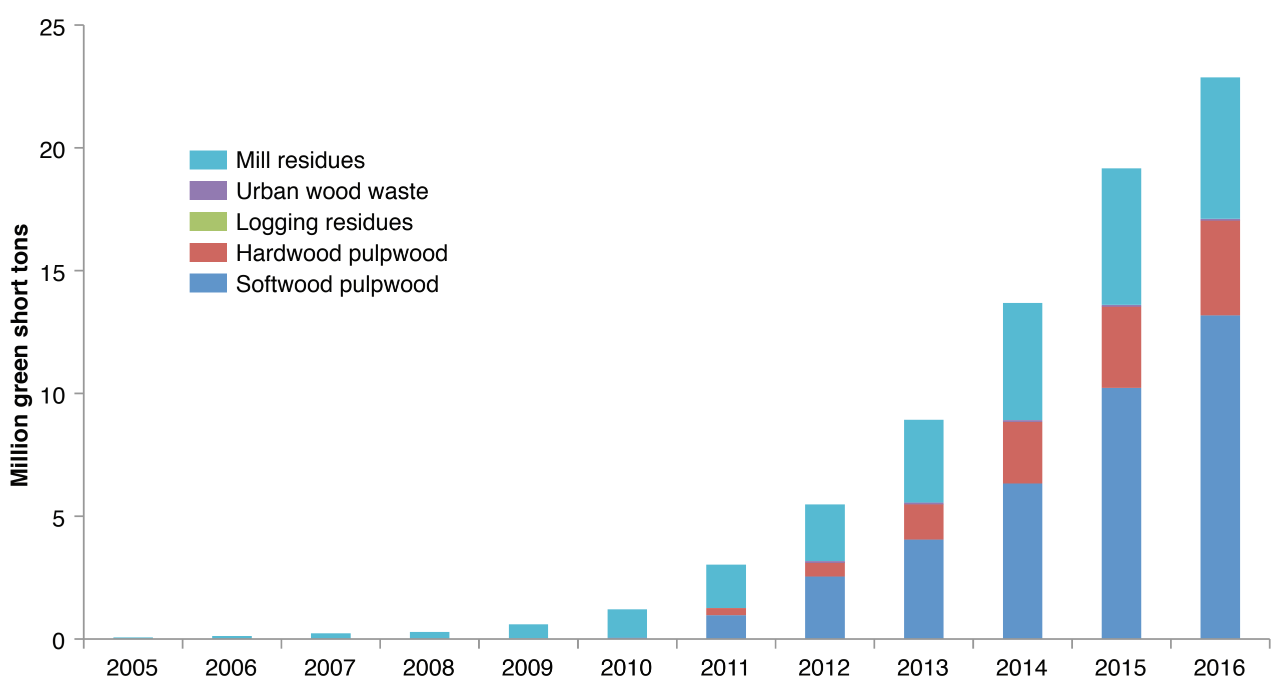

Figure 7—Actual and announced feedstock source for use in pellet production in the U.S. South for 2005–2016. Source: Forisk Consulting (2014).

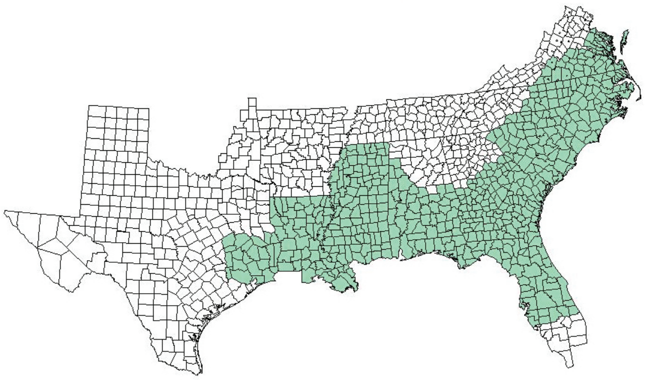

Figure 8—U.S. Coastal South region, showing counties and wood procurement regions for announced and operating pellet and bioenergy facilities.

Table 6—Aggregation of U.S. Southern Coastal States and survey units into subregions for analysis

State	Survey unit included	Region label
AL	1, 2, 3, 4	Southeast Coast
FL	1, 2, 3	Southeast Coast
GA	1, 2, 3	Southeast Coast
LA	1, 2, 3, 4, 5	Gulf Coast
MS	1, 2, 3, 4, 5	Gulf Coast
NC	1, 2, 3	Mid-Atlantic Coast
SC	1, 2, 3	Mid-Atlantic Coast
TX	1	Gulf Coast
VA	1, 2	Mid-Atlantic Coast

The baseline assumed demand trends for non-bioenergy products for each subregion are shown in figures 9A–D. These trends reflect a strong housing recovery, continued strength in pine non-sawtimber demand, and flat demand for hardwood products. These non-bioenergy demands were also applied to the bioenergy simulation. The baseline demands for bioenergy products were held constant at current levels. Figure 9 also shows the total adjusted announced bioenergy capacity (Forisk Consulting 2014) for each subregion and the total for the U.S. Coastal South. For these projections, we used the adjusted Forisk capacity to represent total bioenergy demand, including combined heat and power (CHP) and biofuels. While we have details on the breakdown of total bioenergy demand between pellet and non-pellet bioenergy (e.g., see fig. 6), we did not distinguish between the two types of bioenergy in the simulations. We also allowed logging residues to meet the stated level of logging residue demand provided in the Forisk Consulting data. Figures 10A–C show the assumed bioenergy demands and the contribution from each source (timber, logging residues, and mill residues) based on the Forisk data for each of the three subregions. SRTS determines mill residue and logging residue supply endogenously, but limits were placed on the logging residue utilization to match the Forisk data. Under the assumption that mill residues are the first choice of all non-sawtimber users (at a given price), mill residues produced were subtracted from total demand before the timber simulation was completed.

Simulation Results

SRTS provides projections of indices for roundwood price, removals, and inventory for each year of the projection by species group (pine and hardwood) and for each size/grade class (non-sawtimber and sawtimber) for both the bioenergy and baseline scenarios. Each of these indices is initialized at 100 in 2010 and then scaled to show percentage changes in the price, removals, or inventory as the simulation progresses. A summary of the projected composition of the bioenergy feedstock is also produced, which shows harvest change and logging residue utilization for each species group, and also shows the portion of total biomass (bioenergy and traditional) demand that is not met from within the region (leakage/displacement). The difference between capacity needs for biomass and biomass provided from within the region could be met partly by biomass imported from other regions (leakage) or could lead to displacement, where mills curtail operations or close because the price of feedstock is higher than they are willing to pay. Below, we focus on only the non-sawtimber results and the bioenergy feedstock composition, with reference to the sawtimber results where relevant.

We present results from the three subregions—Southeast Coast, Gulf Coast, and Mid-Atlantic Coast—as well as from the aggregate U.S. Coastal South. We would expect the larger region to have smaller price changes and less leakage/displacement than the sum of the smaller subregion simulations because the aggregate model captures the

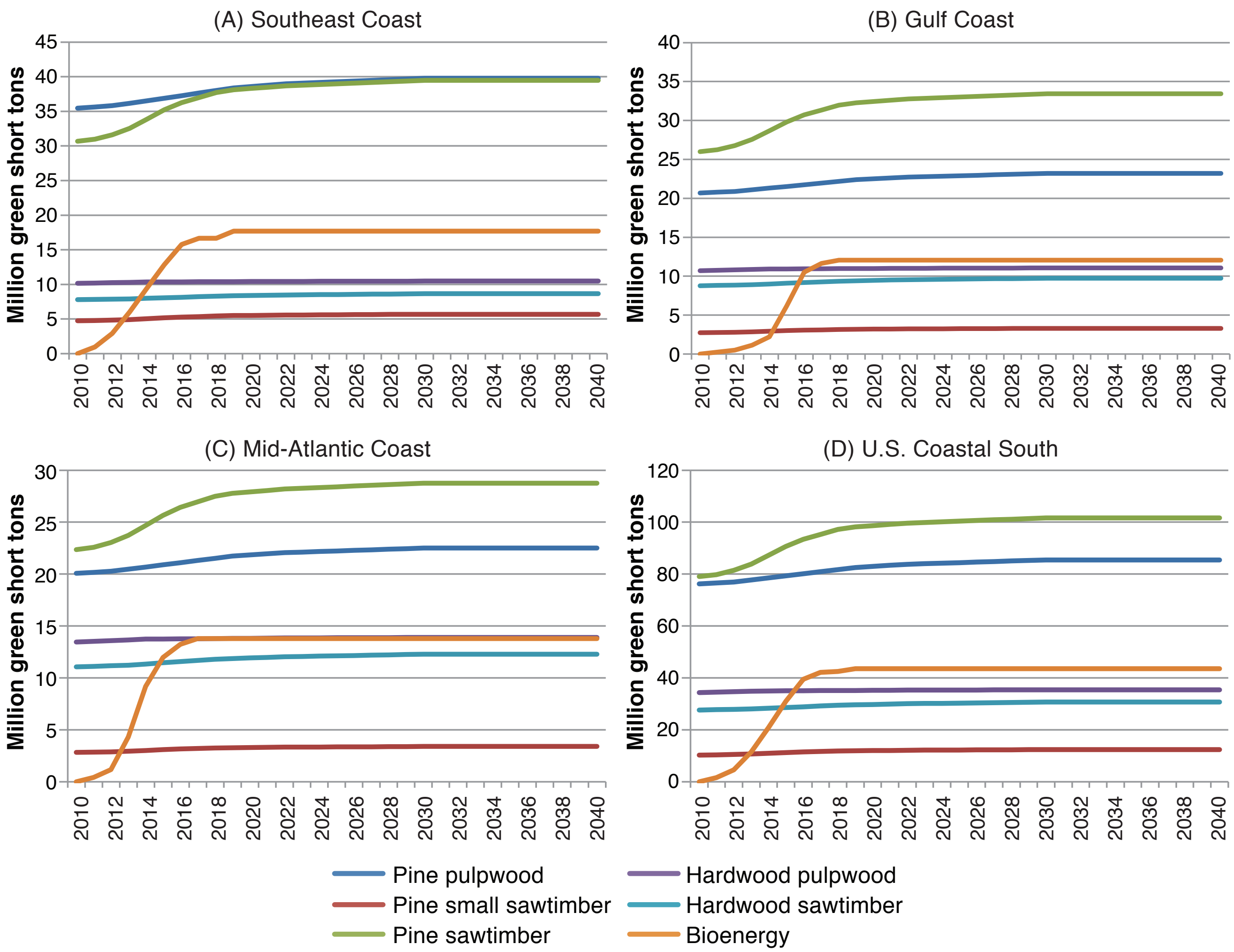

Figure 9—Timber and bioenergy demands by subregion and in total for the U.S. Coastal South for 2011 to 2040. The timber demands are used in both the baseline and bioenergy scenarios, while the bioenergy demands are used in only the bioenergy scenario. Source: Forisk Consulting (2014) for bioenergy demand, see text for other demands. A=Southeast Coast; B=Gulf Coast; C=Mid-Atlantic Coast; D=U.S. Coastal South.

shifting of harvests among subregions. The results are shown in figures 11–19 and in table 7.

Southeast Coast subregion—This subregion includes the highest level of both current and announced bioenergy capacity of the three coastal subregions (Forisk Consulting 2014) (fig. 10A and table 7). Projected bioenergy capacity rises through 2020, with most of the increase occurring before 2016.

Under the baseline scenario for pine non-sawtimber, the projection shows price increases midway through the projection even without bioenergy demands, and then, as the adjustment in planting and inventory occurs, prices fall to below the 2010 level (fig. 11A). Imposing the bioenergy demand leads to large price increases (index = 240) by about 2025. Similar to the baseline scenario, the planting and inventory response to these higher prices begins to be felt as harvests continue to rise to meet the increased bioenergy demand (fig. 11B). Prices end the projection only 20-percent higher than the initial 2010 level.

For hardwood non-sawtimber, the baseline scenario shows prices falling throughout the projection period, with expected increases in both inventory and removals (fig. 11C). This implies that an increasing inventory will keep prices falling and removals rising. The assumed price and inventory elasticities reflect landowners' willingness to sell timber as timber prices fall. These inelastic responses mean that prices will fall proportionately more than the quantity reduction. The bioenergy scenario shows a different story, as the increased demand for feedstock for pellets and other bioenergy leads to price increases through 2016, even though prices for hardwood non-sawtimber fall below current levels by the end of the projection (fig. 11D).

The potential leakage/displacement in the Southeast Coast is roughly 3.1 mgt, rising to a maximum of 7.6 mgt in 2024 as demand increases and price begins to affect long-term demand. After 2023, however, the potential leakage/displacement falls, as the area and inventory boost from the higher prices is reflected in increased removals (fig. 12).

Gulf Coast subregion—The Gulf Coast subregion can be defined, in part, by the current high volume of large pine sawtimber inventory. An earlier boom in planting followed by decreasing demand for sawtimber in this subregion has left a glut of large sawtimber. Unfortunately, this does little to provide feedstock for pellets or other bioenergy demands in this subregion. The total bioenergy demand in this subregion is the lowest of the three, at about 12 mgt (fig. 10B and table 7).

Under the baseline scenario, pine non-sawtimber prices fall, while inventories rise somewhat and prices stay nearly steady, implying an equilibrium under our assumptions (fig. 13A). Adding the bioenergy demand once again leads to price increases through about 2025 (index = 193) and to price decreases from 2026 through the end of the projection as new inventory becomes available, allowing increased removals. Pine inventories are higher at the end of the bioenergy simulation (index = 115). Removals rise in the early years, and then stay about 20 percent higher than 2010 values (fig. 13B).

Hardwood non-sawtimber shows slightly declining prices along with rising inventory and somewhat higher removals in the baseline scenario over the entire projection period (fig. 13C). The bioenergy scenario, as in the other subregions, shows an initial rise in prices through mid-projection, then a fall in prices as inventory and removals rise (fig. 13D).

Potential leakage/displacement is high, at nearly half of total bioenergy demand (fig. 14). The projection shows some recovery, however, from increasing harvest—primarily pine harvest—toward the end of the projection.

Mid-Atlantic Coast subregion—This subregion includes a relatively high level of current bioenergy demand (fig. 10C, table 7), and a large portion of that demand is assumed to come from hardwoods (Forisk Consulting 2014). Projected bioenergy demand rises through 2020, though most of the pellet demand occurs before 2016.

The baseline scenario (figs. 15A and 15C), which does not include any new bioenergy demands, continues to show a small but increasing trend in both species groups' inventories through the end of the projection. The baseline price increases for pine non-sawtimber are relatively small compared to the bioenergy scenario (figs. 15A and 15B), where the price index rises until 2020 before declining to an index of just over 150 by 2040. This price rise occurs because the removals rise in the bioenergy scenario to provide feedstock to the pellet and other bioenergy producers. Inventory declines while the price is rising, then recovers as the higher price elicits more planting and conversion to timberland.

For hardwoods, the baseline scenario shows that non-sawtimber removals rise steadily over the projection, but prices still fall (fig. 15C). The addition of bioenergy demand, however, leads to a rapid price rise between 2010 and 2016 in concert with the increased pellet demand (fig. 15D). Hardwood non-sawtimber inventory continues to increase, but at a lower rate than under the baseline scenario.

Figure 16 shows the feedstock composition and the potential leakage/displacement from this subregion if all of the announced capacity is built and other model conditions hold. Overall potential leakage rises to 3.5 mgt in 2017, then gradually shrinks as inventory gains affect the hardwood and pine sawtimber removals. There is little change in the sawtimber harvest or prices (not shown).

U.S. Coastal South—Developing a projection for an aggregate of these three subregions allows for intraregional trade—an increase in demand in one subregion can be met, at least partially, by additional harvests in the adjacent regions (fig. 17). This has the effect of dampening both price increases and projected leakage/displacement relative to our stand-alone projections for each region due to increased bioenergy use. Transporation costs are not explicitly modeled in SRTS because it is a stumpage model rather than a delivered wood model, so we cannot say the extent to which there will be increased intraregional trade. The results of the projections are consistent with this hypothesis, however, showing a price increase in the bioenergy scenario that is somewhere between the extremes of the Southeast Coast and the Gulf Coast subregions. In addition, the overall potential leakage/displacement (to areas outside the coastal South) is lower for this larger geographic region than it would be if the potential leakage/displacement amounts from the three independent subregions were merely added together (table 7).

The U.S. Coastal South model still shows a substantial potential leakage/displacement, indicating that there may be the potential for trade (in timber) between this region and the more interior regions that were not part of our analysis (figs. 8 and 18). Alternatively, there could be increased international imports of either timber or residues. This could allow the final processing to continue in the region, closure or curtailment of existing wood-using mills, and/or increased imports of final goods for consumption in the United States. The SRTS model, and this analysis, do not

Table 7—Comparison of the subregion simulations and the U.S. Coastal South region simulation

Subregion	Wood inputs: All bioenergy	Wood inputs: Pellet production	Maximum Projected Displacement/Leakage	
	million green tons		*million green tons*	*as percent of wood inputs for pellets*
Southeast Coast	18	11.5	7.6	66%
Gulf Coast	12	10.6	5.2	49%
Mid-Atlantic Coast	14	9.4	4.8	51%
U.S. Coastal South	44	32.2	17.0	53%

Softwood non-sawtimber price index

	Baseline scenario				Bioenergy scenario			
	2010	2020	2025	2040	2010	2020	2025	2040
Southeast Coast	100	99	116	92	100	201	240	120
Gulf Coast	100	79	83	68	100	173	193	134
Mid-Atlantic Coast	100	100	106	98	100	207	228	153
U.S. Coastal South	100	93	103	88	100	194	222	127

Hardwood non-sawtimber price index

	Baseline scenario				Bioenergy scenario			
	2010	2020	2025	2040	2010	2020	2025	2040
Southeast Coast	100	96	93	86	100	128	123	115
Gulf Coast	100	101	100	96	100	139	138	136
Mid-Atlantic Coast	100	94	90	84	100	129	123	114
U.S. Coastal South	100	97	94	89	100	130	126	120

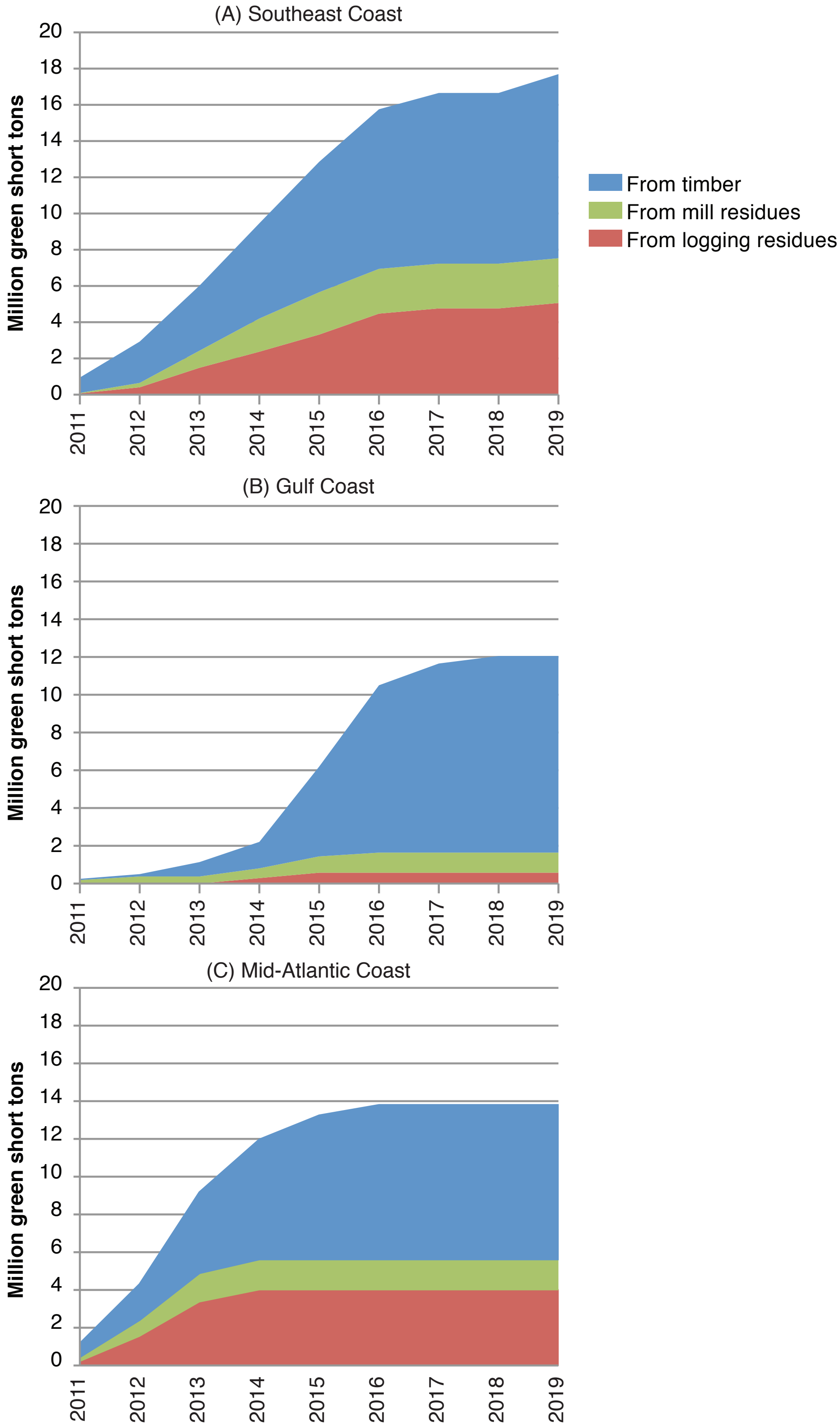

Figure 10—Total announced bioenergy capacity by source type and U.S. Coastal subregion for 2011 through 2019. Source: Forisk Consulting (2014). A=Southeast Coast; B=Gulf Coast; C=Mid-Atlantic Coast.

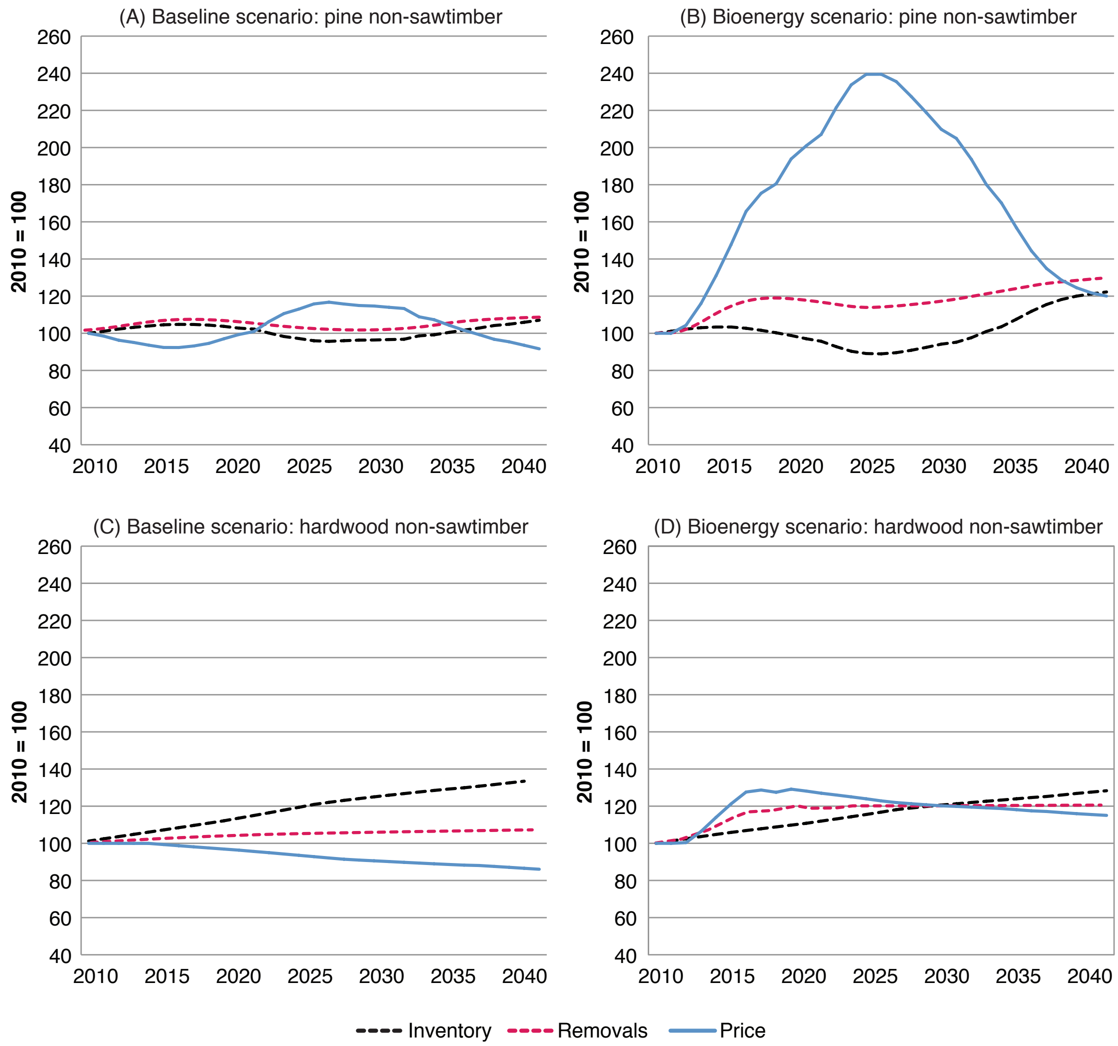

Figure 11—Southeast Coast projection results showing inventory, removals, and price indices for non-sawtimber for 2010–2040 for both the baseline and bioenergy scenarios and both pine and hardwood. A=Baseline scenario: pine non-sawtimber; B=Bioenergy scenario: pine non-sawtimber; C=Baseline scenario: hardwood non-sawtimber; D=Bioenergy scenario: hardwood non-sawtimber.

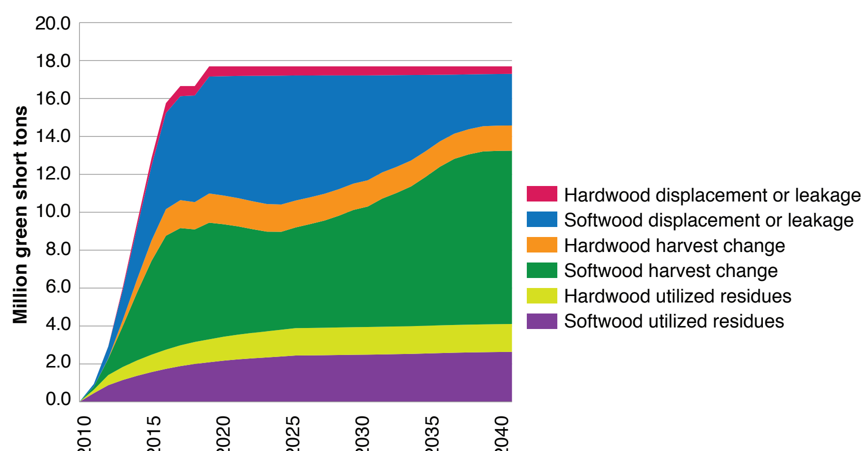

Figure 12—Southeast Coast feedstock composition projection for 2010–2040, showing total quantity change in bioenergy feedstock demands from Forisk Consulting (2014) and the projected source of feedstock from the simulation model.

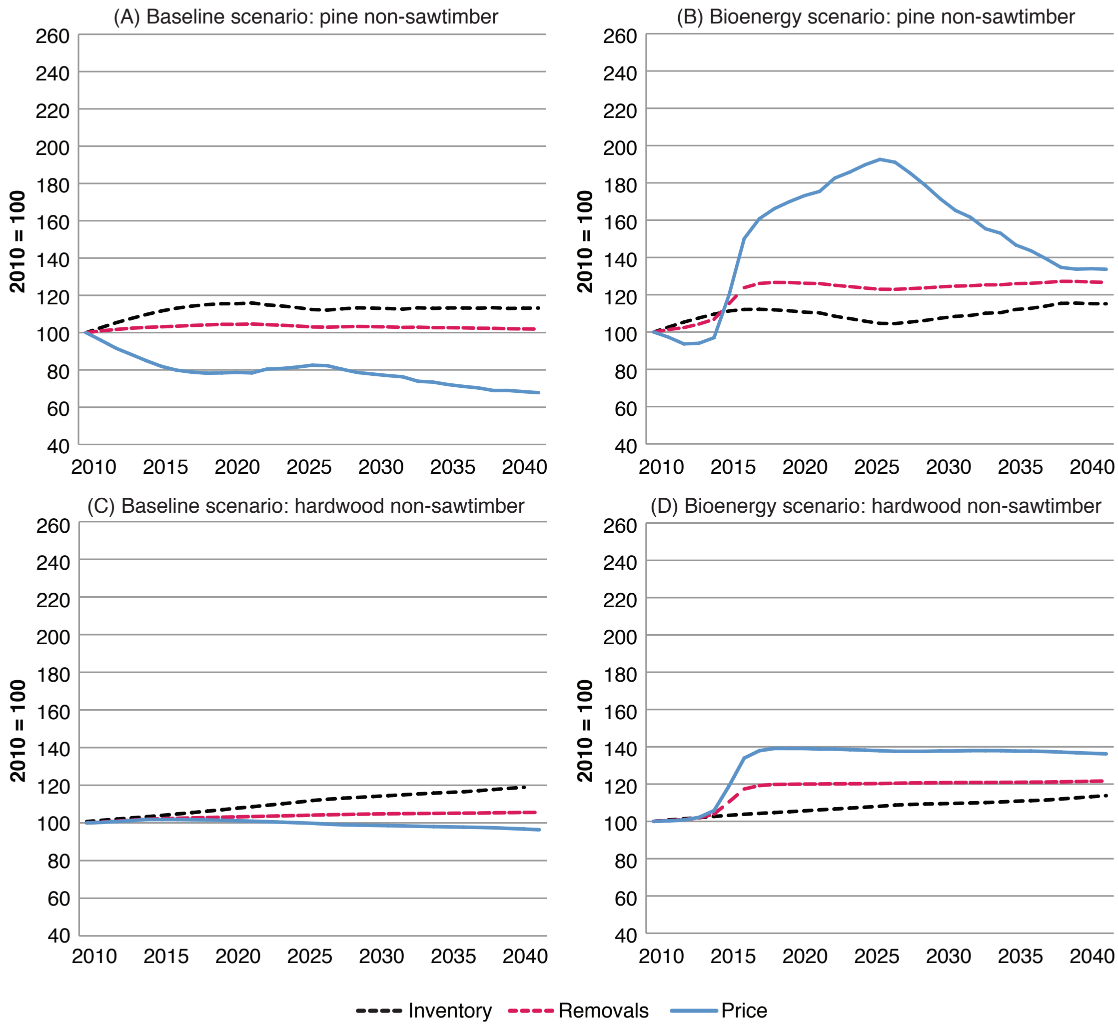

Figure 13—Gulf Coast projection results showing inventory, removals, and price indices for non-sawtimber for 2010–2040 for both the baseline and bioenergy scenarios and both pine and hardwood. A=Baseline scenario: pine non-sawtimber; B=Bioenergy scenario: pine non-sawtimber; C=Baseline scenario: hardwood non-sawtimber; D=Bioenergy scenario: hardwood non-sawtimber.

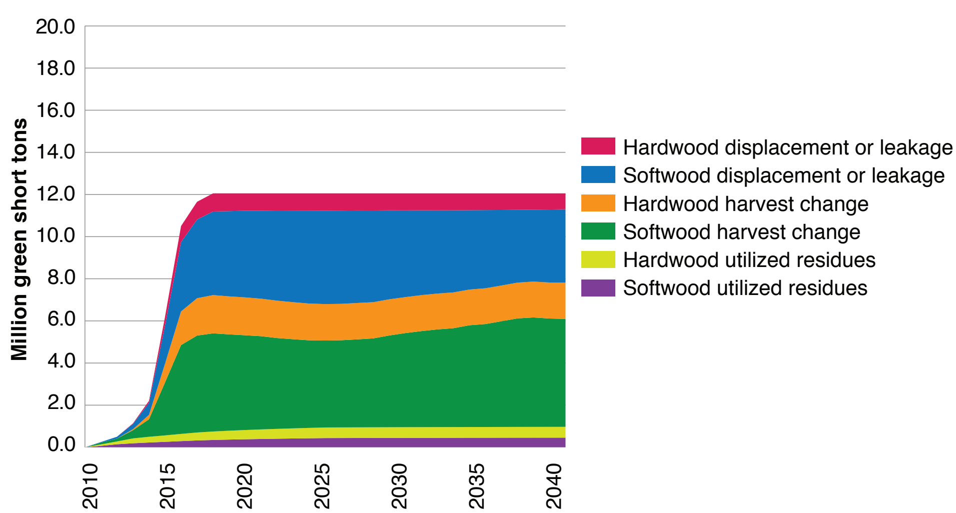

Figure 14—Gulf Coast feedstock composition projection for 2010–2040, showing total change in bioenergy feedstock demands, as well as the demand quantities provided by pine and hardwood utilized residues, harvest change, and displacement/leakage.

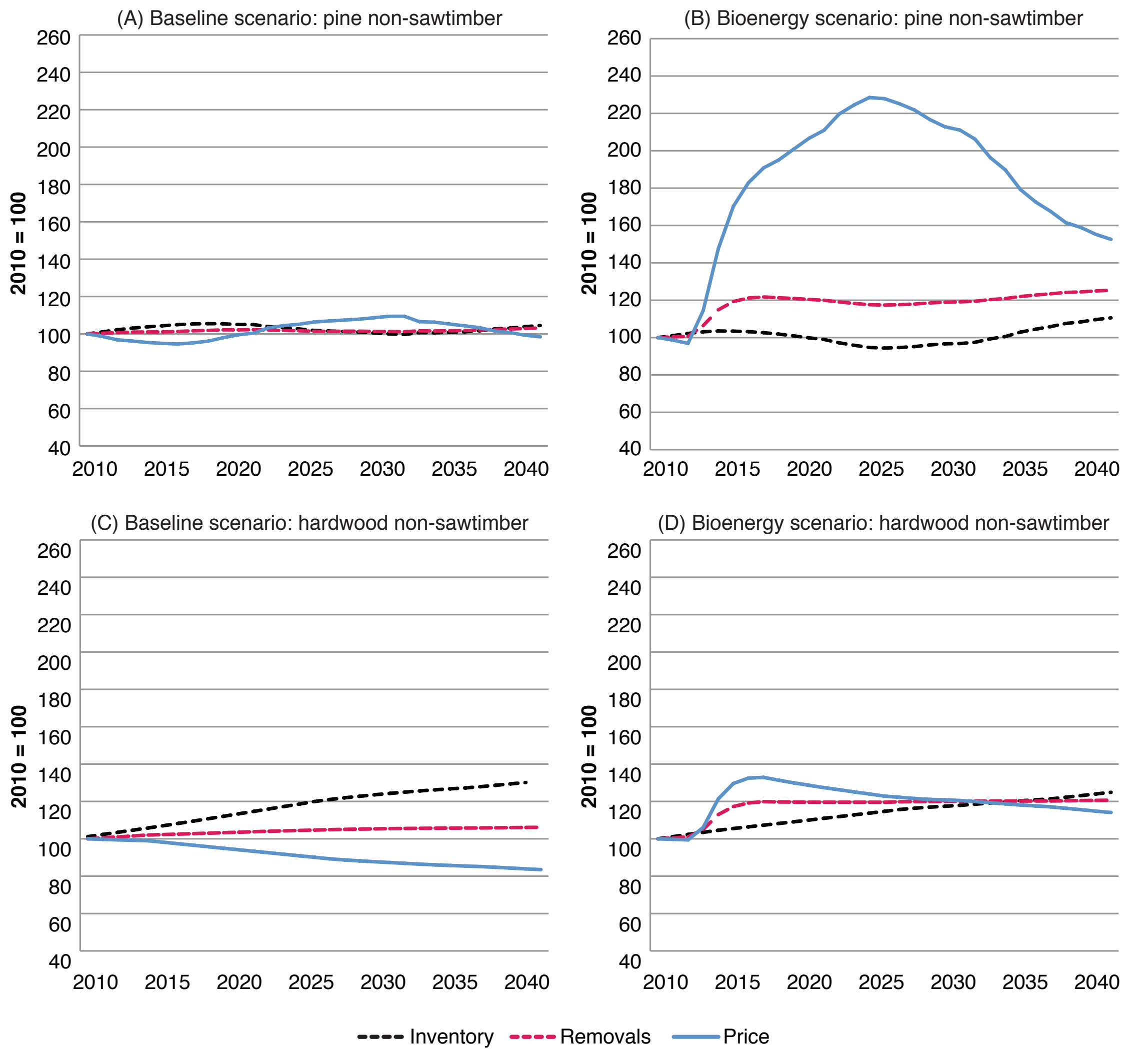

Figure 15—Mid-Atlantic Coast projection results showing inventory, removals, and price indices for non-sawtimber for 2010–2040 for both the baseline and bioenergy scenarios and both pine and hardwood. A=Baseline scenario: pine non-sawtimber; B=Bioenergy scenario: pine non-sawtimber; C=Baseline scenario: hardwood non-sawtimber; D=Bioenergy scenario: hardwood non-sawtimber.

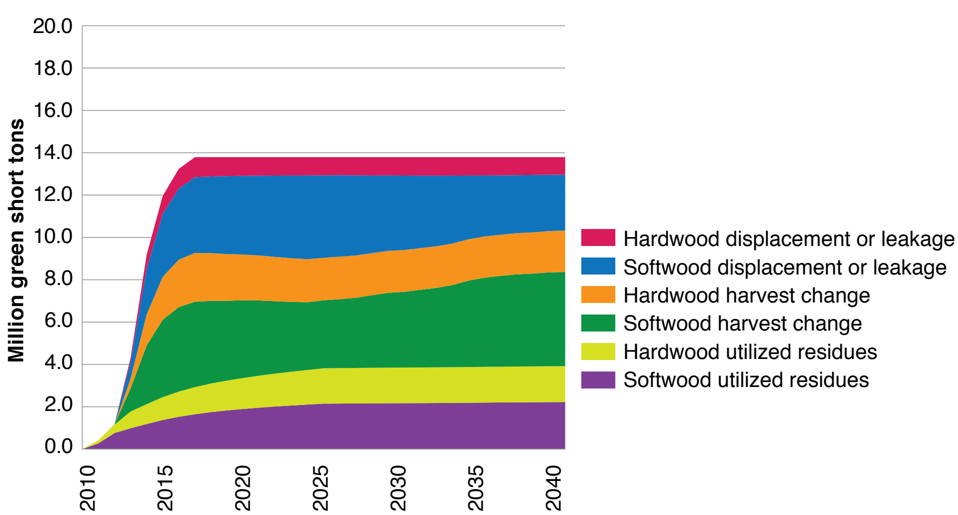

Figure 16—Mid-Atlantic Coast feedstock composition projection for 2010–2040, showing total change in bioenergy feedstock demands, as well as the demand quantities provided by pine and hardwood utilized residues, harvest change, and displacement/leakage.

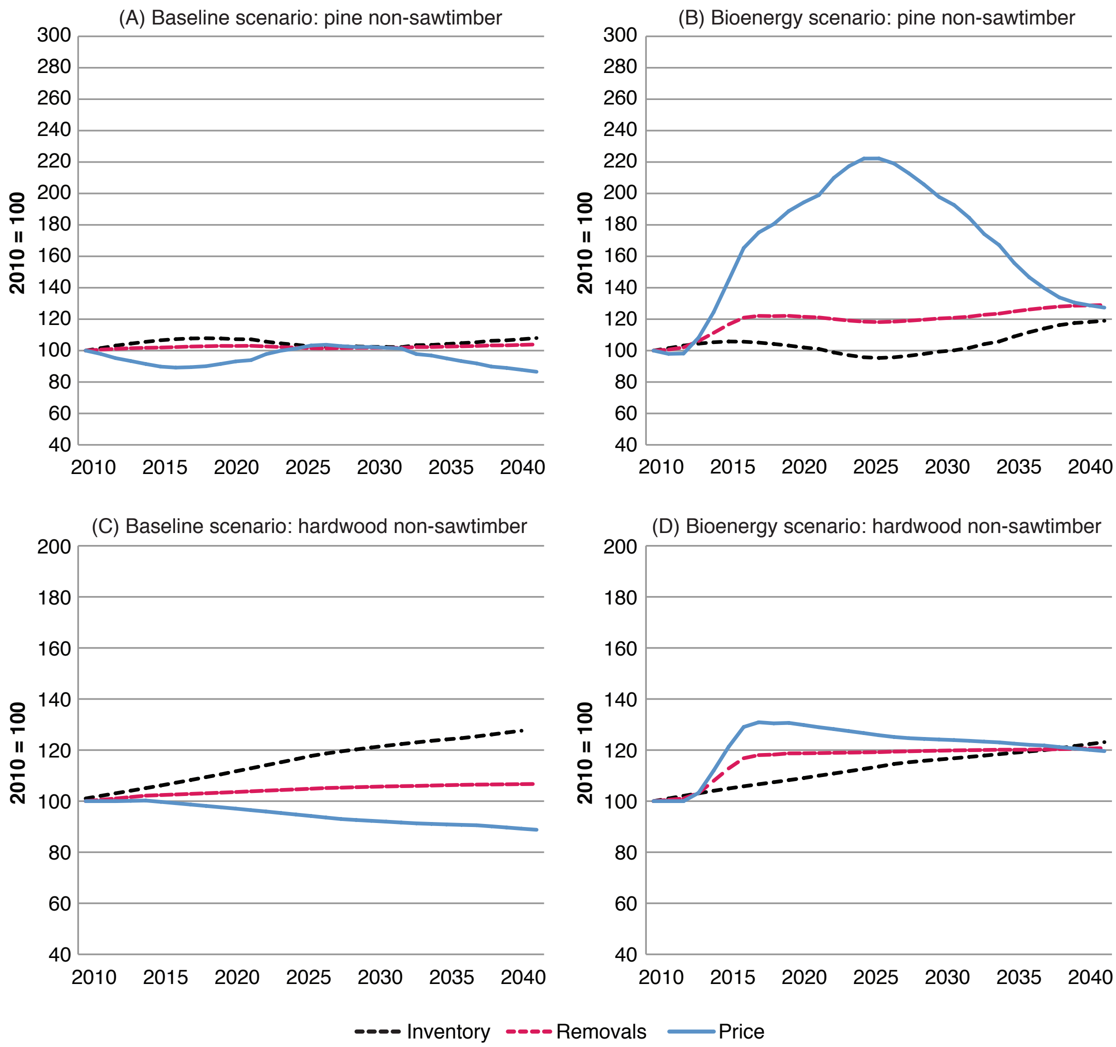

Figure 17—Total U.S. Coastal South projection results showing inventory, removals, and price indices for non-sawtimber for 2010–2040 for both the baseline and bioenergy scenarios and both pine and hardwood. A=Baseline scenario: pine non-sawtimber; B=Bioenergy scenario: pine non-sawtimber; C=Baseline scenario: hardwood non-sawtimber; D=Bioenergy scenario: hardwood non-sawtimber.

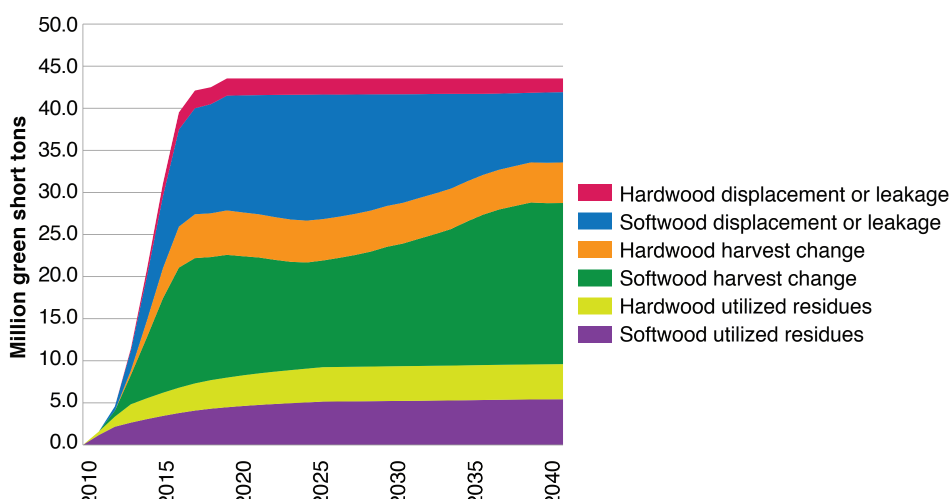

Figure 18—Total U.S. Coastal South feedstock composition projection for 2010–2040, showing total change in bioenergy feedstock demands, as well as the demand quantities provided by pine and hardwood utilized residues, harvest change, and displacement/leakage.

evaluate the potential for or level of these types of international or final goods market trade-offs.

The land area model captures the impact of timber rents relative to an assumed flat agriculture rent baseline (Hardie and others 2000). Pine sawtimber prices recover as housing starts increase, but the prices do not recover to pre-recession levels due to significant increases in inventory. After the initial increase, sawtimber prices are flat for the long run, which leads to a continued long-term loss of plantation and natural timberland in the baseline run (fig. 19). Increases in prices due to the increased demand for bioenergy are assumed to lead to increased timberland area in the bioenergy scenario.

The land area model, however, does not inform how rents affect the composition of the forest. For these runs, we assumed that plantation acres were twice as sensitive to prices as natural pine, oak-pine, and upland hardwood stands. We assumed lowland hardwood acres were half as price-sensitive as other natural forest land. The spike in pine non-sawtimber prices in the 2015 to 2030 period significantly influences forest rents, so that plantation acres increase and loss of timberland to agriculture decreases. Plantation acres expand at the expense of natural forest land and marginal agriculture, but this loss of natural forests to plantation acres is largely offset by the reduction in loss to agriculture. After the price bubble, the long-term decline continues, and at the end of the projection there is an approximately 3-percent increase in timberland area, with plantations making up 34 percent of timberland in the bioenergy run and 31 percent in the baseline run. These simulations include only the Coastal Plain and Piedmont, areas where marginal agriculture and pine plantations historically compete. An assumption of increasing agriculture rents would have dampened the land use dynamics and led to either more conversion of natural forest to plantations or a continuation of higher prices.

Summary—Modeling

Based on our assumptions, the results indicate increased bioenergy demand could result in an increase in pine non-sawtimber prices. Without increased bioenergy demand, mill residues from the assumed strong housing recovery could be used to meet increasing demand for wood to make pulp and composite panels. However, the additional demand for feedstock from this predominately pine resource base, along with price-inelastic supply, leads to sharp price increases and potential leakage and displacement. In the longer run, the price increase leads to expansion of the timberland base, which increases inventory and restores prices and inventory to near starting-point positions by 2040. By assumption, the increase in timberland area leads to an increase in pine plantation area. The potential for a shift in the use of pine from traditional products to bioenergy, however, could lead to structural changes in the industry and have job and income effects, which are beyond the scope of this paper.

For hardwoods, the demand increase leads to a price spike, but inventories continue to increase and dampen prices over time, except in the Gulf Coast subregion where prices remain high. Increased demand for hardwoods leads to an increase in harvest of hardwoods, both upland and bottomland hardwoods, but does not exceed the underlying growth in hardwood inventories.

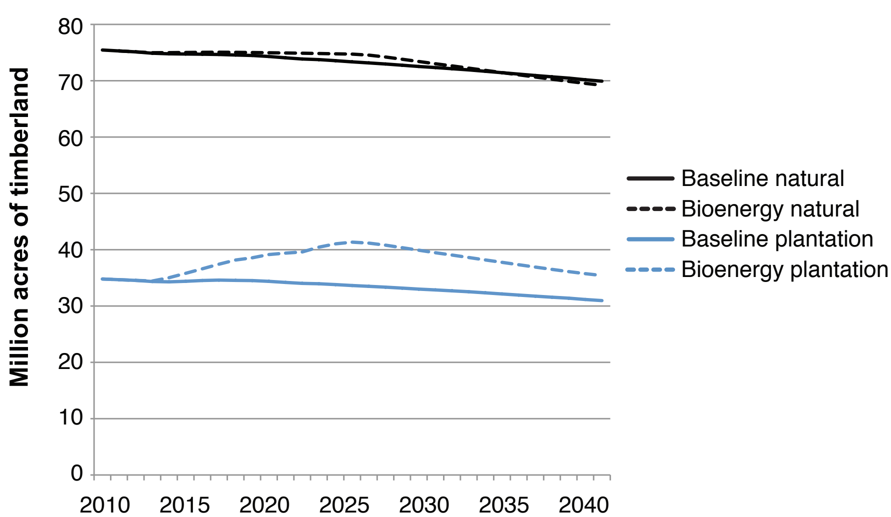

Figure 19—Projected land use for U.S. Coastal South, 2011–2040, showing assumed split between pine plantations and natural forest for both the baseline and bioenergy scenarios.

It is generally recognized that there is disparity between total inventory and available inventory for hardwoods. This was partially accounted for in the model, where available inventory or supply was assumed to increase at half the rate of total inventory. However, the sensitivity of hardwood supply to wet weather conditions and a more heterogeneous supply landscape (e.g., ownership objectives and tract size) makes hardwood availability difficult to project with any certainty.

The simulations did not include restrictions on land use due to sustainability criteria, which are expected to decrease inventory and increase equilibrium price. The simulations also included assumptions regarding the changes in land use that reflect historical management type changes (e.g., conversion of natural pine to pine plantations), which may not be indicative of future management type changes. The simulations also encompassed an empirical model of land use changes between urban, forest, and agricultural land uses that may not accurately reflect current or future land use changes. Finally, the simulations' harvest decisions replicated historical harvest patterns by landowner, species group, age class, and forest management type. This may not be indicative of future harvest patterns.

Our modeling assumptions used the Forisk Consulting (2014) announcements to represent wood feedstock demand for bioenergy uses. Except for the first year, the announced facilities were assumed to run at 100-percent capacity, which is likely an overstatement of demand. In addition, we included all announcements, not just those with viable technologies; this could be a second way we overstated demand. In contrast, however, because at least some of these facilities are quick to propose and build, there could be additional capacity installed that is not yet part of the announcements, leading to an understatement of demand. Finally, the announcements do not continue beyond 2020, while continued increases in bioenergy demand are expected in some forecasts (Cocchi and others 2011; U.S. Department of Energy, Energy Information Administration 2014)—a second way we may have underestimated future demands.

If the demands before 2020 are lower than projected by Forisk Consulting (2014), then prices and timberland area will likely increase less. If the demands after 2020 are higher than we have projected, then prices and timberland area are expected to increase more, or to stay at a higher level beyond 2020. The precise outcome would depend on assumed level of demand for each subregion or aggregate.

SUMMARY AND RESEARCH NEEDS

Currently, the major U.S. pellet exporting region is the U.S. South, and this is expected to continue. The major pellet importer is the United Kingdom, and the United Kingdom and other EU countries are expected to continue to be major importers, within the constraints of both EU and their own renewable and sustainable energy policies. There is some uncertainty regarding whether the United States will continue to be the source of choice, depending on specific sustainability and GHG emission reduction policies at the EU and Member State levels. On the other hand, if renewable energy policies in non-EU countries lead to an increased demand for pellets in the Pacific Rim, and these pellets are supplied from Western Canada, then this could put additional pressure on the U.S. South, as well as the U.S. North, Eastern Canada, and other countries to supply pellets to the EU.

The major impact from these policies is the level of increased demand for wood, including both timber and logging residues, from U.S. forests. This increase in demand will lead to increased timber harvests and increased timber prices, in addition to short-run gains to forest landowners and short-run losses to non-pellet producers (traditional and domestic bioenergy producers). Long-run impacts will depend on how each industry adapts to changing prices, how land use changes in response to timber price changes, as well as the specifics of changes in international and domestic policies.

The level of projected increase in non-sawtimber prices, combined with low current and projected sawtimber prices, is unprecedented in the U.S. South. To evaluate the effect of projected increases in demand on markets, we use simulation and assumptions based on expert opinion and empirical relationships defined for traditional wood products. The results from these simulations show that the increased policy-induced demand is projected to lead to greater harvest of both pine and hardwood non-sawtimber as well as increased prices for both. The higher prices lead to an increase in land rents, which in turn leads to a projected increase in timberland area.

One limiting factor in preparing this analysis is that these are new markets, and little empirical research has been done on them, so the models use assumptions based on research for other product types. A second limiting factor is that policies continue to evolve, both domestically and internationally, and thus there is no stable policy world upon which to base our projections. Uncertainty in policies, ranging from the Boiler MACT to the EU 2030 renewable energy policy, will likely raise the costs of doing business as a pellet-for-export manufacturer in the United States. However, whether any of these policies will have a deterrent effect on U.S. pellet export demand is unknown; this will depend on the scale of subsidies and incentives, as well as penalties and certification requirements. The emergence and/or competitiveness of other wood pellet suppliers (e.g., Canada and Brazil) in terms of price and ability to meet sustainability criteria may also affect demand for U.S. pellets.

To improve future forecasts, in addition to improvements in modeling, we recommend further research in six areas: (1) the effect of current sustainability policies on inventory availability and cost of feedstock procurement; (2) price responsiveness of logging residue supply and demand; (3) potential carbon impacts from leakage/displacement and conversion of agricultural land to forestry; (4) the effect of delivered product price changes on harvest location decisions, including stumpage, harvest, and transportation costs; (5) the impact of new and evolving EU and Member State renewable energy and sustainability policies and subsidies on pellet export from the U.S. Coastal South; and (6) the effect of future timber price increases on long-term viability of traditional timber users.

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Current policies in the European Union (EU) requiring renewable and low greenhouse gas-emitting energy are affecting wood products manufacturing and forests in the United States. These policies have led to increased U.S. pellet production and export to the EU, which has in turn affected U.S. forests and other wood products manufacturing. At this time, the primary exporting region in the United States is the South, and the primary importing countries in the EU are the United Kingdom, Belgium, and the Netherlands. The policies and some Member State subsidies are expected to continue in place until at least 2020, with the potential to continue beyond that date. Key drivers of U.S. pellet feedstock supply include both the age structure of current timber inventory and the policies that define sustainability. Also influencing the effect of increased demand for timber for pellets are the price-inelastic supply and demand. A simulation of the market responses to increases in both pellet and other bioenergy demand in the U.S. South suggests that prices will increase for timber as harvest increases, and will in turn lead to long-term changes in inventory and forest land area.

Keywords: Bioenergy, biomass, Renewable Energy Directive, timber supply, wood pellets.

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